THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF ECONOMICS

AN APPLICATION OF ENTRY AND EXIT MODELLING TO THE INTERNET SERVICE PROVIDER MARKET

JOSH CARLE
SPRING 2015

A thesis
submitted in partial fulfillment
of the requirements
for baccalaureate degrees
in Economics and Electrical Engineering
with honors in Economics

Reviewed and approved* by the following:

Charles Murry
Assistant Professor of Economics
Thesis Supervisor

Russell Chuderewicz
Senior Lecturer
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

This paper explores different types of modelling, all of which are applied to the Internet Service Provider (ISP) market. The primary goal of this paper is to further understand the ISP market structure. In all models, the dependent variable is the number of ISPs located in a given zip code. A zip code is assumed to represent a geographically isolated ISP market. Using the models presented in this paper, I first analyze how population, income, and geographic variables affect market concentration. Then, I use a different modelling technique to determine that almost all of the increase in competition in the ISP market appears with the addition of the first additional firm, or the 4^{th} firm. Because of the format of the ISP data that was acquired by the FCC, markets with between 1 and 3 firms are all counted as a 3 firm market.

With regards to modeling techniques, the first model is a linear regression that explores which variables are significant in predicting market concentration. I also edit this model to add fixed effects that account for which state the ISP market is located in.

The next model is an ordered probit model that uses theory from the Bresnahan and Reiss paper (1991). I begin by using an ordered probit model to model the demand in the ISP region, which finds that demand increases the most with the addition of the 4^{th} firm. I continue by implementing a model that is a very close version of the Bresnahan and Reiss model. This version models variable profits, fixed costs, and market sizes with varying numbers of competitors.

I then use these components to determine entry threshold ratios for each market size. These ratios are used to determine how much competition in the market increases as each additional firm enters the market. The results are similar to what Bresnahan and Reiss find,

meaning Model 2.2 finds that the majority of the increase in competition takes place when the first additional firm, or the 4th firm, enters the market. However, Model 2.2 finds that the initial increase in competition is more extreme than in the Bresnahan and Reiss model. This could be due to the FCC data grouping 1-3 firm markets together and because both papers are studying different markets.

In the model that uses theory from the Bresnahan and Reiss paper, some variables have very high standard errors. This could be attributed to irregularities in the data such as not differentiating between 1-3 firm markets or having a large proportion of the markets being very small. The result would be data that does not fit the model very closely. However, there is also a relatively large standard error in the Bresnahan and Reiss model, so the direct application of their model may simply be prone to higher standard errors.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

First, I would like to thank my thesis supervisor, Dr. Charles Murry. He was always willing to meet with me to discuss the structure the paper, economic theory, or specifics on computer modelling techniques. It was a pleasure working with him, and I could not have asked for a more helpful thesis supervisor. I would also like to thanks Dr. James Tybout for his instruction and feedback throughout the school year. The periodic meetings with Dr. Tybout were very beneficial in ensuring I stay on a good pace, and his advice certainly helped me through this process. Without both of these Professors, this thesis would not have been possible.

Chapter 1

Introduction

Many economists have worked to define the market structure for various industries, such as by analyzing competition, predicting entry and exit, or observing what variables predict market concentration. Although it is relatively easy to analyze a theoretical market of given structure (monopoly, oligopoly, perfect competition, etc.), it is much less trivial to model a realistic market and the competition within it. In 1991, Bresnahan and Reiss created a classic model that approached this goal in an intelligent and unique way. By observing numerous small geographically isolated markets including doctors, dentists, druggists, plumbers, and tire dealers, they created threshold values that estimated how large the market size in a given industry needed to be to support a certain number of firms. This allowed them to observe how much competition changed as the market size and number of firms changed in a given market.

Although analyzing entry and exit is not relatively new, very little research has applied it to the ISP market, and with a new proposed merger between Comcast and Time Warner Cable and constant debates about desired internet regulations such as net neutrality, the ISP market is certainly a popular topic.

The goals of this paper are twofold: to explore what variables explain market concentration in the ISP market, and to apply a version of the Bresnahan and Reiss entry and exit threshold model to the ISP market. I will approach these goals by creating two primary models. In the Chapter 4, I create a linear model that explains what variables are significant in explaining market concentration in the ISP market. I also address multicolinearity and add fixed effects that account for what state the given market is located in. The addition of fixed effects causes the R^2 value of the model increases.

In Chapter 5, I develop an ordered probit model similar to Bresnahan and Reis' model. The first version of the model attempts to model the demand in the ISP market and how the demand changes as market size changes. The second ordered probit model is a more direct application of the Bresnahan and Reiss model, and it explains how much the competition changes in the market as the number of firms changes. The results from this model are similar to Bresnahan and Reiss' findings. Analyzing these models will help to further understand a largely unexplored, yet very important market.

Chapter 2

Literature Review

From technical analyses to qualitative discussions, a multitude of papers have been written to define and describe the Internet Service Provider (ISP) market. There are also many papers written about modeling markets by predicting the entry and exit of firms, evaluating competition in isolated markets, and determining what factors contribute to the number of firms in a market. However, very few studies are focused on the specific goals of this paper: to apply an entry and exit model to regional ISP markets in order to analyze the variables that determine market concentration and also how competition changes as the number of firms in a market changes.

Although there have not been many papers that focus solely the goals I am pursuing in this paper, it is valuable to review literature in various areas related to the main topics in this paper. Specifically, I will first introduce the ISP market in general terms. Then, I will analyze relevant literature regarding entry and exit models. Finally, I will conclude by reviewing what literature has been written on consumer welfare in the ISP market. The combination of this literature will provide valuable information for this study.

The Internet Service Provider (ISP) Market

One distinguishing factor about the ISP market is that its structure varies depending on the geographical region in the United States. In other words, because citizens can only obtain internet service in the area where they live, each town and city can be viewed as a geographically isolated market. Therefore, when firms decide to merge or if new laws in the ISP market are passed, it may affect different regions in different ways.

The recent proposed merger between the two largest ISPs Comcast and Time Warner Cable has the potential to significantly alter the ISP market. The Washington Post reported that Comcast offered 45 billion dollars to purchase TWC, and the purchase will result in Comcast owning almost two-thirds of the national ISP market share. Could the merger promote innovation, or could the increased market power of Comcast decrease the market efficiency and welfare of customers in various regions?

The ISP market encompasses all firms that provide some type of internet service to customers. However, this paper will analyze data from companies that reported providing "high-speed" internet service to customers. The FCC reported that by 2009, over 60 percent of households had subscribed to some sort of high speed internet, and the number is increasing each year. Also, only 3 percent of Americans still use dial-up internet, which was the first widespread form of internet access. Dial-up is the most popular form of internet service that is not classified as high-speed, so most Americans have transferred to high-speed service.

In addition, new litigation in the ISP market regarding net neutrality or municipal broadband laws could also affect the ISP market and consumer welfare. The models in this paper will attempt to achieve a better understanding of the ISP market and the effects of mergers and litigation.

There are no strict guidelines to what ISP firms can qualify as high-speed internet. Typically, high-speed internet speeds are in the range of 5-50 Mbit/s, while dial-up internet speeds are around 40-60 kbit/s. Also, high speed internet is generally used interchangeably with “broadband” internet service. In 2009, the FCC defined broadband internet as “internet access that is always on and faster than the traditional dial-up access". The FCC then updated their definition in 2010 by claiming that basic broadband must have internet speeds faster than 4 Mbit/s.

The FCC lists various forms of high-speed internet service in their annual reports. The chart below, created in an annual FCC report, shows types of high speed internet along with their popularity. Note that FTTP (fiber to the premises) internet service uses fiber cables to provide internet access.

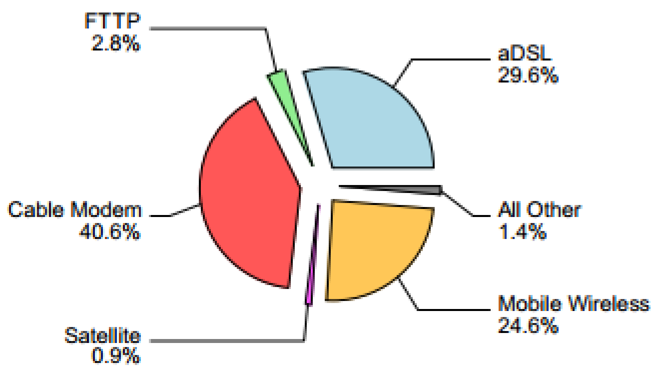

Figure 1. High-Speed Connections by Technology as of December 31, 2008

This paper will use data that is from all forms of internet service listed in Figure 1. However, the models will not differentiate between types of high-speed internet. If any high speed internet service provider is providing internet service in a given region, they will be included in the dataset.

