

Banerjee, Aniruddha

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## Price elasticity estimation for converged telephone, data, and video services

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# **The 19th ITS Biennial Conference 2012**

## **“Moving Forward with Future Technologies: Opening a Platform for All”**

18 - 21 November 2012, Thailand

**Price Elasticity Estimation for Converged Telephone, Data, and Video Services**

**Aniruddha Banerjee, Ph.D.**

**CENTRIS**

**[abanerjee@centris.com](mailto:abanerjee@centris.com)**

## Price Elasticity Estimation for Converged Telephone, Data, and Video Services

Aniruddha Banerjee, Ph.D. (CENTRIS)

### 1. Introduction

Traditional telephone, cable, and Internet access companies throughout the world now operate, or are moving towards, convergent platforms from which they can offer the “triple play,” i.e., integrated bundles of telephone, data (Internet access), and video services. Consumers see these services as all belonging on a single spectrum of communications and entertainment services rather than as discrete services to be purchased from different service providers. As companies with convergent platforms compete over essentially the same slate of services, product differentiation is becoming paramount. Importantly, pricing individual tiers of those services, and the triple play itself, so as to maximize revenues, profits, market share, etc. is becoming both necessary and increasingly complex.

Efficient pricing methodologies abound in the economics literature, many specifically for network industries.<sup>1</sup> Whatever the service provider’s financial objective, price elasticities are central to managing the pricing function for converged services. Apart from own-price elasticities for these services, several cross-price elasticities are at play: (1) those among a service provider’s own services and (2) those between the services of one service provider and similar services offered by its competitors. Yet another set of cross-price elasticities, often overlooked in service providers’ own revenue calculations or by empirical researchers, arises when customers *cross-subscribe*, i.e., construct their own bundles of services by subscribing to different service providers rather than a single source.

For a company that offers the triple play and its component services separately, pricing efficiently may require tracking a large number of price elasticities. This paper demonstrates how a household-survey based approach can generate the data and a mixed logit modeling approach can be used to produce all of the required price elasticities. Price elasticities can be estimated under assumptions of both price increase and price reduction. The estimated elasticities can then be loaded into a simulator suitable for the pricing toolkit of a company offering multiple services and bundles. Apart from helping to set prices, the simulator can also predict the revenue outcomes of the pricing actions of a company and/or its competitor. In this manner, this paper makes a significant contribution to pricing and competitive scenario analysis in the modern environment with convergent platforms for telecommunications and entertainment services.

### 2. Pricing Environment for Converged Services

Since the mid-1990s, change has been sweeping through industries offering telephone, television, and Internet access services throughout the world. Fundamental technological

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<sup>1</sup> See Jean Tirole, *The Theory of Industrial Organization*, The MIT Press, Cambridge, MA, 1993; Robert B. Wilson, *Nonlinear Pricing*, Oxford University Press, New York, 1993; Lester D. Taylor, *Telecommunications Demand in Theory and Practice*, Kluwer Academic Publishers, Boston, MA, 1994.

change has driven previously discrete networks for the three types of communication and entertainment services towards convergent platforms. Now, telephone companies can use fiber-based technology to offer both video and Internet access services alongside their staple telephone services, while erstwhile television-focused cable and satellite companies have found ways to offer either network-based or synthetically bundled telephone and Internet access services. Much, if not most, of this change has been facilitated by reform of regulatory regimes, including outright deregulation or the use of unbundling, interconnection, and licensing arrangements to enable greater competition.

The convergence of platforms has changed the landscape in which digital communications, entertainment, and information services are offered and consumed. Consumers now increasingly see telephone, data, and video services as three peas in the same pod, even though they each serve different needs. There are several reasons for this.

1. The availability of all three services from the same service provider makes budgeting and purchasing easier for consumers, most of all because common billing often leads to price discounts, easier access to customer service, and service integration at customer premises.
2. Even though the three services would appear to be distinct, they share features that promote interchangeability (such as when high bandwidth for Internet access also enables online streaming of video content and games, or emails and call notifications can occur through all three services).
3. The advent of high-speed wireless communications (most notably, 4G Long-Term Evolution) now extends the customer experience with all three types of services to all types of locations (indoors and outdoors, fixed or on the move) and devices (TV sets, computers, handsets, tablets, gaming consoles, etc.).
4. Where convergent platforms have been adopted, service providers no longer see any benefit to providing discrete services. Technological, service, and market integration brought on by convergence makes it more efficient, profitable, and customer-retentive to compete for the triple play (or the “quadruple play” where wireless services are also included) than for individual services.

In order to compete, however, service providers with convergent platforms must go beyond single flavors of the three types of services. Efficient operation and maintenance of convergent platforms require that service providers be able to exploit opportunities for economies of scale and scope. This, in turn, requires that service providers develop installed consumer bases of “sufficient” size and sell as many services to their consumers as possible. This is a challenge for two reasons. First, consumers vary in needs, incomes, and tastes, making one-size-fits-all (i.e., commoditized) service provision risky. Second, scale and scope economies tend to limit the number of competing service providers in any given market to just a handful, which makes it all the more necessary to compete through product differentiation, market segmentation, and customer loyalty. Inevitably, this leads to the offering of multiple flavors of all three types of services, e.g., (1) unlimited vs. zonal

or time-limited telephone calling plans, (2) tiered Internet access at different speeds, and (3) varying levels of television service, including packaged and *a la carte* programming.<sup>2</sup>

Multi-tiered/multi-level service provision and service bundling creates very complex pricing environments. For example, even at the highest level of aggregation, there are at least seven services/bundles to consider: video only, telephone only, data only, video/telephone, telephone/data, video/data, and video/telephone/data. For this minimal set of services, at least 60 elasticities exist, and possibly many more. Consequently, estimating and using these elasticities on an integrated basis is a herculean task and almost always goes unattempted. The data requirement alone, let alone the complex modeling methodology needed, can prove prohibitive for most companies. It is no surprise, therefore, that pricing for them often means using ad hoc rules of thumb or trial-and-error.

### **3. Estimating Price Elasticities for Converged Services**

#### **3.1. Estimation from Survey Data**

Significant advances in consumer theory and econometric techniques for modeling demand at the individual consumer level now provide the means for estimating a large number of own-price and cross-price elasticities from consumer survey data. This development is noteworthy for several reasons.

First, consumer surveys can be conducted without requiring access to service providers' proprietary or confidential data on service revenues and subscriber counts. This not only makes data collection easier, it also frees researchers from being bound by conditions placed by those providing confidential data.

Second, consumer surveys can capture the full range of purchases — across services and service providers — made by individual consumers. That is, they can account for not merely consumers who purchase all their services from the same service provider, but also those who cross-subscribe. Service providers observe only the purchases made from them and the revenues that accrue to them. Such data provide only a partial view of the market and cannot be used to capture the substitution behavior that occurs through shifts in cross-subscription.

