

# Willingness to Pay and the Demand for Broadband Service

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## Introduction

This paper revisits the general concept of the demand curve, the computation of price elasticity and the question of willingness to pay (WTP), specifically estimated or derived from survey data. The estimation of either a price or income elasticity is typically the focus of most empirical demand studies. Somewhat less interest has been directed to the role and value of WTP. WTP is a core concept and the underlying basis on any demand curve. Its value or computation, however, requires knowledge of the entire demand curve in question. Lacking such information, econometricians work with models that provide, at a minimum, a way to estimate elasticities.

We argue that having knowledge of a consumer's demand curve in general and their WTP in particular, provides direct guidance for decisions associated with product pricing, marketing and positioning. Estimates of WTP also guide public policy debates as far ranging from environmental initiatives to proposed regulations concerning the health and safety of the community. Accordingly, this paper presents a method for using survey-based information that uses self-reported WTP to derive the underlying market demand curve for a specific product or service. We apply this method by modeling the demand for broadband services, the demand for DVD players, and the demand for digital cameras. For broadband services, we compare the derived elasticities from this approach with estimates derived from conventional choice-based models.<sup>2</sup>

## Background

There is a sizeable literature on WTP. The contexts cover a wide array of issues, from an assessment of a consumer's valuation of risks to the pricing of new products and services.<sup>3</sup> The methodologies available to estimate WTP are often variations of the contingent valuation approach or the revealed preference / hedonic models. The contingent valuation approach is direct. One simply asks a sample of representative individuals how much they value a specific commodity, a set of risks, or specific attributes of a commodity. Since it is based on surveys, the implementation of the approach is straightforward. They are, to be sure, a number of criticisms with this approach.<sup>4</sup> The revealed preference / hedonic market focuses on consumer decisions in

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<sup>1</sup> The authors wish to thank Dr. Dale Kulp of Management Systems Group for access to their omnibus survey and to Kevin Babyak of Econsult for research assistance.

<sup>2</sup> See for example "An Econometric Study of the Demand for Internet Access", Rappoport et. al (1999).

<sup>3</sup> See for example "Estimating Consumer Willingness to Pay to Reduce Food Borne Risk", James K. Hammitt, RAND Report R-3447-EPA, 1986 and

<sup>4</sup> The list of criticisms is substantial. Most deal with the possibility that the respondent cannot in a meaningful way place a value on a the product or service in question.

actual situations to infer the value of a choice or an attribute. This approach rests on the researcher's ability to either track these decisions over time or by simulating the range of alternatives in a survey.<sup>5</sup>

In this paper we start from a straightforward analysis of consumer behavior and, with only a few assumptions concerning the existence of a threshold price, derive the underlying demand curve for a specific product. Since the focus is on the demand function, WTP is a by-product of our analysis. We combine the directness that is part of the contingent valuation method with the choice-based underpinnings that are required for the revealed preference model.

### The Model: Lognormal Demand Curves

We assume that individual consumer's decision to purchase a product is a function of the actual market price,  $p_m$  and their threshold price,  $p_o$ .<sup>6</sup> The individual demand curve would then be described by:

$$(1.1) \quad \begin{aligned} q_i &= 1 \text{ if } p_o > p_m \\ q_i &= 0 \text{ otherwise} \end{aligned}$$

If we assume a lognormal distribution for  $p_o$  with parameters  $\mu_{p_m}$  and  $\sigma_{p_m}^2$  we have:

$$(1.2) \quad P(q = 1 | p_m) = P(p_o \geq p_m) = 1 - A(p_m; \mu_{p_m}, \sigma_{p_m}^2)$$

Letting  $Q$  represent the expected proportion of buyers in a given market yields:

$$(1.3) \quad Q(p) = 1 - A(p_m; \mu_{p_m}, \sigma_{p_m}^2) = A\left(\frac{1}{p_m}; -\mu_{p_m}, \sigma_{p_m}^2\right)$$

We note that, given (1.1) and (1.2) above, the plot of  $Q(p)$  yields a demand curve based on parameters  $\mu_{p_m}, \sigma_{p_m}^2$ . Given the demand curve as represented by  $Q(p)$ , the array of

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<sup>5</sup> This approach requires a well crafted survey design if the data collection vehicle is a survey. The use of conjoint analyses and rank ordered logit procedures lead to estimate these valuations. For more information on price studies using Conjoint refer to D. Frank Jones, "A Survey Technique to Measure Demand Under Various Pricing Strategies," *Journal of Marketing*, 39 (July 1975), 75-77; Paul Green and V.R. Rao, "Conjoint Measurement for Quantifying Judgemental Data," *Journal of Marketing Research*, 8 (August 1971), 355-63; and Patrick J. Robinson, "Applications of Conjoint Analysis to Pricing Problems," *Market Measurement and Analysis*", ed. David Montgomery and D. R. Wittink, Marketing Science Institute, 1980, pp. 183-205.

