

# The Economics of Usage-Based Pricing in Local Broadband Markets

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## Executive Summary

While price discrimination based on some measure of either quality or quantity for a product or service is standard commercial practice in many industries and generally is not a matter of policy concern, its recent application to high-speed broadband Internet service has been the subject of some controversy. Critics have claimed that the practice, commonly referred to as usage-based pricing (UBP), of offering “tiers” of Internet service that are priced according to the volume of data service provided to the customer are a serious threat to consumer welfare.

It is true that usage-based pricing of broadband service is likely to affect consumer welfare—but not in the harmful manner suggested by its critics. To the contrary, as we show in this report, the substantial research literature on the subject of differential pricing based on usage and quality suggests that the effects of well-designed UBP plans on consumers are likely to be beneficial, as are the effects of UBP on investments in the broadband infrastructure.

### Pricing Efficiency and Consumer Welfare

Our review of the literature on quality-based differential pricing shows that while, as a general matter, the efficiency effects of differential pricing are theoretically ambiguous, there is good reason to expect that for broadband, as with other information goods, differential pricing will in most circumstances *increase* economic welfare. There are several reasons why this is the case:

- I Compared to UBP, a government-mandated single-price approach to pricing broadband biases the design and pricing of service toward the interests of subscribers willing to pay the most to the detriment of low volume and low income consumers who are less likely to be offered service packages they are willing to purchase. On the other hand, with UBP it may be profitable for ISPs to offer lower-priced options attractive to consumers who otherwise would not take service, thereby ensuring that a larger percentage of the US population enjoys the benefits of broadband.
- I By making it easier for customers to shift to a higher price-higher volume option when they have short-term needs to consume greater volumes of data service, UBP can be an efficient contract adjustment mechanism for customers whose demands for service fluctuate over time.
- I By reducing the cost of trying broadband technology for the first time, the low cost-low usage tiers in UBP plans can encourage experimentation by first time users, bring new users online, and in the long run increase broadband penetration.

### Infrastructure Investment

Private suppliers of network services invest to improve and expand their networks when it is profitable to do so. By enabling ISPs to profitably offer services to different groups of customers based on their differential needs and usage of broadband service, UBP not only makes the benefits of broadband service available to consumers who otherwise would not be willing to pay for service, but also makes the provision of broadband service more profitable. This, in turn, encourages investments in network improvements and extensions, including investments in unserved and underserved areas.

For these reasons, which are grounded in established economic principles and research, there is no basis for assuming that UBP will have harmful effects in the broadband marketplace, and there is good reason to expect that the effects will be beneficial.

## I. Introduction

Most Americans who pay for broadband service to their homes have long been accustomed to choosing from a menu of service options that vary in the maximum speeds at which data will be delivered to their Internet-connected devices. By-and-large these differentiated offerings have been accepted by policymakers as legitimate business practices with no adverse impacts on the public. Such criticisms as have been voiced have received little attention in the broader ongoing debate over broadband policy. By contrast, the more recent moves by prominent broadband service providers to introduce monthly usage tiers to further differentiate their offerings have become the subject of vocal and sustained criticism by advocacy groups that has been picked up in the popular press, in trade publications, and policy blogs.

There is considerable variation in the mixes of price and service options broadband providers offer their customers, but today most pricing schedules feature usage tiers with upper bounds that function as thresholds beyond which users must pay extra for additional data service. Typically below threshold data consumption is sold for a flat fee and smaller blocks of data are available at a different price for above-threshold consumption. Some providers have multiple usage thresholds while others have just one, and fees vary for data consumed in excess of specified usage levels. Because subscriber payments may vary with the amount of data service used, the term “usage-based-pricing” (or UBP) is commonly used to describe these plans.<sup>1</sup>

Among other things, critics have argued that usage tiers with fees for above-threshold consumption in UBP plans are unwarranted impediments to what should be unrestricted access to the riches of the internet, that UBP can be employed by cable and telephone companies to handicap nascent over-the-top (OTT), Internet-based competition to their own content and voice services, and that they increase providers’ profits at the expense of consumer welfare.

To this point there has been no systematic response on the part of the industry and it is fair to say that the policy debate over UBP for broadband, which has been conducted largely in the public media, has done as much to muddy the analytical waters as to clarify the critical questions involved. Even the lengthy and analytically more complex report for Public Knowledge by Odlyzko, Arnaud, Stallman, and Weinberg (2012), which has been receiving increasing attention, betrays a bit of analytical schizophrenia: observing at one point (p. 4), for example, that there is nothing “inherently problematic about offering consumers usage-based pricing options,”<sup>2</sup> but asserting later that “UBP plans must be justified in terms that explain why the circumstances motivating them are unique” (p. 22).

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<sup>1</sup> UBP encompasses a much broader array of pricing plans than what is now typical for broadband services. For example, the upper bounds of usage tiers might instead be absolute caps on data consumption, or above-threshold consumption might be sold on a metered basis or provided at reduced quality of service.

<sup>2</sup> Emphasis in original.