Third, consumer surveys can take advantage of major gains made in the econometric literature over the past two decades with discrete choice models of individual-level purchase decisions. This is in contrast to the system-of-demand-equations methodology for estimating price elasticities that held sway until recently. While that methodology proved reasonably sound for estimating price elasticities for and among multiple *homogeneous* products or services, its limitations are evident when product differentiation creates multiple tiers of the same service with a different price charged for each. This also

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<sup>2</sup> In the U.S., realizing the potential threat of bypass of conventional TV service by online streaming of video content, many cable companies have opted for a “big tent” or “TV Everywhere” strategy that allows their customers to seek video content either conventionally or through streaming as long as the providers of the streamed content can first verify that those customers already subscribe to the cable companies. This arrangement is known as “authentication.”

complicates efforts to ensure that various conditions implied by demand theory for systems of demand equations (e.g., adding-up, homogeneity, and symmetry) are satisfied.<sup>3</sup>

Finally, well-designed consumer surveys can elicit actual prices paid by individual consumers and account for the price variation that is introduced by sales promotions and market segmentation. The system-of-demand-equations methodology relies intrinsically on revenue shares of services calculated from aggregate revenues earned by those services. Hence, it cannot reflect actual price variation across consumers of the same services nor capture the impact on price elasticity of such variation. Tariffed or averaged prices, often used as proxies for actual prices, fail to represent what consumers actually pay in many circumstances.

### 3.2. Modeling Methodology

Discrete-choice models can take advantage of subscription, price, and other economic data at the level of the individual consumer. This makes it possible to associate geo-demographics and other relevant characteristics with individual consumer demand and, thereby, to build consumer profiles and estimate price elasticities.<sup>4</sup>

The modeling methodology for household choice among different configurations of converged services needs to have several desirable features:

1. The choice set can be depicted as a portfolio of converged services, from which a household (consumer) chooses exactly one at any one time.
2. The portfolio of converged services must be small enough to keep the number of price elasticities to be estimated at a manageable level but detailed enough to capture the full range of consumer experiences with those services.
3. The methodology must be able to account for price variations *within* services in the portfolio that arise from there being multiple levels or tiers for those services and a different price associated with each.
4. Relevant household-level drivers of service choice (geo-demographics, actual prices paid, bundling activity, competitive alternatives, etc.) can be included.

The *mixed logit* model possesses all of these features and is ideally suited for estimating a variety of price elasticities from household survey data.<sup>5</sup> This is a flexible model that can approximate any random utility model and relieve many of the limitations of the standard

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<sup>3</sup> See, e.g., Angus Deaton and John Muellbauer, *Economics and Consumer Behavior*, Cambridge University Press, New York, 1980.

<sup>4</sup> In a discrete-choice framework, demand outcomes are measured by categorical variables (binary or multi-level) for *choices* made with respect to available services or products, rather than by quantities purchased. Therefore, in contrast to typical price elasticities of demand (for which the quantity purchased represents the demand variable), discrete-choice models produce price elasticities of the *probability* of choosing or purchasing a service or product.

<sup>5</sup> See Kenneth E. Train, *Discrete Choice Methods with Simulation*, Cambridge University Press, New York, 2003.

logit model, such as by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time.<sup>6</sup>

The mixed logit model's most useful specification is as a random coefficients model. Suppose a household  $n$  has to choose one from among  $J$  alternatives (i.e., converged services or bundles). The utility of household  $n$  from alternative  $j$  (where  $j = 1, 2, \dots, J$ ) can be written as

$$U_{nj} = \beta'_n x_{nj} + \varepsilon_{nj}$$

where  $x_{nj}$  are all observed variables representing characteristics of the alternative (service)  $j$  and the decision-maker (household)  $n$ ,  $\beta_n$  is a vector of coefficients specific to that household representing the effects of the observed variables ("tastes"), and  $\varepsilon_{nj}$  is a random term that is independently and identically distributed with the Extreme Value I distribution. Unlike the standard logit model,  $\beta_n$  are not fixed but assumed to vary by household  $n$  according to the density  $f(\beta)$ .

Even though each household is assumed to know its own tastes (observed variables) and chooses alternative (or service)  $i$  if and only if  $U_{ni} > U_{nj}$ , for all  $j \neq i$ . The mixed logit probability of such a choice is expressed by

$$P_{ni} = \int \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} f(\beta) d\beta$$

To estimate this random coefficients model, a suitable density  $f(\beta)$  must first be specified (common choices are normal or lognormal, but other distributions are possible). This specification is particularly useful for capturing variation in household tastes. Those tastes may be regarded as varying when households choose different tiers of the same service and, hence, pay different prices. This form of modeling flexibility overcomes the limitation of other modeling techniques (including the standard logit) which cannot accommodate heterogeneity within the service itself.<sup>7</sup>

The mixed logit model is estimated by the method of simulation, i.e., by maximizing a simulated log-likelihood function. The maximum simulated likelihood estimator ("MSLE") of  $\beta$  is the value of  $\theta$  that maximizes the value of the simulated log likelihood, where  $\theta$  represents parameters (such as the mean and covariances) of the underlying distribution  $f(\beta)$ .<sup>8</sup>

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<sup>6</sup> Train, *op cit.*, p. 138.

<sup>7</sup> In a less flexible model, variation of price by tier of service would appear simply as price variation for a single homogeneous service.

<sup>8</sup> All methodological details, including estimation by simulation, are available from Train, *op cit.*, pp. 141-149.

### 3.3. Price Elasticity Estimation

CENTRIS conducted a survey of over 6,000 households in 2011, collecting data on households' choices of services and service providers, prices paid, bundling discounts, geo-demographic information, and indices of competition. The mixed logit model was employed to estimate a variety of price elasticities for the seven services/bundles under assumptions of both price increase and price reduction.<sup>9</sup> In effect, the choice set for each household in the survey consisted of 18 possible service configurations (as described in Section 5). Each household had a one for the configuration actually chosen and a zero for the remaining 17 configurations. While price and other service characteristics (including the prices charged by both a service provider and its competitor) varied for each service in the choice set, household characteristics were the same for all 18. Hence, household characteristics were entered into the model after interacting them with a service characteristic, namely price. This allowed the model to remain estimable.<sup>10</sup>

### 4. Price Elasticity-Based Pricing Tool for Converged Services

Centris has developed a comprehensive pricing tool for video, data, and telephone services that has, at its heart, the full spectrum of own-price and cross-price elasticities within and among those services. This pricing tool has a number of important properties and features.

1. The pricing tool starts with price elasticities for a “host” firm, i.e., a service provider whose prices have to be optimized. It then incorporates price elasticities for a representative or typical competitor and additional price elasticities for cross-subscribing consumers.
2. Revenue-maximizing prices can be determined for all services, either individually or in some combination (as in bundles). Given cost information, profit-maximizing prices can be determined as well. The most likely scenario is that a firm offering the converged services starts with an existing set of prices and then resets those prices in order to increase revenue (whether at the service or the aggregate level) or its market share of customers.
3. Prices can be reset or optimized for revenue within different markets or geographies. In the U.S., some service providers (e.g., cable companies) offer their converged services at geographically differentiated prices, i.e., prices that vary across their overall footprints. Other service providers (e.g., direct broadcast satellite companies) follow a strategy of nationally averaged or uniform prices for their services. In either case, Centris' pricing tool can be structured to yield revenue-optimizing prices.
4. The pricing tool's most useful application is the prediction of revenue and subscriber count consequences over time of changing service prices, whether for one service at a time or for multiple services simultaneously. The tool can also be

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<sup>9</sup> All estimation was carried out using the **mixlogit** program in the software package STATA®/MP for Windows 12.1.

<sup>10</sup> To conserve space, details about estimation of the model and conversion of estimated coefficients to own-price and cross-price elasticities are not provided here. Those details are available from the author upon request.



used to play “what-if” games of competitive interactions between the host firm and its competitor, e.g., based on matching or non-matching price responses to each other’s price changes.