Modeling Firm Entry and Exit

Bresnahan and Reiss (1991) wrote a classic entry and exit paper titled “Entry and Competition in Concentrated Markets” that will be an important resource for this paper. They create a type of ordered probit model to analyze the entry and exit of firms in 202 relatively small geographically isolated markets including dentists, barbers, plumbers, and tire salesmen. An ordered probit model is used for applications where the dependent variable takes on multiple discrete values, and the values have some natural ordering like profits as a function of the number of competitors. This is the case in the Bresnahan and Reiss model, where the number of firms in a market is the dependent variable.

The small geographically isolated markets are chosen so Bresnahan and Reiss can assume each geographic location is an entire market. Also, they can then use population data to estimate market sizes for their study because the markets are geographically isolated. If the markets were not geographically isolated, the population data would not be an accurate representation of the market size of a region. Another advantage of their method is they do not require pricing and quantity data to estimate entry and exit in their markets.

They use variables such as income, percent elder population, median household value, and fraction of farmland to model variable profits and the value of farmland and buildings to estimate fixed costs. The market size S(Y) is estimated with population parameters labeled as Y such as town population, positive population growth, and negative population growth. Also, even though these markets are meant to be geographically isolated, parameters such as nearby population and commuters outside of the city are used in the market size calculation to create a more accurate market size estimate. Their goals are to estimate market sizes, to create market size thresholds to predict when a firm will enter or exit, and to use the thresholds to observe how the market competition changes as market size and number of firms in a market changes.

To analyze the entry and exit of firms, market size S, variable profits V, and fixed costs F are used to create market size threshold ratios ($\frac{s_{N+1}}{s_N}$) that denote the ratio of the per firm market size when N+1 firms are predicted to be in the market compared to when N firms are predicted. Bresnahan and Reiss approach this task by writing profits for the "Nth" firm as:

$$\Pi_N = [P_N - \mathrm{AVC}(q_N, \mathbf{W}) - b_N]d_N\frac{S}{N} - F_N - B_N, \qquad \text{(Equation 1)}$$

This equation states that the profit for one of N firms is the difference between the price of the good and its variable costs multiplied by the per firm market size. Then, fixed costs are subtracted out of the revenue. Note that b_N and B_N are implemented so new firms can experience lower variable profits and higher fixed costs. Both of these variables are required to be greater than or equal to 0, so newer firms can only have lower variable profits and higher fixed costs. Next, they take the zero profit condition where the Nth firm makes no profit, or $\pi_N = 0$. They write this equation in the form of Equation 2.

$$s_N = \frac{S_N}{N} = \frac{F_N + B_N}{(P_N - \mathrm{AVC}_N - b_N)d_N}. \qquad \text{(Equation 2)}$$

Equation 2 claims the per firm entry threshold s_N equals the ratio of fixed costs (F_N) to variable profits (V_N) for each firm. Then, Bresnahan and Reiss run an ordered probit with variables they define to affect fixed costs and variable profits to calculate entry thresholds. Equations 3, 4, and 5 show how variable profits, fixed costs, and entry thresholds were calculated.

$$V_N = \alpha_1 + \mathbf{X}\beta - \sum_{n=2}^{N} \alpha_n \qquad \text{(Equation 3)}$$

$$F_N = \gamma_1 + \gamma_L W_L + \sum_{n=2}^{N} \gamma_n \qquad \text{(Equation 4)}$$

$$S_N = \frac{\hat{\gamma}_1 + \hat{\gamma}_L \overline{W}_L + \sum_{n=2}^{N} \hat{\gamma}_n}{\hat{\alpha}_1 + \overline{X}\hat{\beta} - \sum_{n=2}^{N} \hat{\alpha}_n} \qquad \text{(Equation 5)}$$

In Equation 3, **X** represents the set of independent variables that model variable profits; these were mentioned earlier. β are coefficients obtained from the ordered probit model, and α_n represents the additional decrease in variable profits for each firm. This is why they are subtracted from the variable profits equation. In Equation 4, the fixed cost variable W_L represents the per-acre value of buildings and farmland, and γ_n represents the additional fixed costs for firm N.

After they ran their model, Bresnahan and Reiss use Equation 5 to predict the margins of firms and the market thresholds for each market. Table 1 shows the results from the Bresnahan and Reiss paper.

Table 1. Results Table from Bresnahan and Reiss Paper

A. Entry Threshold Estimates

Profession	Entry Thresholds (000's)					Per Firm Entry Threshold Ratios			
	S_1	S_2	S_3	S_4	S_5	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Doctors	.88	3.49	5.78	7.72	9.14	1.98	1.10	1.00	.95
Dentists	.71	2.54	4.18	5.43	6.41	1.78	.79	.97	.94
Druggists	.53	2.12	5.04	7.67	9.39	1.99	1.58	1.14	.98
Plumbers	1.43	3.02	4.53	6.20	7.47	1.06	1.00	1.02	.96
Tire dealers	.49	1.78	3.41	4.74	6.10	1.81	1.28	1.04	1.03

B. Likelihood Ratio Tests for Threshold Proportionality

Profession	Test for $s_4 = s_5$	Test for $s_3 = s_4 = s_5$	Test for $s_2 = s_3 = s_4 = s_5$	Test for $s_1 = s_2 = s_3 = s_4 = s_5$
Doctors	1.12 (1)	6.20 (3)	8.33 (4)	45.06* (6)
Dentists	1.59 (1)	12.30* (2)	19.13* (4)	36.67* (5)
Druggists	.43 (2)	7.13 (4)	65.28* (6)	113.92* (8)
Plumbers	1.99 (2)	4.01 (4)	12.07 (6)	15.62* (7)
Tire dealers	3.59 (2)	4.24 (3)	14.52* (5)	20.89* (7)

Note.—Estimates are based on the coefficient estimates in table 4. Numbers in parentheses in pt. B are degrees of freedom.
* Significant at the 5 percent level.

The entry thresholds in Table 1 (S_N) represent the number of people (in thousands) at which the Nth firm is predicted to enter. For example, in the tire dealers market, the first firm is predicted to enter (S_1) when 490 people are in the market. The per-firm entry threshold ratio represents how much bigger the market had to get (per firm) until another firm entered. Therefore, if the per firm entry threshold ratio is above 1, Bresnahan and Reiss draw the conclusion that the firm's per consumer profit margins had to have fallen with the addition of the newest firm, hence competition had to increase.

They conclude this because if the market had to increase by more than the previous per firm market size to entice an additional firm to enter, competition must be increasing because more people are required (per firm) to support the new number of competitors. The increase in required per firm market size is attributed to firms obtaining smaller per consumer profit margins to be competitive in the growing market. Overall, Bresnahan and Reiss find that most of the increase in competition (highest threshold ratios) takes place with the addition of the second and third firms.

For my thesis, the Bresnahan and Reiss paper is worth analyzing in detail for multiple reasons. First, this paper observes market characteristics of geographically isolated markets. I am assuming the ISP markets by region are geographically isolated because consumers can only obtain internet service in the region they live in. Also, the Bresnahan and Reiss paper is able to analyze competition, predict market sizes and changes in profits, and draw conclusions without any pricing or quantity data. Pricing or quantity data would be very difficult to obtain from ISP providers, so this method will be a valuable model to analyze the ISP market with. I will apply a version of this model to the ISP market later in this paper.

Other articles also discuss predicting the amount of firms in markets and the resulting efficiencies and inefficiencies. In industrial organization economics, many studies focus on the airline market. One particular study observing the airline market is written by Berry (1992). He uses methods similar to Bresnahan and Reiss by predicting profits and market structure. Berry then ventures further into analyzing the probit model by stating that simulation estimators need to be introduced for accurate results. He claims that the simulation errors are introduced to increase the accuracy of his model and allow him to introduce heterogeneity between goods. In my paper, I will model the oligopolistic competition in a similar manner to Berry and Bresnahan and Reiss. However, I am assuming high speed internet is a homogenous good, so I will not introduce simulation errors into my models to account for heterogeneity of goods like Berry does.