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Overlooked in the heat of this exchange over the merits of UBP for broadband is the fact that for broadband service providers UBP is a critical component of a product differentiation strategy that is similar economically to second-degree price discrimination strategies employed in many other markets without controversy. A substantial research literature has shown that consumers often benefit from this type of differential pricing because it can give suppliers an incentive to offer lower priced options they otherwise would not find profitable. A policy discussion of UBP for broadband would be incomplete if not situated in the context of the findings of the well-developed economics literature on second-degree price discrimination, and especially the substantial work on its application to information goods and services.

It must also be recognized that, because UBP affects revenue, it affects the return a broadband service provider can expect from the investments in network infrastructure required to offer consumers more advanced and faster services or to extend a network into geographic regions it does not currently serve. In an era when broadband has become critical infrastructure and increased coverage and penetration are national priorities, the negative impacts of pricing restrictions on investment incentives should not be overlooked.

A balanced discussion of the policy merits of UBP for broadband requires that the efficiency properties of UBP as a mechanism for price discrimination and its implications for network investment be carefully considered. Both are addressed in this report.

Section II of this report provides a brief introduction to the basics of second-degree price discrimination and an overview of the literature on its application to information goods. Applying this analytical framework to UBP, we conclude that, as with other information goods, if anything the goals of policy analysis would be better served by starting with an initial presumption that consumers benefit from UBP, rather than the reverse. Due to natural, and likely considerable, variation among consumers in the personal benefits they receive from data consumption, a positive flat fee for service that is applied uniformly to all customers will unavoidably cause some consumers to forego service. Because service providers can profitably employ UBP to sell plans with lower monthly data allowances at prices many of the otherwise excluded consumers would be willing to pay, we would expect broadband penetration to be greater if UBP is allowed than if it is not. We also point out that giving customers a low hassle mechanism for temporarily increasing the amount of data service purchased on rare occasions when the amount of service desired exceeds its normal range is a hitherto overlooked benefit of UBP. Furthermore, UBP may make it feasible for service providers to extend service to geographic territories where it would be financially infeasible otherwise. We elaborate on this point in Section III, which examines the implications of UBP for future investments that might improve the quality of broadband service and extend it further into unserved and underserved areas.

## II. UBP and Differentiated Service Options

To an economist, UBP is a form of second-degree price discrimination, a term that has no pejorative connotations in the economics literature. It simply refers to one of several ways in which sellers may offer the same or similar goods at different prices. Second-degree price discrimination is the subject of a substantial scholarly literature and it is important that the research findings reported in this literature be brought to bear in assessing the policy implications of this form of differential pricing. This section draws on the relevant economics literature to examine UBP as a component of a second-degree price discrimination strategy for broadband services.

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## II.1. Second-Degree Price Discrimination and UBP

Second-degree price discrimination is a type of differential pricing where customers must choose among two or more differentiated versions of a product or service that typically are sold at different prices. All individuals selecting the same option pay the same price, but people selecting different options pay different amounts. Second-degree price discrimination is often contrasted with first-degree price discrimination, where a consumer pays a different price for each unit of a product she purchases (these prices may also vary among customers), and third-degree price discrimination, where different people are charged different prices for the exact same product or service. A fruit vendor who charges a customer \$5 for the first apple purchased and lowers the price by a dollar for each additional apple she buys (up to five) could be engaging in first degree price discrimination if the prices charged reflect the maximum the consumer is willing to pay for each unit purchased. The reality is that sellers never have this much information about their customers' demands and implementing such a scheme would likely be prohibitively difficult if they did. So first-degree price discrimination serves mainly as a theoretical benchmark for economists. Third degree price discrimination, however, is extremely common. We see it, for example, when the same clothing items are sold at lower prices in outlet malls than in department stores and when the same brand of gas is sold at a different price near freeway exits than at the neighborhood filling station.

Second-degree price discrimination is also extremely common and is encountered on a regular basis by almost everyone. For example, at the time this report was written Lansing, Michigan Chevrolet dealers were offering eight different models of the 2013 Malibu with recommended dealer prices ranging from \$22,390 to \$30,165.<sup>3</sup> Models differed in horsepower, quality of upholstery, quality of sound system, and whether they used hybrid or standard engine technologies among other things. Manufacturers of personal computers, tablet computers, and smart phones sell multiple versions of their products that differ in attributes such as weight, thickness, screen size, processing power, and memory capacity. Otherwise identical printers that print at different speeds are sold at different prices. Airlines sell economy and business class seats at different prices and further discriminate among business and leisure travelers by charging business customers higher prices for round-trip tickets with fewer restrictions on departure and return dates. Books are often sold in hard cover, paperback, and digital versions at different prices. Almost every home appliance is available in standard and high-end models offered by the same manufacturer. Many types of computer software are sold with multiple versions whose prices vary with the number of features provided.<sup>4</sup> Financial accounting software packages sold with consumer and business editions are an example. This list could be extended indefinitely. Second-degree price discrimination is so common for information goods that the term "versioning" has been coined to describe it (Varian, 1996; Shapiro & Varian, 1999). We encounter second-degree price discrimination on such a regular basis that in most cases it is unremarked, let alone a subject of controversy.

Given the prevalence of second-degree price discrimination strategies in the economy in general and especially in markets for information goods and services, their use to segment demand heterogeneous broadband customers into more homogeneous subgroups should come as no surprise and by itself should not be cause for alarm. Any notion that "UBP plans must be justified in terms that explain why the circumstances motivating them are unique" (Odlyzko et al., 2012, p. 22) is certainly unfounded. If anything the burden of proof should be on those alleging harm.