5. The foremost advantage of such a pricing tool is its ability to break down overall revenue or subscriber count changes (in response to price changes) into separate component changes attributable to different elasticities (own-price, within-firm cross-price, competitor cross-price, and cross-subscriber cross-price) that apply simultaneously.

Centris’ pricing tool is operationalized by a web-based pricing simulator.<sup>11</sup> By design, the layout of the simulator is intuitive and user-friendly. The user only has to change prices (in either absolute or percentage terms) and revenue and subscriber count consequences are instantly produced in both numbers and charts. Moreover, because the revenue and subscriber count effects shown are those expected to be realized over the long run, the simulator has a built-in feature that shows how those effects are likely to be distributed over time.<sup>12</sup>

## 5. Pricing Simulator

The simulator is designed with a “complete market” view in mind. That is, it incorporates information about services and service bundles offered by both Company<sup>13</sup> and its competitors. It recognizes that, while some consumers may subscribe *exclusively* to services offered by either Company or a competitor, other consumers tend to subscribe to services from both. These are neither Company-only subscribers nor competitor-only subscribers: in the simulator, they are termed “cross-subscribers.” The inclusion of all three types of subscribers allows the simulator to account for the entire market.

To keep the simulator at a manageable size, the following simplifications are made:

1. All types of competitors are lumped together into the generic “Competitor” category. The only requirement for belonging in that category is that the firm in question must offer a service that competes with a corresponding service available from Company.

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<sup>11</sup> An optional Microsoft Excel-based version of the simulator is available as well. While that version is more complex and is not as intuitive as the web-based version, it is also “open architecture” by design so that users can easily alter native and underlying parameters and inputs (which are “locked in” in the web-based version) and customize the simulator itself to suit their needs. In the web-based version, all price elasticities and starting subscriber counts for all services are pre-set and only prices may be altered. In the Microsoft Excel-based version, the price elasticities and subscriber counts can be altered as well.

<sup>12</sup> This feature relies on a customized time profile (based on actual service provider experiences) that allocates the total expected revenue or subscriber count effect over intervening time periods (typically months). This time profile is hard-wired into the web-based version of the simulator but may be freely altered in the Microsoft Excel-based version.

<sup>13</sup> In the rest of this paper, the term “Company” is used generically for the host firm. Similarly, the term “Competitor” is used for any rival that Company faces within its service footprint.

2. Despite the large variety of services and bundles actually offered to consumers within Company's service footprint, only *seven* aggregate service categories are considered. These are Video only ("V"), Telephone only ("T"), Data only ("D"), Video and Telephone ("V/T"), Video and Data ("V/D"), Telephone and Data ("T/D"), and Video, Telephone, and Data ("V/T/D"). The various tiers of video, telephone, or data services commonly offered by Company or its competitors are subsumed into one or the other of these seven service categories.
3. In some instances, categories with two or more services are true bundles, i.e., taken from the same firm. In other instances, they are combinations of services taken from different firm. Company-only or Competitor-only subscribers subscribe to bundles, while cross-subscribers subscribe to combinations. In the simulator, there are seven Company-only service categories, seven Competitor-only service categories, and four cross-subscriber service categories, making 18 service categories in all.

There are several benefits of the complete-market approach to simulator design:

1. Market shares of all 18 service categories can be accurately estimated from comprehensive surveys of the three types of subscribers.
2. Price elasticities can be more accurately estimated than would be possible by using subscription and price data from the Company alone.
3. Several types of price elasticities determine eventual revenue outcomes, particularly if Company and its competitors react to each other's price changes. A simulator based on the complete-market approach can account for the individual and collective effects of the different price elasticities at play and produce a consolidated revenue outcome.

The simulator, as presently designed, accounts for four types of price elasticities:

1. Own-price elasticity ("OPE"), which measures the percent change in subscribers following a given percent change in the price of a service. OPE is always negative because a higher (lower) price causes the number of subscribers to fall (rise).
2. Cross-price elasticity ("CPE"), which measures the percent change in subscribers for one service (say, V) following a given percent change in the price of another service (say, D), where both services are offered by the same firm. CPE can be positive (if the two services are substitutes), negative (if the two services are complements), or zero (if demand for the two services are independent).
3. Competitor cross-price elasticity ("CCPE"), which measures the percent change in subscribers for a service offered by Company following a given percent change in the price of an equivalent service offered by Competitor. As with the CPE, a positive CCPE signifies that Company's service is a substitute for Competitor's service.
4. Cross-provider<sup>14</sup> cross-price elasticity ("CRCPE"), which measures the percent change in subscribers for a *cross-subscribed* bundle following a given percent change

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<sup>14</sup> The "cross-provider" is a fictitious entity, i.e., there is no such firm in the real world. It merely represents a circumstance in which the services being combined are neither exclusively from Company nor exclusively from a competitor.

in the price of that bundle. By definition, a cross-subscribed bundle is made up of services from different firms. For example, a cross-subscribed V/D bundle could be a combination of V from Company and D from Competitor or a combination of D from Company and V from Competitor.<sup>15</sup> No matter which firm initiates the price change, or for which service in the cross-subscribed bundle, the net effect is for the number of subscribers for that bundle to change. Because a higher (lower) price of that bundle is expected to reduce (increase) the number of subscribers for it, the CRCPE is expected to be negative. Also, the CRCPE for the *same* cross-subscribed bundle is expected to be different for Company and Competitor.

In addition, all four types of price elasticities vary by (1) firm and (2) direction of price change. That is, Company has one set of OPEs, CPEs, CCPEs, and CRCPEs, and Competitor has another. Furthermore, both Company and Competitor have one set of those elasticities for occasions when prices are raised and another set for occasions when prices are reduced.<sup>16</sup>

Table 1 shows the number of price elasticities (of each type) that appear in the simulator, given the 18 service categories.

**Table 1. Price Elasticities in Simulator**

Firm	Price Change	OPE	CPE	CCPE	CRCPE
Company	Increase	7	42	7	4
	Reduction	7	42	7	4
Competitor	Increase	7	42	7	4
	Reduction	7	42	7	4

The simulator presently has, in all, 28 OPEs, 168 CPEs, 28 CCPEs, and 16 CRCPEs, i.e., a total of 240 price elasticities accounting for the 18 service categories.<sup>17</sup>

Different types or sequences of price changes (by Company and its competitors) are expected to trigger different combinations of these elasticities. Accordingly, the simulator is designed to automatically select the relevant elasticity effects and produce a consolidated revenue outcome for Company.

<sup>15</sup> The situation with a cross-subscribed V/T/D bundle is more complicated. This could include (1) V from Company and T/D from Competitor, (2) D from Company and V/T from Competitor, (3) T from Company and V/D from Competitor, (4) V/D from Company and T from Competitor, (5) V/T from Company and D from Competitor, and (6) T/D from Company and V from Competitor. Some of these are more likely than others.

<sup>16</sup> In reality, consumers treat price increases and price reductions of equal magnitude differently.

<sup>17</sup> Incorporating more detail into the service categories (e.g., including different levels of video, telephone, or data service) would lead to significant increases in the number of price elasticities. Thus, the cost of greater realism or disaggregation would be considerably more complexity in the use of the simulator.