Reiss and Spiller (1989) also apply a model similar to that of Bresnahan and Reiss to the airline market. They observe only small airline markets to negate the effect of unobserved fixed costs. Bresnahan and Reiss also do this. Although this method may eliminate unobserved fixed costs, it also may introduce a selection bias to the data. In my research, I will have to consider the issue of unobserved fixed costs because there can certainly be large fixed costs in the ISP market depending on the type of service being provided (DSL, cable, wireless, FTTP, etc.). Also, because Model 2.2 uses only data from Pennsylvania, I will have to attempt to eliminate any selection bias as well. However, data from only Pennsylvania seems to be a good estimate of national data, so I can assume this does not produce significant selection bias.

With regards to predicting efficiencies in the deregulated airline market, it seems different studies yield different conclusions. Bailey and Panzar (1981) find that entry, or even the threat of entry, into a city-pair monopolistic or oligopolistic market will increase the efficiency of the market because if firms do not set competitive prices, other firms can enter to capture the market share. They also note that these markets are contestable.

However, Borenstein (1989) claims that airline pricing does not follow the "perfect contestability ideal". He then says this allows firms in the airline markets to make economic profits and not act as a contestable market. These papers may be referring to different subsets within the airline markets, but the contrast between results is worth noting.

It will be important to consider if the ISP market is contestable and relatively efficient. Are firms free to enter into the ISP market in certain regions? Does this keep prices competitive? Answers to these questions could help to provide insight into my models' implications regarding the feasibility of municipal broadband laws, mergers, and other litigation.

Consumer Welfare in the ISP Market

When considering consumer welfare in the ISP market, the majority of literature focuses on net neutrality. However, because the scope of this paper is to model the ISP market and analyze the competition with respect to regional markets, I will not use this model's results to delve into the theory, specifics, and debate on net neutrality. The breadth of net neutrality is large enough for an entire thesis on its own. However, the results from this paper will help to provide a clearer picture of the ISP market and effects of related mergers and antitrust litigation. Therefore, this paper can help to analyze the effectiveness of antitrust litigation and see if this litigation could be a viable option.

Also, net neutrality would not affect firms' actions if the markets are considered to be competitive. This is because since the firms are competitive, they would not have a chance to charge varying prices for different internet services or access to different websites. If a competitive firm raises their price from competitive pricing, another firm will have a lower price that takes the price increasing firm's market share.

Economists have analyzed antitrust regulation when considering consumer welfare in the ISP market. Bruce Owen claims antitrust regulation is the best method to regulate the ISP market, and it would be prudent to wait to implement net neutrality "ex post" if necessary (Owen 2011). Carlton and Becker reiterate the belief that antitrust regulation is the better option to address their concerns. He believes net neutrality may not solve the concerns regarding competition and innovation, and net neutrality regulation could hurt overall consumer welfare (Becker, Carlton, Sider, 2014). As previously stated, the specifics of net neutrality litigation are out of the scope of this paper. This paper will analyze competition changes at various market sizes and help to evaluate the value of antitrust litigation.

Chapter 3

Data

To effectively model the ISP market, I gathered data on the number of ISP competitors in various zip codes and labelled the variable as N. As stated earlier, I assume zip codes represent a geographically isolated ISP market. Therefore, this data will allow us to analyze predictors of N and the competition in various isolated markets.

N contains 28,715 observations from 2005, and the variable includes data for the vast majority of zip codes in the United States and Puerto Rico. The minimum number of ISP competitors in a zip code is 3, and the maximum is 21. However, the minimum of N may actually be lower than 3, but the ISP data does not differentiate between zip codes that have 3 or less firms. Figure 2 shows a histogram of the variable N.

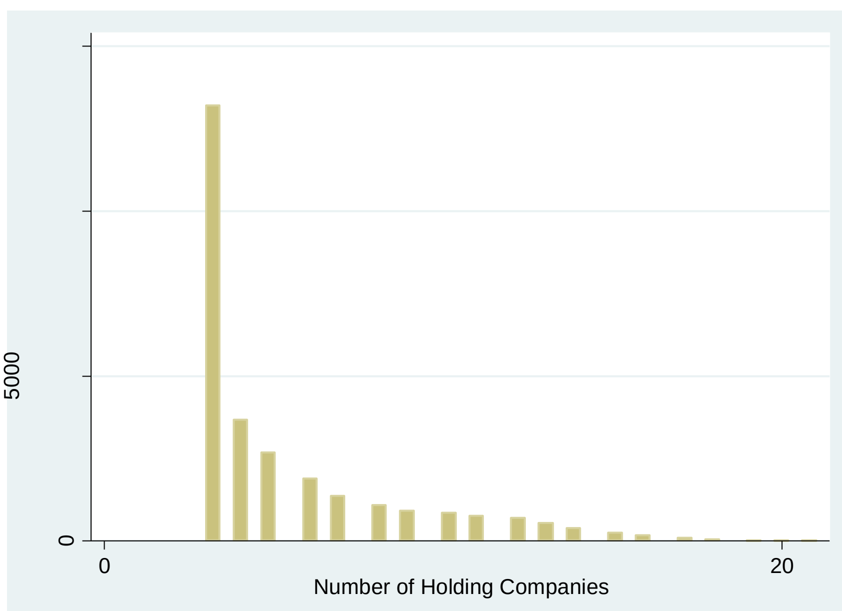

Figure 2. Histogram of N

Notice that a large proportion of N is location is located at the minimum of 3 competitors. This is for two reasons. First, there are a lot more zip codes in small markets, such as in the Midwest or South, than in large markets. Therefore, it seems reasonable that the number competitors would be small in a lot of markets.

Second, the FCC provided the variable N, and if the number of ISP competitors in a given zip code was 3 or less, the FCC labeled N with a star. Therefore, it was not clear whether a zip code has 1, 2, or 3 competitors in this dataset. To address this issue, I set N to 3 firms if the FCC labeled it with a star.

After attempting to contact the FCC, I still could not obtain data for when N was less than 3, and I also did not get an answer to why data was gathered like this. I assume the FCC did not differentiate between 0 and 3 firm markets to make the data gathering easier to complete. It may have been difficult to differentiate between the number of ISPs in very small rural areas that have between 0 and 3 ISPs.

Predictors of N

After obtaining the dependent variable N, I found independent variables that could both predict N and also model variable profits, fixed costs, and market size. The latter function of the independent variables will be further discussed in Chapter 5. Table 2 summarizes all of the independent variables and the dependent variable N. Note that the variable "state" is a string. For example, if the zip code of a given market was in Pennsylvania, state would equal PA. Therefore, there are no numerical qualities of this variable.

Table 2. Summary of Variables

Variable	Name	Number of Observations	Mean	Standard Deviation	Min	Max
Independent Variable						
Number of ISP Firms	N	28715	5.34	3.278	3	21
Dependent Variables						
Population	popnum	33120	9434.27	13753.94	0	113916
Rural Population / Population	ruralprop	32976	0.6157	0.4362	0	1
Number of Households	housenum	31818	3710.56	5137.145	0	44432
Per Capita Income	income	32481	25504.77	11942.51	127	376207
Median Value of House	houseval	31573	169793.5	140409	10000	1000000
65 and Older Population / Population	eldratio	32976	0.1563	0.06827	0	1
Median Age	agemed	33120	40.98	7.5145	0	86.7
State Abbreviation (Non-numeric)	state	28715	N/A	N/A	N/A	N/A

As seen in Table 2, the models in this paper will use various population and demographic variables to predict N and estimate competition. I found all of the independent variables from the United States Census Bureau. Also, other than the variables N and income, I obtained all variables from 5 year estimations that were conducted between 2005 and 2010. N is from 2005, while income is from a 5 year estimation between 2006 and 2011. Although these years are not identical, they are very similar and should suffice for this study. Also, we can assume that the variables are changing at a fairly constant and small rate throughout the small range of years in this paper, so data from different years will still yield similar relationships.

Another discrepancy worth noting is the number of observations of each variable. Ideally there would be an equal number of observations for each variable, but Table 2 shows this is not the case. However, I matched all variables based on their given zip code and if they shared a zip code with the dependent variable N. Therefore, when I run regressions, the total number of observations is 27,698. Figure 3 shows a histogram of the Number of Households in each zip code in the United States and Puerto Rico.

