PRESCRIPTION DRUG PRICE DISPERSION

IN HETEROGENEOUS MARKETS

by

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ABSTRACT

A homogeneous good is one that does not vary in quality, time, or space. In a perfectly competitive market with no information or transportation costs, all sellers would charge the same price. However, dispersion exists even for seemingly homogeneous goods. A prescription drug is one of the best examples of a homogeneous good because an individual can buy the drug from several different pharmacies but still receive the exact same good. However, prices for prescription drugs vary tremendously among pharmacies. The purpose of this research is to examine the conditions under which price dispersion exists.

This study finds three major causes of price dispersion: differing amounts of search and information costs, differing degrees of competition in each drug market, and differing levels of variation among production costs. Extending previous research, this study includes variables that account for effects caused by differing market characteristics by using variables that measure the percent of individuals in poverty, the percent of the population over 65, and the distance from a Canadian market. Using variables that measure purchase frequency, number of substitutes, average cost, number of manufacturers, and whether or not the drug is a brand or generic, the effects of search, competition, and production costs are examined across drug markets. In addition, the effects of pharmacy heterogeneity on price dispersion are examined by developing a model for price determination. Several variables are used that control for differences in services and quality of pharmacies, such as delivery, convenience to consumers, whether or not the pharmacy is a chain, and location. Additional hypotheses are developed from the price determination models, and the effects of search and competition on prices are reviewed again using the drug and market characteristic variables.

CHAPTER 1

INTRODUCTION

The purpose of this study is to understand why prescription drug prices vary by looking at pharmaceutical prices in the state of Montana. A homogeneous good is one that does not vary in quality, time, or space. In a perfectly competitive market with no information or transportation costs, all sellers would charge the same price. A prescription drug is one of the best examples of a homogeneous good because an individual can buy the drug from several different pharmacies but still receive the exact same good. However, prices for prescription drugs vary considerably among pharmacies as illustrated in tables 1-6 in which range, standard deviation, coefficient of variation, and average price are given for several drugs in each of six markets.

The purpose of this research is to examine the determinants of this price dispersion. This study finds three major causes of price dispersion: differing levels of search, differing degrees of competition, and differing levels of variation among production costs in each market. The price dispersion of seventy-four drugs is examined in five geographically distinct markets. Using variables that measure purchase frequency, number of substitutes, average cost, number of manufacturers and repackagers, and whether or not the drug is a brand or generic, the effects of search, competition, and production costs are examined across drug markets. Using variables that measure the proportion of individuals in poverty, the proportion of the population over 65, and the distance from a Canadian market, the effects of search and competition are examined across geographical markets.

The effects of pharmacy heterogeneity on price dispersion are examined by developing a model for price determination. Several variables are used that control for differences in services and quality of pharmacies, such as delivery, convenience to consumers, whether or not the pharmacy is a chain, and location. Additional hypotheses are developed from the price determination models, and the effects of search and competition on prices are reviewed using the drug and market characteristic variables.

The thesis proceeds as follows, chapter 2 reviews theoretical and empirical literature on the economics of price dispersion, including Sorensen's (2000) study on the pharmaceutical market from which this study draws heavily. In chapter 3, a theoretical model is developed that investigates circumstances under which price dispersion may exist and the factors that may influence the degree of price dispersion and the average price of a commodity. Several hypotheses were developed from this theory and data were collected to test them. Chapter 4 explains the procedure for obtaining the data to test these hypotheses. Chapter 5 presents the empirical models used to estimate the effects of search, competition, and production costs on price dispersion in the pharmaceutical market. The inclusion of variables that control for differences in market characteristics extends the previous research on the determinants of price dispersion (See Aalto-Setala 2003; Adams 1997; Sorensen 2000; and Yoskowitz 2002). The addition of these variables provides new and interesting results about the empirical models of price dispersion. Chapter 6 discusses the empirical results from these models, and chapter 7 summarizes the major finding of this study, the implications, and possibilities for future research.

Table 1. Range, Standard Deviation, Coefficient of Variation, and Average Price: All Pharmacies.

Drug	**Quantity**	**Range**	**Standard Deviation**	**Coefficient of Variation**	**Average**
ACETAM.COD.#3 TABS	20	9.91	2.14	19%	11.19
ALLEGRA – D	30	23.38	5.74	6%	90.31
ALLEGRA 180 MG TAB	60	16.80	3.90	5%	76.58
ALPRAZOLAM 0.5 MG	30	24.31	5.30	41%	12.84
ALTACE 2.5 MG	30	17.41	4.18	9%	46.90
ALTACE 5.0 MG	30	20.10	4.23	9%	48.63
AMBIEN 5 MG	30	34.92	6.24	8%	78.52
AMOXIL 250 MG CAP	30	14.75	2.93	27%	10.93
AMOXIL SUSP 400 MG/5ML	100	13.16	3.40	21%	16.23
ATENOLOL 25 MG	30	25.96	4.83	48%	10.17
AUGMENTIN 875 MG TABS	20	53.87	13.34	11%	118.22
AUGMENTIN ES 600 MG/5ML	125	38.39	6.61	9%	70.87
BENZACLIN GEL	25	24.96	5.56	8%	71.26
BIAXIN XL 500 MG	20	31.42	6.69	7%	100.39

Table 2. Range, Standard Deviation, Coefficient of Variation, and Average Price: Billings.

Drug	**Quantity**	**Range**	**Standard Deviation**	**Coefficient of Variation**	**Average**
ACETAM.COD.#3 TABS	20	1.74	0.58	6%	9.80
ALLEGRA – D	30	14.02	4.97	5%	93.90
ALLEGRA 180 MG TAB	60	3.16	1.40	2%	78.76
ALPRAZOLAM 0.5 MG	30	21.34	8.14	64%	12.80
ALTACE 2.5 MG	30	7.89	2.84	6%	48.89
ALTACE 5.0 MG	30	4.08	1.43	3%	49.89
AMBIEN 5 MG	30	15.07	5.34	6%	82.56
AMOXIL 250 MG CAP	30	9.95	4.40	33%	13.51
AMOXIL SUSP 400 MG/5ML	100	8.00	2.72	17%	15.55
ATENOLOL 25 MG	30	8.32	3.19	32%	9.95
AUGMENTIN 875 MG TABS	20	43.88	15.92	13%	121.13
AUGMENTIN ES 600 MG/5ML	125	23.69	8.51	13%	66.90
BENZACLIN GEL	25	13.64	5.81	8%	73.46
BIAXIN XL 500 MG	20	24.81	8.97	9%	101.95

Table 3. Range, Standard Deviation, Coefficient of Variation, and Average Price: Bozeman.

Drug	Quantity	Range	Standard Deviation	Coefficient of Variation	Average
ACETAM.COD.#3 TABS	20	7.89	2.93	22%	13.51
ALLEGRA – D	30	13.77	5.42	6%	89.65
ALLEGRA 180 MG TAB	60	9.53	3.65	5%	76.55
ALPRAZOLAM 0.5 MG	30	7.99	3.26	26%	12.63
ALTACE 2.5 MG	30	12.91	5.16	11%	47.15
ALTACE 5.0 MG	30	13.38	5.46	11%	50.26
AMBIEN 5 MG	30	13.24	4.96	6%	79.55
AMOXIL 250 MG CAP	30	9.15	4.08	35%	11.70
AMOXIL SUSP 400 MG/5ML	100	11.85	4.79	28%	16.83
ATENOLOL 25 MG	30	5.53	2.07	22%	9.49
AUGMENTIN 875 MG TABS	20	16.98	6.23	5%	122.20
AUGMENTIN ES 600 MG/5ML	125	12.48	5.43	8%	71.33
BENZACLIN GEL	25	17.05	6.14	9%	71.51
BIAXIN XL 500 MG	20	15.36	5.70	6%	100.92

Table 4. Range, Standard Deviation, Coefficient of Variation, and Average Price: Great Falls.

Drug	Quantity	Range	Standard Deviation	Coefficient of Variation	Average
ACETAM.COD.#3 TABS	20	7.72	2.89	26%	11.17
ALLEGRA – D	30	11.99	5.62	6%	87.41
ALLEGRA 180 MG TAB	60	5.71	2.12	3%	75.47
ALPRAZOLAM 0.5 MG	30	13.21	5.33	39%	13.58
ALTACE 2.5 MG	30	6.09	2.80	6%	45.42
ALTACE 5.0 MG	30	4.10	1.64	4%	46.82
AMBIEN 5 MG	30	9.22	4.23	6%	75.26
AMOXIL 250 MG CAP	30	3.42	1.64	16%	10.28
AMOXIL SUSP 400 MG/5ML	100	4.80	2.37	15%	16.36
ATENOLOL 25 MG	30	20.99	8.96	75%	11.97
AUGMENTIN 875 MG TABS	20	35.55	14.23	14%	103.24
AUGMENTIN ES 600 MG/5ML	125	30.00	11.32	15%	74.92
BENZACLIN GEL	25	9.39	4.01	6%	69.00
BIAXIN XL 500 MG	20	12.68	5.33	5%	97.92

Table 5. Range, Standard Deviation, Coefficient of Variation, and Average Price: Kalispell.

Drug	Quantity	Range	Standard Deviation	Coefficient of Variation	Average
ACETAM.COD.#3 TABS	20	5.71	1.83	16%	11.14
ALLEGRA – D	30	13.10	4.82	5%	89.65
ALLEGRA 180 MG TAB	60	13.00	4.39	6%	76.60
ALPRAZOLAM 0.5 MG	30	7.00	2.34	21%	10.94
ALTACE 2.5 MG	30	8.90	3.31	7%	46.41
ALTACE 5.0 MG	30	15.66	4.94	11%	46.96
AMBIEN 5 MG	30	16.39	5.36	7%	79.23
AMOXIL 250 MG CAP	30	8.07	2.47	24%	10.26
AMOXIL SUSP 400 MG/5ML	100	9.05	3.49	21%	16.47
ATENOLOL 25 MG	30	4.50	1.48	16%	9.44
AUGMENTIN 875 MG TABS	20	34.00	11.42	10%	116.89
AUGMENTIN ES 600 MG/5ML	125	10.71	3.14	4%	71.97
BENZACLIN GEL	25	11.33	4.22	6%	70.04
BIAXIN XL 500 MG	20	15.10	4.74	5%	101.27

Table 6. Range, Standard Deviation, Coefficient of Variation, and Average Price: Missoula.

Drug	Quantity	Range	Standard Deviation	Coefficient of Variation	Average
ACETAM.COD.#3 TABS	20	5.94	2.16	21%	10.48
ALLEGRA – D	30	13.01	4.57	5%	88.39
ALLEGRA 180 MG TAB	60	12.51	5.00	7%	74.50
ALPRAZOLAM 0.5 MG	30	16.28	5.16	42%	12.21
ALTACE 2.5 MG	30	12.93	4.35	10%	45.47
ALTACE 5.0 MG	30	14.86	5.33	11%	49.04
AMBIEN 5 MG	30	28.45	8.17	11%	76.72
AMOXIL 250 MG CAP	30	7.64	2.69	27%	9.82
AMOXIL SUSP 400 MG/5ML	100	11.49	3.90	24%	16.40
ATENOLOL 25 MG	30	7.81	2.55	32%	7.91
AUGMENTIN 875 MG TABS	20	25.16	8.82	7%	119.52
AUGMENTIN ES 600 MG/5ML	125	15.16	5.58	8%	69.77
BENZACLIN GEL	25	20.98	6.70	10%	69.84
BIAXIN XL 500 MG	20	23.31	7.09	7%	98.06

CHAPTER 2

LITERATURE REVIEW

Search and equilibrium price dispersion models are designed to provide explanations as to why in the real world even homogeneous goods appear to exhibit evidence contradictory to the "law of one price."[1] A homogeneous good is defined as a commodity that is exactly identical among sellers; that is, its attributes do not vary with respect to quality, time, or space. In other words, the firms that provide these exactly identical items must do so at the same time and the same place for the good to be considered homogeneous.

The theoretical and empirical literature on the economics of price dispersion is reviewed in this chapter. The theoretical section begins by discussing Stigler's seminal paper on search and information costs (Stigler 1961). Models are examined that rely on *ex ante* search heterogeneity to develop a price dispersion equilibrium. These papers are then compared with the *ex post* search heterogeneity model developed by Burdett and Judd (1983). The next section examines the empirical literature on the measures and determinants of price dispersion. One strand of the empirical literature examines dispersion brought about by differing search costs and propensities to search. Another strand considers the effects of differing production costs. The role of different market characteristics on price dispersion is also investigated (Aalto-Setalo 2003). Sorensen (2000) has examined the effects of search on price dispersion in the prescription drug

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[1] The law of one price states that in a perfectly competitive market for a particular good if consumers have no search costs and producers have no transaction and transportation costs, then all sellers will sell the good at the same price (Eckard 2004).

market. This study adopts many of the approaches and methods used by Sorensen in order to examine price dispersion in the pharmaceutical market in Montana, while extending his research by accounting for market characteristics.

Theoretical Review of Price Dispersion

While search costs may have been considered in previous economic research, the first influential work on this subject was by Stigler in his 1961 paper "The Economics of Information." Stigler defines search in the following manner: because a buyer is not able to immediately know every price that various sellers quote, he must survey several sellers in order to identify a favorable price.

Stigler analyzes the causes of price dispersion, and the factors that influence the amount of search and thus, also affect price dispersion. He notes that price dispersion among sellers exists even when goods are seemingly homogeneous. It is rare that absolute homogeneity in goods exists, because some amount of price dispersion arises from heterogeneity in the form of convenience to consumers, differing transportation costs, or various incalculable services provided with a good. However, not all dispersion can be explained by heterogeneity between goods. Price dispersion can also be created by ignorance in the market, and can indicate the amount of search for information occurring in the market.

When price dispersion does exist, different sellers of the commodity offer a distribution of prices. If the main cost of searching can be measured in time, then the number of sellers in the market influences the cost of becoming informed of all these prices. For an additional unit of time spent searching, the expected savings for any buyer is equal to the expected reduction in price multiplied by the quantity the buyer plans to purchase. As price dispersion increases, the expected reduction or expected savings from each unit of search becomes greater because the minimum price is lower.

Although search costs can generate price dispersion, Stigler shows that a stable equilibrium depends on the cost structure of the sellers. With increasing returns to scale, a seller can price high, and earn more than what the commodity costs to produce, as long as he is content with selling only a small volume. As a firm lowers its price, the number of buyers from that seller increases, resulting in high-priced firms that are low-volume sellers and low-priced firms that are high-volume sellers. Another high-priced seller cannot eliminate the per unit markup of other high-priced firms, but can share in the volume of business by setting its price at the same level. Alternatively, the firm can also lower its asking price, thereby rewarding and increasing the amount of search. With constant returns to scale, competition among sellers eliminates the profits that can be made by high-priced firms and low-priced firms. In other words, extreme pricing becomes unattainable, causing price dispersion to decrease when the decrease in average cost per output becomes greater or as the curve of the average cost function becomes flatter. Therefore, a price dispersion equilibrium can only exist when firms have average cost functions that exhibit increasing returns to scale.

Stigler notes that factors that influence either the benefit to the buyer or the cost of search will affect the amount of search. Such factors include the volume of the purchase, fraction of income spent on the good, experience or knowledge of the market, and the size of the market. If there are repeat purchases, the volume of each purchase must be considered because repetition affects both total expenditure on a commodity and experience with the market. Savings from search are larger, the greater the fraction of income spent on that commodity, increasing the amount of search, and reducing price dispersion. Repeat purchasing also influences the amount of experience a buyer has in the market. On average, inexperienced buyers pay higher prices than do experienced buyers. As the fraction of repeat buyers increases, the amount of search increases, which leads to a decrease in price dispersion. Finally, as the size of a market increases, both geographically and in terms of the number of firms, the cost of search increases. Firms that specialize in collecting and selling information develop as the size of the market grows in both dollars and the number of traders.

Extending Stigler's insights, several models examined price dispersion caused by *ex ante* search heterogeneity among buyers and/or sellers. Salop and Stiglitz (1977) assume that individual buyers have differing search costs. McMillan and Morgan (1988) provide a dynamic model in which buyers have different constant marginal costs of search. Wilde and Schwartz (1979) assume buyers have differing tastes and propensities to search, while Reinganum (1979) uses differing production costs to explain price dispersion. Other analyses, such as Carlson and McAfee (1983) and MacMinn (1980), account for both varying production costs and search costs.

While those models use *ex ante* search heterogeneity to develop a price dispersion equilibrium, Burdett and Judd(1983) show that *ex ante* heterogeneity is not a necessary requirement to create an equilibrium price dispersion. What is needed is *ex post* search heterogeneity of information. When there is a positive probability that a randomly chosen consumer knows only one price, firms are likely to offer different prices. Any mechanism that forces this positive probability generates dispersion in prices. Finally, Arnold (2000) shows that asymmetric information is not necessary to create a price dispersion equilibrium. He does so by assuming that firms are constrained by the quantity they can sell.