The simulator has several embedded worksheets. The first two worksheets contain sections in which data (pertaining to prices, price elasticities, market shares, subscriber counts, etc.) are entered. The remaining worksheets perform all necessary revenue change calculations using information on subscriber counts, price changes, and the relevant price elasticities.<sup>18</sup>

Although it produces final results almost instantaneously, the simulator conducts its computations in three steps. First, when given a change in price for one or more of the seven services, the simulator calculates the “own-price effect.” For each service with a price change, the pre-installed OPE for that service is used to compute the change in demand (equivalent, in this case, to the change in the subscriber count) and the new revenue at the changed price and demand.

Second, the simulator computes all of the relevant internal “cross-price effects” that are triggered by the same price change(s). Thus, if changing the price of V affects the demand for bundles with V in it, such as V/T, V/D, and V/T/D, then the applicable pre-installed CPEs (depending on whether price has risen or fallen) are used to compute the additional revenue and subscriber count effects.

Finally, a price change of any component service affects cross-subscribed bundles as well. For example, when Company changes the price of its V service, the effective price of any cross-subscribed bundle that has Company’s V service in it — such as a bundle with Company’s V and Competitor’s D, or a bundle with Company’s V and Competitor’s T, or a bundle with Company’s V and Competitor’s T and D (or T/D) — also changes. This, in turn, triggers additional revenue and subscriber count effects which affect cross-subscribed customers. These “cross-subscribed cross-price effects” are calculated using the pre-installed CRCPEs.

The sum of all three effects provides the final revenue and subscriber count effects. It is important to note that by separating out these effects, the simulator draws attention to the types of cross-currents that can often affect the final revenue and subscriber count results. For example, because the OPE is always negative, a price increase should always reduce the subscriber count (or not increase it if the OPE is zero). If the OPE is in the “elastic” range, i.e., exceeds one in absolute value, then revenue will fall as well (with the opposite happening if the OPE is in the “inelastic” range, i.e., between zero and one in absolute value). Knowing the magnitude of the OPE, and given its negative sign, it is easy to form an expectation about the revenue and subscriber count results at the own-price effect stage.

However, the operation of CPEs and CRCPEs can sometimes trigger changes in revenue and subscriber counts that oppose those due to the OPE alone. If the two effects are not separated out, the *net* revenue or subscriber count result can seem counter-intuitive. For

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<sup>18</sup> In the Microsoft Excel version, one of these worksheets is used whenever Company leads with a price change and Competitor responds, while the other worksheet applies when price changes occur in reverse order. Because intermediate results in the two scenarios are not symmetric, the revenue and subscriber count consequences can be different depending on the sequence in which the two firms change prices, even if they start and end with the same prices in either scenario.

example, a price increase for a service with elastic OPE can nevertheless produce a *net* expansion in revenue if the CPE and CRCPE effects more than offset the revenue reduction due to the own-price effect.<sup>19</sup>

Interactions with competitors, such as through price competition for substitutable services, trigger yet another layer of elasticity-based revenue and subscriber count effects, this time through the CCPE. Depending on how these interactions occur (e.g., Company changes price but Competitor does not react, or Company changes price and Competitor responds with its own price change, or Competitor leads with a price change to which Company either reacts or not), the simulator computes the revenue and subscriber count effects on Company by making appropriate use of the CCPEs.<sup>20</sup>

While this ability to show the separate component effects on Company's revenues and subscriber counts is a significant advance in the design and application of pricing simulators, there are several other features that make the simulator even more useful:

1. The simulator allows for price changes to be made in either absolute or percentage terms. The web-based version of the simulator allows easy input of new prices by moving either the button, or using the end arrows, on the slider below the initial prices.
2. The simulator recognizes whether a price has been increased or reduced. It then draws upon the appropriate pre-installed price elasticities, depending on the direction in which price has changed.
3. Although initial prices and subscriber counts, as well as all price elasticities, are kept fixed within the simulator, all such inputs can be changed or updated. In this manner, the user can incorporate the most current market and firm-specific conditions in all uses of the simulator. Centris can make those periodic updates in the web-based version of the simulator on behalf of the user.<sup>21</sup>
4. Recognizing that predicted changes in revenue and subscriber counts are all "long run" results, the simulator can distribute those effects over a chosen period of time. For this, the user has to specify the length of time over which the effects are likely to be distributed (typically, 12 months or more) and the pattern of distribution itself (typically, a declining percentage over time).
5. The simulator shows both the *total* revenue or subscriber count change from a particular price change scenario and the *component* changes due to the various price elasticity effects. In addition, the user can impose an alternate computation on the simulator: using judgment or external information, the user can also ask the simulator to produce a more tempered set of revenue and subscriber count effects

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<sup>19</sup> The distinction between *elasticities* and *effects* (e.g., in monetary terms) is important for understanding why this can happen. While cross-price elasticities are generally smaller than own-price elasticities, the cross-price effects themselves can nevertheless be significantly larger than own-price effects.

<sup>20</sup> The simulator is set up *only* to compute the revenue and subscriber count effects on Company, even if Competitor also changes its price(s) or experiences its own revenue and subscriber count effects.

<sup>21</sup> The user retains the ability to make those changes and updates directly in the Microsoft Excel version of the simulator.

(in the long run and over intervals of time) if the initial computations appear unrealistic or too aggressive.<sup>22</sup>

6. All revenue and subscriber count effects can be shown in either absolute or percentage terms.<sup>23</sup>

The pricing simulator has a variety of useful business — and even academic research — applications.

1. The simulator is a scientific business management tool. In a complex service provision, pricing, and competitive environment, it helps to reduce uncertainty and guesswork by providing a reasonable and thorough framework for predicting how revenues and subscriber counts can change in alternative pricing and competitive interaction scenarios. While dealing with complexity in a straightforward way, it still allows the user to employ sound business judgment to temper all results.
2. The simulator can help to identify the “best” pricing options (given the firm’s objectives) among the many that may be available. This is particularly useful for converged services which tend to be offered in bundles of different sizes, and firms may be interested in adjusting prices so as to strike the “right” balance between providing those services individually or in bundles of different sizes.
3. The simulator enables playing competitive games in advance of implementing any actual price changes. This can lead to prices that are appropriate for meeting competitive threats or restoring competitive balance.
4. Specifically, the simulator can be invaluable for informing business strategies, whether they pertain to designing and running promotions, timing “roll-offs” (ends to promotions), managing ongoing acquisition and migration plans,<sup>24</sup> or tackling the competitive threat posed by internet-based provision of video services.
5. The simulator can be an asset in planning resource allocations, service development and positioning, sales efforts, budgeting, and revenue optimization.
6. In the ultimate analysis, it is the best “fact-checking tool” available to the firm when it comes to its pricing and service positioning decisions.

The over-arching benefit from using the simulator is that it can account for the hidden cross-currents in demand and revenue flows when prices are changed for converged services. The range of price elasticity-driven effects is complex enough when only one firm changes prices or when the price of only one service or bundle is changed. It gets even more so when prices of multiple services or bundles change, sequentially or simultaneously, and when Company and Competitor engage each other in strategic pricing games. As shown in Section 7, sometimes price changes produce counter-intuitive movements in revenue that are not apparent without a deep analysis. These happen

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<sup>22</sup> This feature is not available in the web-based version of the simulator presently.

<sup>23</sup> The effects can be obtained only in absolute terms in the web-based version of the simulator presently.

<sup>24</sup> Acquisition is the process of bringing in new customers, whether from competitors or by expanding the market. Migration is the process of moving existing customers up the firm’s value chain, e.g., by making customers of individual services buy bundles, or making customers of bundles of two services buy the triple-play.

whenever the own-price effect and various cross-price effects of a price change produce opposing revenue changes. Cross-subscribed services are a large part of these cross-currents and, therefore, they cannot be ignored when making pricing decisions. Most importantly, the pricing simulator for converged services is not merely about getting to a revenue outcome, but also about how that outcome comes about.