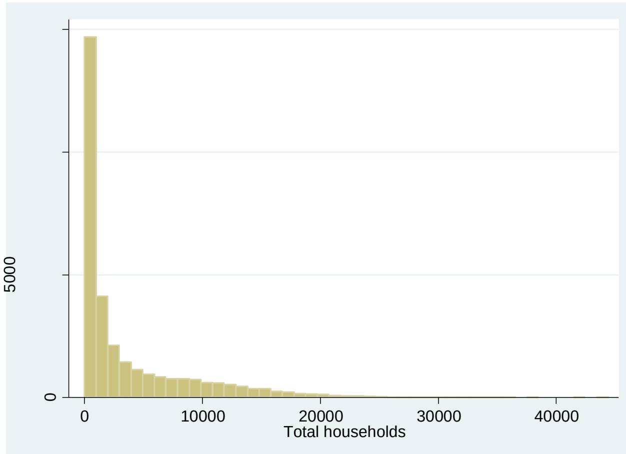

Figure 3. Histogram of Number of Households

Notice that Figure 3 is heavily skewed to the right. This supports the statement earlier that the majority of zip codes in this dataset represent a relatively small market. Also, this helps to explain why a large portion of competition in the ISP market takes place with three or less competitors.

Another interesting variable to analyze is the rural population divided by total population, or ruralprop. Because ruralprop is a proportion, the distribution will be between 0 and 1 where 0 is a purely urban zip code and 1 is a purely rural zip code. Figure 4 shows a histogram of ruralprop.

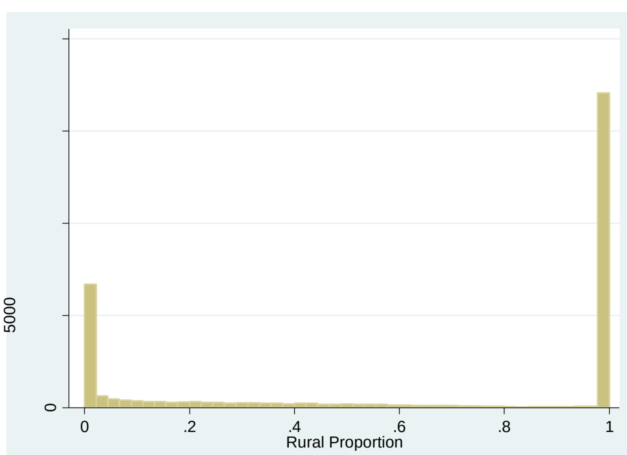

Figure 4. Histogram of Rural Proportion

From Figure 4, we can see that most zip codes are either purely urban or purely rural. Also, more zip codes are purely rural than purely urban which supports the small market majority discussed in the previous data. Although Figure 3 shows some valuable data, it is difficult to see the distribution of the ruralprop variable because the frequencies of 0 and 1 are both so high. To observe the distribution of ruralprop more clearly, we can eliminate the extremes of the variable and create a new histogram. Figure 5 shows this distribution.

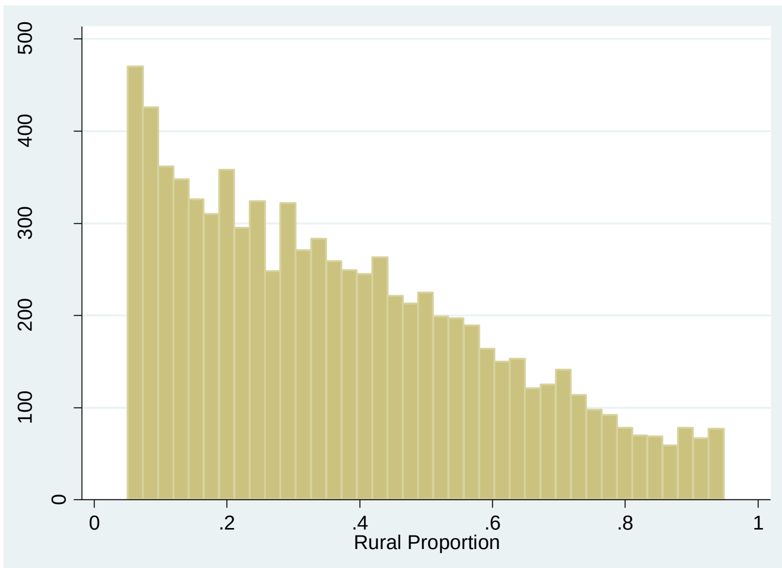

Figure 5. Histogram of Rural Proportion without Extremes

Figure 5 shows that in zip codes which have both rural and urban components, the majority of the market is likely more urban. In other words, there are more urban markets with small rural parts than there are rural markets with small urban components. This makes sense because usually urban areas have a significantly larger population than rural areas.

The ruralprop variable is important for modeling the ISP market in this study, especially for the entry threshold analysis. It provides a relatively unique variable when compared to other more standard variables such as population, households, or income, because it depicts the geographical makeup of a given market. Also, we can use the ruralprop variable to estimate the fixed costs of a competitor or potential competitor. In the ISP market, a large fixed cost is the infrastructure required to provide internet service. The type of infrastructure varies depending on the type of internet being provided, but existing infrastructure is generally more prevalent in urban areas where consumers are closer and it is more feasible to create the infrastructure.

For example, DSL internet providers can use the same cable to provide internet to consumers. A potential DSL supplier will then incur a lower fixed cost if there is already cable available in the region. Using this logic, we can see that the fixed cost of a given region can be captured in the ruralprop variable. This will be important for the competition model later in this paper.

Chapter 4

Linear Models 1.1 and 1.2:

The first model this paper presents is a linear model that explores predictors of N. For this model, we start by letting the number of competitors (N) be a linear function of the independent variables introduced in Chapter 3. This will be called Model 1.1. Equation 1 depicts this relationship. This regression yields results seen in Table 3.

$$N_i = \beta_0 + \beta_1 popnum_i + \beta_2 ruralprop_i + \beta_3 housenum_i + \beta_4 income_i + \beta_5 houseval_i + \beta_6 eldratio_i + \beta_7 agemed_i + \epsilon_i \quad \text{(Equation 6)}$$

Table 3. Model 1.1 Results

Name	Coefficient	Standard Error	t-value	p-value
popnum (β1)	-2.49E-06	4.41E-06	-0.56	0.572
ruralprop (β2)	-2.071	0.04162	-49.76	0
housenum (β3)	0.00031	0.000012	25.86	0
income (β4)	0.0000317	1.62E-06	19.49	0
houseval (β5)	2.35E-06	1.29E-07	18.16	0
eldratio (β6)	-2.1085	0.398	-5.3	0
agemed (β7)	-0.022	0.004	-5.49	0
Constant (β0)	5.3433	0.11	48.48	0

Observations = 27698
R-squared = .6647

Because there are so many observations, it was fairly likely that these variables would have a very small p-value and hence are statistically significant. In fact, the population variable is the only variable that is not significant. This was initially surprising, but after further analysis it was found that the popnum results can be attributed to multicollinearity. The correlation coefficient between the number of people (popnum) and number of houses (housenum) is .9834, meaning these variables are almost perfectly positively correlated. Therefore, if we eliminate either variable, the other variable will suffice in predicting N. In Model 1.2, popnum was erased and the results were recorded in Table 4.

Table 4. Model 1.2 Results

Name	Coefficient	Standard Error	t-value	p-value
ruralprop (β2)	-2.0715	0.0416	-49.77	0
housenum (β3)	0.0003	3.14E-06	96.73	0
income (β4)	0.0000319	1.58E-06	20.23	0
houseval (β5)	2.33E-06	1.27E-07	18.35	0
eldratio (β6)	-2.08	0.3949	-5.27	0
agemed (β7)	-0.0219	0.004	-5.48	0
Constant (β0)	5.3433	0.109	48.91	0

Observations = 27698
R-squared = .6647

Between Models 1.1 and 1.2, the biggest change was the t-value for housenum increasing from 25.86 to 96.73. Both t-values suggest the number of houses is a strong predictor of N, but the change is worth noting.

Overall, the results from Model 1.2 yield interesting theories on how these independent variables affect the amount of ISP competitors in a given market. The proportion of rural population has a large effect on N. According to Model 1.2, a purely rural population is predicted to have about 2 fewer competitors than an urban population, ceteris paribus. This could be due to lower fixed costs present in an urban region resulting from better infrastructure relative to rural areas.

The number of houses was positively correlated with N. This makes sense because more houses will yield more demand for internet, ultimately attracting more firms. Per capita income and the median value of houses were also positively correlated with N which suggests that internet is a normal good.