Salop and Stiglitz were among the first to develop a model that explains price dispersion in a competitive market based on the assumption that information is costly to gather. They also assume that each consumer pays a fixed cost to become informed about prices, but this fixed cost differs among customers. These circumstances lead to a price dispersion equilibrium. In addition, suppose each firm charges the perfectly competitive price. Then some firms can raise their price without losing customers because the customers would be unwilling to gather the information in order to switch stores. For example, as long as, the difference between store A's price and other stores' prices is less than the cost of gathering information, the store will not lose customers. Since it is relative prices that matter, it would then seem that all stores could raise their prices continuously. However, a price dispersion equilibrium exists because other stores can then respond by lowering their prices to induce search.

Salop and Stiglitz model a market that assumes that both informed and uninformed consumers exist. Their model has three possible equilibriums: *(i)* a single-price equilibrium (SPE) at the competitive price, *(ii)* an SPE at the monopoly price, and *(iii)* a two-price equilibrium (TPE) in which the lower price is the competitive price and the higher price is no greater than the monopoly price. The final spread of prices depends on the costs of information to consumers and the average production costs of firms. The equilibrium of importance for the present study is the TPE, in which price dispersion occurs.

The most crucial assumptions of the Salop and Stiglitz model concern information costs and the flow of information between firms and consumers. Consumers differ in their cost of gathering information as a result of differing preferences, cost of time, and ability. Each consumer chooses whether or not to become perfectly informed.

The property that allows for the TPE equilibrium is that consumers with high information costs rationally choose to remain uninformed and purchase from a random store while low information cost consumers choose to search for the lowest priced store and purchase from that store. Therefore, high-priced stores only sell to unlucky, uninformed consumers while low-priced stores sell to lucky uninformed consumers and informed consumers. Assuming that all consumers only purchase one unit of the commodity, a low-priced store will sell a larger quantity than a high-priced store.

McMillan and Morgan create a dynamic model where sellers have the same average cost of production and buyers have the same tastes, but different constant marginal costs of search. This search model also allows for repeat purchases by consumers. Repetition then creates a kinked demand curve for each seller. Under these conditions, a single-purchase search model cannot predict price dispersion, but allowing for repeat purchases can generate such an equilibrium.

Wilde and Schwartz's model follows Salop and Stiglitz in assuming that each firm produces a homogeneous good with the same technology. In addition, consumers are heterogeneous. However, instead of a distribution of search costs, consumers have different propensities to search and no knowledge of the price distribution. Consumers are divided into two groups. Some individuals search only one firm and purchase from that firm, while others search a finite number of firms before purchasing from the lowest priced firm. The existence of consumers that search only one firm allows sellers to charge different prices and price dispersion to exist. Firms are assumed to have a fixed marginal cost, a fixed cost $F>0$, and a capacity constraint, s, that minimizes average cost. In this environment, a market behaves competitively if the ratio of searchers to non-searchers is high, searchers canvass several firms, and the capacity constraint is small.

Taking a different approach, Reinganum develops a simple model in which the buyers are identical with elastic demand curves, but firms have different marginal costs. Buyers use a sequential search strategy in an attempt to maximize their expected utility by ascertaining the minimum price for the product. So a buyer continues to search as long as the expected increase in utility is positive. The elasticity of demand is critical to this equilibrium because buyers decrease the quantity they purchase as price increases, rather than purchase the same quantity regardless of its price. A seller is assumed to be perfectly informed of buyers' reservation prices and demand curves, and sets its price to maximize expected profits. A distribution of firms with differing marginal costs is essential to this equilibrium because firms then have differing optimal prices given their objective of maximizing expected profit. Given these behaviors of buyers and sellers, a price dispersion equilibrium can exist.

Combining both approaches, Carlson and McAfee present a model in which firms differ in their cost functions and consumers differ in their search costs. These differences allow for some comparative static predictions about the mean and variance of the distribution of prices. One hypothesis is that an increase in the variance of production cost leads to an increase in the variance of prices. A second is that the variance of prices varies directly with the number of firms, but indirectly with the slope of the marginal cost functions and the density of the distribution of consumer search costs.

MacMinn develops a sequential search model similar to that of Carlson and McAfee in that it shows that differing search costs and production costs are sufficient to prove that price dispersion can exist in a competitive market. MacMinn also develops comparative static results involving the mean and variance of the price distribution. One important prediction is that as the intensity of search increases, the mean of the price distribution decreases and the variance ultimately decreases.

Burdett and Judd model a market with identical, rational agents on both sides of the market. Consumers minimize their expected cost of purchasing one unit each, given their knowledge about the distribution of prices in the market. Firms maximize expected profits, given their knowledge about consumer behavior. Price dispersion is generated from the fact that consumers have different information about firms. They show that price dispersion can exist in either a non-sequential search or a “noisy” search. Burdett and Judd describe a “noisy” search as the collection of information in which the consumer pays a cost to receive one price quote with the chance that more than one price is observed. The consumer can then either purchase from the lowest priced firm found or choose to search again at an additional cost. Thus, in a non-sequential search, the consumer knows the prices of some but not all firms. Consumers have identical search costs, but each consumer has different information regarding prices because the firms that they canvass are random. This allows firms to charge different prices, and the model to maintain a multi-price equilibrium.

Finally, Arnold shows that a Nash price dispersion equilibrium can exist even if all consumers are identical, firms are identical, and all players are fully informed. He demonstrates that price dispersion can exist in markets where individuals are fully informed, but firms cannot guarantee the item to be in stock. The assumptions that generate this equilibrium are that search is costly and firms are constrained by capacity, which prevents them from selling to every customer. With this important constraint, price reductions affect the quantity of sales for a firm in two ways. A lower price creates a higher probability of search, which increases sales, but it also increases the probability that the firm runs out of stock for the buyer, which reduces sales.

Empirical Review of Price Dispersion

Most empirical studies on the effects of search on price dispersion find evidence to support the hypothesis that search costs affect price dispersion. Aalto-Setala (2003) also considers the role of market structures in his analysis of price dispersion among grocery products. Other studies have examined the role of differing firm costs as a cause of some amount of price dispersion. Finally, this research is based on Sorensen's (2000) study of the prescription drug market, which explains that while some dispersion in prices is caused by pharmacy heterogeneity, search also has an impact on price dispersion. However, Sorensen does not examine the effects of market characteristics on price dispersion, a feature that is examined in this study.

Several studies report that search has an effect on price dispersion. Adams (1997) compares the dispersion of gasoline prices with the dispersion of prices for items inside the store. Due to lower search costs for price information, gasoline exhibits less price dispersion than items inside the store. His findings support the hypothesis that information and search costs have an impact on price dispersion for homogeneous goods. Yoskowitz's (2002) analysis of a spot market for water provides results that support the same conclusion. Pratt, Wise, and Zeckhauser (1979) examine the standard deviations of prices in several different markets. The most important model that they develop in order to explain price dispersion is based on the assumption that consumers perform costly sequential searches. They find that these search costs lead to price dispersion equilibria. Finally, Dahlby and West (1986) examine the market for automobile insurance and conclude that the primary contributing factor to price dispersion is costly consumer search.

Moorthy, et al. (1997) also investigate price dispersion by focusing on consumer search and by assessing people's perceptions of the market for the good. They suggest that a consumer searches until the marginal benefit of additional search equals marginal cost. Three factors that drive the amount of search are the consumer's involvement and experience with the product, search cost, and the perception of the market. Experience and search are expected to have a U-shaped relationship due to the amount of knowledge gained and benefits from search. Moorthy, et al. surveyed consumers before and after they purchased a car. Their findings suggest that price dispersion is caused by both differences in consumer propensities to search and differences in search costs.

Aalto-Setala provides an empirical analysis of price dispersion among grocery products, and includes variables that examine the effects of different market characteristics, such as the concentration between firms, the number of stores, medium income, proportion of households with children, and total population. He does not find evidence that market structure has an effect on price dispersion. He does, however, find that demographic characteristics have a considerable effect on price dispersion.

Abbott (1989) and Goldberg and Verboven (2001) also examine price dispersion. In his study of the manufacturing sector, Abbott reports that price dispersion exists in all industries in some form. He uses two different statistical measures of price dispersion, the coefficient of variation and the range of price differences. He finds that price dispersion does not imply differences in quality of products but rather that price differences are caused by differences in local input and output market and by manufacturers having market power. Goldberg and Verboven examine price dispersion in the European automobile market. They report that the primary reasons for price dispersion are differences in firms' cost and in the discounts firms offer. They also found that a major cause of price dispersion among the European Union automobile markets is price discrimination.

Controlling for differences in firms, Sorensen empirically tests the search models presented by Stigler, and Salop and Stiglitz using market data on prescription drug prices. Sorensen collects data on approximately 240 drugs. Legislation in the state of New York requires pharmacies to post the prices of the 150 top-selling prescriptions. Price data were obtained from these posters, while information on drug characteristics, typical dosage, duration of therapy, and Average Wholesale Price (AWP) were collected from the physician desk reference Mosby's GenRX 8th Edition. Data on pharmacy characteristics were based on Sorensen's personal observations. Using this data, he found that benefits or costs to searching for price information influence price dispersion. The proposition that consumers' incentives to price-shop increases if a prescription drug must be purchased repeatedly is central to his analysis.

Sorensen tests several hypothesis and his findings are relevant to the empirical models presented in this study. First, he reports that as purchase frequency increases price dispersion decreases, supporting the hypothesis that repetitive purchasing leads to more experienced shoppers, more search, and price dispersion. Although his results are not statistically significant, he finds prices for drugs produced under brand labels to be less dispersed than generics, which may reflect price dispersion at the wholesale level. If production costs for pharmacies vary, then retail prices are expected to exhibit more dispersion. Furthermore, he finds no evidence that prices are set differently for patented brand and competitive brands. Sorensen also uses a dummy variable to compare Newburgh and Middletown and finds that prices in one of the markets to be less dispersed. Finally, he provides some evidence that the class of drug has an effect on price dispersion. Specifically, he reports that *ceteris paribus* drugs used to treat infections and diabetes exhibit the least amount of price dispersion, while drugs that treat anxiety and hypertension exhibit the most. Even after controlling for pharmacy heterogeneity, Sorensen finds that consumer search variables have explanatory power, suggesting that some dispersion is generated from search cost.

Sorensen also considers other possible sources of price dispersion, such as pharmacy heterogeneity, cost heterogeneity, and different uses of the drugs. Since pharmacies cannot be ranked consistently as “high-priced” firms or “low-priced” firms, he finds that pharmacy heterogeneity can at most account for one-third of all price variation. Secondly, he does not review cost heterogeneity empirically but provides a hypothesis regarding brand and generic drugs, and discounts from wholesalers to chain, independent, and food stores. Brand name drugs are expected to exhibit less price dispersion because they are single-source drugs provided by only one supplier. Generic drugs have more price dispersion because they are typically multi-source drugs causing variation at the wholesale level. Citing Ellison (1997), Sorensen suggests that if chain stores pay less than independent stores, and independent stores pay less than food stores, then the stores receiving the highest discounts will have the lowest prices. However, he finds no evidence to suggest these discounts explain price dispersion. Finally, Sorensen suggests further research to identify how market characteristics affect dispersion.

Extending the research done by Sorensen, the present study also examines the prescription drug retail market but includes market characteristics, such as the proportion of individuals in poverty, the proportion of the population over 65, and the distance to

Canada. Collecting price data on prescription drugs from several pharmacies in cities throughout the state of Montana, this research analyzes the effects of drug and market characteristics on price level and price dispersion. Using two measures of price dispersion, the standard deviation and the range, the effects that search and competition have on dispersion are estimated. Different drug and market characteristics are used to examine these effects. Because price dispersion can also be caused by differences in firms and differing costs incurred by firms, these features must also be examined. The addition of variables to control for market characteristics enhances the research done by Sorensen.

Summary

This chapter has presented a review of previous literature on theoretical and empirical examinations of price dispersion. Beginning with the seminal paper by Stigler, the role of search and information costs in generating price dispersion is examined. Several papers have been discussed that present both *ex ante* and *ex post* search heterogeneity models, which generate a price dispersion equilibrium. This heterogeneity can arise from differences in consumer search costs, differences in production costs, or both, and all three cases are presented. Next, the empirical section reviews papers that test for the effects of these different types of heterogeneity. While most papers find search or production costs to be the cause of price dispersion, Aalto-Setalo includes market characteristics in order to see how market structure effects price dispersion. He finds that market demographics are statistically significant, but market structures are not.

Finally, Sorensen’s empirical analysis of the prescription drug market, which this study extends, is reviewed at length, and his findings are also examined. Like Sorensen, this study estimates the effects of drug characteristics on price dispersion, but extends Sorensen’s work by also analyzing the effects of market characteristics. In the next chapter, theories are presented to develop hypotheses about why price dispersion exists in the pharmaceutical market in Montana.

CHAPTER 3

THEORETICAL MODELS

A prescription drug is a classic example of a homogeneous good. After a doctor writes a prescription, the patient takes the prescription to a pharmacy. No matter where he takes the prescription, he gets the same drug. In a perfectly competitive market with rational, utility maximizing individuals and profit-maximizing firms, homogeneous goods have only one price. However, in the real world even seemingly homogeneous goods exhibit some price dispersion. The purpose of this chapter is to present conditions under which price dispersion exists and to discuss factors that influence price level and dispersion in the pharmaceutical market. On the demand-side Salop and Stiglitz (1977) developed a model that shows that price dispersion can arise from differing search costs of consumers. On the supply-side Reinganum (1979) developed a model that shows that price dispersion can arise from differing production costs. The model developed in this study uses both concepts and defines price dispersion to be a set of prices charged by different firms that contain more than one price. It also takes into consideration that some price dispersion arises from pharmacy heterogeneity.

The Price Dispersion Model

Price dispersion can be driven and affected by the amount of search, differing production costs, and the degree of competition in a market. The cost of search, the fraction of informed consumers, and the structure of the market, all influence the amount of search by affecting the costs or benefits from collecting information. In turn, search affects price dispersion because *ceteris paribus* more search results in less price dispersion. Next, the cost of supplying a drug and whether the drug is a brand or generic influences the acquisition costs that individual pharmacies face for the drug. The more diverse are the cost of production, the more disperse prices will be. Finally, competition also affects price dispersion. One measure for the degree of competition a product faces is the number of substitutes for it. As the degree of competition increases, price dispersion will decrease.

Pharmacy heterogeneity can also generate price dispersion. To control for this factor, Sorensen estimated price determination models and computed the dispersion of the residuals from those models to measure price dispersion. The theory behind the determination of the price level of a drug is also examined.

Search Costs

To understand price dispersion in the pharmaceutical market, a model is developed that draws heavily on Salop and Stiglitz. Suppose in a market there is a distribution of prices $\{p_1, p_2, p_3, \ldots\ p_j, \ldots\ p_n\}$ where n is the number of firms. Consumers are identical, rational agents whose objective is to minimize the cost of purchasing a prescribed drug. They only differ in their search costs, which creates a distribution of search costs $\{c_1, c_2, c_3, \ldots\ c_i, \ldots\ c_L\}$. The i^{th} consumer knows where he can obtain the drug and the distribution of prices, but not what price each pharmacy charges. He can obtain price information about all of the pharmacies for a cost of, c_i.[2] This cost may be the cost of buying and reading a newspaper or the cost of driving to all of the pharmacies to find all of the prices charged. Due to differing search costs, some consumers become informed and purchase from the lowest priced store, while uninformed consumers purchase from a pharmacy at random. Assuming that p_l is the lowest price charged and p^* is the average price, individuals become informed if their total expected expenditure from search, $E^i_S = p_l + c_i$, is less than their total expected expenditure from not searching $E^i_N = p^*$. Therefore, informed individuals that have a c_i less than c, where $c = p^* - p_l$, incur a total cost of $c_i + p_l$. Individuals that are not informed have a search cost, c_i greater than c, and incur a total cost of p_j, where p_j is the price they pay at a randomly selected pharmacy. The informed portion of the population, γ, has a $c_i < c$, while the rest of the population, $(1- \gamma)$, has a $c_i > c$.

Suppose also that pharmacies are profit-maximizing agents that are free to enter and exit the market. Firms have the same technology defined by a fixed cost T and variable cost function $v(q)$, which depends on the quantity, q, produced. Firms are also identical with increasing marginal cost curves $(v'(q)>0)$ and U-shaped average cost curves $A(q)$. Firms are assumed to have perfect information about both the prices other firms charge and the distribution of consumers' search cost. In other words, a firm can predict how consumers search and what their demand curves look like. Therefore, firms have complete information, allowing each one to set its prices by two methods, simultaneously. First, each firm follows a Nash price-setting behavior in which it takes

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[2] Rothschild (1974) confirms that the comparative statics of a sequential search model is essentially the same as a one-time search model.

all other firms' prices as given when maximizing its profits. Secondly, each firm follows a Stackleberg behavior in which it takes the consumer search rule as given. The firm knows that a consumer searches if $c_i < c$, and that the price the firm sets affects $c = p^* - p_l$. Finally, if there are positive profits, then more firms enter the market until a zero profit equilibrium is reached, because entry into the industry is assumed to be costless. Under these conditions, the price each firm sets equals its average cost.

