

# Focusing on Demand: Using eBay data to analyze the demand for telescopes.

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## **Abstract**

This paper analyzes the value of using data from on-line auctions to determine product market definitions and competitive effects of mergers. Traditionally this type of demand analysis has been based on retail transaction data, particularly "scanner" data. However, such data is not always readily available and may be difficult to interpret. Auction data, particularly data

# 1 Introduction

Antitrust economists working at the FTC and the DOJ are routinely asked to determine the answer to two questions when evaluating a potential merger:

- What is the product market?
- What will be the competitive effects of the merger?

Traditionally, evidence from interviews and documents have been complemented by econometric evidence based on retail price and transaction data. Recently, the use of scanner data has become widespread. This data allows for the estimation of cross-price elasticities which are used to determine product market definitions, and own-price elasticities which are used to determine the price effects of a merger.<sup>1</sup> Unfortunately, transaction data is not always available, and even when such data is available the results may not be easy to interpret.<sup>2</sup> On the other hand, on-line auction data may be readily available from sites such as eBay.com. It is possible that auction data is able to provide enough information to identify each bidder's "willingness to pay" for the item and thus the demand curve for the item. Further, it may be possible to determine an individual's willingness to pay for multiple items and thus identify a demand system over multiple products.

This paper presents an analysis of eBay auction data for three types of telescopes, Meade's ETX90EC, ETX125EC and LX200, that retail for between \$500 and \$1,500. This data was collected over an eight week period in April, May and June of 2002, and includes information from over 58 separate auctions with over 200 separate bidders. The data was used to estimate the demand for the three telescopes and calculate own-price and cross-price elasticities. The results suggest that demand for these telescopes is very elastic. This result corresponds with our understanding that these telescopes are

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<sup>1</sup>See Hosken et al. (2002) for a discussion of some of the issues involved with using such data.

expensive luxury items, generally bought by hobbyists and high end consumers. The results also suggest that the Schmidt-Cassegrain telescopes and the Maksutov-Cassegrain telescopes are in different product markets. This result supports the claim that was made by the Commission in a previous merger case regarding this industry,<sup>3</sup> as well as in the more recent merger case.<sup>4</sup>

eBay and other online auction houses may be a rich source of data for economists analyzing the market structure of certain industries. There exists a number of papers that have used data from online auctions to analyze different aspects of the auction mechanism and the value of information available to buyers and sellers. For example, Lucking-Reiley et al. (2000), Livingston (2002) and Hasker et al. (2001) discuss the importance of seller's ratings, reserve prices and the length of the auction, and Roth and Ockenfels (2000) analyze the effect of the fixed endpoint of eBay auctions as compared to the "going, going, gone" feature of Amazon.com auctions. While it is not the focus of the paper, Hasker et al. (2001) analyze the effect on bids of characteristics of computer monitors sold on eBay (flat screen, dpi, size), the good being sold (like new, refurbished), as well as the auction (secret reserve price). There are also a number of papers that look at the question of whether bids in auctions can be used to infer demand functions. In particular, Haile and Tamer (2002) propose two different methods of bounding demand curves (actually the distribution of private values) from English auction data similar to the data found in eBay auctions. The authors use these methods to make predictions on reserve price policies from timber auction data. The analysis presented below will explicitly look at inferring demand from eBay auction data and discuss some of the concerns relating to this type of inference.

The rest of the paper proceeds as follows. Section 2 discusses the data and how it was obtained. It also describes the telescopes and provides some background information on the product market. Section 3 analyzes the demand for these telescopes, based on high bids from the eBay auctions. This section will present own-price and cross-price demand elasticities and discuss

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<sup>3</sup>FTC v. Harbour Group Investments, 1990 WL 198819 (D.D.C. 1990).

<sup>4</sup><http://www.ftc.gov/opa/2002/05/meadecelstron.htm>.

some of the issues and concerns with the estimations. Section 4 concludes.