<sup>6</sup> This section follows closely the discussion of J.S. Cramer, *EMPIRICAL ECONOMETRICS*, North-Holland, 1969 Chapter 3.

demand elasticities can be computed anywhere on the demand curve. To be sure, the computation of price elasticity depends on the parameters  $\mu_{p_m}, \sigma_{p_m}^2$  and is given by

$$\eta = \frac{d \log Q(p_m)}{d \log(p_m)} \text{ or using 1.3}$$

$$(1.4) \quad \eta = -\frac{1}{\sigma_{p_m}} \frac{n(v; 0, 1)}{N(v; 0, 1)}$$

$$v = \frac{\mu_{p_m} - \log p_m}{\sigma_{p_m}}$$

The parameters  $\mu_{p_m}, \sigma_{p_m}^2$  can be readily estimated from survey data or derived from simulations.

The impact of other factors such as age, region of the country, occupation and so forth can not be directly incorporated into  $Q(p)$ . However, given sufficient sample size, a family of curves  $Q(p)'$  can be constructed where a member of the family of curves might, e.g., refer to households with high incomes. A time dimension can be added by successively computing the curve over successive periods.<sup>7</sup>

### The Practical Side

The implementation of (1.3) requires information on the behavior of consumers at different prices. If the researcher had access to detailed transactions data for a large number of consumers, (1.3) could be directly estimated. This situation is almost never present.

Consider a survey that includes questions that asks the respondent to provide the least price for which the item in question would be considered “too expensive”. This price corresponds to the threshold price,  $p_0$ .<sup>8</sup>

The demand curve,  $Q(p)$ , is found by plotting the fraction of respondents having a threshold price that exceeds the market price. The proportion,  $Q(p)$ , is simulated by comparing the threshold price to a series of market prices. Not surprisingly, the fraction represented by  $Q(p)$  is greatest when the market price is 0.

As with the straight contingent valuation method, this process depends on the respondent providing a meaningful threshold price. We believe this requirement is less problematical when the product under investigation is well known. Further, using equation (1.3), the

<sup>7</sup> This process would enable the researcher to incorporate learning or general knowledge of the product (marketing success) into the analysis

<sup>8</sup> A lower bound would be determined by asking for the highest price for which the respondent would dismiss the product as inferior.

role of the threshold price is not to provide estimates of WTP but rather to assist in the derivation of the demand curve. In this sense, the method briefly outlined differs from the typical applications that use contingent valuation.

Note that the procedure outlined above does not depend on the same econometrics that would typically accompany the estimation of a demand function. One could simply plot  $Q(p)$  against  $p$  on lognormal paper to obtain the underlying demand curve. Contrast this approach with other survey approaches where a respondent is asked directly whether he would purchase an item at a specific price. Estimating price elasticities in this case requires a larger survey since a number of alternative prices are required to obtain price variation.

## **Applications**

Demand curves for four products and services are derived. The first two are related to high speed Internet access. Service 1 is for cable modem access. Service 2 is for ADSL access. Two additional products are included in the study to help assess the procedure's applicability. These are for digital cameras and DVD players.

Threshold questions were included in the Marketing Systems Groups' national omnibus survey, Centris®.<sup>9</sup> The survey was administered for 2 weeks in March, 2002. 2,011 completed surveys were recorded.

Two variations of the threshold question for high speed Internet access were tested. These were:

- 1a. What is the most you would be willing to pay on a monthly basis for high speed Internet service provided by your (telephone) (cable TV) company?
- 1b. What is the highest monthly price at which you would consider purchasing high speed Internet service provided by your (telephone) (cable TV) company?

For the DVD player and the digital camera, the questions were:

- 2a. What is the most you would be willing to pay for a (digital camera) (DVD player)?
- 2b. What is the highest price at which you would consider purchasing a (digital camera) (DVD player)?

The placement of the questions was varied. Both variants of the threshold question were tested. No respondent was asked both variations.