As in Salop and Stiglitz, if a market has L consumers and a proportion, δ, of the stores offer the low-price, then the number of unlucky, uninformed consumers is $(1-\delta)(1-\gamma)L$. Because the number of high-priced stores is $(1-\delta)n$, then $q_h = (1-\gamma)L/n$. A low-priced store gets $1/n^{th}$ of the uninformed customers and δn of the informed consumers. Thus, $q_l = (1-\gamma)L/n + \gamma L/\delta n$. Denoting $AC = A(q)$, the zero-profit assumption implies that $p_l = A(q_l)$ and $p_h = A(q_h)$. Moreover, the lowest price must be the competitive price, because if low-priced firms were slightly above the competitive price, then any given firm could lower its price and gain all of the informed consumers. From these equations, the following equilibrium equations can be found: $p_l = A[(\gamma/\delta + (1-\gamma))L/n]$ and $p_l + c/(1-\delta) = A[(1-\gamma)L/n]$. Figure 1 illustrates this TPE, which is dependent on the cost of search c, the fraction of informed consumers γ, and the fraction of low-priced stores δ.

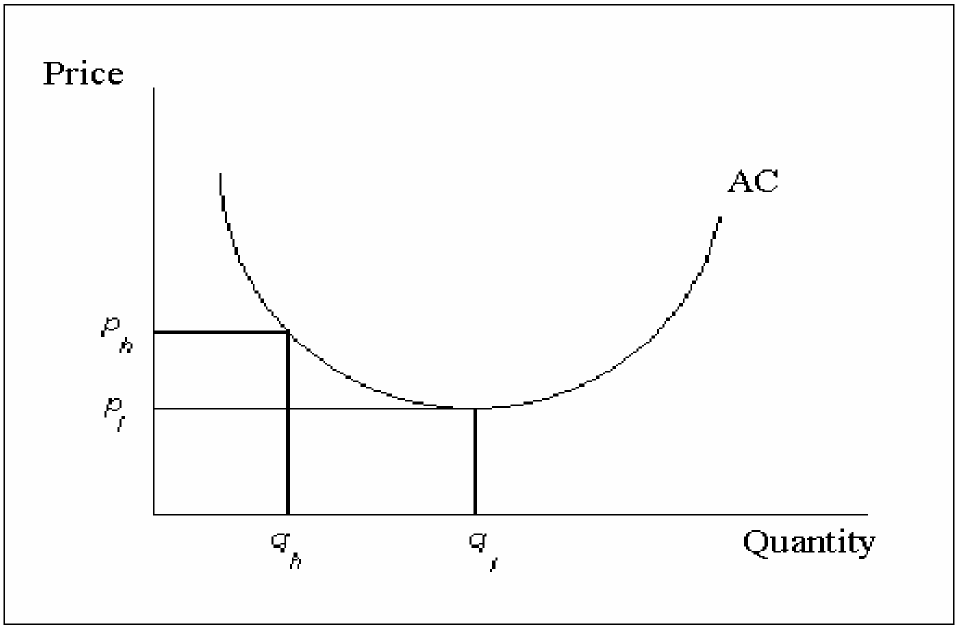

Figure 1. Two-price equilibrium model.

In the Salop and Stiglitz price dispersion equilibrium model, high-price firms exist because for some consumers their expected cost of searching for the lowest price is greater than the expected benefits. Therefore, some rationally uninformed consumers end up purchasing drugs from high-priced pharmacies, which allows an equilibrium with price dispersion to exist. Therefore, changes to search can affect dispersion in two ways: by changing the benefits from becoming an informed consumer that searches for the lowest price or by changing the cost of searching.

In the pharmaceutical market, purchase frequency can affect both search benefits and costs. The duration of therapy has an effect on how much benefit a person derives from searching for the lowest priced drug, since longer therapies mean that consumers will have to make several purchases of a drug. Benefits from search increase because savings from finding a low price can be reaped multiple times, assuming the identity of low-priced firms do not change. For example, suppose there exists two drugs, A and B.

Drug A is only used once to cure a temporary ailment, while drug B is a maintenance drug that is taken every day for a year and must be purchased every month. The market for drug B is likely to have a greater amount of experienced consumers because having to purchase the drug multiple times creates greater benefits. As consumers purchase a drug repeatedly they also build up human capital. They gain experience with the market and by doing so the cost of becoming informed of the lowest priced firm decreases. Because more experienced consumers exist in the market, more search occurs for drug B than for drug A, causing there to be less price dispersion for drug B. Therefore, as purchase frequency increases, people gain more from searching for the lowest price.

Salop and Stiglitz describe the effect that informed buyers have on a price dispersion equilibrium. The percentage of informed buyers in the population determines the number of high-priced firms that can exist. Informed buyers are assumed to be perfectly informed about pharmacies' locations and which firms charge the lowest prices. If the fraction of informed buyers increases, then the survival of high-priced firms becomes harder. This will increase the fraction of low-priced firms, which will then decrease average price, p^*, and reduce the price charged by high-price firms. In the pharmaceutical market, informed consumers are likely to be those that must pay directly for the drug without insurance or those who use drugs frequently, such as the elderly.

Comparing across towns and holding all other variables constant, towns with a larger fraction of individuals in poverty have more individuals without insurance or cash-paying customers. Individuals without insurance have a greater incentive to search for the lowest price compared to individuals with insurance, because individuals with insurance typically pay the same co-payment price regardless of the pharmacy. More searching consumers exist because the expected benefits from finding a low-priced store are greater for individuals in poverty. Searching consumers affect price dispersion because with a larger fraction of searching consumers fewer high-priced firms can exist because less people are willing to pay a high price. This decreases the average price, p^*, charged by firms, and in turn decreases the expected reduction in price, c. Because $p_h = p_l + c/(1-\delta)$, then as c decreases price dispersion decreases. As a result, a higher proportion of individuals in poverty decreases price dispersion.

Using similar logic, the elderly population is examined for the effects of searching consumers. Senior citizens are most affected by drug prices, because older age groups typically use more drugs. Because the elderly typically purchase more drugs than other age groups and typically purchase them more frequently, they are usually more informed consumers. In addition, some elderly who reside in institutions or use institutions to purchase their drugs may not be informed consumers, but these institutions still have incentives to find the lowest priced stores in order to cut costs. Therefore, towns with larger elderly populations are likely to have more informed consumers. Thus, fewer high-priced firms are likely to exist, increasing the fraction of low-priced firms, and consequently, there is likely to be less price dispersion.

Production Costs

The model presented so far only allows for a single or two-price equilibrium. No other equilibriums can exist. However, suppose that instead of having the same production costs, firms have a distribution of production costs $\{A_1(q), A_2(q), A_3(q), \ldots A_i(q), \ldots A_n(q)\}$. The varying production costs create an array of prices, allowing for multiple prices at the retail level. The i^{th} firm still sets its price, $p_i = A_i\ (q_i)$, in order to maximize profits, and consumers still search only when expected search costs are less than expected search benefits.

Differences in production costs among firms may result in differences in prices paid by consumers. Comparing brand drugs and generic drugs is one way to examine differing production costs. For simplicity, a brand name drug with generic substitutes will be termed a competitive brand, and a brand name drugs without generic substitutes will be called a patented brand. Price dispersion is lowest for patented brand name drugs because there is only one manufacturer, and hence only a single-source from which the drug is made. A competitive brand has multiple sources from which the drug can be obtained by pharmacies, while a patented brand has only one source. Competitive brands are expected to exhibit more price dispersion because of the multiple sources from which it can be obtained.

The number of firms in each sector of the industry also affects price dispersion. For example, if several manufacturers produce a drug, then more sources exist for a pharmacy to obtain that drug. If the drug can be obtained from multiple sources with varying production costs, then opportunity for price dispersion at the retail level increases. Production costs for pharmacies are expected to vary when there are a larger number of repackagers and wholesalers that carry the drug. If the number of manufacturers and repackagers decreases, then a pharmacy has fewer options for obtaining a drug, and the probability that pharmacies use the same supplier increases. In turn, price dispersion decreases because fewer sources exist from which it can arise.

Competition

Competition for a drug enters the market through alternative treatments and medical procedures. As competition for a drug increases, price dispersion in the retail sector is likely to decrease. One way to measure competition for a drug is to examine the number of substitutes or alternative treatments. As the number of substitutes for a particular drug increases, competition increases which decreases the prevalence of high-price sellers, consequently causing price dispersion to decrease.

The Determination of Drug Price Levels

Competition, market characteristics, search costs, pharmacy heterogeneity, and the pharmacy's cost of acquiring and dispensing a drug can all affect how much an individual pharmacy charges for a drug. These factors are included in the models that estimate price level. The residuals from these estimated models were then used to calculate a measure of price dispersion that controls for pharmacy heterogeneity.

Competition affects price level in that as competition increases there is more pressure for firms to lower prices. For prescription drugs competition can be found in the number of substitutes. As the number of substitutes for a particular drug increases, competition increases, causing price levels and price dispersion to decrease. Similarly, patented brands, competitive brands, and generic drugs exhibit different degrees of competition. Among these three categories of drugs, generics may have the lowest prices because they have the most competition, which drives down prices. Patented brands may have the highest price level because they have the least amount of competition and often have a higher markup than competitive brands, which are in the middle.

In Montana, another source of potential competition are Canadian drugs. Canadian drugs cannot be legally imported, but because Canada has differing laws and regulations involving prescription drugs, prices are sometimes lower for the same drug.[3] Consumers are sometimes able to buy the same drug in Canada at a lower price than in Montana. However, as the distance to Canada increases, people may be less likely to use Canadian drugs as a substitute because travel costs are too high.

The structure of the market in which a drug is sold can affect the price level. The number of firms affects supply, and the number of buyers affects demand. One measure for the size of supply is the number of pharmacies. As more pharmacies per 1000 people enter the market, supply shifts outward and the market for prescription drugs becomes more competitive. This increase in competition causes the average price level to decrease. On the demand side, the number of repackagers is a reasonable proxy measure for the size of the market. Assuming repackager costs of supplying a drug are not affected by the type of drug, then the size of the market only depends on demand. For example, suppose the demand for drug A is larger than for drug B, but supply costs and the number of pharmacies are the same. Then drug B is likely to be priced lower, have less quantity sold, and consequently have fewer repackagers. As demand shifts outward

[3] Under the Prescription Drug Marketing Act of 1988, it is illegal for anyone to re-import into the United States a prescription drug that was manufactured in the United States, other than the original manufacturer (Hubbard 2004).

the size of the market grows, increasing the number of repackagers and also the average price.

Search affects average price by altering the number of high-priced firms and low-priced firms. The more search that occurs or the higher the fraction of people searching the harder it is for high-priced firms to exist. Therefore, the ratio of high-price firms to low-priced firms falls, causing average prices to decrease. A drug that requires more frequent purchases results in increased expected benefits from search and also lowers search costs by increasing human capital and experience with the market. An increase in the percent of informed consumers decreases the prevalence of high-priced firms. Therefore, increased purchase frequency and an increase in the percent of informed consumers in the market increases search, which decreases average prices.

Although the drugs themselves do not vary from one store to another, pharmacies can exhibit heterogeneity in the services they provide. The heterogeneity in quality created by pharmacies may also cause price dispersion. Services such as staying open on the weekend, counseling patients, or free delivery may all affect the quality of care the patient receives and the prices of drugs sold by the different pharmacies. Who the pharmacy uses for their primary and secondary wholesalers, whether or not the pharmacy is a chain, whether or not it is part of a department or grocery store, and the total number of hours open are all variables that may affect production costs, and in turn influence average prices. Moreover, personal communication with pharmacists indicated that chain pharmacies may have higher markups for brand name drugs while keeping generic drug prices lower than those offered at independent pharmacies. This interaction between the type of drug and the type of pharmacy may also have an effect on prices.

Finally, higher costs for manufacturers to make a drug will increase retail prices. While perhaps not an ideal measure of acquisition costs, Average Wholesale Price (AWP) is used often by government agencies and insurance companies to determine cost.[4] Including this measure of pharmacy acquisition, cost accounts for the possibility that price level affects the amount of price dispersion.

Another source of cost for suppliers is the cost of transportation. Because Montana is geographically large and highly rural, transportation costs may have a large impact on price level. Stores located near the Canadian border may exhibit higher transportation costs because of their distance from drug distributors. Stores farther away from Canada may have lower transportation costs and therefore charge lower prices. Again, the distance to Canada has an effect on price level. As the distance to Canada increases, price levels may be lower because transportation costs for suppliers are less.

Summary

This chapter developed theories on price dispersion and price level for prescription drugs. Using the model presented by Salop and Stiglitz, several hypotheses are examined as to why price dispersion exists for pharmaceuticals. Search costs, production costs, and competition are among the variables considered. Then, several

[4] Thompson Healthcare publishes the AWP based on values reported by the manufacturers, repackagers, and private labelers, or AWP is calculated using a markup specified by the manufacturer. If the manufacturer does not provide AWP, then it is calculated using Wholesale Acquisition Cost (WAC). However, AWP and WAC do not necessarily reflect the actual average wholesale cost or wholesale acquisition cost because these calculations rely solely on the values reported by the manufacturers.

hypotheses are presented that explain differences in price levels. Included in these variables are competition, market characteristics, search costs, pharmacy heterogeneity, and production costs. The next chapter explains how data were collected and used to test these hypotheses.

CHAPTER 4

DATA

To test the hypotheses presented in chapter 3, three types of data were collected. First, price data were obtained in order to measure price dispersion. A survey was designed that gathered this information from forty-two pharmacies in eight segregated markets in Montana and also from two other pharmacies in Montana communities that were adjacent to the Canadian border. Next, data on drug characteristics were collected, including information on brands, generics, purchase frequency, number of manufacturers and repackagers, and number of substitutes, in order to control for differences in each drug market. Finally, to control for socio-economic and demographic differences in each geographical market, data were collected on city characteristics, such as age distributions and poverty rates. The addition of these variables extends the work done by Sorensen on price dispersion in the retail market for prescription drugs.

The central hypothesis of this study is that search affects price dispersion. Search costs, expected benefits, and the number of experienced buyers all affect the amount of search occurring in a market. Increases in search lead to decreases in price dispersion, because more informed consumers make operations for high-priced firms more difficult due to a decrease in quantity sold. Other hypotheses involve the effects of production cost on price dispersion and the effects of competition on price levels and price dispersion. As production costs become more disperse, price dispersion is expected to increase. More competition is expected to decrease the prevalence of high prices, and create less price dispersion. The purpose of this chapter is to describe the data used to analyze these hypotheses and how the data were obtained.

Price Data

For each drug in each market, price dispersion can be measured in several different ways. Following much of the previous empirical work on price dispersion, this study uses both the range and standard deviation of observed prices to measure price dispersion. Therefore, price information on each drug had to be collected from several pharmacies in each market. Because no such price data were available for pharmaceuticals in Montana from secondary or tertiary sources, a survey instrument was designed to collect as much information on drug prices as possible without making the process cumbersome for pharmacies.

The survey instrument was designed to gather prices charged by pharmacies and differences in pharmacy characteristics. Thousands of prescription drugs have been approved for consumer use by the Food and Drug Administration. However, only information on drugs that are most often prescribed was collected in order to simplify the survey. These drugs were identified as follows: in the state of New York, pharmacies are required to display prices of the top 150 prescribed drugs as determined by the New York Board of Pharmacies. A list of these 150 drugs was obtained for this survey. In the pre-trial surveys, all 150 drugs were included in the survey.

To collect variables that control for price dispersion caused by heterogeneity in pharmacies, the survey also included several questions about each pharmacy. These questions focused on variables that may affect the cost of the drug or the level of convenience to the consumer. These variables included delivery services, time spent counseling consumers, being associated with a chain or united buying group, primary and secondary wholesalers, location near a retirement community, hospital or medical center, discounts offered, location in a grocery or department store, and pharmacy hours.

A supplemental survey was also created to collect price data on non-prescription items. This survey instrument contained thirty-eight questions about price information on items typically carried by pharmacies, such as band-aids, pain relief medications, allergy medicines, cough relief medicines, and vitamins. Several brand name items were included in the survey to ensure the same product and quantity was being sufficiently compared across pharmacies. Items such as hydrogen peroxide and witch hazel were common enough to allow for a comparison of generics. These price data are not used in the final model, but were used as an instrument for pharmacy heterogeneity. *Non-Prescription Items Missing* is the number of non-prescription items for which no price data existed because that pharmacy did not carry those products. In other words, the variable for number of items missing takes into consideration the amount and variety of non-prescription items carried by a pharmacy, which may account for some differences in production costs.

Contact and location information was collected for all pharmacies in Montana to determine whether each pharmacy would be included in the survey. Pharmacies in retirement homes or hospitals were excluded from the sample because they cater to a specific portion of the population. For similar reasons, pharmacies or clinics that serve only low-income households were also excluded. "Compounding only" pharmacies were also excluded from the sample, because they make drugs that a general pharmacy does not or will not supply, and do not carry the typical prescription drugs for consumers. Finally, pharmacies that required a membership fee were excluded.