## 2 EBay Data on Bids for Cassegrain Telescopes

### 2.1 Product Market

Telescopes come in three major optical configurations, refractors, reflectors and catadioptric (mirror-lens). The first type of telescope to be invented was a refractor. These telescopes were developed by Galileo and use lenses to magnify the light. The major advantage of refractors is that they can give a sharp image of the object. Refractors are generally used for observing planets, the moon and the sun. The next to be developed was the reflector. This type of telescope was developed by Sir Isaac Newton. This telescope uses a mirror at its base to focus and magnify the light. The major advantage of reflectors is that they can be made at very large apertures very cheaply. This means that they can let in a lot of light, enabling the observer to view very faint objects, such as small galaxies. Newest are the catadioptric optical systems, including the Schmidt-Cassegrain and the Maksutov-Cassegrain designs. These telescopes are also reflectors but they use multiple mirrors to increase the focal distance (the magnification) in a smaller physical space. These are good all-purpose telescopes that tend to have large apertures and large focal lengths for their physical size. The two ETX models are Maksutov-Cassegrain designs, while the LX200 is a Schmidt-Cassegrain design.

The most important characteristic of the telescope is aperture size. Magnification and light gathering ability are both functions of the aperture size. Light gathering ability is a function of the area of the mirror or lens, and thus a function of the square of the telescope's diameter. The greater the light gathering ability the fainter the objects that can be seen. The ETX90EC is the smallest at 90mm (3.5 inches), then the ETX125EC at 125mm (4.9

two Maksutov-Cassegrains (ETX90EC and ETX125EC) and the Schmidt-Cassegrain (LX200) is not as important as the difference in aperture (a 3 inch difference between the ETX125EC and the LX200).

In the 1990 case, the Commission argued that the appropriate antitrust market was for 8 inch Schmidt-Cassegrain telescopes (of which the LX200 is one).<sup>5</sup> Only two firms manufactured and sold 8 inch Schmidt-Cassegrain telescopes in the United States, Meade and Celestron, and these two firms were planning to undertake a joint venture. This joint venture was seen by the Commission as being equivalent to a merger. Because of their high quality optics, relatively low prices and relatively compact size, these telescopes were the most popular telescope for the serious amateur astronomer. Due to the Commission's actions, the merger was never consummated. Since 1990, both companies have introduced a line of smaller and cheaper Maksutov-Cassegrain telescopes. Two of Meade's Maksutov-Cassegrain telescopes are the ETX90EC and the ETX125EC. The ETX series is the most popular type of telescope sold by Meade, with sales of around \$70 million dollars annually,<sup>6</sup> although the Schmidt-Cassegrain remains highly prized by the serious hobbyists.<sup>7</sup> Recently the Commission stated, "that the two companies together would monopolize the market for Schmidt-Cassegrain telescopes and would eliminate substantial actual competition between Meade and Celestron in the market for performance telescopes."<sup>8</sup>

## 2.2 Auctions Methods on EBay

EBay runs a second price English auction for a variety of consumer goods, including telescopes. The auction is "second price" because the winner pays

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<sup>5</sup>At the time, the Maksutov-Cassegrain designs were made by very small scale manufacturers and were substantially more expensive than the comparable Schmidt-Cassegrain designs.

<sup>6</sup>This estimate is based on Meade's 2001 10K filing with the SEC and statements by

the

## 2.3 EBay Auction Data

At the close of each auction, eBay provides the following information: a description of the product, including photos and other information at the seller's discretion, the date and time of each bid, the identification name for each bid (their eBay account name), and the amount of each bid, except for the highest bid.<sup>11</sup> We collected data from 31 auctions for the ETX90EC, 20 auctions for the ETX125EC and 7 auctions for the LX200 during April, May and June of 2002. Table 1 presents some summary statistics for the auctions that we observed. These figures clearly show that the ETX90 is the most popular of the three telescopes, with greater numbers of both buyers and sellers. Note that the retail prices are for the basic units which don't come with tripods or the "go to" system in the case of the ETX products (both are included in the price of the LX200). Winning bids are greater than the retail prices because many of the telescope auctioned come with accessories. Note also that the retail price for the LX200 is actually the retail price for the