## 6. Pricing Simulator: A Demonstration

In this section, several pricing scenarios and their revenue and subscriber count consequences are demonstrated using screenshots of the web-based version of the simulator in action.

Figure 1 shows the opening screen when the simulator is accessed. Company's initial (or default) prices for the seven services are shown across the top of the screen. The user may change any price by simply using the slider below. Price may be changed in either absolute or percentage terms by selecting the appropriate radio button located right below the initial prices.

Figure 1 also shows two sets of control tabs. The first, located at the top right corner of the screen, enables the user to specify whether the simulator should generate only the pure OPE effect (the "Own Price Elasticity" tab), or the OPE effect combined with all CPE effects (the "Cross Price Elasticity" tab), or OPE and CPE effects combined with CRCPE and CCPE effects (the "Competitor Price Elasticity" tab). The second set of control tabs appear along the right edge of the screen. These enable the user to specify whether the simulator should generate total overall and service-level revenues (the "Revenue" tab), or total overall and service-level subscriber counts (the "Subscribers" tab), or service-level revenue effects distributed monthly over a 12-month interval. When all control options and price inputs have been selected, pressing the "Run" button initiates all computations.

Figure 2 shows what appears on the screen when default prices are retained (which means that none of the price elasticities are engaged), the Revenue tab is selected, and "Run" is pressed. Two sets of charts are now displayed. The first comprises paired vertical bars, one for each of the seven services, which compare service revenue at the default price with the revenue that results when one or more prices are changed.<sup>25</sup> These bars are labeled to show revenues in thousands of dollars. At the bottom of the screen, two lines appear to show both initial total revenue (when all prices are held at default levels) and new total revenue (when at least one price has been changed). The net change in total revenue is displayed to the right. In Figure 2, because "new" and default prices are the same, all service-level bars are of the same height and the net change in total revenue is zero.

The second set of charts consists of a pie chart that displays the revenue shares of the seven services. In Figure 2, because default prices have not been changed, the pie chart shows the initial revenue shares of the services. Below the pie chart, the direction of revenue change for each service is shown. When a service's revenue remains unchanged,

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<sup>25</sup> Note that a service's revenue may change *even if* its default price is maintained. This can happen because of cross-price effects from other services for which prices do change.

as for all services in Figure 2, the shaded circles with opposing arrows indicate “no change.” The circle turns red with a single arrow pointing downward when the revenue of the corresponding service declines, and it turns green with a single arrow pointing upward when that revenue increases.

Figure 3 captures the effect of calculating only the own-price effect of increasing Company’s V service from \$55 to \$60. As expected, the revenue from the V service turns downward by more than \$65,000. This is also how much total revenue declines because no cross-price effects have been taken into account. As a result, only the vertical bars for the V service change and the reduction in V revenue is shown by a red circle with a downward arrow (while the circles for all other services show no change). Below the vertical bars, a third (area) chart is now displayed with a visual depiction of how (and how much) service revenue changes (here, only for V).

Figure 4 is similar to Figure 3 in all respects, except that it pertains to subscriber counts rather than revenues. To generate this screen, the user must first select the “Subscribers” tab. The net change in the subscriber count for Company’s V service, as also the net change in total subscriber counts, is shown to be just over 2,000.

Figure 5 displays total service revenues converted into distributed revenues over a 12-month period, using the same scenario as shown in Figure 3. To generate this screen, the user must first select the “Distribution” tab.

In a similar manner, Figures 6-8 display the revenue and subscriber count effects on Company’s V service of increasing V’s price to \$60, but now allowing for both own-price and internal cross-price effects. That is, revenue and subscriber counts are now the outcomes of both own-price and cross-price effects. To generate these screens, the “Cross-Price Elasticity” tab has to be selected. Figures 6-8 illustrate how an apparent loss of over \$65,000 and over 2,000 customers when only own-price effects are taken into account (see Figures 3 and 4) can turn into a *gain* of over \$3.3 million and over 25,000 customers when cross-price effects are included as well.<sup>26</sup> While a Company strategist’s first instinct may be to forego the price increase for Company’s V service based solely on the expected own-price effect, an opportunity to actually gain significant revenues and customers is likely to be lost without factoring in the cross-price effects as well. This is a good illustration of the multiple benefits of the pricing simulator alluded to earlier.

Figures 9-16 reflect computations of revenue and subscriber count outcomes under other pricing scenarios, including some in which Competitor is assumed to respond to Company’s price change leads.

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<sup>26</sup> This provides a cautionary tale for the use of elasticities to predict revenue and demand outcomes. The swing in outcomes from negative to positive territory can be particularly impressive for converged services when sold in bundles of different sizes.



In Figures 9 and 10, Company raises the price of V to \$60 and Competitor matches that price (up from its own initial price of \$57). Computations are performed under the “Competitor Elasticity” tab.

In Figures 11 and 12, Company raises its prices for V, V/T, and V/D services while lowering its price for V/T/D service. No competitor response is assumed. Computations are performed under the “Cross Price Elasticity” tab.

In Figures 13-16, a pricing scenario in which Company lowers its price for V/T/D service is explored in two variants: one without any Competitor response and the other with Competitor matching Company’s reduced price. As expected, Figures 13 and 14 show significant gains in revenue and subscriber count from making the triple-play service markedly cheaper. However, as Figures 15-16 show, those gains are attenuated when Competitor decides to follow suit by matching Company’s reduced price. Company’s eventual gains in revenue and subscriber count are reduced quite a bit as well.



**Figure 1. Web-based Pricing Simulator's Opening Screen**



**Figure 2. Company Service Revenues in Default Scenario (Before Price Change)**



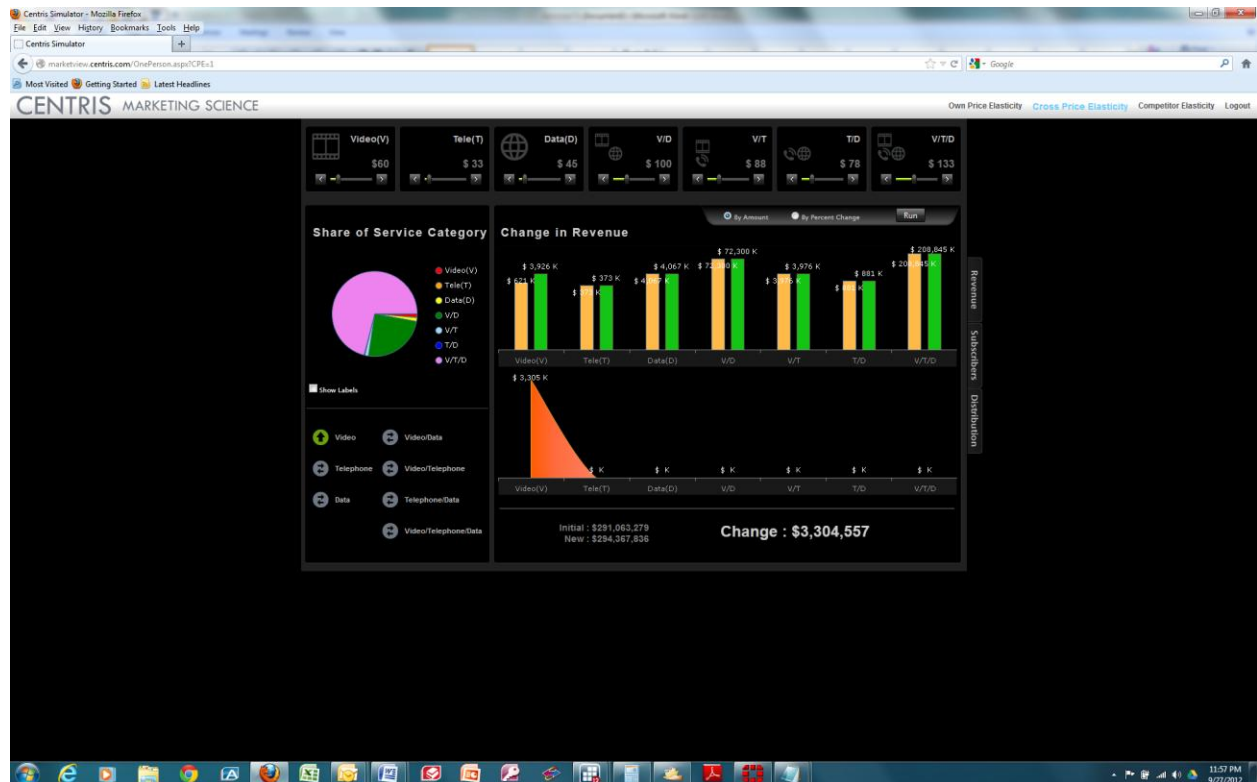
**Figure 3. Revenue Effect of Company Increasing V Service Price (OPE Based Effect Only)**