To pre-test the survey, two preliminary surveys were administered during June 2004 to three pharmacies in Livingston, MT and four pharmacies in Butte, MT. In Livingston, the survey included 150 drugs and was left overnight so that pharmacies could fill out the survey at their convenience. Based on conversations with three pharmacists in Livingston who responded to the pre-test survey, the number of drugs examined was cut to seventy-five because they regarded the length of the survey as too burdensome. The task was more taxing for pharmacies that did not have prices in a computer database. In the Butte pre-test, the survey was reduced to seventy-five drugs and left with the pharmacy for a week instead of overnight. However, leaving the survey at the pharmacy for an extended period of time appeared to reduce the likelihood of a response.

Using geographical and population information as a factor for determining markets, seven distinct markets in Montana were identified as sufficiently large to be included in the study. Billings, Great Falls, Helena, Kalispell, and Missoula were regarded as five separate markets and pharmacies within the city limits of each community were considered to be part of that market. The cities were all more than eighty-five miles apart, making them separate and distinct markets. Pharmacies in Bozeman and Belgrade, communities that are ten miles apart, were considered to be in the same market because of relative proximity. Finally, pharmacies in towns along the northern border of Montana and east of the Continental Divide were considered to be in identical markets. The towns selected to be included in this market were Havre, Glasgow, Shelby, and Plentywood because of their similarities, proximity to Canada, and isolation from larger cities. Figure 2 is a map of Montana showing each of the cities surveyed.

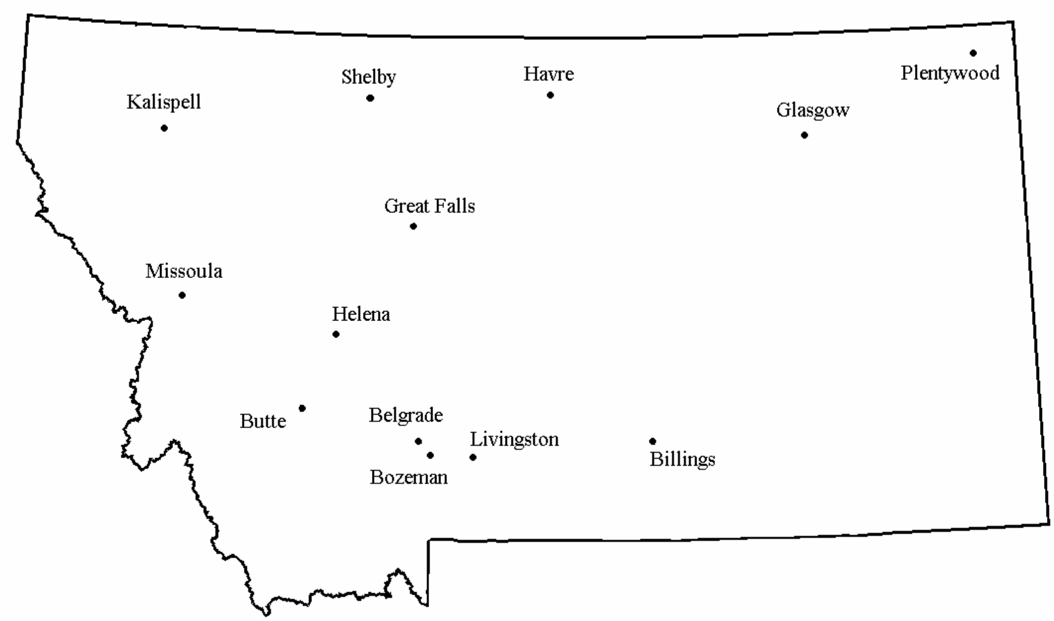

Figure 2. Map of Montana of cities surveyed.

The survey instrument was administered in the cities of Bozeman, Billings, Helena, Missoula, and Great Falls over the period of June 1 to August 15 of 2004. Each pharmacy was presented a survey on Montana State University letterhead containing seventy-five questions on drug prices and fifteen questions about the operations of the pharmacy (See Appendix A). An explanation of the purpose of the research was attached to the survey along with a statement that price data would remain confidential. In addition, the pharmacist or pharmacy technician who would respond to the survey was verbally assured that price information and pharmacy names would not be published.

Individuals were asked to complete the survey at their convenience. If a person indicated that the survey could not be returned within the day, a self-addressed stamped envelope was provided to the pharmacy allowing them a more reasonable time to complete the survey. After the survey was delivered, the survey administrator also collected data on non-prescription items for the supplemental survey. For items that were on sale, the regularly charged price was collected. If the item was located but carried in a different size or quantity, then no data were collected for that item. If the item was not in stock, then no data were collected. Finally, if a pharmacy declined to participate in the survey on prescription drugs, no data were collected on non-prescription items on that pharmacy.

If pharmacies were far away from Bozeman, the pharmacy was called to notify them about the study, and survey material was mailed to them directly. The cities in which pharmacies were surveyed by mail included Kalispell, Havre, Glasgow, Plentywood, and Shelby. The survey material sent to these pharmacies included questions on the seventy-five drugs, fifteen questions about the operations of the pharmacy, the supplemental survey on non-prescription items, and a self-addressed, stamped envelope. After three weeks, pharmacies that had not responded to the initial mailing received a follow-up telephone call to remind them of the survey.

Altogether, eighty-two pharmacies received survey material, including the pharmacies from the two preliminary surveys. Forty-four pharmacies returned the completed survey for a response rate of fifty-four percent. Some pharmacies were unable to complete the survey due to time constraints, while others stated that they were restricted from filling out surveys due to corporate policies or declined to fill out the survey due to disagreements with the objectives of the research. To estimate the standard deviation, at least five pharmacies were required in each market. Allowing for a much higher criterion decreased the number of observations, and therefore, price data had to be collected from a minimum of five pharmacies for a market to be included in the study.

Five markets satisfied these criteria, consisting of Billings, Bozeman/Belgrade, Great Falls, Kalispell, and Missoula. In Billings, eleven pharmacies received and six completed surveys with a response rate of fifty-five percent. In both Bozeman/Belgrade and Great Falls, eleven pharmacies received and five completed surveys with a response rate of forty-five percent. In Kalispell, twelve pharmacies received and eight completed surveys with a response rate of sixty-seven percent. In Missoula, thirteen pharmacies received and nine completed surveys with a response rate of sixty-nine percent.

In four markets (Helena, Butte, Livingston, and the market along the northern border), less than five pharmacies provided survey responses and so measures of price dispersion were not calculated for these markets. However, the data from pharmacies that did respond were still used in the estimation of the determinants of price levels. Several small towns along the northern border of Montana were surveyed with the objective of grouping them in one market. In the market along the Canadian border, nine pharmacies in four towns were surveyed but only two pharmacies responded. In Helena, seven pharmacies were surveyed but only four responded. In Butte, five pharmacies were surveyed but only three responded. Finally, in Livingston, two of the three pharmacies surveyed responded.

Non-response bias may be an issue, given that some chain pharmacies cited corporate policy as their rationale for non-response. One concern was that either high-priced or low-priced pharmacies were being systematically omitted from the sample because of response bias. To examine this problem, correlations between non-prescription item prices and drug prices were examined. If systematic correlations existed, non-responders could be identified as either high-price or low-price firms, based on the prices charged for non-prescription items, which had been collected in the surveys. However, no statistically significant correlations were found between the prices of non-prescription items and prescription drugs among responders. Moreover, some pharmacists and medical professionals that were interviewed agreed that pharmacies that consistently did not respond to the survey were not unusual in their pricing policies.[5] Thus, there is no evidence to suggest that response bias is a serious problem. However, these experts did suggest that chain stores offer low-priced brand drugs, but then try to recover their loss by charging higher prices for generics. To account for this possibility, interaction variables were constructed that accounted for brands and generics, and whether or not the pharmacy was a chain store. These variables were used only to explain the determinants of price level.

[5] Confidentiality by the researcher was granted to those experts who were interviewed.

Drug Characteristics

Data on drug characteristics were collected and variables were generated to control for differences in the markets for individual drugs. *Purchase Frequency* and drug class variables account for search, while the variables *Brand with Substitutes* and *Number of Substitutes* control for competition. Finally, *Brand*, *Average Cost,* and *Number of Manufacturers* are variables that control for differing production costs.

Purchase Frequency is a measure of the amount of search that occurs for each drug. More frequently purchased drugs are expected to have greater expected benefits and lower search costs when compared with drugs that are purchased only once. When drugs are purchased more frequently the benefits from finding the lowest priced store can be rewarded multiple times as opposed to just once with a one-time purchased drug. Moreover, purchasing a drug every month allows individuals to gain more knowledge and experience with the market, increasing human capital and decreasing search costs. Purchase frequency per year is measured as follows:

*dosage per day * length of treatment / quantity prescribed*.

This formula estimates the number of times in a year the typical patient has to purchase the drug. For example, Atenolol is a beta-blocker that is typically taken once a day for the rest of a person's life. The prescription in this survey is for a quantity of 30 pills. Therefore, annual frequency of purchase for Atenolol is estimated as (1 * 365)/ 30 = 12.17. Drugs with an estimated annual purchase frequency of less than one were allocated a purchase frequency of one, because an individual must purchase the drug at least once in order to use it. For each drug, *Purchase Frequency* is estimated using information on the most typical daily dosage and the duration of treatment obtained from Mosby's 2004 Drug Guide and additional consultation with a pharmacy technician.

Brands, generics, and the number of substitutes are expected to affect the level of competition in each market, with the different drug classes controlling for different propensities of search. *Brand* is a binary zero-one variable where a value of one means the product is a branded drug. *Brand with Substitutes* is also a binary variable that is used to differentiate between patented drug brands and competitive drug brands. A value of one means the brand drug has generic substitutes, making it a competitive brand. The number of substitutes, *Number of Substitutes*, measures the number of alternative drugs available in the United States used in the treatment of the same ailment. Finally, drug class categorical variables are used as a crude control for differences in demand or the composition of the drug's users. Thus, these variables are used as controls for the likelihood that *ceteris paribus* users of drugs such as anti-depressants (Class 8) have differing propensities to search than users of drug such as antibiotics (Class 5). A description of the sixteen different classes is presented in table 7. Information on patented drug brands, competitive drug brands, and generics was obtained from the U. S. National Library of Medicine and the National Institutes of Health. Data on the number of substitutes and the class of each drug were also collected from these sources.

The variable *Average Cost* is included to control for differences in acquisition cost and the probability that price level affects the amount of price dispersion. The measures for price dispersion, range and standard deviation, are not normalized to control for the different price levels of the drugs. Thus, *Average Cost* is included to account for the possibility that the amount of price dispersion is related to drug acquisition cost. Two pharmacists were consulted on how cash prices for prescription drugs are determined. Both pharmacists described the process of Medicaid reimbursements, and how reimbursements from insurance contracts can similarly affect cash prices. Under the Medicaid Drug Rebate Program, pharmacies are encouraged to charge the highest cash price possible in order to maximize pharmacy reimbursements to assure that Medicaid receives a rebate from the drug manufacturer.[6] Often, contracts between pharmacies and insurance companies use similar formulas as Medicaid to determine reimbursement rates based on Average Wholesale Price (AWP). In Montana, Medicaid reimbursements for pharmacies equal eighty-five percent of AWP plus a dispensing fee of $4.70, with no maximum allowable cost program. In other words, there is no maximum amount that Medicaid recipients can spend. Therefore, the sum of eighty-five percent of the AWP and $4.70 is used as a measure of the cost to the pharmacy to supply a drug. The *Average Cost* was calculated using data collected from Thompson's 2003 Drug Topics® Redbook.

Thompson's 2003 Drug Topics® Redbook also included a list of all manufacturers and repackagers of a drug. These data were collected to estimate the variable *Number of Manufacturers,* which serves as a proxy for the number of sources

[6] The Medicaid Drug Rebate Program as considered under the provision of the Omnibus Budget Reconciliation Act (OBRA) of 1990 requires a drug manufacturer to enter into and have in effect a national rebate agreement with the Secretary of the Department of Health and Human Services for States to receive federal funding for outpatient drugs dispensed to Medicaid patients. Drug manufacturers are required to enter a pricing agreement with the Secretary of Health and Human Services and various agreements with the Department of Veterans Affairs. A drug manufacturer must sign an agreement with these two programs in order to have its drugs covered by Medicaid. In other words, drug manufacturers must enter a rebate program in order for their drugs to be covered by Medicaid (Morton 1997).

from which a drug can be obtained and also as a proxy for the size of the market for the drug.

Demographic and Socio-economic Data

Data for each of the cities included in the analysis (Billings, Bozeman, Butte, Great Falls, Helena, Havre, Livingston, Kalispell, and Missoula) were collected to control for differences in each geographical market. The demographic data for each city were obtained from the 2000 United States Census Survey on income, age, and population size (United States Census Bureau). Data on the percentage of individuals living in poverty, *Percent of Individuals in Poverty*, and the percentage of the population over 65, *Percent of Population over 65*, were obtained to account for differences in the geographical markets regarding the proportion of informed consumers in the market. The total number of individuals in poverty, the total population over 65, and the total population in each city were collected from the census and used to estimate these variables.

The variables *Distance to Canada* and *Distance to Canada*^{2} were generated to account for the effects created by competition from Canadian suppliers. Three Canadian markets, Fernie, BC; Taber, AB; and Cardston, AB, were compared to each city in Montana. Distances to each market were collected and the shortest of those three distances was used as a measure of the cost of obtaining drugs from Canada. Yahoo!® Maps was used to collect distance in tens of miles for these variables.

The variable *Pharmacies per 1000 People* is used to account for competition in each market. The number of pharmacies in each city was gathered from the 2004 Blue

Cross Blue Shield of Montana publication of pharmacies in Montana. The presence of each pharmacy was also verified by phone or observation. Pharmacies in hospitals and nursing homes were excluded along with clinics that serve only those in poverty and pharmacies that require a membership. Their exclusion is due to omission of specific consumers, because their customer base is only a targeted portion of the population, and not the general population. The number of pharmacies and the total population data collected from the Census Bureau were then used to calculate *Pharmacies per 1000 People.*

Summary

The data described in this chapter are used to test two main hypotheses. The first hypothesis is that search affects price dispersion. Variables, such as purchase frequency, drug classes, percent of the population over 65, and percent of the individuals in poverty, were used to control for differing amounts of search in each market. Secondly, competition is expected to affect price level and in turn affect price dispersion. The binary variable for brands with generic substitutes along with the number of substitutes and distance to Canada, account for differing amounts of competition in each market. Summary statistics for these variables can be found in table 8. The summary statistics for the range and standard deviation of residuals are separated out by the two models used: excluding and including the class categorical variables. Finally, additional variables are included to control for other possible sources of dispersion such as pharmacy heterogeneity, differences in cost, or variation from wholesalers.

Table 7. Descriptions of each Drug Class Variable.

Class 1	Adrenergic agonists; Anorexiants; Amphetamines; Stimulants, central nervous system
Class 2	Analgesics, narcotic; Analgesics, non-narcotic; Nonsteroidal anti-inflammatory drugs. Antigout agents.
Class 3	Angiotensin converting enzyme inhibitors
Class 4	Antiadrenergics, beta blocking; Antiadrenergics, alpha blocking
Class 5	Antibiotics, penicillins; antibotics, macrolides; Antibiotics, cephalosporins; Antibiotics, quinolones; Antibiotics, lincosamides; Anti-infectives, topical; Anti-infectives, ophthalmic; Antibiotics, amino glycosides; Anti-infectives, otic; Corticosteroids, otic; Keratolytics
Class 6	Anticoagulants, Platelet inhibitors;
Class 7	Anticonvulsants; Antipsychotics
Class 8	Antidepressants, serotonin specific reuptake inhibitors; Antidepressants, miscellaneous
Class 9	Antidiabetic agents; Biguanides
Class 10	Antiemetics/antivertigo; Antihistamines, H1; Antitussives; Decongestants, nasal; Phenothiazines; Leucotriene antagonists/inhibitors
Class 11	Antifungals; Antifungals, topical; Dermatologics; Antivirals
Class 12	Antihyperlipidemics; HMG CoA reductase inhibitors
Class 13	Anxiolytics; Benzodiazepines; Relaxants, skeletal muscle; Sedatives/hypnotics
Class 14	Corticosteroids; Corticosteroids, inhalation; Anti-infectives, ophthalmic; Corticosteroids, ophthalmic; Hormones/hormone modifiers; Thyroid agents
Class 15	Diuretics, loop; Diuretics, thiazide and derivatives
Class 16	Gastrointestinals; Proton pump inhibitors

Drugs are categorized into 16 classes described above. Each class variable is a binary variable.

Table 8. Summary Statistics.