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	ETX90	ETX125	LX200
Number of Auctions	31	20	7
Number of Bidders	157	98	44
Average Bidders	6.7	6.9	7.9
Average Bid	\$394.68	\$785.19	\$1166.39
Average High Bid	\$506.47	\$966.68	\$1555.07
Highest High Bid	\$830	\$1349.01	\$1750
Lowest High Bid	\$270	\$680	\$1331.50
Retail Price (Basic)	\$495	\$895	\$1,499

Table 1: Summary Statistics of Telescope Auctions

to catch a glimpse of Saturn’s rings and Jupiter’s moons. It is in excellent condition.”

Sellers often describe their telescope as being “like new” or “as if new”. Hasker et al. (2001) shows that this type of statement is an important determinant of computer monitor prices. Another important characteristic of the Meade telescopes is the inclusion of the “go to” or Autostar computer controller. All of Meade’s telescopes come with a computer located in the mount of the telescope. Once the telescope is aligned, this computer can point the telescope at any of the thousands of celestial objects that are programmed into the computer’s database.<sup>12</sup> The Autostar controller allows the user to access the computer. The other vital accessory is the tripod, especially for the larger telescopes. The camera adapter (T-adapter) allows a 35mm SLR camera to be attached to the telescope for celestial photography.

Table 3 presents information on the 85 bidders who bid in more than one auction for one of the three products during the time in which the data was being collected. The first row states that for bidders who bid multiple times and bid on the ETX90, 56 % bid only on the ETX90, 39 % also bid on the ETX125, and 11 % also bid on the LX200. Of the 85 bidders who

<sup>12</sup>This system is also fairly simple to align. The process involves setting the telescope level and pointing north, entering time and location (unnecessary with GPS), and correcting the alignment against two prominent stars.



	ETX90	ETX125	LX200
"Like New"	20 %	56 %	42 %
"Go to"	53 %	86 %	58 %

%

## 3 Inferring Demand for Telescopes from EBay Data

### 3.1 Estimation Techniques

We use bids from these auctions to estimate the demand for the ETX90, the ETX125 and the LX200. If in the population, we know each person's value or "willingness to pay" for each particular telescope, then we can calculate the demand for each telescope. At each price, all those people with values greater than the price will buy a telescope and choose the telescope with the highest consumer surplus, giving the quantity demanded at that price. By changing the prices and recalculating demand for the three telescopes at the new prices, we can calculate own and cross-price elasticities. If however, we have valuations for a random sample of the population then we can estimate the demand. The eBay data gives a sample of the population, although not a random sample of the population. The sample is a self-selected group willing to bid on telescopes on eBay. This sample is also not a sample of each person's valuation, but rather a sample of each person's bid for a particular telescope. The following is a list of assumptions necessary to use this data to estimate demand.

**Assumption 1** *The sample represents buyers for new telescopes.*

Assumption 1 captures three issues. First, it assumes that eBay bidders for telescopes are representative of the general population of telescope buyers. Unfortunately, we are not aware of any demographic information on either eBay bidders or telescope buyers. However, in 2002 there were over 50 million registered eBay users, and there is no reason to expect a substantial difference between the two groups. Second, it assumes that eBay bidders are randomly selected out of the population of telescope buyers. Due to the low cost of searching and bidding on-line, such buyers may have a greater elasticity of demand than off-line buyers. Therefore, our estimates may be biased to the high side. Third, it is based on people buying second-hand

telescopes. It is not clear how this affect the interpretation of our elasticity estimates.