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<sup>3</sup> Figures taken from an online ad checked September 30, 2012 at: [http://www.chevydealer.com/?cs:pro=cgt2&cs:dma=551&cs:loc=en\\_US&cs:i=chevrolet:malibu&cs:e=g&cs:gn=s&cs:cid=9831474616&cs:kw=%2Bchevy%20%2Bmalibu&cs:kt=41L34B4100&gclid=CP-C-dig3r1CFYVFMgodZ04ABw](http://www.chevydealer.com/?cs:pro=cgt2&cs:dma=551&cs:loc=en_US&cs:i=chevrolet:malibu&cs:e=g&cs:gn=s&cs:cid=9831474616&cs:kw=%2Bchevy%20%2Bmalibu&cs:kt=41L34B4100&gclid=CP-C-dig3r1CFYVFMgodZ04ABw).

<sup>4</sup> For a recent empirical study of versioning in computer software, see Ghose and Sundararajan (2006).

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Not surprisingly, second-degree price discrimination has been the subject of considerable research, both theoretical and empirical, by economists and other researchers. Much of this work, and especially research on differential pricing for information goods, has focused on situations where alternative versions of a product (or service) differ in an attribute that in some way increases the product's value for all users, but to differing degrees for different users. Creating and selling at different prices versions of a product or service that differ in the amount of the attribute that all consumers value is commonly referred to as vertical differentiation or quality-based differentiation.<sup>5</sup> It is not hard to see that total monthly data consumption might be such a differentiating factor for broadband service. While there will be exceptions, in general, we would expect that broadband users who frequently stream movies and TV programs for viewing through their PCs and television sets would be willing to pay more for a larger monthly data allowance than would individuals who spend most of their time online visiting shopping sites and friends' Facebook pages.

Theoretical work shows that vertical differentiation will not be profitable for all products and services in all circumstances (Bhargava & Choudhary, 2001), a point that will also be clear in the example we develop below. On the other hand, from the prevalence of quality-differentiated offerings in real world markets we know that the conditions required for quality-differentiation to enhance profits are frequently satisfied. For such situations, theory tells us that welfare is often increased by such offerings (Hausman & MacKie-Mason, 1988; Deneckere & McAfee (1996); Varian (1996), which also means that regulatory or legislative prohibitions on such differentiation could reduce welfare. One source of increased welfare is the provision of lower quality versions of a product to consumers who would not be willing to pay for the higher quality version that would be offered if vertical differentiation were not allowed. In some cases, provision of the lower quality version will result in other users paying more for a higher quality version than they otherwise would have. In these circumstances the gains to consumers willing to pay less for quality will have to be balanced against the higher charges to those willing to pay more. On the other hand it will often be the case that the price of the high quality version will fall after a low quality version is introduced.<sup>6</sup> In this case consumers willing to pay more for quality, consumers who value quality less, and the seller can all be made better off if the lower quality version of the product is provided. Keneckere and McAfee (1996) show that this is the case even if the seller incurs an additional cost to provide the lower quality version of the product.<sup>7</sup> Recognizing that real world demands for broadband service are considerably more varied, we develop an example with two representative consumer types who differ in their monthly demands for data service to show how second-degree price discrimination may be employed to extend service to people who would not take service if the broadband service provider were restricted to collecting a single flat fee from all its customers.

**Figure 1** depicts marginal valuation schedules for monthly data consumption for two representative consumers, H and L.<sup>8</sup> H values broadband data more than does L and the solid line labeled MVH that runs from \$30 on the vertical axis to 3X on the horizontal axis shows the rate at which the marginal value of an additional unit of monthly data consumption declines

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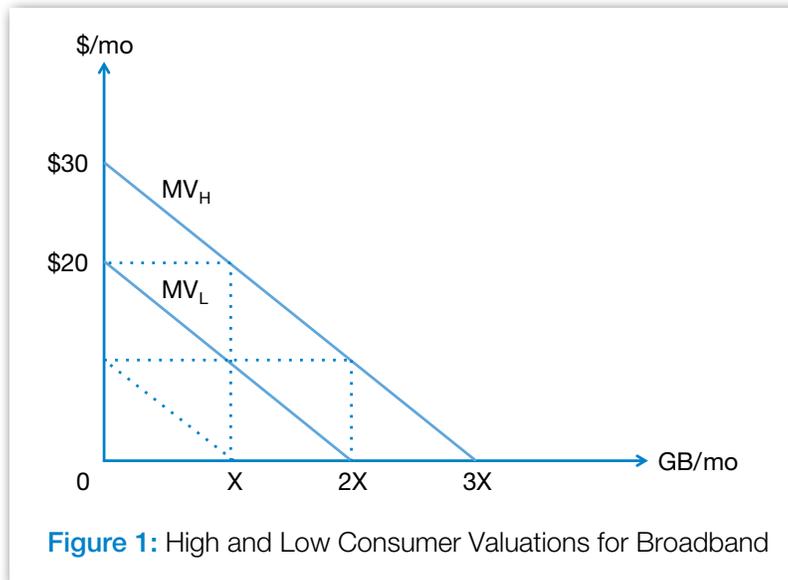
<sup>5</sup> For books the differentiating factor is the time from publication until a version is available to consumers. Consumers must endure a longer wait for the lower-priced paperback edition.