Price Dispersion

Variable	Obs	Mean	Std. Dev	Min	Max
Range	370	15.84065	11.09147	1.74	71.82
Standard Deviation	370	5.855	3.949614	0.58	28.44
Number of Sub.	370	16.82432	26.28505	0	106
Purchase Frequency	370	7.167729	5.352538	1	12.16667
Percent of Population over 65	370	13.446	3.737944	8	18.3
Percent of Individuals in Poverty	370	15.598	2.716188	11.58	18.76
Distance to Canada	370	23.77988	8.30429	11.63828	33.48569
Brand	370	0.6216216	0.4856394	0	1
Brand with Substitutes	370	0.1621622	0.3690986	0	1
Average Cost	370	57.22943	55.32022	6.4	245.42
Number of Manufacturers	370	4.351351	3.509308	1	16

Residuals Excluding Class Categorical Variables

Variable	Obs	Mean	Std. Dev	Min	Max
Range of Residuals	370	14.23696	10.02094	0.7547	64.3118
Standard Deviation of Residuals	370	5.278134	3.614295	0.2962	26.2659

Residuals Including Class Categorical Variables

Variable	Obs	Mean	Std. Dev	Min	Max
Range of Residuals	370	14.22145	10.0088	1.1752	64.6282
Standard Deviation of Residuals	370	5.270019	3.605835	0.4778	26.3465

Price Level

Variable	Obs	Mean	Std. Dev	Min	Max
Drug Price	2775	59.31601	52.83021	3.92	350.9
Number of Sub.	2775	16.77694	26.21015	0	106
Purchase Frequency	2775	7.179686	5.343723	1	12.16667
Percent of Population over 65	2775	13.95859	3.412698	8	18.3
Percent of Individuals in Poverty	2775	15.46005	2.536406	11.58	18.76
Distance to Canada	2775	23.34949	7.763694	11.63828	33.48569
Distance to Canada^2	2775	605.4518	350.9513	135.4496	1121.292
Pharmacies per 1000 People	2775	0.3854342	0.2432631	0.15	0.84
Brand	2775	0.6216216	0.4850701	0	1
Brand with Substitutes	2775	0.1596396	0.3663375	0	1
Average Cost	2775	57.14562	55.07406	6.4	245.42
Number of Manufacturers	2775	4.353874	3.500051	1	16

CHAPTER 5

EMPIRICAL MODELS

The purpose of this study is to examine empirically the causes of price dispersion in markets for the seemingly homogenous goods of prescription drugs. This chapter presents the models used to estimate the effects of search, competition, and production costs on price dispersion in the pharmaceutical market. Price dispersion is initially measured by either the range or standard deviation of observed prices in each market. Different drug and market characteristics affect price dispersion through search and seller costs. To test the hypotheses presented in earlier chapters, models of price dispersion should also account for pharmacy heterogeneity. To control for this factor, price determination models are estimated that include variables to control for differences among pharmacies. The residuals from these models are then used to estimate price ranges and standard deviations for each drug within individual markets as additional measures of price dispersion. The estimation methods using price determination and price dispersion models are discussed in this chapter with the parameter estimates presented in the next chapter.

Price Dispersion Models

In chapter 3, several hypotheses were developed to explain why price dispersion exists. The costs and expected benefits of search, competition, and production costs influence price dispersion. Variables that measure these factors include different drug characteristics, different market characteristics, and pharmacy heterogeneity. Price dispersion for a specific drug i in market j at pharmacy k, PD_{ijk}, can be written as a function of these vectors of variables $\underline{x}_i$, $\underline{y}_j$, and $\underline{z}_k$; that is

(1) $$PD_{ijk} = f(\underline{x}_i, \underline{y}_j, \underline{z}_k)$$

The vector $\underline{x}_i$ includes all the variables that account for differences among drugs that affect amounts of search, degree of competition between sellers, and variation in production costs among suppliers. Such variables influence the expected benefits and costs of search effort, competition, and production costs. Different market characteristics for the five markets studied may also reinforce varying amounts of price dispersion by affecting expected costs and benefits of search or competition. The vector $\underline{y}_j$ contains demographic and socioeconomic variables that account for these differences among markets. Finally, price dispersion may also be affected by differences in quality or services provided among pharmacies. The vector $\underline{z}_k$ includes variables that account for differences in pharmacy characteristics that affect price dispersion at pharmacy k.

In this study, the drug characteristics vector, $\underline{x}_i$, includes the following variables: *Purchase Frequency,* which controls for search, *Brand with Substitutes* and *Number of Substitutes,* which control for competition, and *Brand, Average Cost,* and *Number of Manufacturers,* which control for production costs. *Purchase Frequency* measures the frequency of purchase for each drug in a year. As this frequency increases, search benefits are expected to increase and search costs decrease, increasing the amount of search and in turn reducing price dispersion.

Brand and *Brand with Substitutes* are dummy variables that account for differences between patented brands, competitive brands, and generic drugs. The variable *Brand* controls for the number of manufacturers. Drugs with this *Brand* variable taking the value 1 have one manufacturer, while generic drugs can have several manufacturers. As the number of manufacturers with different production costs increases, prices are expected to exhibit more variation causing increased retail price dispersion. The variable *Brand with Substitutes* is also included to control for differing amounts of competition among brand drugs. This variable takes the value of 1 if the product is branded and has generic substitutes. Patented brands have no generic substitutes, while competitive brands have generic substitutes. More competition is expected to lower the prevalence of high-priced sellers, which in turn reduces price dispersion.

Number of Substitutes is a measure of the number of alternative drugs or treatments available in the United States. As the number of substitutes increases, competition increases, which is expected to decrease the prevalence of high-priced sellers and reduce price dispersion.

The variable *Average Cost* is a measure of a pharmacy's cost of obtaining and dispensing a specific drug. Range and standard deviation measures of price dispersion are not normalized to control for differences in drug acquisition costs. Thus, *Average Cost* is included to control for differences in acquisition cost and the possibility that price level affects the amount of price dispersion. As *Average Cost* increases, price dispersion is expected to increase.

Finally, the variable *Number of Manufacturers* is used to account for price dispersion caused by variation in the cost of obtaining a drug. As the number of manufacturers and repackagers supplying a drug increases, production costs are expected to be more diverse. In turn, price dispersion is expected to increase at the retail level.

The market characteristics vector, $\underline{y}_j$, includes demographic and socio-economic variables that may also affect price dispersion. The variables included here are *Percent of Individuals in Poverty* and *Percent of Population over 65,* which control for search, and *Distance to Canada,* which controls for competition. The variable *Percent of Individuals in Poverty* measures the proportion of a market's population in poverty and is included to account for the proportion of uninsured consumers in a market. As the fraction of individuals in poverty increases, the proportion of uninsured consumers in the population increases. Uninsured customers often pay cash, while insured patients with drug coverage plans often pay the same price for a drug regardless of the pharmacy from which it is purchased. Due to this contrast, uninsured customers may be more likely to search due to higher expected benefits from search. Thus, as the percent of individuals in poverty increases, the amount of search is likely to increase and price dispersion to decrease.

Percent of Population over 65 is also included to account for variations in search efforts among markets. Individuals over 65 years of age typically take more medication than any other age group (HHS Weekly Report), and are therefore likely to be more experienced consumers of prescription drugs. In addition, elderly people may have lower search costs in terms of time. Moreover, a third party that purchases medications for elderly individuals still has incentives to find the lowest price. For poor elderly individuals, this third party is most likely a family member, who also benefits from search and is repeatedly purchasing the drug. Thus, as the proportion of the population over 65 increases, the market includes a larger elderly population with low search costs and relatively high benefits from search, resulting in more search and less price dispersion. However, the elderly in institutional facilities are in this population and often have their medications purchased via the nursing home or hospital pharmacy. These individuals are included in the measure for the proportion of elderly in the population and are not easily identifiable. Therefore, based on the characteristics of the data, the models developed do not account for these individuals.

Distance to Canada is included to control for competition from Canadian markets in each city. As the distance to Canada increases, transportation costs for Canadian drugs increase, which may decrease the amount of competition from Canadian markets, and as competition decreases, price dispersion may increase. However, sales via the internet and the transportation cost for U. S. wholesalers may reduce this effect.

Measures of Price Dispersion

Price dispersion is initially measured as either the range or the standard deviation of observed prices for a drug in each city. However, price dispersion may also occur from pharmacy heterogeneity (vector $\underline{z}_k$). To account for this possibility, residuals are obtained from empirical price determination models that account for differences in pharmacies, drugs markets, and cities as follows:

(2) $PL_{ijk} = f(\underline{t}_i, \underline{u}_j, \underline{v}_k) + \varepsilon_{ijk}$

First, estimates of PL_{ijk} are obtained from the price determination models and then ε_{ijk} is calculated for each drug at each pharmacy in each market. These residuals are then used to calculate range and standard deviation for each drug across each city, producing the variables *Range of Residuals* and *Standard Deviation of Residuals* as additional measures of price dispersion. These variables can be expressed as follows:

(3a) $Range\ of\ Residuals_{ij} = Range\{\varepsilon_{ij1}, \ldots\ \varepsilon_{ijk}, \ldots\}$

(3b) $Standard\ Deviation\ of\ Residuals_{ij} = Standard\ Deviation\{\varepsilon_{ij1}, \ldots\ \varepsilon_{ijk}, \ldots\}$.

Range of Residuals and *Standard Deviation of Residuals* are used as alternative measures of price dispersion that control for pharmacy heterogeneity.

Price Determination Models

Drug price level models are estimated to create measures of price dispersion that control for variations generated by heterogeneity among pharmacies, such as the services they provide, location, and other attributes that affect pharmacy pricing or production costs. Drug prices are also assumed to be a function of drug characteristics, differences in market characteristics, and differences in pharmacies, and are estimated using equation (2). PL_{ijk} is the observed price for drug *i* in city *j* at pharmacy *k*.

The vector $\underline{t}_i$ in equation (2) includes such variables as *Purchase Frequency, Brand, Brand with Substitutes, Number of Substitutes, Average Cost,* and *Number of Manufacturers*. The variable *Purchase Frequency* controls for differing search costs and benefits for each drug. A higher purchase frequency creates lower search costs, increases expected benefits, and reduces average price. *Brand* and *Brand with Substitutes* are included to account for competition in the market along with differences in how brands and generics are priced. Among brand drugs, patented brands are expected to have the highest markups and therefore the highest prices, while competitive brands are expected to have lower prices. Generics are expected to have the most competition, the lowest markups, and the lowest prices. The variable *Number of Substitutes* also controls for competition, because more substitutes increase the amount of competition and may decrease average prices. *Average Cost* controls for the cost to a pharmacy for obtaining and dispensing a drug; therefore, as costs increase, so do prices. Finally, *Number of Manufacturers* is included to control for the number of suppliers of a drug.

The vector $\underline{u}_j$ in equation (2) includes variables that affect prices through differences in market characteristics. These include *Percent of Individuals in Poverty* and *Percent of Population over 65*, which control for differences in demographics. In addition, *Distance to Canada, Distance to Canada*^{2}*,* and *Pharmacies per 1000 People* account for differing amounts of competition in each city.

The vector $\underline{v}_k$ in equation (2) includes variables that affect prices through different qualities or services of pharmacies or different production costs. They include *Non-Prescription Items Missing, Delivery, Free Delivery, Chain, Hospital, Grocery, Department, Hours Open, Open Saturdays, Open Sundays, Primary Wholesaler,* and *Secondary Wholesaler*. After compiling a list of non-prescription items typically carried by pharmacies, *Non-Prescription Items Missing* is the number of non-prescription items from the supplemental survey that a pharmacy does not carry. *Delivery* and *Free*

Delivery are dummy variables for whether or not a pharmacy has a delivery service (including mail-delivery) and, if they do, whether or not the delivery service is free. *Chain* is a dummy variable that controls for chain pharmacies. *Hospital* is a dummy variable that accounts for pharmacies that are within one mile of a hospital. *Grocery* and *Department* are dummy variables that control for pharmacies that are attached to a grocery store and/or department store. *Hours Open* is the total number of hours a pharmacy is open per week, and *Open Saturdays* and *Open Sundays* are dummy variables that account for pharmacies that are open on Saturday and Sunday. *Primary Wholesaler* and *Secondary Wholesaler* are categorical variables that control for differences in wholesalers.

Finally, interaction terms between drug characteristics and pharmacy variables are included to account for the possibility that some pharmacies specialize in specific drugs while keeping the cost of others higher. *Chain* Brand* and *Chain*Brand with Substitutes* are variables that account for chain pharmacies that might have different markup rates for patented brands, competitive brands, and generic drugs.

Price Dispersion Estimation Models

Following Sorensen, the price dispersion models in this study use four measures for price dispersion. The range and standard deviation of observed prices are two measures, while the range and standard deviation of residuals in equations (3a) and (3b) are two alternative measures of price dispersion that control for pharmacy heterogeneity. The price dispersion models presented by Sorensen also use these four measures of price dispersion, as well as several of the drug characteristic variables described in vector $\underline{x}_i$, and a dummy variable to account for the two different cities he examines. This study estimates models using all of the variables of drug characteristics described above; that is,

$$\textit{Model (1):}\ \ PD_i = \beta_0 + \beta_1\,\textit{Purchase Frequency}_i + \beta_2\,\textit{Brand}_i + \beta_3\,\textit{Brand with Substitutes}_i + \beta_4\,\textit{Number of Substitutes}_i + \beta_5\,\textit{Average Cost}_i + \beta_6\,\textit{Number of Manufacturers}_i + \varepsilon_i$$

This study differs from Sorensen because we also developed a model that includes variables that control for differences in market characteristics. That is,

$$\textit{Model (2):}\ \ PD_{ij} = \beta_0 + \beta_1\,\textit{Purchase Frequency}_i + \beta_2\,\textit{Brand}_i + \beta_3\,\textit{Brand with Substitutes}_i + \beta_4\,\textit{Number of Substitutes}_i + \beta_5\,\textit{Average Cost}_i + \beta_6\,\textit{Number of Manufacturers}_i + \beta_7\,\textit{Percent of Individuals in Poverty}_j + \beta_8\,\textit{Percent of Population over 65}_j + \beta_9\,\textit{Distance to Canada}_j + \varepsilon_{ij}$$

The *Models (1)* and *(2)* are then re-estimated by also including class variables for each of the drugs; that is, the additional models are estimated:

$$\textit{Model (3):}\ \ PD_i = \beta_0 + \beta_1\,\textit{Purchase Frequency}_i + \beta_2\,\textit{Brand}_i + \beta_3\,\textit{Brand with Substitutes}_i + \beta_4\,\textit{Number of Substitutes}_i + \beta_5\,\textit{Average Cost}_i + \beta_6\,\textit{Number of Manufacturers}_i + \sum_{c=7}^{23} \beta_c\,\textit{Class}_{ic} + \varepsilon_i$$

$$\textit{Model (4):}\ \ PD_{ij} = \beta_0 + \beta_1\,\textit{Purchase Frequency}_i + \beta_2\,\textit{Brand}_i + \beta_3\,\textit{Brand with Substitutes}_i + \beta_4\,\textit{Number of Substitutes}_i + \beta_5\,\textit{Average Cost}_i + \beta_6\,\textit{Number of Manufacturers}_i + \beta_7\,\textit{Percent of Individuals in Poverty}_j + \beta_8\,\textit{Percent of Population over 65}_j + \beta_9\,\textit{Distance to Canada}_j + \sum_{c=10}^{26} \beta_c\,\textit{Class}_{ic} + \varepsilon_{ij}$$

Each drug is allocated to one of sixteen different classes based on its intended use.[7] These categorical variables are included to control for differences in the propensities to search for different types of drugs; that is, class variables account for the

[7] Appendix B shows results from a model with 23 class variables instead of 16. Because some of these 23 classes only had one drug in it, the classes were reduced to avoid single drug effects.

possibility that, say, users of anti-depressants have differing propensities to search than users of antibiotics or users of heart medications.

Finally, the price determination models, estimated to obtain residuals, are developed using the variables described for the vectors $\underline{t}_i$, $\underline{u}_j$, and $\underline{v}_k$, and the interaction terms, *Chain*Brand* and *Chain*Brand with Substitutes*.[8] The model is then re-estimated by including the sixteen drug class categorical variables.[9]

Estimation Methods

Each of the above models was estimated in linear form using the Ordinary Least Squares procedures in Stata. The Cook and Weisberg's (1983) tests for heteroscedastic errors were then conducted for each model. Each price dispersion model exhibited heteroscedasticity. To correct for this problem, the price dispersion models were re-estimated in Stata using the robust standard error procedures.[10]

Summary

This chapter has presented four empirical models of the effects of search, competition, and production costs on price dispersion. The explanatory variables affect price dispersion through differences in (1) drug characteristics, (2) market characteristics, and (3) the quality and services of each pharmacy. Price dispersion is measured using the

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[8] Appendix C shows the price level models used to estimate the residuals.
[9] A random effects model was also used to account for the possibility of differences between classes. Results using this model are given in Appendix D.
[10] The possibility exists that endogeneity may occur in the models that use residuals from the price determination models to measure price dispersion. There may exist correlation between the error term in price determination models and the error term in models using *Range of Residuals* and *Standard Deviation of Residuals*. To mitigate this problem residuals are used instead of predicted values, and the range and standard deviation of the residuals are used to measure price dispersion.

range and standard deviation of observed prices and the range and standard deviation of residuals of a price determination model. The four models of price dispersion were developed to account for drug and market characteristics, while the range and standard deviation of residuals controlled for the quality of each pharmacy. In addition, two models of price determination were also developed to account for the explanatory power of pharmacy heterogeneity on the distribution of observed prices. Parameter estimates of these models are presented and evaluated in the next chapter.