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<sup>9</sup> For more information on Centris, go to [www.m-s-g.com](http://www.m-s-g.com)

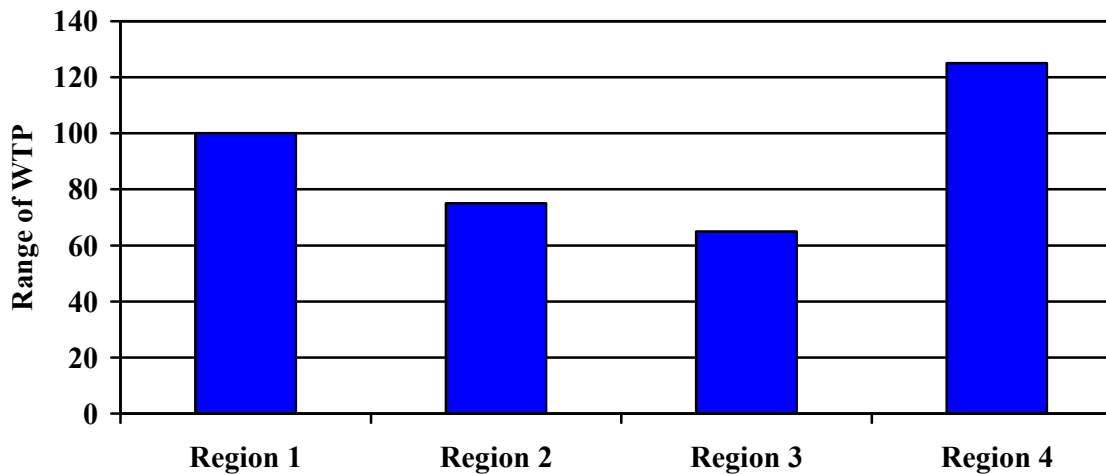
The following considerations come into play when assessing the demand for high speed Internet access. First, it is an open question whether the availability of the service would matter in the construction of the “demand” curve. To test the questions of availability requires having information regarding the deployment of cable modem services and ADSL services by specific geographies. The second issue concerns whether one should focus the analysis on only households with any Internet access. This is probably less a concern since if a household placed no value on high speed Internet access, we would expect a threshold price of 0.

Asking a respondent to provide WTP can lead to the respondent providing their estimate of the market price, rather than their individual valuation or WTP for the specific service. This situation is best handled by structuring the survey questions to guide the respondent through this issue.

### Survey Based Willingness to Pay

Chart 1 displays WTP for Broadband Access by Census Region.

**Chart 1: WTP by Census Region**



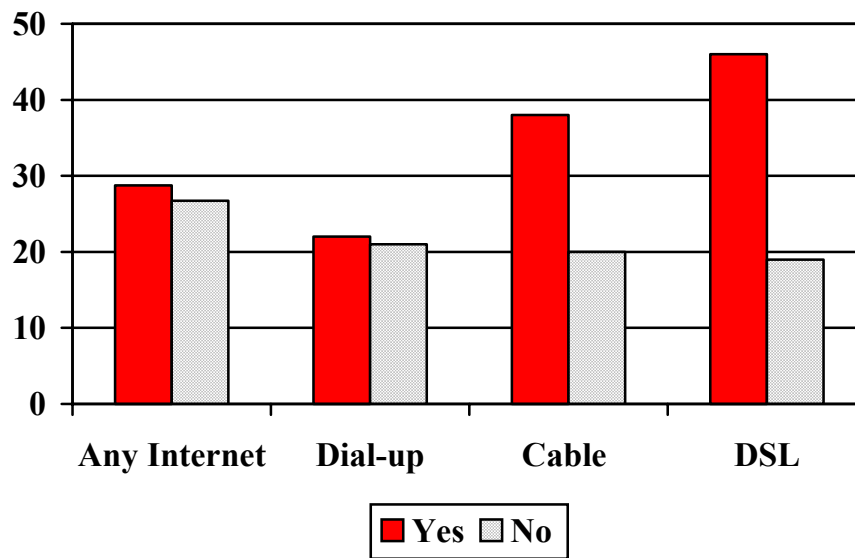
Region 1 (East) and Region 4 (West) display the most variability in WTP (as measured by the range in WTP). This result is consistent with other findings.<sup>10</sup>

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<sup>10</sup> See for example “Falling through the Net: Toward Digital Inclusion”, US Department of Commerce, NTIA, October 2000.