**Assumption 2** *Each bidder's highest bid in each auction is equal to that bidders value for the product being auctioned.*

We assume that the highest bid that a person makes in a particular auction is equal to that person's valuation for the product sold in that auction. There are two characteristics of eBay auctions that justify this assumption.

interpret  $X_j^-$  as representing the “common value” for the telescope and  $z_{ij}$  as representing the “private value” for the telescope. In the results section,  $X_j^-$  and  $z_{ij}$  are estimated using OLS.

**Assumption 4** *Each  $B_{ij}$  represents a distinct buyer,  $k$ .*

**Assumption 5** *Each buyer,  $k$ , has a value  $v_{kl}$  for each of the three telescopes, denoted  $l \in \{ETX90; ETX125; LX200\}$ .*

Assumptions 4 and 5 form the basis for the demand estimation. Even though one bidder may bid in multiple auctions, their bids in the different auctions are assumed to represent distinct bidders. This is mainly done for simplicity. The fact that bids are not independent can be accounted for by bootstrapping the standard errors. The distribution of errors (private values) across the three telescopes is accounted for by Assumption 6. This method allows the own and cross-elasticities to be calculated without making unreasonable assumptions on the distribution of errors. The distribution of errors is drawn from the actual residuals, with correlation across telescopes based on the actual probability that different bidders bid across different types of telescopes.

**Assumption 6**

$$v_{kl} = \begin{cases} \exp(X_l^- + \log(z_k)) & \text{if } j = l \\ \exp(X_l^- + \log(z_k)) & \text{w/prob } p \text{ if } j \neq l \\ 0 & \text{w/prob } 1 - p \text{ if } j \neq l \end{cases} \quad (2)$$

Where  $p$  is calculated from Table 3. For example, for a buyer  $k$  whose bid comes from an ETX90, their value for the ETX90 is  $\exp(X_{ETX90}^- + \log(z_k))$ . While, buyer  $k$ 's value for the ETX125 is either 0 or  $\exp(X_{ETX125}^- + \log(z_k))$ . Which, depends on the probability that a bidder on the ETX90 will also bid on the ETX125. In this case,  $p = .39$ . Setting the buyer's value to 0 is somewhat arbitrary. The important point is that the buyer's value is “low enough” so as not be included in the cross-elasticity calculation.

Demand is estimated in three steps. Step 1 estimates  $\hat{\beta}$  using OLS and Equation (1), where the  $X_j$  variables include dummies for the ETX90, the ETX125, a dummy for “like new”, a dummy for the “go to” system, a dummy for a tripod, and a dummy for a camera adapter.

Step 2 calculates the “new” value of each of the three types of telescopes for every observation (that is for every bidder’s high bid in an auction). This is done using  $\hat{\beta}$ , the estimated residual ( $z_{ij}$ ), and the elasticities of bidding across products calculated from Table 3, where each telescope is assumed to be “like new” and have no camera adapter. Additionally, in the case of the LX200, the telescope is assumed to have a tripod and “go to”. In the case of the ETX90 and the ETX125, the telescope is assumed to have neither. Therefore, for bidder  $i$  who bid in auction  $j$ , where auction  $j$  is for an ETX90 telescope, their value for the ETX90,  $v_{ij}(ETX90)$  that is “like new” and doesn’t have any accessories is given by,

$$v_{ij}(ETX90) = \exp(X_{ETX90} \hat{\beta}_{ETX90} + X_{likeneew} \hat{\beta}_{likeneew} + \hat{\beta}_{z_{ij}})$$

tion that are 0, is determined by the probabilities from Table 3, and the observations are assigned 0 at random.<sup>14</sup>

Step 3 uses these valuations and the prices to determine whether each bidder  $i$  for auction  $j$  will purchase an ETX90, an ETX125, a LX200 or nothing. An ETX90 is purchased if