CHAPTER 6

RESULTS

A major element of this study is to test the following hypotheses about causes of price dispersion for seemingly homogeneous commodities. Price dispersion is expected to decrease if one of the following occur: expected benefits from search increase, search costs decrease, the fraction of informed consumers in the market increases, the degree of competition that a drug faces increases, or the variation of production costs decreases. A secondary hypothesis of the study is to examine the determinants of prices charged for drugs at individual pharmacies. These determinants include drug characteristics, market characteristics, and variables that account for differences in pharmacies. This chapter presents the empirical results from the different models designed to explain price dispersion and price levels among pharmacies in Montana.

Estimated Models of Price Dispersion

Price dispersion results are presented in tables 9 - 12. Parameter estimates for *Model (1)* are presented in table 9 for each of the four different measures of the dependent variable. The results of the model that use range and standard deviation of observed prices in each city as the measure of price dispersion are presented in columns 1 and 2. The results of the models that use the range and standard deviation of residuals are presented in columns 3 and 4. The results in tables 10, 11, and 12 are presented in a similar fashion for price dispersion *Models (2), (3),* and *(4)*, respectively. *Models (1)* and

(3) account for the effects of drug characteristics on price dispersion. *Models (2)* and *(4)* also include variables to control for differences in market characteristics.[11] Including these variables extends the research done by Sorensen.

A central hypothesis in this study is that more search lowers the degree of price dispersion for a good. For prescription drugs, one measure influencing the level of search is purchase frequency. *Ceteris paribus* a greater purchase frequency lowers search costs and/or increases expected benefits, and price dispersion decreases. A person will have lower search costs and higher benefits if he is required to purchase a drug more frequently rather than just once. A frequently purchased drug produces greater rewards from finding the lowest priced-store, assuming that prices charged among stores remain stable over time, because the benefits can be reaped multiple times. Moreover, purchasing a drug frequently allows an individual to gain more knowledge and experience with the market, increasing his human capital and decreasing search costs. Therefore, as purchase frequency increases, price dispersion declines. The estimated coefficients in tables 9 and 10 for *Purchase Frequency* are statistically significant and negative regardless of the measure of price dispersion. These results support the hypothesis that drugs that have to be purchased more frequently exhibit less price dispersion than drugs that are purchased less frequently, strengthening the findings reported by Sorensen.

In tables 11 and 12, class variables are included to control for the drug users' different propensities to search but the estimated coefficients for these variables are not

[11] Appendix B reports results for models that included twenty-three class categorical variables, and a description of the variables is included. Appendix D reports results for random effect models run on the different drug classes and on the different cities.

reported. These variables are jointly significant with a p-value of less than 0.01 for every measure of price dispersion in tables 11 and 12. However, *Purchase Frequency* has estimated coefficients that are not statistically significant and are positive regardless of the measure of price dispersion. These results may be a consequence of multicollinearity between *Purchase Frequency* and the class dummy variables, since both are used to measure search. Evidence to support this hypothesis is provided in the estimated coefficients for the class variables. The estimated coefficients of frequently purchased class variables, such as Class 7 and 8, are lower than infrequently purchased class variables, such as Class 5 and 11. These results suggest that the class categorical variables may be capturing the same effects as the variable *Purchase Frequency.*

As described in chapter 4, *Brand* and *Brand with Substitutes* are dummy variables that account for differences between patented brands, competitive brands, and generic drugs. Competitive brands have generic substitutes, while patented brands do not. The existence of multiple manufacturers of a drug can create more price dispersion at the retail level than if a drug is supplied by a single manufacturer because of differences among manufacturers with respect to production costs. The variable *Brand* accounts for the number of manufacturers making a drug and the variable *Brand with Substitutes* controls for competition. The estimated coefficient for *Brand with Substitutes* allows for differences with respect to price dispersion between competitive brands and patented brands. If *Brand with Substitutes* is not statistically different from zero, then the data does not provide evidence that competitive brands and patented brands exhibit different amounts of price dispersion, and the estimated coefficient for *Brand* measures the change in price dispersion for a brand drug compared to a generic drug. However, if *Brand with Substitutes* has a statistically significant effect on price dispersion, then the variable *Brand* accounts for differences in price dispersion for patented brand drugs and generic drugs and the variable *Brand with Substitutes* measures the differences in price dispersion for competitive brand drugs and patented drugs. For example, column 3 of table 11 shows the estimated coefficients for *Brand* to be –4.39 and *Brand with Substitutes* to be 5.65 and both are statistically significant. Therefore, in this particular model patented brands exhibit less dispersion than generics, and competitive brands exhibit more dispersion than patented drugs.

Patented brands are expected to have less dispersion than generics, because they are made by a single manufacturer. However, when comparing competitive brands and generics, there are two opposing hypotheses. Competitive brands are expected to exhibit less dispersion than generics, because they are made from a single manufacturer, but competitive brands are also expected to exhibit higher price dispersion than generics. While they may face the same amount of competition, markups and therefore average prices for brand name drugs tend to be higher, which increases price dispersion.

Tables 9 and 10 provide some support for these hypotheses. The estimated coefficient for *Brand* is negative for every measure of price dispersion, and in columns 3 and 4, it is statistically significant. This supports the hypothesis that brands have less price dispersion than generics because brands typically have one manufacturer. However, *Brand with Substitutes* is not statistically significant and the sign is not consistent in *Models (1)* and *(2)* in tables 9 and 10. Thus, the data provide no evidence that competitive brands and patented brands exhibit different amounts of price dispersion. In tables 11 and 12, the estimated coefficient for *Brand* is again negative and statistically significant regardless of the measure of price dispersion.

The estimated coefficient for *Brand with Substitutes* is positive, larger in magnitude than the coefficient for *Brand*, and statistically significant across all measures of price dispersion. Therefore, the results in *Models (3)* and *(4)* in tables 11 and 12 suggest that patented brands exhibit less dispersion than generics and competitive brands. However, an F-test was carried out to see if the sum of the coefficients associated with *Brand* and *Brand with Substitutes* was statistically significant.[12] The F-test indicated that the sum of these coefficients was not significantly different than zero, indicating that competitive brands and generics do not display different amounts of price dispersion.

The results presented in tables 9-12 provide conflicting evidence with respect to the inclusion of class variables in *Models (3)* and *(4)*. Thus, no conclusions can be drawn about the effects competitive brands and patented brands have on price dispersion. Sorensen, in models that include class categorical variables, finds no evidence that patented brands and competitive brands are priced differently.[13]

The variable *Number of Substitutes* is a control for the amount of competition faced by each drug. As the number of substitutes increases, competition increases and price dispersion is expected to decrease. The results in tables 9-12 support this hypothesis. The estimated coefficient for *Number of Substitutes* is either negative and

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[12] Given the general model for price dispersion of $PD_i = \beta_0 + \beta_1 Brand_i + \beta_2 Brand\ with\ Substitutes_i + \varepsilon_i$, the F-test performed tests the null hypothesis that $\beta_1 + \beta_2 = 0$.

[13] The class variables used in this study are different than those used by Sorensen. Direct comparison can not be made because different sets of drugs are used in his study.

statistically significant or, as in columns 3 and 4 of table 11 and column 4 of table 12, negative but not statistically significant. As the number of substitutes increases, price dispersion for a given drug decreases.

As described in chapter 4, *Average Cost* is used as a proxy for the cost incurred by the pharmacy in acquiring and dispensing a drug. *Average Cost* is included to control for the possibility that higher price levels increase price dispersion. The results in this study presented in tables 9-12 support this hypothesis. The coefficient for *Average Cost* is positive and statistically significant in every model for every measure of price dispersion, indicating that increases in cost lead to increased price dispersion. Sorensen reports similar findings.

The variable *Number of Manufacturers* is also included to control for differing acquisition costs for pharmacies. If a drug has several manufacturers and repackagers, price dispersion among pharmacies is expected to increase because of variation in acquisition costs. The estimated coefficient for this variable is positive in all models and measures of price dispersion. The coefficient is statistically significant in column 4 of table 10, 11 and 12, and columns 1 and 2 of tables 11 and 12. This empirical evidence provides some support to the hypothesis that as the number of manufacturers and repackagers increases so does price dispersion.

The demographic variables *Percent of Individuals in Poverty* and *Percent of Population over 65* were included in *Models (2)* and *(4)* for tables 10 and 12 to control for differences in each geographical market. Price dispersion can be affected by how "wealthy" a town is. In towns with a larger proportion of uninsured and low-income individuals, more people pay cash prices for their drugs. This suggests that a larger fraction of the population may benefit from searching for the lowest price. Data were collected only on cash prices, and therefore the uninsured or individuals in poverty are the typical customer base that these data examine. Thus, the percent of individuals in poverty is one control for the fraction of searching customers, because the uninsured may have higher expected benefits from search. As the *Percent of Individuals in Poverty* increases, price dispersion is expected to decrease. In tables 10 and 12, the estimated coefficient for *Percent of Individuals in Poverty* is negative in each model and every measure of price dispersion, and is statistically significant in columns 2 and 4 of both tables. This provides some support for the hypothesis that a larger fraction of searching customers decreases price dispersion.

A similar hypothesis is used when examining the variable *Percent of Population over 65.* Senior citizens are the most affected by drug prices, because that older age group typically takes more drugs. Moreover, half of the elderly population has no prescription drug insurance coverage (Rand 1999). The elderly are typically repeat or experienced buyers, and are therefore expected to have greater benefits of search and lower search costs due to increased human capital. In towns where a higher percent of the population is elderly, there are more informed consumers, and therefore price dispersion is expected to be less. In tables 10 and 12, the estimated coefficient for *Percent of Population over 65* is negative in each model and measure of price dispersion, and is statistically significant in columns 2 and 4 of both tables. This provides some support to the hypothesis that a larger percent of informed consumers decreases price dispersion.

The variable *Distance to Canada* was included to examine the effects of Canadian drugs on price dispersion. As the distance to Canada increases, people are less likely to use Canadian drugs as a substitute because the transportation cost of obtaining those drugs is higher. Therefore, more competition exists for pharmacies close to the Canadian border decreasing price levels and price dispersion. In tables 10 and 12, the estimated coefficient for *Distance to Canada* does not support this hypothesis. The estimated coefficient is negative in all of the models and measures of price dispersion in which it is included, but is only statistically significant at the 10% level in column 4 of tables 10 and 12. Thus, these models provide little evidence that proximity to Canada has an effect on dispersion. This model does not control for other variables that may diminish the effects of *Distance to Canada,* such as purchases made via the internet for Canadian drugs or transportation costs for U. S. suppliers.

Percent of Individuals in Poverty, Percent of Population over 65, and *Distance to Canada* are market characteristic variables included in *Models (2)* and *(4)* as an extension of the research done by Sorensen. These variables provide some evidence that market characteristics are important when studying price dispersion.

Estimated Models of Price Determination

Price determination models are estimated to obtain measures of price dispersion that control for differences in pharmacies. Such differences, as described in chapter 4, are the availability of delivery services, convenience for customers, patient counseling, and location. Column 1 of table 13 presents results for a price determination model that includes drug characteristic variables to explain price levels. Column 1 of table 14 presents results from a similar model that also includes the sixteen class variables, whose estimated coefficients are not reported. Column 2 of each table presents results for a model that also includes variables that control for pharmacy heterogeneity.[14] Column 3 in each of these tables presents results for a model that also includes interaction terms for *Brand, Brand with Substitutes,* and *Chain.* Finally, column 4 presents a model that examines the effects of drug characteristics, pharmacy heterogeneity variables, drug and pharmacy interaction terms, and market characteristic variables. Residuals obtained from the model presented in column 4 of tables 13 and 14 are used to estimate range and standard deviation measures of price dispersion that are purged of pharmacy heterogeneity effects.

Although only a few pharmacy heterogeneity variables are statistically significant, such as *Hospital, Department,* and *Open Sundays,* F-tests indicate that the pharmacy variables are jointly significant in all of the models. These variables are jointly significant with $F(18, 2748) = 2.45$ and a p-value of less than 0.01 in column 2 of table 13 and with $F(18, 2733) = 5.33$ and a p-value of less than 0.01 in table 14. In column 3, these variables are jointly significant with $F(20, 2746) = 2.55$ and a p-value of less than 0.01 in table 13, and with $F(20, 2731) = 5.03$ and a p-value of less than 0.01 in table 14. The pharmacy heterogeneity variables in column 4 are jointly significant with F(21,

[14] Appendix E shows the results for the pharmacy heterogeneity variables excluding the primary and secondary wholesaler variables.

2746) = 2.06 and a p-value of less than 0.01 in table 13, and with F(20, 2726) = 4.28 and a p-value of less than 0.01 in table 14.

While most of the hypotheses in this paper involve price dispersion, some hypotheses on price determination are included. The variable *Purchase Frequency* controls for differing search costs for each drug, and it is expected that a higher purchase frequency creates lower search costs and reduces average price. The results in tables 13 and 14 support this hypothesis. In every model, the coefficient for *Purchase Frequency* is negative and statistically significant.

The variables *Brand* and *Brand with Substitutes* account for competition in the market along with markups. Patented brands are expected to have the least amount of competition, and the highest price level. Competitive brands are expected to be priced higher than generics, because brands are more likely to have higher markups than generic drugs. In tables 13 and 14, the estimated coefficient for *Brand* is positive, statistically significant, and larger in magnitude than the estimated coefficient for *Brand with Substitutes*, which is also statistically significant. This supports the hypothesis that patented brands have the highest prices while generics typically have the lowest.

Number of Substitutes also controls for competition. As the number of substitutes increases the degree of competition faced by a drug increases, which decreases average price by reducing the prevalence of high-priced firms. Again, the results in tables 13 and 14 support this hypothesis, with a negative coefficient for *Number of Substitutes* that is statistically significant in every model.

In tables 13 and 14, the estimated coefficients for *Average Cost* and *Number of Manufacturers* are both positive and statistically significant in every model, which supports the following hypotheses. The variable *Average Cost* controls for the cost to the pharmacy for obtaining and dispensing a drug, and as cost increases, so does price level. The variable *Number of Manufacturers* is included to control for the number of suppliers of a drug. As demand increases, the size of the market grows increasing the number of manufacturers and repackagers and also price.

Next, hypotheses on different city effects were developed to account for differences in the markets. *Distance to Canada* and *Distance to Canada*^{2} were included to account for competition from Canadian drugs. As the distance to Canada increases, people are expected to be less likely to use Canadian drugs as a substitute. Therefore, less competition exists from Canadian pharmacies and price level is expected to increase but at a decreasing rate, because the effects from Canadian markets are expected to diminish with increased distances. *Pharmacies per 1000 People* is included to control for the size of the market. As the number of pharmacies increases, competition increases and average price decreases. While none of the results for these variables in tables 13 and 14 are statistically significant, the estimated coefficients for *Distance to Canada* and *Distance to Canada*^{2} is positive and the estimated coefficient for *Pharmacies per 1000 People* is negative, providing some evidence that increased competition decreases the price level. However, the market characteristic variables are jointly significant in table 13 with $F(5, 2741) = 1.95$ and a p-value of 0.08, and in table 14 with $F(5, 2726) = 4.56$ and a p-value of less than 0.01.

Summary

The central hypotheses of this study are supported by the empirical results presented in this chapter. The results of the estimated coefficient of *Purchase Frequency* in tables 9 and 10 provides support that lower search costs and greater expected benefits from search reduce price dispersion among pharmacies. More disperse production costs, measured by *Brand* and *Number of Manufacturers,* cause price dispersion to be greater, and more competition, measured by *Number of Substitutes,* reduces price dispersion. The inclusion of the variables *Percent of Individuals in Poverty, Percent of Population over 65,* and *Distance to Canada* extend the research presented by Sorensen by accounting for differences in market characteristics. These variables provide some evidence that markets with a greater fraction of informed consumers have a lower amount of price dispersion among pharmacies.

Furthermore, Sorensen includes drug class categorical variables to control for different propensities of the users to search. However, the inclusion of these variables may create multicollinearity problems with other variables causing the results to be less significant. The results of this study suggest that the inclusion of these variables may not be appropriate for this model.

Additional hypotheses of this study involve the effects of search and competition on price levels. The empirical results of the variables *Purchase Frequency, Brand, Brand with Substitutes,* and *Number of Substitutes* support the hypotheses that larger amounts of search and greater competition reduce average price. In the price determination models, only the variables for drug characteristics are statistically significant. The results for the pharmacy heterogeneity variables are jointly significant along with the results for the market characteristic variables. However, the market characteristic variables do not provide any conclusive evidence for effects on average prices.