**Figure 4. Subscriber Count Effect of Company Increasing V Service Price (OPE Based Effect Only)**



**Figure 5. Revenue Effect of Company Increasing V Service Price (OPE Based Effect Only), Distributed Over 12 Months**



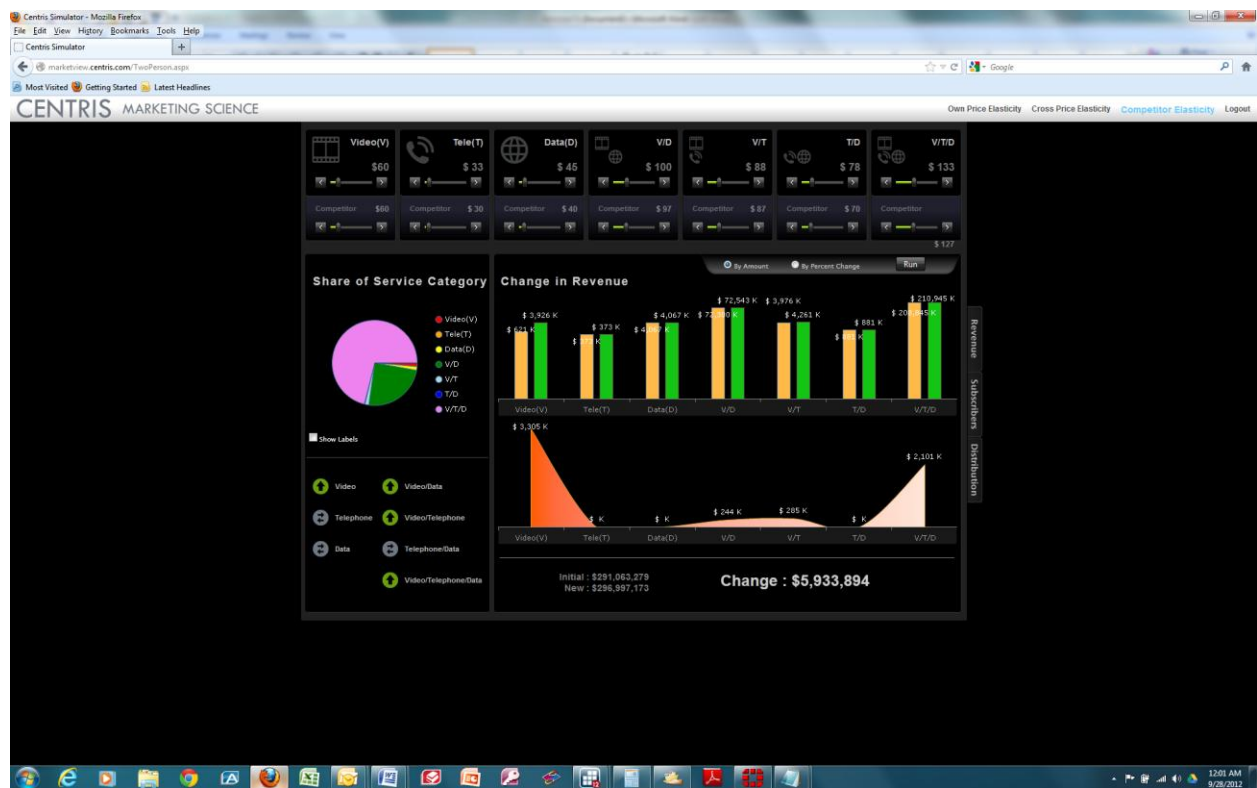
**Figure 6. Revenue Effect of Company Increasing V Service Price (OPE and CPE Based Effects)**



**Figure 7. Subscriber Count Effect of Company Increasing V Service Price (OPE and CPE Based Effects)**



**Figure 8. Revenue Effect of Company Increasing V Service Price (OPE and CPE Based Effects), Distributed Over 12 Months**



**Figure 9. Revenue Effect of Company Increasing V Service Price and Competitor Matching Company's Price (OPE, CPE, CRCPE, and CCPE Based Effects)**



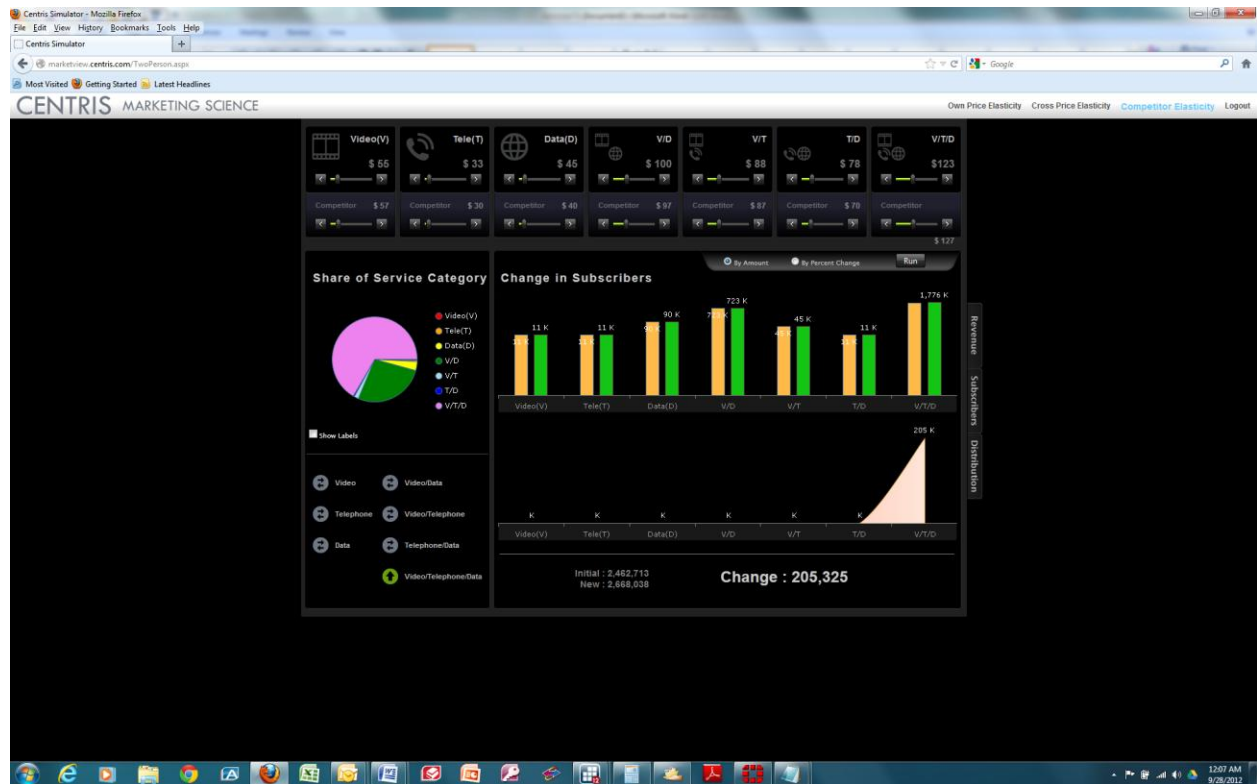
**Figure 10. Subscriber Count Effect of Company Increasing V Service Price and Competitor Matching Company's Price (OPE, CPE, CRCPE, and CCPE Based Effects)**