<sup>6</sup> This happens in part because the availability of a lower quality version at a lower price will limit the amount that consumers will be willing to pay for the higher quality version.

<sup>7</sup> Keneckere and McAfee (1996) provide a number examples where the least expensive way to produce a high and low quality version of a product is to produce the high quality version first and then create the lower quality version by incurring an additional cost to modifying the high quality version in a way that reduces its value to consumers.

<sup>8</sup> Figure 1 is adapted from a similar diagrammatic illustration in employed by Varian in a 1997 working paper (Varian, 1997).

for H from its initial value of \$30 for the first unit. Beyond  $3X$  additional data has zero value to H. Similarly, the solid line labeled  $MV_L$  that runs from \$20 on the vertical axis to  $2X$  on the horizontal axis shows the rate at which the marginal value of an additional unit of monthly data consumption by L declines from an initial value of \$20 for the first unit until the value of the marginal unit falls to zero at  $2X$ . If  $X$  were 100 gigabytes and there was no limit on what might be consumed, H would use no more than 300 gigabytes of data service per month and L's monthly consumption would not exceed 200 gigabytes even if service was free. The monthly value of such a service to H is the area under the triangle enclosed by the  $MV_H$  schedule and the two axes and for L it is the triangle enclosed by the  $MV_L$  schedule and the two axes. Simple geometry tells us that the monthly values are \$45 for H and \$20 for L.



Suppose a broadband service provider has 100 potential subscribers exactly like H and another hundred potential customers exactly like L. If the marginal cost of bandwidth is zero and the provider is forced to offer unlimited data service at a common price to all customers, a profit-maximizing provider would set its monthly subscription fee at \$45 and sell only to H-type customers because doing so would generate a monthly revenue stream of \$4500, while the maximum \$20 dollar price that would generate sales to both H-type and L-type consumers would produce only \$4000 a month. In the more realistic scenario where the broadband provider must invest in additional costly capacity to serve both types of consumers, the profit gain from selling only to H-types at \$45 rather than to both groups at \$20 would be even greater. Of course, increasing the number of low valuation consumers relative to high valuation consumers would increase the appeal of a single price low enough to attract L-type customers. For the two marginal valuation schedules in this example, revenue from a single low price of \$20 would equal that for a single price of \$45 if there were 125 L-type consumers and 100 H-type consumers. Further increasing the number of L-types would make the \$20 price more attractive if the costs of the additional bandwidth are ignored.

It is also easy to show that even though a provider with 100 potential customers of each type will sell the \$45 option to H types and ignore L types if restricted to uniform pricing, it will offer a service L-types are willing to pay for if given free rein to use differential pricing. With differential pricing, the provider will charge L-types \$15 a month for  $X$  gigabytes of service and it will sell a service that provides  $3X$  or more gigabytes a month to H-types for \$35.

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We demonstrate this effect on service offerings following a switch to differential pricing by first noting, with the aid of the light dotted lines in **Figure 1**, that the triangle under the MVH schedule is composed of nine equal-size right triangles and the area under the MVL schedule is composed of four of these triangles. The area inside of each of the smaller triangles therefore has a value of \$5 per month. We can thus see that X in monthly data service is worth \$25 to a H-type consumer. If a service option with monthly data consumption of X is available at a price of \$15, an H-type would take a second option with 3X or more of monthly data, which has a use value of \$45, only if its price were no more than \$35. Otherwise the benefits net of price to an H-type consumer would be less than \$10. Suppose the broadband service provider offers its customers the two options just described. With this set of price-service combinations, the provider will sacrifice \$10 per month on each of its 100 H-type customers compared to \$45 per month they would pay if only the high-end option were sold, but it will gain \$15 per month from each of the 100 L-type customers that otherwise would not take service. So total revenue will increase to \$5000. That this combination of price-data quantity combinations maximizes revenue is demonstrated in a footnote.<sup>9</sup>

As this example is constructed, only H-type consumers benefit from the introduction of the lower priced service option because H-types end up paying \$35 monthly for a service they value at \$45 while L-types are charged the full value for the service they receive. In the real world we would never expect to see just two internally homogeneous groups of consumers. Instead we would observe a continuum of consumer valuations and consumers with somewhat different valuations for service would clump around the more limited number of price-quality combinations sellers would find it most profitable to offer. The effect is to produce a downward-sloping demand curve for each option (given the prices for the other options) with most customers realizing positive surplus as is generally the case when a single price is charged for a product with downward sloping demand. Depending on how service tiers are priced, we may also find many, and perhaps most, of a service provider's customers regularly consuming data at a lower rate than their plans allow before incurring additional charges.