Table 9. Price Dispersion Model (1): No Class.

Variable	**Range (1)**	**Standard Deviation (2)**	**Residual Range (3)**	**Residual Standard Deviation (4)**
Purchase Frequency	-0.3385***	-0.1121***	-0.2941***	-0.1089***
	(0.1130)	(0.0400)	(0.1078)	(0.0386)
Brand	-0.7867	-0.3612	-2.9231**	-1.1793**
	(1.3970)	(0.4953)	(1.3241)	(0.4722)
Brand with Substitutes	-1.1997	-0.4077	0.5612	0.2928
	(1.6051)	(0.5489)	(1.5220)	(0.5478)
Number of Substitutes	-0.0626***	-0.0213***	-0.0437***	-0.0157***
	(0.0150)	(0.0055)	(0.0132)	(0.0046)
Average Cost	0.1014***	0.0379***	0.0861***	0.0334***
	(0.0175)	(0.0063)	(0.0166)	(0.0062)
Number of Manufacturers	0.2530	0.0949	0.2213	0.0974
	(0.1820)	(0.0646)	(0.1744)	(0.0604)
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Constant	13.0994***	4.7244***	12.9168***	4.6734***
	(1.7926)	(0.6531)	(1.5951)	(0.5679)
Observations	370	370	370	370
R-squared	0.2587	0.2738	0.1856	0.2082

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 10. Price Dispersion Model (2): No Class.

Variable	**Range (1)**	**Standard Deviation (2)**	**Residual Range (3)**	**Residual Standard Deviation (4)**
Purchase Frequency	-0.3385***	-0.1121***	-0.2941***	-0.1089***
	(0.1129)	(0.0398)	(0.1073)	(0.0383)
Brand	-0.7867	-0.3612	-2.9231**	-1.1793**
	(1.3899)	(0.4930)	(1.3195)	(0.4734)
Brand with Substitutes	-1.1997	-0.4077	0.5612	0.2928
	(1.6055)	(0.5499)	(1.5245)	(0.5505)
Number of Substitutes	-0.0626***	-0.0213***	-0.0437***	-0.0157***
	(0.0149)	(0.0054)	(0.0129)	(0.0045)
Average Cost	0.1014***	0.0379***	0.0861***	0.0334***
	(0.0174)	(0.0063)	(0.0166)	(0.0062)
Number of Manufacturers	0.2530	0.0949	0.2213	0.0974*
	(0.1831)	(0.0637)	(0.1725)	(0.0589)
Percent of Individuals in Poverty	-0.2448	-0.5911*	-0.5538	-0.6232*
	(0.8343)	(0.3230)	(0.8503)	(0.3250)
Percent of Population over 65	-0.5818	-0.6796**	-0.4655	-0.5856*
	(0.8963)	(0.3423)	(0.9073)	(0.3428)
Distance to Canada	-0.1344	-0.1757	-0.2630	-0.1955*
	(0.2843)	(0.1101)	(0.2844)	(0.1096)
Constant	27.9347	27.2612**	34.0691	26.9176**
	(31.2445)	(12.0775)	(31.7023)	(12.1034)
Observations	370	370	370	370
R-squared	0.2659	0.2874	0.1980	0.2218

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 11. Price Dispersion Model (3): Class.

Variable	**Range (1)**	**Standard Deviation (2)**	**Residual Range (3)**	**Residual Standard Deviation (4)**
Purchase Frequency	0.0863	0.0530	0.0753	0.0487
	(0.1368)	(0.0484)	(0.1195)	(0.0398)
Brand	-3.0204*	-1.2249**	-4.3878***	-1.9355***
	(1.5990)	(0.5740)	(1.5178)	(0.5468)
Brand with Substitutes	4.5625***	1.6907***	5.6463***	2.2667***
	(1.6789)	(0.5638)	(1.7263)	(0.5955)
Number of Substitutes	-0.0440***	-0.0139**	-0.0240	-0.0082
	(0.0157)	(0.0055)	(0.0145)	(0.0050)
Average Cost	0.1855***	0.0673***	0.1548***	0.0593***
	(0.0220)	(0.0077)	(0.0213)	(0.0074)
Number of Manufacturers	0.3046*	0.1071*	0.2633	0.0989*
	(0.1744)	(0.0621)	(0.1678)	(0.0587)
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Constant	-28.0405***	-9.9744***	-22.6154***	-8.7735***
	(6.2167)	(2.2092)	(5.8137)	(2.1357)
Observations	370	370	370	370
R-squared	0.4145	0.4302	0.3434	0.3694

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 12. Price Dispersion Model (4): Class.

Variable	**Range (1)**	**Standard Deviation (2)**	**Residual Range (3)**	**Residual Standard Deviation (4)**
Purchase Frequency	0.0863	0.0530	0.0753	0.0487
	(0.1360)	(0.0479)	(0.1189)	(0.0393)
Brand	-3.0204*	-1.2249**	-4.3878***	-1.9355***
	(1.5901)	(0.5682)	(1.4960)	(0.5401)
Brand with Substitutes	4.5625***	1.6907***	5.6463***	2.2667***
	(1.7092)	(0.5662)	(1.7050)	(0.5818)
Number of Substitutes	-0.0440***	-0.0139**	-0.0240*	-0.0082
	(0.0155)	(0.0055)	(0.0145)	(0.0050)
Average Cost	0.1855***	0.0673***	0.1548***	0.0593***
	(0.0221)	(0.0076)	(0.0206)	(0.0071)
Number of Manufacturers	0.3046*	0.1071*	0.2633	0.0989*
	(0.1750)	(0.0608)	(0.1657)	(0.0570)
Percent of Individuals in Poverty	-0.2448	-0.5911**	-0.4811	-0.6001**
	(0.7057)	(0.2748)	(0.7508)	(0.2855)
Percent of Population over 65	-0.5818	-0.6796**	-0.3900	-0.5621*
	(0.7557)	(0.2899)	(0.7978)	(0.2998)
Distance to Canada	-0.1344	-0.1757*	-0.2427	-0.1889*
	(0.2419)	(0.0938)	(0.2533)	(0.0967)
Constant	-13.2052	12.5624	-4.0949	12.6368
	(27.0557)	(10.2701)	(28.4423)	(10.5763)
Observations	370	370	370	370
R-squared	0.4218	0.4438	0.3561	0.3824

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 13. Price Determination Models: No Class.

Variable	**Drug Effects (1)**	**Drug and Pharmacy Effects (2)**	**Drug, Pharmacy, and Drug & Pharmacy Effects (3)**	**Drug, Pharmacy, Drug & Pharmacy, and City Effects (4)**
Purchase Frequency	-1.0967***	-1.0961***	-1.0966***	-1.0964***
	(0.0975)	(0.0970)	(0.0970)	(0.0969)
Brand	39.7780***	39.7897***	37.8457***	37.8593***
	(1.2382)	(1.2337)	(1.7475)	(1.7400)
Brand with Substitutes	-34.9445***	-34.9992***	-34.1385***	-34.1833***
	(1.7980)	(1.7983)	(2.9784)	(2.9808)
Number of Substitutes	-0.0802***	-0.0804***	-0.0803***	-0.0803***
	(-0.0802)	(0.0105)	(0.0105)	(0.0105)
Average Cost	0.6767***	0.6767***	0.6768***	0.6767***
	(0.0246)	(0.0246)	(0.0246)	(0.0246)
Number of Manufacturers	1.0437***	1.0426***	1.0426***	1.0433***
	(0.0886)	(0.0878)	(0.0878)	(0.0875)
Percent of Individuals in Poverty	-	-	-	0.8079
				(0.8237)
Percent of Population over 65	-	-	-	0.8856
				(0.8066)
Distance to Canada	-	-	-	0.1712
				(1.9638)
Distance to Canada^2	-	-	-	0.0021
				(0.0363)
Pharmacies per 1000 People	-	-	-	-6.8475
				(9.9351)
Chain*Brand	-	-	2.9291	2.9230
			(1.7816)	(1.7741)
Chain*Brand with Substitutes	-	-	-1.3019	-1.2571
			(3.5051)	(3.5082)
Constant	6.1697***	1.0107	2.0499	-20.1929
	(1.2788)	(8.0809)	(8.0830)	(38.7999)
Observations	2775	2775	2775	2775
R-squared	0.8072	0.8104	0.8106	0.8113

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 14. Price Determination Models: Class.

Variable	**Drug Effects (1)**	**Drug and Pharmacy Effects (2)**	**Drug, Pharmacy, and Drug & Pharmacy Effects (3)**	**Drug, Pharmacy, Drug & Pharmacy, and City Effects (4)**
Purchase Frequency	-0.1599**	-0.1618***	-0.1624***	-0.1626***
	(0.0623)	(0.0598)	(0.0597)	(0.0591)
Brand	24.1443***	24.1632***	22.1868***	22.1970***
	(1.3331)	(1.3200)	(1.6586)	(1.6487)
Brand with Substitutes	-6.8463***	-6.9152***	-6.5303***	-6.5735***
	(0.8450)	(0.8209)	(1.2092)	(1.2027)
Number of Substitutes	-0.0296**	-0.0302***	-0.0301***	-0.0301***
	(0.0116)	(0.0116)	(0.0116)	(0.0116)
Average Cost	1.0588***	1.0588***	1.0589***	1.0588***
	(0.0198)	(0.0196)	(0.0195)	(0.0195)
Number of Manufacturers	1.1104***	1.1107***	1.1111***	1.1121***
	(0.0942)	(0.0931)	(0.0930)	(0.0926)
Percent of Individuals in Poverty	-	-	-	0.8204
				(0.5527)
Percent of Population over 65	-	-	-	0.8722
				(0.5417)
Distance to Canada	-	-	-	0.0872
				(1.3360)
Distance to Canada^2	-	-	-	0.0035
				(0.0247)
Pharmacies per 1000 People	-	-	-	-7.7557
				(6.7779)
Chain*Brand	-	-	2.9710**	2.9650**
			(1.4485)	(1.4379)
Chain*Brand with Substitutes	-	-	-0.5954	-0.5479
			(1.3851)	(1.3812)
Constant	-170.4652***	-175.2668***	-174.1470***	-194.8683***
	(4.6941)	(7.1241)	(7.1196)	(26.6902)
Observations	2775	2775	2775	2775
R-squared	0.9101	0.9133	0.9134	0.9142

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

CHAPTER 7

CONCLUSIONS

The purpose of this study has been to examine the conditions under which price dispersion exists for prescription drugs in Montana. Price dispersion is affected by differing levels of search, differing degrees of competition, and variation among firms with respect to production costs.

Price dispersion is measured using the range and standard deviation of observed prices in five markets, and the range and standard deviation of residuals from models of price determination at the same five markets. Variables are examined that control for search, competition, and production costs among the different drugs and geographical markets. To control for pharmacy heterogeneity, price determination models were estimated, and residuals from these models were used to obtain measures of price dispersion purged of pharmacy heterogeneity effects. Additional hypotheses were developed about the determinants of price levels at the individual pharmacies. These hypotheses examine the effects of search and competition on prices.

Search costs affect price dispersion in the following manner: a person searches a pharmacy when the cost of search is less than or equal to the expected benefits from search. If the cost of search is greater than the expected benefits, then the individual will choose not to become informed of all the prices and will buy from a random store. This allows high-priced firms to exist. The prevalence of high-priced firms decreases when the fraction of informed consumers becomes greater, decreasing the average price and in turn decreasing price dispersion. Therefore, search costs, expected benefits, and the percent of informed consumers all affect price dispersion. The results for purchase frequency provide support to the hypothesis that experience and expected benefits affect the degree of price dispersion.

Sorensen reports similar findings but includes class variables that control for the different drug users' propensities to search. When similar variables are included in this study, results for purchase frequency become insignificant suggesting a problem of multicollinearity. The results from this study suggest that multicollinearity may be a problem between frequency of purchase and class variables when such class variables are included.

The proportion of individuals in poverty and the proportion of the population over 65 measure the fraction of searching or informed consumers in the market. Parameter estimates for these two variables provide support to the hypothesis that the percent of informed consumers affect price dispersion. These findings support the hypothesis that market characteristics are important determinants of price dispersion and that, as suggested by Sorensen, empirical models of price dispersion that do not account for these effects are partially misspecified.

Competition affects price dispersion by decreasing the prevalence of high-priced firms. Fewer high-priced firms will decrease average price and in turn price dispersion. Therefore, an increase in competition is expected to decrease price dispersion. The results for the number of substitutes in this study provide support to this hypothesis. Distance from Canada provides no conclusive evidence.

Increased variation in production costs is also expected to increase price dispersion. An increase in the number of manufacturers and repackagers allows for more disperse production costs, increasing dispersion at the retail level. The results for whether or not the drug is a brand and the number of manufacturers and repackagers provide support for this hypothesis.

The price determination models developed allow for additional hypotheses regarding prices. The results show that increased search and competition lower the price level of a drug. Variables that account for demographic or socioeconomic factors across geographical markets provide no statistically significant results but are jointly significant. Drug characteristic variables, such as purchase frequency, whether or not the drugs is a brand, whether or not a brand has generic substitutes, and the number of substitutes, provide evidence that search and competition affect prices. Additional variables that control for average cost and the size of the market are found to also affect price levels. The variables that control for pharmacy heterogeneity were found to be jointly significant in the price determination model.

Information on the prices of drugs and alternative treatments is costly to obtain and the expense for an individual to become well informed may be rationally large. Topics for further research in this area include examining the effects of price advertising by pharmacies and direct-to-consumer advertising on information costs and therefore on price levels and dispersion. Direct-to-consumer advertising allows manufacturers to advertise their products directly to the consumer, as opposed to through a doctor. It may also be useful to examine the costs of obtaining information on alternative treatments for drugs, such as the information costs for a patient to discuss with a physician costs and benefits of alternative treatments.

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APPENDICES

APPENDIX A

SAMPLE SURVEY

(Montana State University Letterhead)

Statement of Purpose

As part of the degree requirements for a Master of Science in Applied Economics at Montana State University, graduate students are required to complete a research project that is new to the field of economics. My research is on prescription drug price dispersion in the state of Montana. Comparing prices between pharmacies within a city, I will then explain variation between cities and between drugs.

The purpose of this research is to understand price variation in a competitive market for a similar good. More specifically this research looks at pharmaceutical prices in Montana and tries to explain why prescription drug prices vary. Variation will be explained by looking at the following variables: purchase frequency, number of substitutes, brand vs. generic, average price, median income, median age, population of city, distance to Canada, number of pharmacies in the city.

Data will be collected from several cities throughout Montana and several pharmacies within each city. Any data collected from pharmacies will only be used for economic research. Pharmacy names and specific drug prices will not be published or given to competitors. Data collected will only be used to understand price variation and the purposes stated above.

Thank you for your time in filling out this survey. If you request it, a copy of the paper can be made available to you. If you have any questions or have any problems please contact me at (406) 994-2282 (e-mail aohler@montana.edu), or my thesis supervisor, Professor Vincent Smith, at (406) 994-5615 (e-mail uaevs@montana.edu).

Adrienne Ohler
Graduate Student
Montana State University

(Montana State University Letterhead)

August 6, 2004

The following is a survey of pharmaceutical prices and other differences pharmacies may have. The purpose of this survey is to collect data for economic research at Montana State University. More detail about this research is given on the statement of purpose on the next page.

Provided in this package is the following:

- Cover letter
- Statement of purpose and prescription drug survey
- Stamped and addressed return envelope.

Please fill out the survey at your earliest convenience and return it in the addressed and stamped envelope provided. You may keep the cover letter and statement of purpose. There are a total of three pages to the survey to be returned. Directions for the survey are given at the top. All information that you provide will be treated as entirely confidential as discussed in the following statement of purpose. Thank you for your time and generosity in filling out this survey. If you request it, a copy of the paper will be made available to you. If you have any questions or have any problems please contact me at (406) 994-2282 (e-mail aohler@montana.edu), or my thesis supervisor, Professor Vincent Smith, at (406) 994-5615 (e-mail uaevs@montana.edu).

Adrienne Ohler
Graduate Student
Montana State University

Below are 75 of the most prescribed drugs according to the New York Board of Pharmacy. Typical dosages and quantities are provided. Under price please write what you would charge to a patient who had a prescription, no insurance provider, or any discount card. If you have any questions or something in this survey is incorrect, please let me know.