**Figure 11. Revenue Effect of Company Increasing V, V/D, and V/T Service Prices and Reducing V/T/D Service Price (OPE, CPE, and CRCPE Based Effects)**





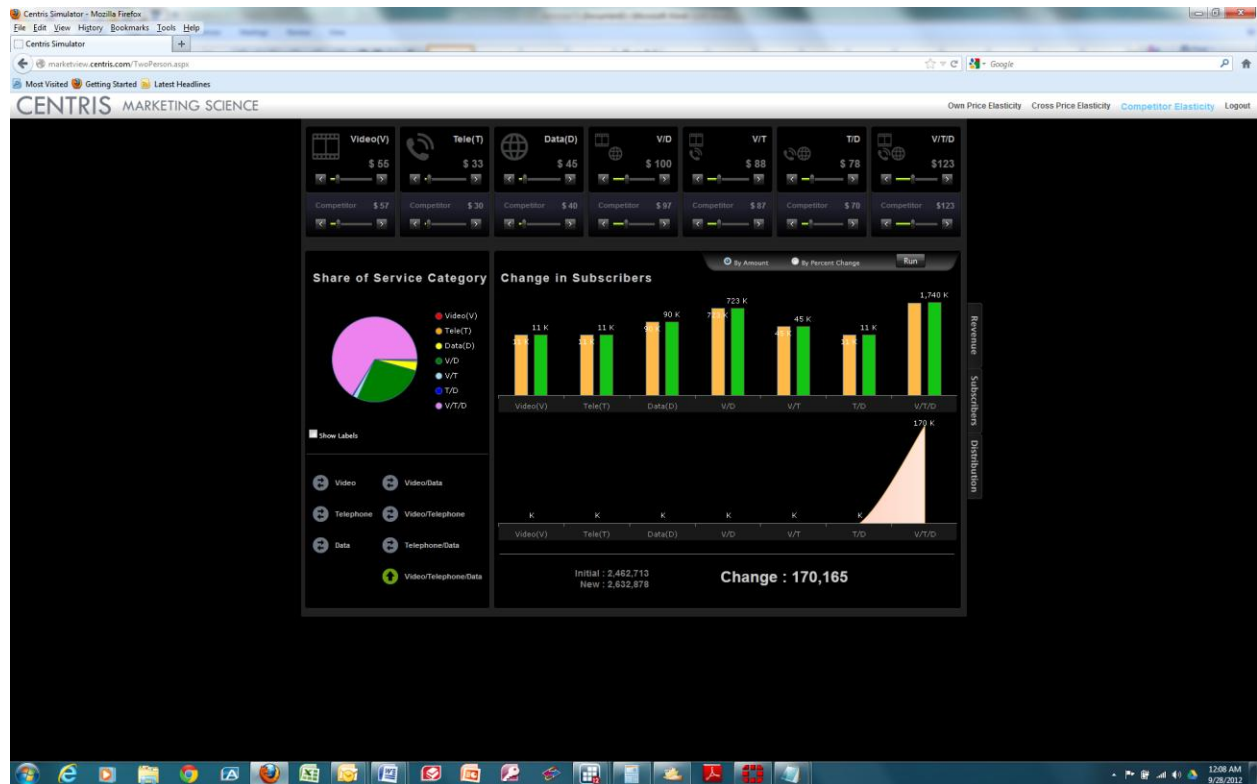


**Figure 14. Subscriber Count Effect of Company Reducing V/T/D Service Price Without Competitor Response (OPE, CPE, CRCPE, and CCPE Based Effects)**



**Figure 15. Revenue Effect of Company Reducing V/T/D Service Price and Competitor's Matching Price Reduction (OPE, CPE, CRCPE, and CCPE Based Effects)**





**Figure 16. Subscriber Count Effect of Company Reducing V/T/D Service Price and Competitor's Matching Price Reduction (OPE, CPE, CRCPE, and CCPE Based Effects)**

## 7. Analysis of More Complex Scenarios

This section illustrates the versatility of the pricing simulator with three examples of more complex scenario analysis. For purposes of this section, Company's and Competitor's initial service prices are given in Table 2.

**Table 2. Assumed Initial Service Prices of Company and Competitor**

Firm	V	T	D	V/T	V/D	T/D	V/T/D
Company	\$55	\$45	\$33	\$88	\$100	\$78	\$133
Competitor	\$57	\$40	\$30	\$87	\$97	\$70	\$127

All estimates of total revenue for Company are based on assumed subscriber counts (not shown here) for all Company and cross-subscribed services, initial prices shown in Table 2, and new prices under each scenario below.

### 7.1. Scenario A

Price changes occur in the following sequence:

1. Company reduces price of V service from \$55 to \$52.

2. Company reduces prices of its other video-inclusive bundles by \$3 each, i.e., price of V/T from \$88 to \$85, price of V/D from \$100 to \$97, and price of V/T/D from \$133 to \$130.
3. Competitor responds by matching Company's new, lower prices for V, V/T, and V/D.
4. Competitor reduces price of its V/T/D bundle from \$127 to \$126.

Company's revenue consequences at each step:

1. Company's net total revenue declines by \$1.99 million (loss of -0.68%).
2. Company gains back net total revenue of \$5.31 million (gain of 1.84%).
3. Company gains some additional net total revenue (mainly because cross-subscribed services are now relatively cheaper and the cross-subscriber count expands) of 0.13 million (gain of 0.05%)
4. Company's net total revenue declines by \$1.05 million (loss of -0.31%)

The overall change in Company's net total revenue from the level experienced when Company's and Competitor's prices were all at initial levels is \$2.40 million (a net gain of 0.83%). This shows how the biggest gain in net total revenue occurs from unilateral price reductions by Company. It also shows how those gains are attenuated by aggressive Competitor action to match or beat Company's prices. Whatever revenue gain is experienced by both Company and Competitor occurs primarily from the expansion of the market for services that have had their prices reduced.