Chart 2 displays WTP by type of current Internet access. This chart points out the problem of confounding WTP with actual market price. Since dial-up service is around \$20 and broadband service is available for \$35-\$50, the chart suggests that respondents were providing WTP based on either their understanding of market prices or the on the prices they were currently paying.

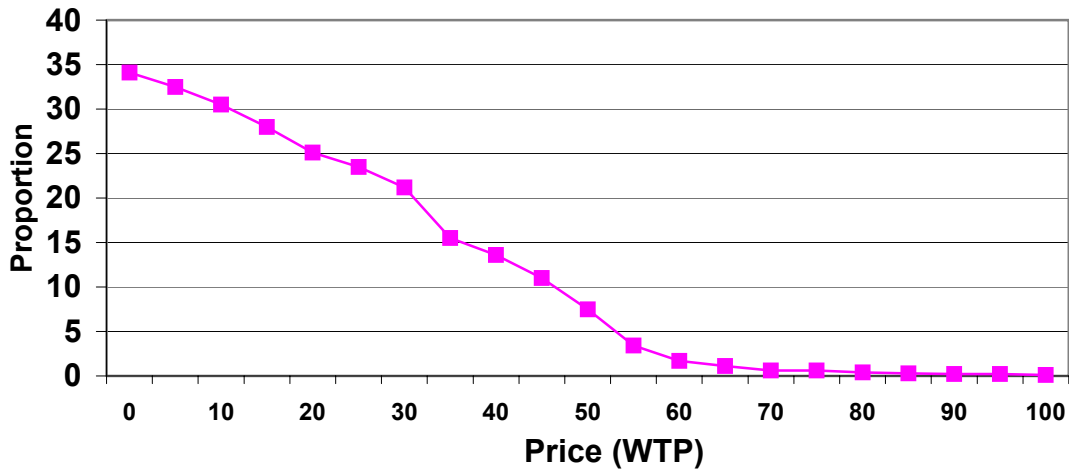
**Chart 2: WTP by Type of Internet Access**



Note that WTP is higher for those respondents that had broadband access. This result is not surprising. WTP is most likely influenced by one's knowledge of the market. Consumer's assimilate and adapt to market prices. The WTP for respondents with any Internet access is similar to the WTP for those without Internet access.

Chart 3 displays the derived demand curve for Cable modem Access.

**Chart 3:: Cable Modem Demand**



As expected, the chart has a long tail. At a market price of \$50 the implied market share is 7% of all households or approximately 14% of households with Internet access. This is close to the current estimate of cable modem penetration rates.<sup>11</sup>

Table 1 displays the derived elasticities for cable modem demand.

**Table 1: Cable modem Elasticities**

Price	Elasticity
\$20	-0.53
\$30	-0.59
\$40	-0.75
\$50	-0.98
\$60	-2.25
\$70	-3.34

Previous estimates of cable modem elasticity ranged from  $-0.84$  to  $-1.05$ . These results are consistent with previous research.<sup>12</sup>

<sup>11</sup> see e.g. <http://www.cabledatacomnews.com/>

<sup>12</sup> See e.g. Rappoport, P.N., Taylor, L.D., Kridel, D.J., and Serad, W. (1998), "The Demand for Internet and On-Line Access," in *Telecommunications Transformation: Technology, Strategy and Policy*, ed. by E. Bohlin and S.L. Levin, IOS Press, pp. 205-218.

The same survey data can be used to construct Lognormal Engle curves. The Engle curve focuses on the consumer's purchase of a product as a function of income, *ceteris paribus*. The assumption underlying the individual Engle curve is that a household will purchase an item if its actual income,  $y$  exceeds its threshold income,  $y_0$ .

Assuming that the underlying distribution of  $y_0$  is distributed as a lognormal, we have:

$$(1.5) \quad A = N(\log z; \mu, \sigma^2) = N\left\{\frac{\log z - \mu}{\sigma}; 0, 1\right\}$$

The expected proportion of households who purchase broadband services as a function of income (alone) is thus given (see 1.2 and 1.3) by:

$$(1.6) \quad Q(y) = A(y; \mu, \sigma^2)$$

Chart 4 displays the Engle curve for broadband Internet access. The Engle curve is positive over the ranges of income, as expected. The Engle curves for cable modem and DSL access are very similar, as expected where two goods are assumed to be strong substitutes for one another.