We discuss other reasons why consumers may purchase data plans with caps that exceed their typical monthly needs in Section III.2. For such consumers, the plans they purchase will feel the same as purely flat rate plans (plans that provide unlimited data service for a single fixed fee) most of the time. Marcus and Monti (2011, p. 44) make exactly this point in a report submitted to Google, observing for wireless service plans that “[t]here are different bands, representing different numbers of total air minutes per month. So long as the consumer does not exceed the maximum number of minutes in the band, the consumer will tend to think of the plan as being purely flat rate.” Their further observation that “the subscriber may occasionally exceed the limit and will be prodded by usage-based fees to upgrade to a larger ‘bucket’” is an indirect acknowledgment that usage bands with thresholds beyond which additional charges are levied are devices that enable operators to effectively discriminate among customers with different demands for minutes, or in the case of broadband, data service. Their characterization of such plans as “banded flat rate arrangements” is entirely appropriate.

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<sup>9</sup> Note first that by construction the vertical distance between MVH and MVL is a constant \$10 and that at X the MVL schedule has a height of 10. Moving the monthly cap for the low usage service slightly to the right will reduce the price for high valuation customers by \$10 times the size of the shift. But because the height of MVL is less than \$10 to the right of X, the increase in the price charged L-type customers must be a smaller amount. So revenue falls if the cap is set to the right of X. Conversely, because MVL has a height greater than \$10 to the left of X, shifting the cap to the left of X must reduce the price charged L-type customers by more than the price for uncapped service can be raised for H-type customers, which also must reduce total revenue.

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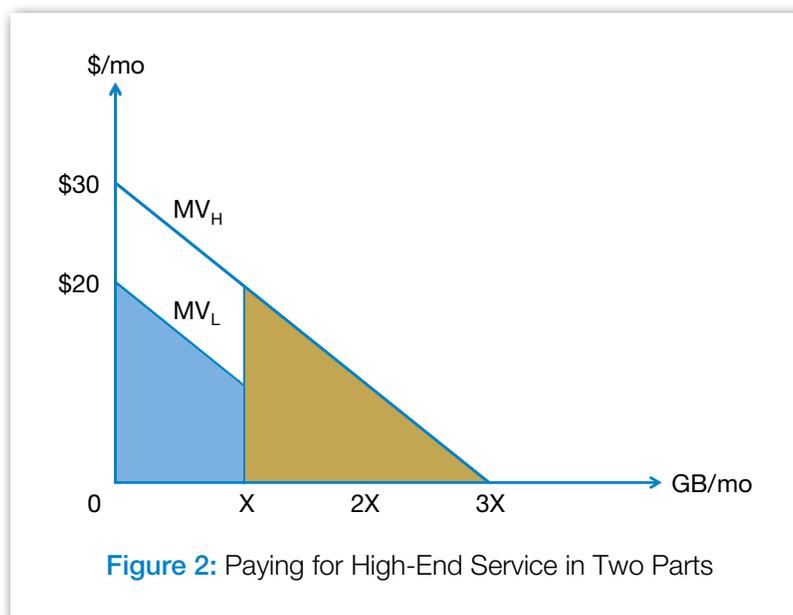
We conclude this subsection by using this example to demonstrate what is a more general conclusion: namely that more lower demand consumers will take broadband service if providers are allowed to employ tiered pricing plans than if they are required to provide all customers with unlimited data service for a single fixed fee (or flat rate). In terms of our example, the reason is that a single flat rate forces the service provider to choose between selling a service it can sell for \$20 to both L-types and H-types or a service it can sell to H-types only for \$45. Simple algebra shows that if the provider employs a single flat rate, a \$20 service will be offered only if there are 25% more L-types than H-Types. On the other hand, with the second-degree pricing scheme described in this section, L-types will be offered a \$15 service as long as there are at least two-thirds as many of them as there are H-types. That is, if there are 100 H-type consumers and the provider employs UBP, a price-quality package L-types find appealing will be offered as long as there are at least 67 L-types. If required to use a single flat fee, a minimum of 125 L-types is required for the provider to offer a price-quality combination L-types find attractive. In addition, for reasons explicated in Section III, if the \$20 service is offered to all users when the provider would prefer to offer a two-tier service and charge H-types more, the service offered will likely be a lower quality service than would be offered H-types if tiering were allowed because the return on investment for network upgrades will be reduced due to lowered profits on sales to the consumers who value service enhancements most.

## II.2. The Mischaracterization of Fees for Above-Threshold Data Consumption

Critics of UPB have complained that usage tiers, and especially charges levied for beyond tier data consumption, deny users the benefits of flat rate pricing because a positive marginal cost discourages use of what is often unused and thus zero opportunity cost capacity. These complaints were aired initially in response to a few providers' announcements of new pricing plans that would replace then standard service agreements with no limits on data consumption with pricing that operated like flat rate agreements up to a common monthly threshold beyond which additional fees kicked in when customers chose to consume additional data. On casual examination, and especially as characterized by their critics, these single band plans appeared to be quite different animals than the multiple (two) band plan described and illustrated in the preceding subsection.

This is a case where appearances are deceiving. The reason is that the above-threshold service sold through these plans was itself sold in blocks. So within block consumption was "essentially flat rate" in the same sense that this was true for data service consumed below the cap. When added capacity is sold in blocks, it can be shown that, as mechanism for differential pricing, the economic logic underlying a pricing plan that has a single initial block of service sold to all customers for a common fixed fee and additional blocks of data available for a separate fee is analytically equivalent to the second-degree pricing scheme illustrated with **Figure 1**. We use **Figure 2**, which is a modified version of **Figure 1**, to show why this is so.