The elderly ratio and median age were both negatively correlated with N. This also most likely relates to the demand for internet. Markets with a high younger population include college towns and towns with a lot of schools in general. Therefore, the demand for internet in these towns may be greater than in other markets. Also, since the internet is a relatively new good, elderly people may not be as inclined to use the internet because they have not been exposed to it as frequently as the younger population.

Linear Model 1.3: Adding Fixed Effects

Another modification to Model 1.2 was to create a fixed effects regression that accounts for the state of every market. To do this, I used the state variable and created a dummy variable for each state. States are important to incorporate into this linear model because they can provide information that may have not been captured in the other variables in Model 1.2. An example of this would be the political structure, culture, or municipal broadband litigation in a state. I created 52 dummy variables which includes Puerto Rico, Washington D.C., and the 50 states. Equation 7 shows the form of the new regression, called Model 1.3.

$$N_i = \beta_0 + \beta_2 ruralprop_i + \beta_3 housenum_i + \beta_4 income_i + \beta_5 houseval_i + \beta_6 eldratio_i + \beta_7 agemed_i + \beta_8 AL + \beta_9 AK + \beta_{10} AZ + \ldots + \beta_{59} WY + \epsilon_i \quad \text{(Equation 7)}$$

Table 5 contains the results from this regression, and Table 6 shows the highest and lowest 6 dummy variable coefficients. The dummy variable for Delaware was omitted to address collinearity. This model allows us to observe effects not present in the original independent variables.

Table 5. Model 1.3 Results not Including Dummy Variables

Name	Coefficient	Standard Error	t-value	p-value
ruralprop (β2)	-2.064	0.0409	-50.46	0
housenum (β3)	0.0003	3.01E-06	97.81	0
income (β4)	0.0000243	1.62E-06	15.05	0
houseval (β5)	3.30E-06	1.48E-07	22.21	0
eldratio (β6)	-2.678	0.3811	-7.03	0
agemed (β7)	-0.0185	0.0039	-4.74	0
Constant (β0)	2.717	0.2675	10.16	0

Observations = 27698
R-squared = .705

Table 6. Results of Highest and Lowest 6 Dummy Variables

Name	Coefficient	Standard Error	p-value
Highest Fixed Effects			
Florida (β17)	3.804	0.2521	0
Georgia (β18)	3.557	0.2550	0
Ohio (β43)	3.190	0.2515	0
Michigan (β30)	3.134	0.2523	0
Texas (β52)	3.122	0.2491	0
California (β12)	3.094	0.2496	0
Lowest Fixed Effects			
Puerto Rico (β47)	-2.341	0.2963	0
Hawaii (β19)	-1.949	0.3237	0
Delaware (β16)	0	N/A	N/A
Rhode Island (β48)	0.4319	0.3265	0.186
Washington DC (β15)	0.6428	0.4554	0.158
Nevada (β41)	0.8938	0.2946	0.002

In Table 5, the R^2 value increased to .705 from .6647 in previous models. This is a relatively small change, but it represents that Model 1.3 explains a slightly higher percent of the variation of the data. I ran an F-Test to check the statistical significance between models, and I determined that the change in R^2 was significant. Also, many of the independent variables changed slightly in magnitude, but there were no changes in sign.

The constant changed from 5.343 in Model 1.2 to 2.717 in Model 1.3. This is because each dummy variable acts as a separate constant for its respective state. For example, the California coefficient of the dummy variable is 3.094, so the constant is the sum of 2.717 and 3.094, or 5.811. This means that if we assume all the independent variables are equal, we predict that 3.094 more firms would compete in a market in California than in Delaware strictly based on their locations. The average of the coefficients for all dummy variables was 2.16, so adding this to the constant of 2.717 in Model 1.3 obtains a constant close to the constant of 5.343 in previous models.

Table 6 contains dummy variables with coefficients at either extreme. The largest coefficient was Florida at 3.804. This model predicts that a market in Florida will have 3.804 more competitors than in Delaware, assuming all other variables are equal. The reason for the change in fixed effects is not entirely clear, but we can speculate on the reasons behind these fixed effects.

It seems that many states with the highest fixed effects also have many large cities or areas with a high concentration of population. Therefore, the fixed effects could be related to the barriers to entry for potential competitors, where states with high amounts of existing infrastructure also have lower fixed costs. Also, in markets in Hawaii or Puerto Rico, fixed costs may be higher for firms because of lacking existing infrastructure.

Another factor that fixed effects could be related to is state litigation. Municipal broadband limitations are implemented in about 20 states in the United States. The severity of the limitation depends on the specific state, but every state except Ohio that has the highest 6 fixed effects has a form of municipal broadband limitation implemented. In the bottom 6 regarding fixed effects, only Washington D.C. and Nevada have municipal broadband limitations. Therefore, it is possible that municipal broadband regulations could promote competition in states and attract more firms.

Chapter 5

Entry Threshold Model

I present two versions of an Entry Threshold Model in this chapter. The first model, Model 2.1, is a simple ordered probit model that models the market demand. Next, Model 2.2 uses an approach very similar to the Bresnahan and Reiss (1991) model to observe how competition changes as market size increases. For both models, I create a new value of N where N_{new} = N-2. I created this so the cutoff values in Model 2.1 and the additional firm fixed costs and variable profits in Model 2.2 could be created.

Ordered Probit Model 2.1:

Model 2.1 uses the same dataset as in Chapter 4, just with the variable N_{new} instead of N. For this model, I wish to run an ordered probit model that models the revenue of firms in the ISP market. Equation 8 provides a general definition for revenue used in this model.

$$D = d(x_i) * S(y) \qquad \text{(Equation 8)}$$

D represents the market demand, d defines the demand per consumer, and S is a given market's size. The variables x_i and y are included to represent independent variables that affect the per consumer demand and market size, respectively.

To model market demand, I ran an ordered probit regression that models Equation 8. To model S(y), I simply used the population variable (popnum) from previous chapters. Bresnahan and Reiss include additional variables such as population change and number of commuters into their market size estimate, but a simple population count should suffice for this model.

Next, I needed to model $d(x_i)$. To complete this, I implemented variables from previous chapters that define the per consumer demand. Equation 9 depicts what variables I assumed to define $d(x_i)$.

$$d(x_i) = \beta_1 income_i + \beta_2 houseval_i + \beta_3 agemed_i + \beta_4 AL + \beta_5 AK + \beta_6 AZ + \cdots + \beta_{56} WY + \epsilon_i \qquad \text{(Equation 9)}$$

Notice that this includes some of the variables used in the models in Chapter 4, but the elderly ratio, rural proportion, population, and number of houses variables were not used. I assumed the elderly ratio contained many of the same effects on demand as the median age would contain, so it was eliminated. I did not include Population because it represents the market size in this model. Also, I removed the number of houses because it was almost perfectly correlated with population. Finally, I assumed rural proportion to represent fixed costs, so it was not included in this equation. I assumed this because, as discussed earlier, I assumed a higher rural proportion would increase the costs of a firm to provide service in that area because the new firms may no longer have access to existing infrastructure. I did not use the rural proportion variable in this model, but it will be important in the next version. The fixed effects were also discussed earlier as affecting fixed costs, but I included these in the per consumer demand for this model.

Next, I used these variables to create the ordered probit model. To accomplish this, I created new variables that multiply population by the per consumer demand. Then, I created the ordered probit model. This model takes the form seen in Equation 10.

$$N^*_i = \boldsymbol{\beta} * \left(popnum_i * (income_i + houseval_i \; + agemed_i + AL + AK + AZ + \right.$$

$$\left. \ldots + \; WY)\right) + \epsilon_i \qquad \text{(Equation 10)}$$

In Equation 10, **β** is the set of coefficients for the demand variables. Also, since this is an ordered probit model, Equation 10 does not represent a linear regression. The model takes the general form seen in Equation 11. We use N^* to predict "cut points" which represent where the number of firms are predicted to change.

$$N = \begin{cases} 0 & if \qquad N^* < 0 \\ 1 & if \quad 0 < N^* < cut1 \\ 2 & if \quad cut1 < N^* < cut2 \\ 3 & if \quad cut2 < N^* < cut3 \\ & \ldots \\ 19 & if \; cut17 < N^* < cu18 \end{cases} \qquad \text{(Equation 11)}$$

Table 7 shows the coefficients from the regression results, including the highest and lowest two fixed effect variables, and Table 8 shows the cut points from the model.