## 7.2. Scenario B

Price changes occur in the following sequence:

1. Competitor reduces price of its D service by 10%, from \$40 to \$36.
2. Company responds by reducing its D service price by only 1%, from \$45 to \$44.55.
3. Company responds instead by reducing its price of D by 2%, from \$45 to \$44.10.

Company's revenue consequences at each step:

1. Company's net total revenue declines by \$0.21 million (loss of -0.07%).
2. Company gains back a modest amount of revenue to have a net total revenue decline of \$0.17 million (loss of -0.06%).
3. Company actually widens its loss of net total revenue to \$0.21 million (loss of -0.07%). In this example, Company loses just as much from a 2% price reduction in responding to Competitor as from not changing its price at all.

This scenario has a counter-intuitive outcome. Company's natural instinct would be to reduce the price of the service for which Competitor has just implemented an aggressive price cut of its own. However, two factors actually work against Company when it does so.

The first factor is an artifact: it so happens that the CRCPE for the *cross-subscribed* T/D bundle is zero when the price of that bundle is reduced. Thus, when both Company and

Competitor reduce their respective prices for D, the cross-subscribed T/D bundle experiences a price reduction as well and, because of a zero CRCPE, Company's revenue from that service falls at the same rate as that bundle's price. This has a negative effect on Company's net total revenue.

The second factor is more substantive. Even though Company gains some revenue for its D service (because of the pure own-price effect) every time it reduces its price, the CRCPEs for cross-subscribed T/D and V/D bundles produce opposing movements in revenue, which increase the more Company reduces the price of D. Eventually, the negative revenue effects induced by the CRCPEs overwhelm the modest positive revenue effects of the OPE, and price reductions result in progressively larger net total revenue losses to Company.

What should Company do in this instance? As counter-intuitive as it may seem, Company's best course of action is to actually *increase* the price of D *despite* Competitor's aggressive price cut. This time, the own price effect of the OPE generates losses to Company but the CRCPEs actually produce progressively larger revenue gains for cross-subscribed T/D and V/D bundles. Thus, increasing the price of D to \$47.70 from \$45 actually earns Company a positive net total revenue gain despite the steep price reduction by Competitor.

This is an unexpected scenario that only arises because of the inherent complexity of competition for converged services and the effect of bundling services. Does this mean that Company can raise its price for D service without any limits whatsoever? Although it would seem that way from the operation of the simulator with price elasticities as currently installed, the answer is most likely "no." Price elasticities are well known to change with the *level* of price and are, therefore, best used for relatively small price changes. When prices change by much larger magnitudes, the price elasticities are themselves likely to change as well. The simulator would then have to be updated with a different, more appropriate, set of elasticities before revenue consequences can be predicted.

### 7.3. Scenario C

In this two-part scenario, price changes occur in two sequences:

1. Company leads by reducing the price of its V/T/D bundle by 5.26%, from \$133 to \$126, i.e., to a level just below Competitor's initial price of \$127 for that bundle. If Competitor responds, by how much must it reduce the price in order to offset whatever net total revenue gain Company experienced by leading with its price cut?
2. Competitor leads by reducing the price of its V/T/D bundle by 5.5%, from \$127 to \$120. If Company responds, by how much must it reduce its price for the same bundle in order to offset whatever net total revenue loss it incurred when Competitor led with its price cut?

Company's revenue consequences and pricing decision in either situation:

1. When Company leads with the price cut to \$126, its net total revenue rises by \$6.55 million (gain of 2.25%). If Competitor responds by reducing its own price for that bundle, does it need a price cut of comparable magnitude? If Competitor's objective is merely to nullify any net total revenue gain that Company stands to make from its price cut, then the answer, in general, is "not necessarily." In the present example, Competitor need only reduce its price by 4.06%, from \$126 to \$120.88, to almost completely nullify any expected net total revenue gain by Company.
2. When Competitor leads with the price cut to \$120, Company experiences a loss of subscribers for its V/T/D bundle and its net total revenue is expected to decline by \$7.27 million (loss of -2.56%). Again, if Company responds by reducing its own price for that bundle, does it need a price cut of comparable magnitude? If Company's objective is merely to nullify any net total revenue gain that Competitor stands to make from its price cut, then the answer, in general, is "not necessarily." In the present example, Company must reduce its price by as much as 5.68%, from \$133 to \$125.44, to almost completely nullify any expected net total revenue gain by Competitor.

These two circumstances are, in a sense, mirror opposites of each other. In the first instance, Competitor needs only a 4.06% price reduction to offset any benefit to Company that leads with a 5.26% price cut of its own. In the second instance, Company must reduce its price by 5.68% in order to offset any benefit to Competitor that leads with a 5.5% price cut of its own. This asymmetry in the gain- or loss-offsetting percent price change for Company is caused in large part by the fact that Company has the higher initial price of the two. Regardless of what other factors may drive that symmetry, the main conclusion is that a *matching* price response (in either absolute or percentage terms) is not necessarily the optimal response if the objective is simply to nullify any revenue advantage being sought by a rival firm that reduces the price of a price-elastic service.<sup>27</sup>

## 8. Conclusion

This paper makes three significant contributions. First, it provides the first unified conceptual and methodological framework for estimating a variety of price elasticities for converged services, namely, video, telephone, and data services now routinely offered from convergent platforms. This effort recognizes that consumers today rarely make discrete and separate purchases of these services but, rather, are more likely to purchase them in bundles, either from the same service provider or from competing providers.

Second, it employs the highly flexible mixed logit modeling methodology to estimate price elasticities from household survey data. The choice set for each household contains as

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<sup>27</sup> In Scenario C, the outcomes in the two situations are driven entirely by two effects: the own-price effect due to the OPE and the cross-price effect due to the CCPE. Prices of cross-subscribed bundles (that mix services from both firms) are unaffected by any change in either firm's V/T/D bundle and, hence, the CRCPE effect is not triggered. Moreover, only price *increases* for the V/T/D bundle are assumed to have a cross-price effect on individual services and two-play bundles. Given a price reduction alone (as in the two situations), that cross-price effect is not triggered.

many as 18 possible service configurations and prices are allowed to vary *within* each such configuration by tier of service. The random coefficients specification allowed by the mixed logit model is an effective way to capture price variation across and within services. Price elasticities are derived from the coefficients estimated in the model using household survey data on choices, prices, other service characteristics, and household characteristics (geo-demographics).

Finally, it shows how the estimated price elasticities can be loaded into a powerful pricing toolkit or simulator and used for multiple pricing-related purposes. In particular, the simulator can be used for selecting optimum prices, playing competitive games, analyzing revenue and subscriber count outcomes under alternative pricing scenarios, revenue and budget planning, and as a fact-checking tool. The simulator is available in both Microsoft Excel and web-based versions. Because it accounts for both the own-price effect and various cross-price effects of a price change, it can reveal revenue and subscriber count consequences of very complex pricing scenarios that are, in general, not evident from simple back-of-the-envelope calculations. In fact, some outcomes that, at first, appear to be counter-intuitive can be explained once the simulator brings the hidden cross-currents in revenue or subscriber count flows into the open.

Periodic updates can be made to both the model-based price elasticity estimates and the simulator itself. This makes the simulator a remarkably flexible and adaptable tool for sound business planning in a very complex environment. Although specifically developed to handle converged services, the modeling technique, price elasticities, and the pricing simulator have useful applications in other fields as well.

Contact author: Aniruddha Banerjee ([axbaner@comcast.net](mailto:axbaner@comcast.net); +1 978 263 9031)