In **Figure 2**, the green-shaded quadrangle is the \$15 the service provider charges L-type customers for monthly data consumption of X or less and the sum of the areas of the green quadrangle and the orange triangle is the \$35 H-type customers willingly pay for the opportunity to consume 3X or more of data when both options are available as described above. Clearly from the perspective of a H-type customer, it really doesn't matter whether her monthly bill lists two separate charges that sum to \$35, as would be the case if 2X of data were sold as a second consumption block at a \$20 price once the initial X was used, or whether the



bill contains only a \$35 charge for 3X or more of data a month.<sup>10</sup> The change in the way the monthly charge is represented on her bill would have no effect on the amount of data consumed or the benefits realized from the service as long as representing the bill as two separate charges did not increase the transaction costs associated with the purchase of the service. With the two-block scheme illustrated in **figure 2**, the service provider would still have the same incentive to offer X of monthly data service for \$15 to L-type customers that materializes when it is able to offer 3X or more of monthly data at a single price of \$35.

Offering customers a tiered plan with the option to purchase above-threshold blocks of service also has a number of additional benefits that should be reflected in a discussion of the merits of UBP for broadband. As discussed in the next subsection, this may be true even when the option is triggered automatically by above threshold data consumption. In fact, the transaction cost savings from invoking the option automatically when consumption exceeds a threshold should be seen as beneficial to all subscribers that have thresholds in their data plans as long as they receive notification as the amount of service taken approaches the monthly threshold.

### II.3. The Efficiency Benefits of Above-Threshold Usage Charges When Demand Varies Over Time

As an analytical convenience, to this point we have assumed that the marginal valuation schedules in **Figures 1 and 2** describe distinctly different types of broadband consumers and, further, that for each consumer type these valuation schedules are stable over time. Suppose instead that MVH and MVL reflect demands for data service for a single individual, but at different times. For instance, the 2012 London Summer Olympics were available for streaming through several online services, including websites maintained by NBC and by YouTube. An

<sup>10</sup> Technically, the service provider might have to charge slightly less than \$20 for the 2X block of data service to ensure that H-type customers are not indifferent between purchasing the second block or not.

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avid follower of various Olympic Sports with a L-type marginal valuation schedule most of the time might well have had an H-type marginal valuation schedule during the two-plus weeks of the Olympic games. Other broadband users' demands for data service may increase from L-type to H-type levels when they want to watch Christmas specials during the Winter holidays, during the baseball playoffs if the local team is doing well, or when they are sick and want to watch movies at home in bed. While it would certainly be possible for customers to contact their service providers to switch to a high data consumption plan when their demand temporarily increased and switch back afterward, the costs to both customers and service providers of these repeated transactions would likely be considerable. Much more efficient is a pre-established arrangement that automatically shifts a customer to a higher price-higher volume plan when short-term needs to consume more data arise. Service contracts with fixed fees for data consumption up to a threshold and additional fees for above-threshold consumption work in precisely this way. Employing them reduces transaction costs for all parties involved and makes possible consumption that might otherwise be foregone if the contracting mechanism were more cumbersome.

In his analysis of video stores' strategy of offering videos for short term rental at a fairly low price while selling the same titles at a higher price, Varian (2000) shows how this dual pricing strategy can be an efficient mechanism for segmenting video consumers into self-selecting groups that differ in how much they value the opportunity to watch a given title repeatedly. Consumers who want to watch a specific video again and again buy, while those whose interest in the video is likely to wane after one or two viewings will rent instead at a considerably lower price. Who rents and who buys will likely vary by title. For those who rent, the video store effectively serves as an intermediary facilitating for each rental title the sharing of a limited number of copies among a potentially much larger number of users. Similarly, as long as the temporary demands for above-threshold service by low volume broadband users are not perfectly correlated, a service agreement that allows customers to temporarily "rent" through charges for above threshold data consumption the extra capacity needed to increase their usage without diminishing the quality of service for other users can serve as an efficient mechanism to facilitate sharing of added network capacity that none of them would be willing to pay for on their own. The efficiencies due to demand aggregation and savings from cost sharing are the same as those that motivate the creation of almost all rental businesses.

#### **II.4. Low Price-Low Data tiers can encourage experimentation by new users**

The marginal valuation schedules in **Figures 1 and 2** assume that consumers know the value to themselves of the different service options offered by a broadband service provider. While this is a reasonable assumption for experienced broadband users, there is good reason to question its accuracy for nonsubscribers with little prior experience with the technology. Broadband is a general-purpose technology that can enable a huge variety of online activities. Inexperienced broadband users will find it extremely difficult to predict in advance which of these many activities they will value and how much. Uncertainty over prospective benefits can itself be a barrier to first time purchases of any product, let alone one with a multiplicity of uses like broadband. Low introductory prices and trial subscriptions are common strategies for promoting consumer goods and low cost-low usage tier options can function in the same way for first time broadband customers. A recent study by LaRose et al (2012) provides evidence that broadband subscribers' willingness to pay for higher bandwidth service increases the

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longer they use broadband, which suggest that use value increases as users acquire experience and learn more about the many things they can do with a broadband connection to the Internet. When increasing citizen access to and usage of broadband has become a national policy priority, the value of low cost-low cap options as inducements to try broadband for the first time should not be ignored.