**Chart 4: Engle Curve for Broadband Services  
(ADSL and cable modem)**

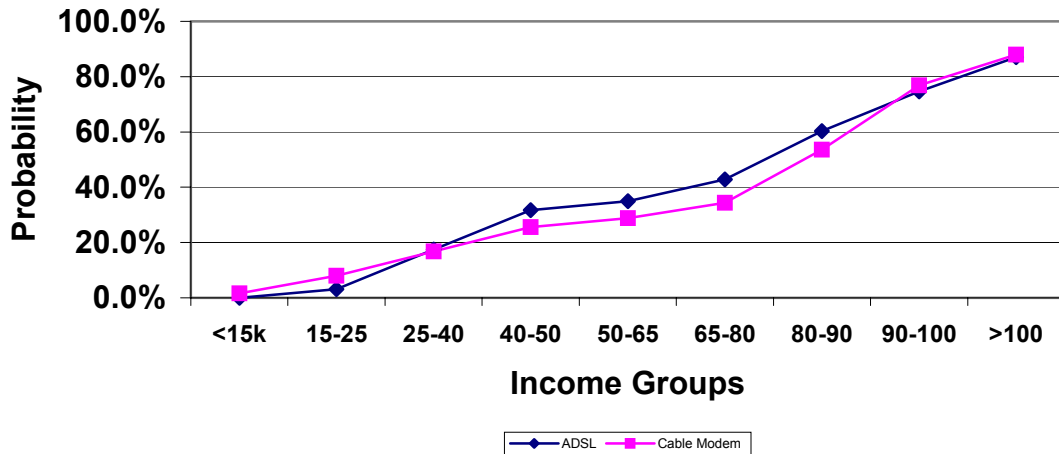
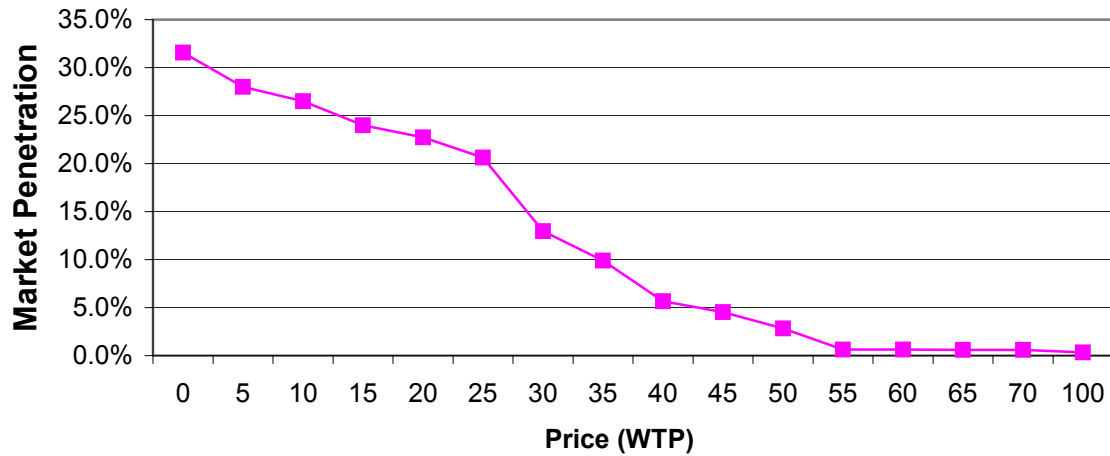


Chart 6 displays the demand curve for DSL access.

**Chart 6: The Demand for ADSL**



The demand curve for DSL is similar to the demand curve for cable modem access. At a market price of \$45, the derived DSL elasticity is approximately 1.17. The expected penetration rate is close to 5%, a number very much in line with other estimates of DSL penetration rates.