Table 7. Model 2.1 Regression Results Excluding Cut Points

Name	Coefficient	Standard Error	z-value	p-value
popincome (β1)	1.39E-09	4.30E-11	32.25	0
popagemed (β2)	1.18E-06	2.98E-08	39.47	0
pophouseval (β3)	-2.69E-11	3.03E-12	-8.88	0
Florida (β14)	1.78	0.159	11.2	0
New Jersey (β35)	1.71	0.17	10.06	0
Puerto Rico (β44)	-1.516	0.219	-6.93	0
Hawaii (β16)	-7.6	106.5	-0.07	0.943

Observations = 27698
R-squared = .6647

Table 8. Model 2.1 Cut Points

Cut Number	Coefficient	Cut(N) - Cut(N-1)	Standard Error
1	1.654	1.654	0.1545
2	2.190	0.536	0.1546
3	2.643	0.453	0.1548
4	3.020	0.377	0.1550
5	3.340	0.320	0.1553
6	3.626	0.286	0.1555
7	3.900	0.274	0.1557
8	4.193	0.293	0.1559
9	4.503	0.310	0.1561
10	4.854	0.351	0.1565
11	5.220	0.366	0.1570
12	5.584	0.364	0.1577
13	5.930	0.346	0.1586
14	6.329	0.399	0.1606
15	6.742	0.413	0.1647
16	7.268	0.526	0.1778
17	7.845	0.577	0.2267
18	8.291	0.446	0.3429

First, we can observe the variable coefficients from Table 7. All of the coefficients of the variables that include population are very small and close to 0. This is due to the fact that population is being multiplied with another variable that is large in value such as income, house value, or median age. The log of each variable could be taken to decrease the magnitude of each coefficient, but I chose not to for this model to ensure I did not affect the results I obtain for the cut points in Table 8.

Although the coefficient of pophouseval is negative, the sign of each number is not particularly important for this model because population is being multiplied with each variable. The cut points are what we can use to observe how demand changes as the number of firms in a market changes. In Table 8 we can observe these cut points. Column 3 of Table 8 shows how much the cut points increase as the number of firms in a market increases. This also represents the estimated level of increase in the demand as modelled in Model 2.1. Notice that the demand shifts the most at the first cut point, or when the first new firm enters the market. In the data I gathered this is referring to when the 4^{th} firm enters the market, because 1-3 firm markets are all counted as a 3 firm market.

Therefore, the main finding from this model is that the demand increases the most from the addition of the first additional firm, or the 4^{th} firm. After that, the demand shifts seem to be fairly constant as the market size and number of firms change.

Ordered Probit Model 2.2: Bresnahan and Reiss Application

Model 2.2 implements a relatively direct application of the Bresnahan and Reiss model to the ISP data that has been analyze in this paper. Chapter 2 discusses the methodology of this model. However, I had to manipulate the ISP data so it could be analyzed in a similar format to the Bresnahan and Reiss model.

First, I used the variable Nnew = N – 2 as I did in Model 2.1. This is so the minimum Nnew value is 1, and the additional fixed costs (γ) and variable profits (α) for each market size corresponds to Nnew.

Next, I only used data from Pennsylvania in this model. In the original dataset used in previous sections, the total number of observations was about 28000. However, that number of observations was computationally challenging for this model. Therefore, I only included data from Pennsylvania. Table 9 shows a summary of the data from only PA. Using only data from Pennsylvania, the number of observations decreased to about 1400.

Table 9. Summary of Variables from PA Data

Variable	Name	Number of Observations	Mean	Standard Deviation	Min	Max
Independent Variable						
Number of ISP Firms - 2	Nnewpa	1403	3.55	3.403	1	17
Dependent Variables						
Population	popnumpa	1392	8926	11375.75	53	68104
Rural Population / Population	ruralproppa	1392	0.514	0.425	0	1
Number of Households	housenumpa	1389	3542.63	4467.3	0	44432
Per Capita Income	incomepa	1391	25694.3	9284.4	127	376207
Median Value of House	housevalpa	1388	152670	87157.5	14300	830700
65 and Older Population / Population	eldratiopa	1392	0.1658	0.044	0.038	0.7
Median Age	agemedpa	1392	42.09	4.96	21.3	80.9
Proportion of Migrants into Zip Code	migrantproppa	1392	0.04165	0.0393	0	0.3327

The statistics above seem fairly similar to the summary statistics in Table 2. Also, although the mean of Nnewpa is 3.55, the actual mean of the number of firms in PA is 5.55 which is close to the mean of 5.34 in Table 2.

I added a new variable into this dataset, migrantproppa. This statistic shows the proportion of citizens in the zip code that migrated there in the last year. It includes citizens that migrated from other counties, states, or countries. I will use this variable in the market size estimation.

The last minor change of the data was to eliminate all observations that could not be matched to other observations. This was to help correct errors in the computer modelling analysis. 20 observations were eliminated, all of which could not be matched to other observations.

To run the model, I took the zero-profit condition of Equation 1. I then estimated the market size. Bresnahan and Reiss use many variables to estimate the market size (as discussed in Chapter 2). However, Model 2.2 would only run if the migrantprop variable was the only variable that defined the market size. This is not an ideal assumption because it assumes that the number of people in a market is correlated with the proportion of the people that migrated there in the past year. There may be some correlation, but it certainly is not an ideal theory.

Although the market size estimation is not very similar to the Bresnahan and Reiss model, the results should still tell a similar story about competition changes. In the Bresnahan and Reiss model, the market size is implemented to “normalize” their entry threshold “S” values. In other words, if we observe Table 1, we can assume that because S_1 for Doctors is .88, 880 people need to enter a given market until a firm will enter. This is an interesting conclusion, but their most important finding is comparing the ratio of per-firm entry thresholds. As stated in Chapter 2, these ratios allow Bresnahan and Reiss to determine how competition changes as the number of firms in a market changes.

Because the per-firm entry threshold ratio is a ratio between two market sizes, it is always normalized to 1. Then, if the ratio is larger than 1 for a given ratio (such as s_2/s_1), we can determine that the competition increased with the additional firm. Chapter 2 discusses this in greater detail, but the important idea for Model 2.2 is that the per-firm entry threshold ratio is not dependent on market size. The market size assumption in Model 2.2 will create entry thresholds “S” that are normalized to the migrantprop variable which is not an ideal estimate of the market size. However, because the most important statistics in this model are the per firm entry threshold ratios, our market size estimation should suffice.

To model variable profits, Model 2.2 used Equation 3. Note that α values refer to the additional variable profits the additional firm receives. A constraint is added to ensure all these values are larger than zero. Since α values are subtracted in Equation 3, we are implanting the constraint that new firms have variable profits that are less than the previous firm. The matrix **X** in Equation 3 included the variables house value, income, median age, and elderly ratio. I will use these variables in Model 2.2. Their model used a few additional variables, but some variables they used (such as log of heating degree) do not apply to the ISP market. Also, the median age was not used because I assumed it contained much of the same information as elderly ratio.

The Bresnahan and Reiss model uses the value of land and buildings to model fixed costs. However, it does not seem intuitive to use the value of land to model fixed costs in the ISP market. As discussed earlier, the amount of existing infrastructure is a more important indicator of fixed costs for a firm. Therefore, I used the rural proportion variable to model fixed costs in Model 2.2. We assume that a higher proportion of rural population will result in lower existing infrastructure and hence higher fixed costs. Also, note that γ represents additional fixed costs that a new firm acquires. Bresnahan and Reiss assume γ is always larger than 0, so new firms will always incur a greater fixed cost. Although this assumption may not always be true in the ISP market, we will leave the assumption in our model.