## III. Shared Capacity and Network Investment

Broadband networks typically have tree and branch architectures. As a result, substantial portions of local infrastructure are shared by an ISP's customers. This is true for individual neighborhoods as well for higher levels of the network. The relative importance of shared versus dedicated network components also varies with the chosen architecture (e.g., FTTC versus FTTH).

Shared network capacity raises several issues. One is the relationship between pricing plans employed and network operators' ability to cover the costs of operating the shared portions of their networks. A second and closely related issue is creating incentives for operators to invest in capacity expansion, especially when demand and traffic are growing. In the long run, network operators' incentives to expand capacity also affect the extent to which congestion in shared elements becomes a problem as demand increases over time. Usage-based pricing (UBP) affects all these issues, although in multi-faceted and sometimes non-obvious ways, as we show with our analyses of share network costs and ongoing capacity investments in the next two subsections.

### III.1 Covering shared network costs

Broadband networks have a peculiar cost structure. A part of a network's cost is directly attributable to each of its individual users, but a considerable portion is shared among several or many users. The relative proportions of private and shared costs depends on the technical solution and the architecture of the network. It will be different in a network that brings fiber to the neighborhood than one that brings fiber to the curb. For our purposes it is sufficient to point to certain general cost characteristics that all these networks share.

Typically, the connection from a user's premises to the closest network node is directly attributable to the user. Costs higher up in the network are shared among ever larger numbers of users. Local networks may be shared among the users in a building complex or a neighborhood. Middle mile and backbone network costs typically are shared among even larger numbers of users.

To recover the capital and operating costs of these shared network facilities, a supplier has to charge prices that embed mark-ups over the directly attributable costs. Whether an ISP can employ differential pricing or not will affect where and how far network facilities are rolled out. Several scenarios for broadband deployment at the neighborhood level are described for a hypothetical neighborhood served by a common network distribution line (NDL) in Bauer et al. (2005). All illustrate the potential importance of differential pricing.

- I **Scenario 1:** The sum of net benefits for broadband users in the neighborhood is less than the cost of the NDL. Absent an external source of funding, presumably the government, broadband will not be made available to neighborhood residents under this scenario.
- I **Scenario 2:** The sum of the benefits to broadband users exceeds the cost of the NDL, but it is necessary to set service fees that vary by customer for a subscriber-supported service to cover the costs of the NDL.

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- I **Scenario 3:** A broadband service can be supported with a single per-customer charge, but the level of demand in the neighborhood is not sufficient to support two or more competing broadband suppliers employing this pricing strategy.
  - I **Scenario 4:** The neighborhood is large enough to support multiple suppliers, each with its own NDL.

The availability of UBP can affect the provision of service for all four types of neighborhoods. To the extent UBP can be employed to increase the revenue service providers can collect from scenario 1 neighborhoods, the cost-revenue gap that must be made up with public funds will be diminished and the public funds available will be able to support service for a larger number of scenario 1 neighborhoods.

For scenario 2 neighborhoods, service can be provided without public support, but only if operators are allowed to employ differential pricing strategies like UBP.

Broadband will be available in scenario 3 neighborhoods whether UBP is allowed or not, but as we showed in Section II, we can expect to see more residents take the service if UBP is allowed than if it is not. It is also likely that some scenario 3 neighborhoods would become more competitive scenario 4 neighborhoods if service providers were allowed to use UBP to enhance their revenues.

For neighborhoods that would be described by scenario 4 regardless of the pricing plans employed, we can still expect service to be extended to a larger number of neighborhood residents if differential pricing strategies like UBP are employed.

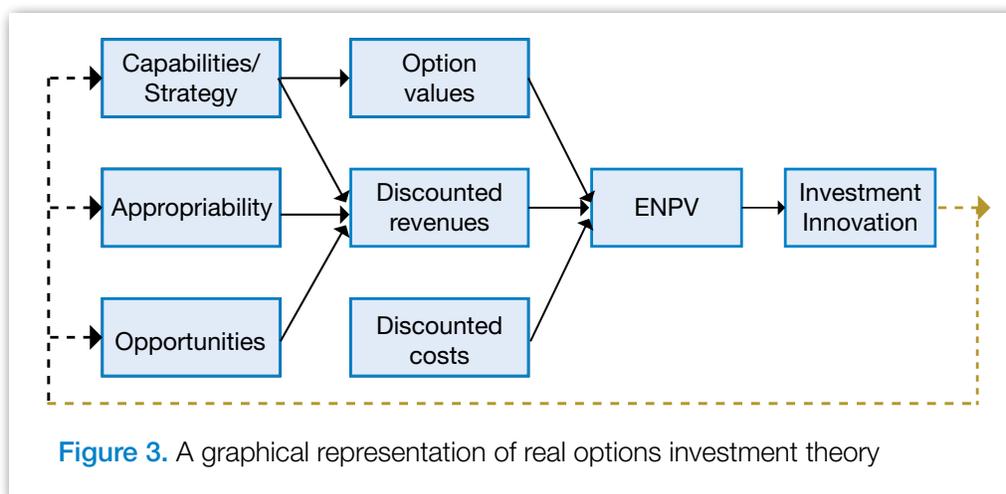
Similar reasoning applies to shared facilities at higher levels of a network. The general takeaway from this analysis is that to the extent limitations on UBP prevent ISPs from collecting contributions to common infrastructure costs from individuals who would take a low price-low data tier option, we can expect service providers to invest in fewer and less extensive networks unless the profit loss is offset by increased government support.