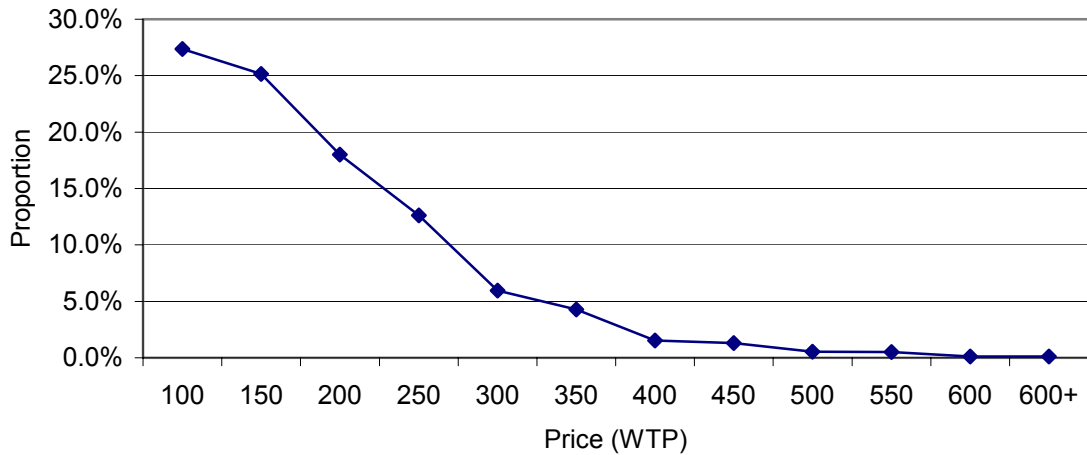
It is an open question whether the WTP for broadband services depends on the availability of broadband services in a particular area.

### **Application to DVD players and Digital Cameras**

Figure 7 displays the derived demand curve for DVD players based on self-reported WTP for DVD players. Current survey results suggest that the estimated current penetration rate is around 27%.<sup>13</sup> Using the demand curve below, the price (WTP) associated with a penetration rate of 27% is around \$125, a price consistent with the average retail price of a DVD player.

<sup>13</sup> MSG Centris Omnibus Survey, first Quarter, 2002

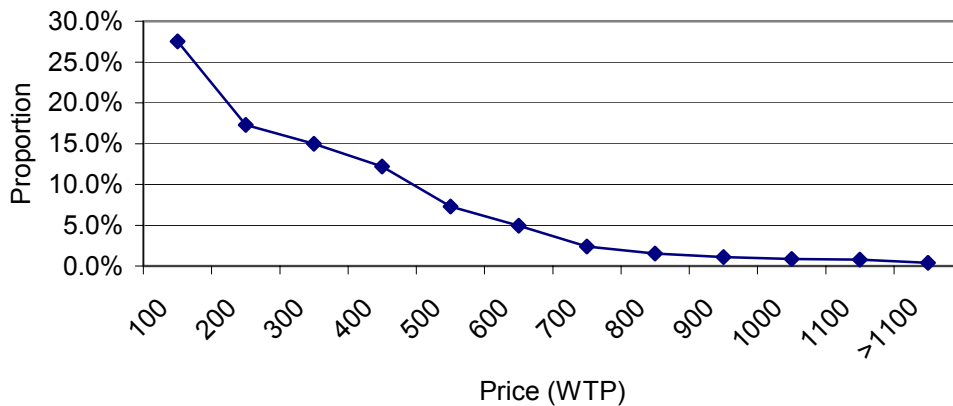
**Chart 7: Demand for DVD**



At a “price” of 0 the maximum penetration rate for DVD players is 81%. That number should be compared to a VCR penetration rate of over 90%.

A similar result is found in a consumer’s maximum valuation of a digital camera. Figure 5 displays the demand curve for digital cameras. This graph is suggestive. There are many variations of digital cameras where the price on the low end is under \$150 and the price on the higher end is under \$1,000.

**Chart 8: Demand for Digital Camera**



The current estimate of the percent of households with a digital camera is 15.7%. This suggests a price of \$325 - \$350 dollars. Note for this product that there is a considerable proportion of respondents whose WTP exceed \$350.

## Conclusions

These examples illustrate the potential applicability of the approach outlined in this paper. The results should be viewed as suggestive. The results do point to the usefulness of WTP for products and services that are generally available and understood. Further, the results demonstrate that surveys can be an efficient vehicle for collecting price information. These surveys need not be overly cumbersome nor do the resulting analyses have to be complicated and expensive.

While these examples appear to “work”, prudence suggests that more tests are required. In particular the wording of the WTP question requires more assessment. For the analysis of broadband services, availability is clearly a limiting factor that needs to be incorporated into the analysis. For products such as DVD players or digital cameras, given the wide range of products on the market, a sequence of questions may be required to fine tune responses.

Broadband questions may well need refinement as well. What is the best way to describe broadband demand if households are given a menu of broadband features and options such as bandwidth, bundled services and so forth. These issues (and many more) are the subjects of follow-on research.