We can combine all of these variables to manipulate Equation 5 to encompass the variables which will be used in Model 2.2. This equation is shown in Equation 12. Next, we can run and evaluate Model 2.2 to obtain the coefficients in Equation 12. Table 10 contains these coefficients.

$$S_N = \frac{\hat{\gamma}_1 + \hat{\gamma}_R * ruralproppa + \sum_2^N \hat{\gamma}_n}{\hat{\alpha}_1 + \widehat{\boldsymbol{B}} * (housevalpa + incomepa + agemedpa + eldratiopa) - \sum_2^N \hat{\alpha}_n} \quad (Eqn. 12)$$

Table 10. Results from Model 2.2

Name	Coefficient	p-value	Name	Coefficient	p-value
Market Size			**Variable Profits**		
migrantprop	13.73	0.745	income	2.90E-05	0.919
			houseval	-8.49E-07	0.919
Fixed Costs			agemed	-0.01313	0.919
ruralprop	2.1174	0	eldratio	-0.23475	0.923
γ1	0	0.951	α1	0.16	0.999
γ2	6.35	0.959	α2	0.6695	0.999
γ3	0.502	0	α3	-0.1359	0.747
γ4	0.456	0	α4	0	
γ5	0.2946	0	α5	0.0128	0.875
γ6	0.293426	0	α6	-0.079	0.756
γ7	0.1736	0.001	α7	0.122	0.75
γ8	0.1	0.007	α8	0.0854	0.75
γ9	0.18	0.001	α9	0.0284	0.795
γ10	0.2422	0	α10	-0.04921	0.767
γ11	0.197	0.001	α11	0.0691	0.758
γ12	0.367	0	α12	-0.0264	0.828
γ13	0.3029	0	α13	-0.02	0.818
γ14	0.2502	0.145	α14	0.231	0.752
γ15	0.254	0.222	α15	0.125	0.782

Observations = 1388
Pseudo R-squared = .747

In Table 10, many observations have very high p-values, including every variable in the variable profits section. One potential reason for this could be that the data was simply not a good fit for this model. Chapter 3 showed that this data was very right skewed, and this could have affected the data's fit to this model.

Another reason for the high p-values could simply be the type of model that was run. In the Bresnahan and Reiss model, many of their values have high standard errors as well. Table 11 shows the results from the Bresnahan and Reiss model. The standard errors are in the parentheses. Notice that some of the standard errors are large relative to the coefficient value. For example, α_1 for plumbers had a coefficient of .06 and a standard error of .52.

Table 11. Bresnahan and Reiss Model Results

BASELINE SPECIFICATIONS

Variable Name	Doctors	Dentists	Druggists	Plumbers	Tire Dealers
OPOP (λ_1)	1.15	−.46	.08	.27	−.53
	(.85)	(.32)	(.37)	(.60)	(.43)
NGRW (λ_2)	−1.89	.63	−.30	.68	2.25
	(1.60)	(.85)	(.97)	(1.10)	(.75)
PGRW (λ_3)	1.92	−.35	−.24	−.45	.34
	(1.01)	(.41)	(.41)	(.36)	(.59)
OCTY (λ_4)	.80	2.72	.16	−.28	.23
	(1.26)	(.98)	(.34)	(.71)	(.94)
BIRTHS (β_1)	−.59	9.86	11.34		
	(6.57)	(8.29)	(10.10)		
ELD (β_2)	−.11	.22	2.61		−.49
	(.55)	(.74)	(.78)		(.75)
PINC (β_3)	−.00	.04	.02	.05	−.03
	(.00)	(.03)	(.02)	(.03)	(.04)
LNHDD (β_4)	.013	.28	.08	.003	.004
	(.05)	(.07)	(.06)	(.06)	(.06)
HUNIT (β_5)				.51	
				(.46)	
HVAL (β_6)				.42	
				(.03)	
FFRAC (β_7)					−.02
					(.08)
V_1 (α_1)	.63	−1.85	−.13	.06	.86
	(.46)	(.61)	(.58)	(.52)	(.45)
$V_1 - V_2$ (α_2)	.34		.29		.03
	(.17)		(.21)		(.15)
$V_2 - V_3$ (α_3)		.12	.19	.15	.15
		(.14)	(.17)	(.09)	(.10)
$V_3 - V_4$ (α_4)	.07	.20	.25	.07	
	(.05)	(.06)	(.14)	(.08)	
$V_4 - V_5$ (α_5)			.04	.04	.08
			(.12)	(.07)	(.05)
F_1 (γ_1)	.92	1.10	.91	1.28	.53
	(.30)	(.25)	(.29)	(.26)	(.23)
$F_2 - F_1$ (γ_2)	.65	1.84	1.34	1.04	.76
	(.30)	(.19)	(.35)	(.14)	(.21)
$F_3 - F_2$ (γ_3)	.84	1.14	1.77	.32	.46
	(.13)	(.46)	(.54)	(.28)	(.21)
$F_4 - F_3$ (γ_4)	.18		.06	.40	.60
	(.23)		(.70)	(.35)	(.12)
$F_5 - F_4$ (γ_5)	.42	.66	.51	.25	.12
	(.13)	(.60)	(.95)	(.35)	(.20)
LANDV (γ_L)	−1.02	−1.31	−.84	−1.18	−.74
	(.53)	(.37)	(.51)	(.48)	(.34)
Log likelihood	−233.49	−183.20	−195.16	−228.27	−263.09

NOTE.—Asymptotic standard errors are in parentheses

Although some of the standard errors in Table 11 are fairly large, they would not result in p-values as high as Model 2.2 yielded. Therefore, it is safe to assume that the type of model and the data's fit to the model both contributed to the high p-values in Table 10.

To calculate the entry thresholds and ultimately the per firm entry threshold ratios, I apply the results from Table 10 to Equation 12. Because all p-values for α are very high, I assumed these values are 0 for Model 2.2. Therefore, I am now assuming that a new firm obtains the same variable profits as the previous firms. Table 12 shows the entry thresholds and the per firm entry threshold ratios.

Table 12. Model 2.2 Threshold Values

SN	Value	$\frac{s_{N+1}}{s_N}$	Value
S3	5.70	s4/s3	5.10
S4	38.75	s5/s4	0.85
S5	41.36	s6/s5	0.88
S6	43.74	s7/s6	0.89
S7	45.27	s8/s7	0.90
S8	46.80	s9/s8	0.91
S9	47.71	s10/s9	0.91
S10	48.23	s11/s10	0.93
S11	49.16	s12/s11	0.94
S12	50.43	s13/s12	0.94
S13	51.45	s14/s13	0.96
S14	53.36	s15/s14	0.96
S15	54.94	s16/s15	0.96
S16	56.24	s17/s16	0.96
S17	57.57	s18/s17	N/A

Observing Table 12, we see results similar to the Bresnahan and Reiss model. In Table 12, all of the competition increase was when the fourth firm entered the market. This is shown by the 5.1 per firm entry threshold ratio for s3/s4. In theory, this means that the market size would have to increase by a factor of 5.1 per firm to support the fourth firm. For example, if each firm in a 3 firm market had 1000 customers (a total of 3000 consumers), each firm in the 4 firm market would need 5100 customers (a total of 20400 consumers) for the fourth firm to enter. The reason the market needs to increase by so much is because the competition in the firm is increasing significantly, so profit margins per customer are falling in the market. The drop in per firm entry ratio from 5.1 to .85 means that the fourth firm entering the market increases competition greatly (ratio >>1), while the fifth firm entering the market does not increase competition (ratio $\approx$ 1).

The Bresnahan and Reiss model does see similar results where almost all of the competition increase is present after the addition of the second firm. However, the increase in competition in their model is not quite as large as in Model 2.2. This is most likely due to the structure of the dataset in Model 2.2, particularly the N variable. Because the N variable does not differentiate between one, two, or three firm markets, the per-firm threshold ratio s4/s3 actually is measuring the change in competition when a firm changes to a four firm market from a one, two, or three firm market. Despite the imperfections in the data, the results still seem fairly close to the Bresnahan and Reiss model. Therefore, Model 2.2 also predicts that the primary increase in competition in the ISP market is when the first new firm enters that market, or the fourth firm with the FCC's data.

Chapter 6

Conclusions and Recommendations

Conclusion

The goal of this paper was to apply market concentration modelling to the ISP market with the hopes to further understand what variables can affect market concentration and how competition changes as the number of firms in a market changes. I started by assuming that a given zip code served as a geographically isolated ISP market. Then, I gathered data regarding the ISP market, demographics, income, etc., for every zip code in the United States, including Washington D.C. and Puerto Rico.

In Model 1.1, I create a simple linear regression that observes what variables are significant in predicting market concentration. Once I accounted for multicolinearity between population and number of households in Model 1.2, all the variables were significant in predicting the number of firms in a market. Also, all of the coefficients had signs that were initially predicted.

In Model 1.3, fixed effects were created to account for the change in predicted market concentration by state. There were significant fixed effects between states, and the highest and lowest fixed effects were presented in Table 6. From Table 6, we can see that Model 1.3 predicts that 6.145 more firms will be in a market in Florida than in Puerto Rico, ceteris paribus. The states with the highest fixed effects generally had many cities with high concentrated population, and many also had municipal broadband laws implemented. States with the lowest fixed effects generally had smaller populations and fewer large cities, suggesting there may not be as much demand for internet or there may be higher fixed costs for firms to enter due to less existing infrastructure.