### III.2 Continued Network Investment

Ongoing investments in network infrastructure are required to keep up with growing demand and to incorporate new technological developments. The timing of such upgrades and expansions as occur will be influenced by the technological conditions of an industry. If capacity investments are lumpy, periods of higher congestion may precede periods when capacity expansion takes place. Such investment patterns are known from other network infrastructure industries.

The pace of network investment and the investment strategies employed will depend on the direct and indirect costs and benefits of alternative strategies (including their pricing components), the competitive situation, and anticipated future developments. Modern theory of investment under uncertainty models an investment decision as a real option. Real options theory can be seen as a generalization of discounted cash flow analysis (Trigeorgis 1999) that incorporates a larger and more realistic set of strategic considerations.

Real options theory takes explicitly into account that investment projects are typically not one-time decisions but that alternative courses of actions may remain available to management as long as a project continues. Among other things, such options would include project termination, pausing a project until more information on market developments is available, and varying the capacity of a network investment. A project's expanded or strategic net present



**Figure 3.** A graphical representation of real options investment theory

value (ENPV) is influenced by discounted revenue and cost streams, as in traditional net present value (NPV) analysis, but also by the value of options available to management, which can improve or reduce the ENPV relative to simple NPV.

The effects of UBP can be integrated into this framework. Other things being equal, the ability to use differential pricing will increase discounted revenues and hence increase the ENPV. Thus, one would anticipate that in an environment that allows UBP, a higher rate of investment will be realized than in an environment where UBP is not allowed.

In practice, network operators will take other factors into consideration that could affect this incremental analysis. For example, users seem to have a preference for flat pricing and often subscribe to plans that provide them with a safety cushion. One explanation is that users face mental transaction costs or decision fatigue if required to monitor usage with respect to a variable schedule of prices or the amount of data service available before bumping into a cap. Another is that users look at the service they buy as including the right to use a certain capacity to address future needs of uncertain timing and magnitude. This option demand (Weisbrod 1964)<sup>11</sup> is similar in some respects to the insurance against exceeding purchased capacity motive described by Odlyzko et al. (2012). In either case, users may purchase the option to download a certain amount of data or to make a certain number of calls even though they may not make full use of it. This is another reason why most users purchasing tiered data plans are likely to bump up against their tiers' thresholds only rarely.

<sup>11</sup> Some authors, e.g. Odlyzko et al. (2012) use the analogy of insurance but the notion of option demand seems to capture the problem more accurately.

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## IV. Summary and Discussion

Broadband networks are general purpose facilities that support a broad range of services with greatly varying bandwidth and quality of service requirements. Except for the local connection, broadband networks are shared among many different users and uses. During past years, data-intensive applications and services have contributed to a large increase in traffic volumes. Although the Internet has grown tremendously, the situation is reminiscent of the 1990s, when concerns about network capacity management resulted in numerous proposals to use pricing to manage scarce capacity and prioritize traffic according to economic value criteria. These initial ideas were not put into practice because network upgrades from dial-up to broadband could be achieved at a relatively reasonable cost and the benefits of flat prices outweighed the costs of upgrades. The present situation is different in that network upgrades require new and additional investment, while the user community has become more heterogeneous and diverse and is placing new demands on the network infrastructure.

Given these developments, it seems reasonable and timely to reassess the uses and benefits, as well as the potential downsides, of usage-based pricing as a tool for keeping network resources aligned with user valuations. This report shows that usage tiers are a form of second-degree price discrimination, a pricing strategy that is employed widely in information and other industries and that arises naturally in competitive markets. A substantial theoretical and empirical literature recognizes the potential efficiency benefits of differential pricing for both consumers and sellers. Our analysis shows that similar effects can be anticipated under the specific technology and cost conditions of broadband networks. While UBP is not guaranteed to improve welfare, in most cases it appears that this will be the case.

One of the key mechanisms through which positive welfare effects are realized is the crafting of lower-priced plans for users who otherwise might not take service, while users who have a more intensive demand for broadband are able to contract for more advanced services. We also showed that UBP has flexibility advantages for users whose data service needs vary over time. Because UBP creates an incentive to offer lower cost-lower usage plans to consumers who otherwise could not profitably be served at a unitary price, UBP can be an effective tool for promoting increased broadband penetration in the United States, a role that is enhanced by the fact that low price-low usage options reduce the financial risks to consumers thinking about trying broadband for the first time.

Tiered pricing also has benefits for the recovery of shared network costs and for network investment. Whereas investment decisions are also influenced by other factors, including the costs of extending networks, potential revenues, and overall economic conditions, we found that, other things equal, usage tiers will likely contribute to better cash flows and stronger incentives to invest in broadband plant, both to improve the quality of service for current customers and to extend networks into unserved and underserved territories.

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