1.  $v_{ij}(ETX_{random-48vPb\_2}) > p_{11n}$

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	Top 8 Bidders	Top 4 Bidders
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	Top 8	Top 4	Last 24 hours	Last 4 hours
ETX90	328.00 (99.40)	336.26 (65.77)	400.00 (66.77)	387.69 (59.47)
ETX125	618.45 (187.42)	654.04 (117.45)	671.46 (112.08)	669.99 (102.78)
LX200	1241.20 (376.14)	1585.17 (284.67)	1541.94 (257.38)	1651.40 (253.33)

Table 5: Mean Value by Telescope Type (Standard Deviation)

value for every telescope. Step 3 uses the values for each type of telescope for each bidder in each auction to calculate the demand system for the three telescopes. The assumption is that each bidder in each auction is a distinct individual demander of telescopes.

Table 6 presents the own-price and cross-price elasticities for the three types of telescopes, calculated at retail prices for the basic telescope (presented in Table 1) using the sample of the top 8 bidders for each auction. The numbers presented are the absolute value of the ratio of a percentage change in the demand for the telescope named at the top of each column over a 10 % *increase* in the price of the telescope named in the left hand column. This table shows that the own-price elasticity of demand for the three types of telescopes is very high, confirming our intuition that these are expensive luxury items. It also shows that while there is a lot of movement between the ETX models (the Maksutov-Cassegrain design), especially down from the ETX125 to the cheaper ETX90, there is no movement between either ETX model and the LX200 (the 8 inch Schmidt-Cassegrain). Table 7 presents the own-price and cross-price elasticity measures calculated at retail prices for the sample of bidders who bid in the last day. The results show that the demand elasticities are higher for this population. However, there is still no movement between the two telescope designs.



	ETX90	ETX125	LX200
ETX90	3.33	0	0
ETX125	13.33	5	0
LX200	0	0	5

Table 6: Demand Elasticities at Retail Prices (Basic) - Top 8

	ETX90	ETX125	LX200
ETX90	5.56	10	0
ETX125	0	10	0
LX200	0	0	4.83

Table 7: Demand Elasticities at Retail Prices (Basic) - Last Day

### 3.3 Issues and Concerns

There are three major concerns with using data from eBay auctions to infer demand for new telescopes. First, in many cases the telescopes sold on eBay are second-hand. Second, we do not have a random sample of potential telescope buyers. Third, bidders may not actually bid their valuation (or willingness-to-pay) for the telescope.

In regards to the first concern, there does not seem to be a major lemons problem with the market and the telescopes seem to hold their value well. We see from Table 1 that the retail price for the ETX90, ETX125 and the LX200 is \$495, \$895, and \$1,499 respectively. The average sale price on eBay is higher because these auctions include accessories. For example, the retail price for the ETX90 does not include the “go to” system or a tripod, while a high proportion of ETX90s sold on eBay come with these accessories. The overall success of eBay suggests that it has been able to resolve the lemons problem in a great number of markets (Cohen (2002); Livingston (2002)). While the estimated coefficients are calculated using all of the telescope auctions, the demand elasticities are calculated at the value for “like new” telescopes.

The second concern is a concern with any data used to infer demand for

the whole population. It is likely that data from different supply channels (speciality telescope retailers, camera shops, department stores) will each give different estimates of elasticity. The value of the data collected from a particular channel, depends on how important that channel is. The telescopes analyzed in this paper are sold on Amazon.com, Ritz Camera (Wolfe Camera), Scope City (a major speciality telescope retailer), the Discovery Store and Astronomics (another major speciality telescope retailer). It seems reasonable to suspect that data collected from eBay is going to give higher elasticities of demand than data collected from a speciality telescope retailer like Scope City.<sup>16</sup> Another issue is that eBay bidders on telescopes may not be representative of buyers of telescopes. However, it is not obvious why there would be a substantial difference between the two groups. eBay users are likely to have higher incomes.

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the overall value of using data from on-line auctions for antitrust purposes.

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