Model 2.1 uses theory from the Bresnahan and Reiss paper to create an ordered probit model that is meant to model the demand of the ISP market. The ordered probit model provides cut points that show at which values of the demand function the number of firms is predicted to change. This model finds that the demand increases the most with the addition of the 4^{th} firm. After that, the shifts in the demand are relatively constant.

In Model 2.2, I directly apply the ordered probit model in the Bresnahan and Reiss paper to the ISP market. I assign variables from the ISP dataset to either predict market size, fixed costs, or variable profits. After running this model, I found similar results than in the Bresnahan and Reiss paper, meaning I found that the majority of the increase in competition took place with the addition of the first new firm, or the fourth firm. Model 2.2 even suggests that the increase in competition due to the first additional firm is larger than in the Bresnahan and Reiss model, and after the addition of the first new firm competition does not increase as more firms join the market. However, because my data placed 1-3 firm markets into the same group, the results are not directly comparable.

Some of the p-values in Model 2.2 were very large, and this could be for two primary reasons. First, the data may not have been a good fit for the model. The data had a majority of small markets in it, so this could have affected the model. Second, the model may be prone to relatively high standard errors. In the Bresnahan and Reiss model, their ordered probit model also had relatively high standard errors.

Recommendations

Further research could certainly improve upon and provide benefits to this topic. The first main assumption this paper made was to use United States zip codes as geographically isolated markets. Although this is a good assumption in many cases, there were some zip codes (most likely in major cities) that had very few people but still a lot of firms. Outliers like this could negatively affect the model. It would be interesting to run these models again breaking up markets by city or Standard Metropolitan Statistical Area (SMSA). This may yield different results, and it could improve upon the Bresnahan and Reiss application, Model 2.2.

Another recommendation for further research in this area is to find data that differentiates between one and three firm markets. The reason the Bresnahan and Reiss paper is such a well-known entry and exit paper was because it found that competition increased greatly when the second firm entered into a given market. Model 2.2 showed that the competition increased greatly from the addition of the first new firm to enter the market, the fourth firm. However, Model 2.2 could not predict the change in competition within markets with 1-3 firms because of the data that was obtained.

Within Model 2.2, it would also improve upon this paper to find a more accurate measure of the market size. The only variable that measures market size in Model 2.2 is the proportion of citizens who were migrants in the last year. This is not a very good representation of the market size of a given zip code. More accurately defining the market size would allow entry threshold values to be stronger in their interpretive power, and it may improve the accuracy of the model in general.

Another method to further improve this research could be to use Models 2.1 and 2.2 to quantify welfare effects. These models do allow us to draw some conclusions about welfare such as when competition increases with the 4th firm, welfare should increase due to lower prices from the increased competition. However, if we could quantify the price drop that would take place and combine that with a demand curve with information from Model 2.1, it would be possible to quantify welfare effects. This would be valuable information.

Finally, further research should certainly be done to continue to analyze the ISP market. Because the internet is such an important good that nearly everybody uses, more research into the market will certainly be beneficial. Also, the market is relatively new, so there is still plenty of research to be done. More research in this topic can certainly help the public to understand what actions and legislation should be implemented to improve consumer welfare and strive for an efficient ISP market.

BIBLIOGRAPHY

American Community Survey 5-Year Estimates. (2007-2011). ACS Demographic and Housing Estimates (DP05). United States Census Bureau.

American Community Survey 5-Year Estimates. (2007-2011). Per Capita Income in the Past 12 Months (in 2011 Inflation-Adjusted Dollars. United States Census Bureau

American Community Survey 5-Year Estimates. (2007-2011). Sex by Age by Veteran Status for the Civilian Population 18 and Over (B2001). United States Census Bureau.

Becker, G., Carlton, D., & Sider, H. (2014). Net Neutrality and Consumer Welfare. *Journal of Competition Law and Economics*, *6*(3), 497-511. Retrieved November 19, 2014, from

Berry, S. (1992). Estimation of a Model of Entry in the Airline Industry. *Econometrica*, 60(4), 889-917.

Borenstein, S. (1989). Hubs and high fares: Dominance and market power in the U.S. airline industry. *Rand Journal of Economics*, 20(3), 344-365.

Bresnahan and Reiss Data Sample. (n.d.). Retrieved from http://www.econ.umn.edu/~karib003/data/BR.csv

Bresnahan and Reiss Model Replication. (n.d.). Retrieved from http://www.econ.umn.edu/~youle001/nloprobit.do

Bresnahan, T. F. & P. C. Reiss (1987), "Do Entry Conditions Vary across Markets?" Brookings Papers Econ. Activity, No.3, 833-882.

Bresnahan, T., & Reiss, P. (1991). Entry and Competition in Concentrated Markets. *The Journal of the Political Economy*, 99(5), 977-1009.

Elizabeth E. Bailey & John C. Panzar, The Contestability of Airline Markets During the Transition to Deregulation, 44 Law and Contemporary Problems 125-146 (Winter 1981) Available at: http://scholarship.law.duke.edu/lcp/vol44/iss1/5

High-Speed Services for Internet Access: Status as of December 31, 2008. Federal Communications Committee. https://apps.fcc.gov/edocs_public/attachmatch/DOC-296239A1.pdf

Kang, C. (2014, February 13). Comcast, Time Warner agree to merge in $45 billion deal. Retrieved October 4, 2014.

Local Telephone Competition and Broadband Deployment. (n.d.). Retrieved October 23, 2014, from http://transition.fcc.gov/wcb/iatd/comp.html

Nagesh, G. (2014, January 14). Court Tosses Rules of Road for Internet.

Owen, B., 2010, "Antitrust and Vertical Integration in "New Economy" Industries with Application to Broadband Access," Stanford Law and Economics Olin Working Paper No. 400, Nov. 10, at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1689278##, 2.

Reiss, P., & Spiller, P. (1989). Competition and Entry in Small Airline Markets. *Journal of Law and Economics, 32*(2), 179-202. Retrieved November 15, 2014.

United States Census Bureau. (2010). Urban and Rural (H2). United States Census Bureau.

Van Schewick, B. (n.d.). Towards an Economic Framework for Network Neutrality Regulation. *Journal on Telecommunications and High Technology Law,* 330-390.

"What is Broadband?". *The National Broadband Plan*. US Federal Communications Commission. Retrieved July 15, 2011

Wrather, Kyle, "Comparative Modalities of Network Neutrality." Thesis, Georgia State University, 2014. http://scholarworks.gsu.edu/communication_theses/111

ACADEMIC **VITA**

Joshua D. Carle

309 East Beaver Avenue
State College, PA 16801

Mobile Phone: 717.623.5810
Email: jqc5441@psu.edu

Education:

The Pennsylvania State University, University Park, PA **Expected Graduation Date – May 2015**

Schreyer's Honors College

Bachelor of Science in Economics

Bachelor of Science in Electrical Engineering

Professional Experience:

Johnson Controls, York, Pennsylvania **Summer – 2013, 2014**

Product Management Intern for Starters and Variable Speed Drives

Selected Achievements:

- Created a Variable Speed Drive (VSD) Competitive Analysis that compared Johnson Control VSDs and Chillers to Competitors.
- Assisted in allocating resources and creating a comprehensive business strategy for certain projects.
- Wrote white papers and other technical documents to clearly present technical information to employees without prior experience in electronics.
- Updated pricing for chiller starters, and also updated the pricing system.

Herley Industries, Lancaster, Pennsylvania **Summer – 2012**

RF Engineering Intern

Selected Achievements:

- Designed and simulated an Ultra High Frequency (700 MHz –1 GHz), 100W min. (P_{1dB}) Push-Pull Power Amplifier.
- Worked with Sales Representatives to choose appropriate components for an RF Power Amplifier design.
- Used Microwave Office and Advanced Design System for RF Power Amplifier Circuit simulations.
- Tested and characterized a Nitronex GaN Power Amplifier to observe linearity and compression characteristics across a large bandwidth (10 MHz – 1 GHz).

Technical Skills:

STATA, Microsoft Office Products, Advanced Design Systems, C++, MATLAB, Simulink, LabVIEW.

Awards and Certifications:

Dean's List (Fall 2011 – Present)

Certified LabVIEW Associate Developer (April 2013 – April 2014)

Agilent RF/MW Industry-Ready Certified Student (May 2014 – Present)