Drug	**Quantity**	**Price**
ACCUPRIL 10 MG TABS	30	
ACETAM.COD.#3 TABS	20	
ADADDERALL XR 20 MG	30	
ALTACE 5.0 MG	30	
ALLEGRA – D	60	
ALLEGRA 180 MG TAB	30	
ALPRAZOLAM 0.5 MG	30	
ALTACE 2.5 MG	30	
AMOXICILLIN 500 MG CAPSULE	30	
AMBIEN 5 MG	30	
AMOXIL 250 MG CAP	30	
AMOXIL SUSP 400 MG/5ML	100	
ATENOLOL 25 MG	30	
AUGMENTIN 875 MG TABS	20	
AUGMENTIN ES 600 MG/5ML	125	
BENZACLIN GEL	25	
BIAXIN XL 500 MG	20	
CEFADROXIL 500 MG	20	
CEPHALEXIN 250 MG	28	
CELEXA 20 MG	30	
CHLORHEXIDINE 0.12%	473	
CIPRO HC OTIC	10	
CIPRO 500 MG	20	
CLINDAMYCIN 150 MG	30	
CLONAZEPAM 1 MG	60	
COUMADIN 5 MG TABLETS	30	
COLCHICINE 0.6 (WW)	60	
CONCERTA 36 MG	30	
DEXAMETHASONE 4 MG	21	
DEPAKOTE 250 MG	60	
DIAZEPAM 5 MG	90	
DIFLUCAN 150 MG	1	
DURICEF 250/5 ML	100	

Drug	**Quantity**	**Price**
FLOMAX 0.4	30	
FLOVENT 110 MCG	13	
FLUOXETINE 20 MG	30	
FUROSEMIDE 20 MG	30	
GUAIFENESIN TR 600 MG	20	
HYDROCOD.7.5/ APAP.5	30	
HYDROCO 10/APAP 650	30	
HYDROCHLOROTHIAZIDE 25 MG	30	
LAMISIL 250 MG TABLET	30	
LEVAQUIN 500 MG	10	
LIPITOR 20 MG	30	
LORAZEPAM 1 MG	90	
MECLIZINE 12.5 MG	90	
METFORMIN 500 MG	60	
NAPROXEN 500 MG	30	
NASACORT AQ SPRAY	16.5	
NEXIUM 40 MG	30	
OCUFLOX EYE DROPS	5	
OXYCODONE 5/APAP 325	20	
PAXIL 20MG	30	
PENICILLIN VK 250 MG	28	
PLAVIX 75 MG	30	
PREDNISONE 5 MG	30	
PREDNISONE 20 MG	30	
PREVACID 30 MG	30	
PROMETHAZINE/CODEINE	120	
RHINOCORT AQ NASAL	8.6	
RISPERDAL 2 MG	30	
SEROQUEL 100 MG	30	
SINGULAIR 10 MG TAB	30	
SYNTHROID .075 MG	100	
TEMAZEPAM 30 MG	30	
TOBRADEX EYE DROPS	5	
TOBRAMYCIN EYE DROPS	5	
TRAZODONE 50 MG	30	
VALTREX 500 MG	30	
VICOPROFEN TAB	40	
WARFARIN 5 MG	30	

Drug	Quantity	Price
ZITHROMAX 250 MG	6	
ZOCOR 10 MG	30	
ZOLOFT 50 MG	30	
ZYPREXA 5 MG	30	

Please circle one:
Do you have a delivery service? Yes No
Do you have free delivery? Yes No
Approximately, how much time on average per patient do you spend counseling on interactions and side effects? ___________________ minutes
Is this pharmacy part of a chain rather than to independently owned? Yes No
Is this pharmacy part of a United Buying Group? Yes No
What wholesaler do you use primarily?________________________
What do you use as a secondary wholesaler?_________________________
Is this pharmacy location within a mile of any retirement community? Yes No
Is this pharmacy location within a mile of any hospital? Yes No
Is this pharmacy location within a mile of any medical center or doctor's office? Yes No
Do you offer a senior citizens discount of any sort? Yes No
If yes, what kind of discount is it (e.g. 20% off all drugs or $10 off all drugs)?________________
Is this pharmacy attached to a grocery store? Yes No
Is this pharmacy attached to a department store? Yes No
What are the pharmacy hours?

Supplemental Survey:

The following items are non-prescription items that you may carry. Please write the price that is regularly charged rather than any sale or discount that is offered that day. For items that you do not carry please write N/A in the column under price. If you do carry an item, but only have it in a different size or quantity please write N/A.

Non-Prescription Items	**Price**
60 plastic Band Aid Johnson & Johnson	
Bactine (first aid liquid) 4 fl oz.	
Generic Hydrogen Peroxide 16 oz.	
Generic Isopropyl Alcohol 16 oz	
Generic Mineral Oil 16 oz	
Generic Witch Hazel 16 oz	
Vaseline petroleum jelly 3.75 oz	
Vaseline petroleum jelly 7.5 oz	
Imodium A-D 12 caplets	
Maalox Regular Strength 12 fl oz	
Pepcid AC 30 tabs	
Pepto Bismol 12 fl oz.	
Preperation H ointment 1 oz	
Prilosec OTC 14 tablets	
Rolaids Org. 150 tablets	
Tums Reg Strength. 96 tablets	
Afrin No Drip Org. 12 hr. Nasal Spray .5 oz	
Claritin 20 tablets - Non Drowsy 24 hr allergy loratadine 10mg/antihistamine	
NyQuil 10 fl oz.	
Sudafed 12 hr. 10 tablets	
Vicks 44 Cough Relief 4 fl oz	
Advil 100 tablets	
Aspercreme 3 oz.	
Bayer Org. Strength 100 tablets	
Excedrin X Strength 24 tablets	
ICY Hot 3.5 oz jar	
Motrin 100 tablets	
Tylenol Extra Strength 50 caplets	
EPT single PDQ (pregnancy test)	
Trojan ENZ lubricated 3 premium	
Compound W Liquid .31 Fl. Oz.	
Lamisil cream 12 grams	
Centrum Silver 100 ct.	
Ensure 6 pack 8 fl. oz. Cans	
Flintstones Complete 60 tablets	
One-A-Day Women's 100 tablets	
Opti-Free 12 fl oz. Rising, Disinfection, and Storage	
Slimfast 6 can 11 fl oz.	

APPENDIX B

PRICE DISPERSION MODELS WITH 23 CLASS VARIABLES

Table 15: Price Dispersion Models with 23 Class Variables.

	Price Dispersion excluding Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	0.0446	0.0411	0.0240	0.0346
	(0.1475)	(0.0503)	(0.1359)	(0.0447)
Brand	-4.1032**	-1.6417***	-5.2371***	-2.2515***
	(1.7215)	(0.6181)	(1.6652)	(0.6033)
Brand with Substitutes	4.4730***	1.7254***	5.8577***	2.3342***
	(1.7092)	(0.5866)	(1.8459)	(0.6459)
Number of Substitutes	-0.0372**	-0.0124**	-0.0194	-0.0070
	(0.0170)	(0.0060)	(0.0170)	(0.0058)
Average Cost	0.1959***	0.0706***	0.1625***	0.0614***
	(0.0237)	(0.0084)	(0.0229)	(0.0080)
Number of Manufacturers	0.2243	0.0731	0.2028	0.0726
	(0.1864)	(0.0640)	(0.1873)	(0.0647)
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Constant	4.1382	1.2921	5.6642	1.7578
	(5.8934)	(1.7140)	(5.2414)	(1.4912)
Observations	370	370	370	370
R-squared	0.4372	0.4510	0.3588	0.3849

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs.

Table 16: Price Dispersion Models with 23 Class Variables.

	Price Dispersion including Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	0.0446	0.0411	0.0240	0.0346
	(0.1470)	(0.0503)	(0.1345)	(0.0441)
Brand	-4.1032**	-1.6417***	-5.2371***	-2.2515***
	(1.7155)	(0.6119)	(1.6352)	(0.5930)
Brand with Substitutes	4.4730**	1.7254***	5.8577***	2.3342***
	(1.7464)	(0.5904)	(1.8034)	(0.6250)
Number of Substitutes	-0.0372**	-0.0124**	-0.0194	-0.0070
	(0.0170)	(0.0061)	(0.0166)	(0.0058)
Average Cost	0.1959***	0.0706***	0.1625***	0.0614***
	(0.0239)	(0.0083)	(0.0222)	(0.0077)
Number of Manufacturers	0.2243	0.0731	0.2028	0.0726
	(0.1862)	(0.0627)	(0.1852)	(0.0631)
Percent of Individuals in Poverty	-0.2448	-0.5911**	-0.4824	-0.6006**
	(0.6926)	(0.2698)	(0.7434)	(0.2829)
Percent of Population over 65	-0.5818	-0.6796**	-0.3918	-0.5627*
	(0.7419)	(0.2848)	(0.7907)	(0.2973)
Distance to Canada	-0.1344	-0.1757*	-0.2442	-0.1893**
	(0.2361)	(0.0917)	(0.2502)	(0.0956)
Constant	18.9735	23.8289**	24.2636	23.1937**
	(26.3936)	(10.0593)	(27.9325)	(10.4295)
Observations	370	370	370	370
R-squared	0.4444	0.4646	0.3716	0.3980

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs.

Table 17: Price Determination Models with 23 Class Variables.

Variable	Drug Effects	Drug and Pharmacy Effects	Drug, Pharmacy, and City Effects	Drug, Pharmacy, City and Drug & Pharmacy Effects
Purchase Frequency	-0.2867***	-0.2893***	-0.2897***	-0.2901***
	(0.0698)	(0.0665)	(0.0663)	(0.0657)
Brand	25.1371***	25.1675***	23.1833***	23.1962***
	(1.4099)	(1.3964)	(1.7131)	(1.7023)
Brand with Substitutes	-6.6061***	-6.6898***	-6.2766***	-6.3214***
	(0.8635)	(0.8377)	(1.2132)	(1.2059)
Number of Substitutes	-0.0153	-0.0156	-0.0155	-0.0155
	(0.0132)	(0.0131)	(0.0131)	(0.0132)
Average Cost	1.0755***	1.0755***	1.0756***	1.0756***
	(0.0206)	(0.0203)	(0.0202)	(0.0201)
Number of Manufacturers	1.3218***	1.3234***	1.3239***	1.3255***
	(0.1032)	(0.1019)	(0.1017)	(0.1014)
Percent of Individuals in Poverty	-	-	-	0.8420
				(0.5478)
Percent of Population over 65	-	-	-	0.8888*
				(0.5366)
Distance to Canada	-	-	-	0.0769
				(1.3222)
Distance to Canada^2	-	-	-	0.0037
				(0.0244)
Pharmacies per 1000 People	-	-	-	-7.8957
				(6.7125)
Chain*Brand	-	-	2.9825**	2.9765**
			(1.4338)	(1.4229)
Chain*Brand with Substitutes	-	-	-0.6393	-0.5911
			(1.3813)	(1.3772)
Constant	-14.1748***	-18.9199***	-17.7856***	-38.8843
	(2.3371)	(5.7690)	(5.7645)	(26.0507)
Observations	2775	2775	2775	2775
R-squared	0.9118	0.9150	0.9152	0.9160

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs.

Table 18: Description of the 23 Class Variables.

Class 1	Adrenergic agonists; Anorexiants; Amphetamines; Stimulants, central nervous system
Class 2	Analgesics, narcotic
Class 3	Analgesics, narcotic; Analgesics, non-narcotic; Nonsteroidal anti-inflammatory drugs
Class 4	Angiotensin converting enzyme inhibitors
Class 5	Antiadrenergics, beta blocking; Antiadrenergics, alpha blocking
Class 6	Antibiotics, penicillins; antibotics, macrolides; Antibiotics, cephalosporins; Antibiotics, quinolones; Antibiotics, lincosamides; Anti-infectives, topical; Anti-infectives, ophthalmic; Antibiotics, aminoglycosides; Anti-infectives, otic; Corticosteroids, otic; Keratolytics
Class 7	Anticoagulants
Class 8	Anticonvulsants;
Class 9	Antidepressants, serotonin specific reuptake inhibitors; Antidepressants, miscellaneous
Class 10	Antidiabetic agents; Biguanides
Class 11	Antiemetics/antivertigo; Antihistamines, H1; Antitussives; Decongestants, nasal; Phenothiazines
Class 12	Antifungals; Antifungals, topical; Dermatologics
Class 13	Antigout agents
Class 14	Antihyperlipidemics; HMG CoA reductase inhibitors
Class 15	Antipsychotics
Class 16	Antivirals
Class 17	Anxiolytics; Benzodiazepines; Relaxants, skeletal muscle; Sedatives/hypnotics
Class 18	Corticosteroids; Corticosteroids, inhalation; Anti-infectives, ophthalmic; Corticosteroids, ophthalmic;
Class 19	Diuretics, loop; Diuretics, thiazide and derivatives
Class 20	Gastrointestinals; Proton pump inhibitors
Class 21	Hormones/hormone modifiers; Thyroid agents
Class 22	Leucotriene antagonists/inhibitors
Class 23	Platelet inhibitors; (DROPPED DUMMY)

Drugs are categorized into 23 classes described above. Each class variable is a binary variable.

APPENDIX C

PRICE DETERMINATION MODELS

The price determination model is estimated using the variables described in chapter 5 for the vectors $\underline{t}_i$, $\underline{u}_j$, and $\underline{v}_k$, and also the interaction terms, *Chain*Brand* and *Chain*Brand with Substitutes*; that is:

$$\begin{aligned} &\textit{Price Determination Model (1):}\ \ PL_{ijk} = \alpha_0 + \alpha_1\,\textit{Purchase Frequency}_i + \\ &\alpha_2\,\textit{Brand}_i + \alpha_3\,\textit{Brand with Substitutes}_i + \alpha_4\,\textit{Number of Substitutes}_i + \\ &\alpha_5\,\textit{Average Cost}_i + \alpha_6\,\textit{Number of Manufacturers}_i + \\ &\alpha_7\,\textit{Non-Prescription Items Missing}_k + \alpha_8\,\textit{Delivery}_k + \alpha_9\,\textit{Free Delivery}_k + \\ &\alpha_{10}\,\textit{Chain}_k + \alpha_{11}\,\textit{Hospital}_k + \alpha_{12}\,\textit{Grocery}_k + \alpha_{13}\,\textit{Department}_k + \alpha_{14}\,\textit{Hours Open}_k + \\ &\alpha_{15}\,\textit{Open Saturdays}_k + \alpha_{16}\,\textit{Open Sundays}_k + \textstyle\sum_{a=17}^{25} \alpha_a\,\textit{Primary Wholesaler}_{ka} + \\ &\textstyle\sum_{b=26}^{30} \alpha_b\,\textit{Secondary Wholesaler}_{kb} + \alpha_{31}\,\textit{Percent of Individuals in Poverty}_j + \\ &\alpha_{32}\,\textit{Percent of Population over 65}_j + \alpha_{33}\,\textit{Distance to Canada}_j + \\ &\alpha_{34}\,\textit{Distance to Canada}^2_j + \alpha_{35}\,\textit{Pharmacies per 1000 People}_j + \\ &\alpha_{36}\,\textit{Chain* Brand}_{ik} + \alpha_{37}\,\textit{Chain*Brand with Substitutes}_{ik} + \varepsilon_{ijk} \end{aligned}$$

This model is then re-estimated by including the drug class categorical variables that account for differences in intended use; that is:

$$\begin{aligned} &\textit{Price Determination Model (2):}\ \ PL_{ijk} = \alpha_0 + \alpha_1\,\textit{Purchase Frequency}_i + \\ &\alpha_2\,\textit{Brand}_i + \alpha_3\,\textit{Brand with Substitutes}_i + \alpha_4\,\textit{Number of Substitutes}_i + \\ &\alpha_5\,\textit{Average Cost}_i + \alpha_6\,\textit{Number of Manufacturers}_i + \\ &\alpha_7\,\textit{Non-Prescription Items Missing}_k + \alpha_8\,\textit{Delivery}_k + \alpha_9\,\textit{Free Delivery}_k + \\ &\alpha_{10}\,\textit{Chain}_k + \alpha_{11}\,\textit{Hospital}_k + \alpha_{12}\,\textit{Grocery}_k + \alpha_{13}\,\textit{Department}_k + \alpha_{14}\,\textit{Hours Open}_k + \\ &\alpha_{15}\,\textit{Open Saturdays}_k + \alpha_{16}\,\textit{Open Sundays}_k + \textstyle\sum_{a=17}^{25} \alpha_a\,\textit{Primary Wholesaler}_{ka} + \\ &\textstyle\sum_{b=26}^{30} \alpha_b\,\textit{Secondary Wholesaler}_{kb} + \alpha_{31}\,\textit{Percent of Individuals in Poverty}_j + \\ &\alpha_{32}\,\textit{Percent of Population over 65}_j + \alpha_{33}\,\textit{Distance to Canada}_j + \\ &\alpha_{34}\,\textit{Pharmacies per 1000 People}_j + \alpha_{35}\,\textit{Chain* Brand}_{ik} + \\ &\alpha_{36}\,\textit{Chain*Brand with Substitutes}_{ik} + \textstyle\sum_{c=37}^{53} \alpha_c\,\textit{Class}_{ic} + \varepsilon_{ijk} \end{aligned}$$

APPENDIX D

RANDOM EFFECTS MODELS

Table 19: Random Effects Models – Price Dispersion.

	Classes as Index excluding Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	-0.2681**	-0.0823*	-0.2259*	-0.0727*
	(0.1229)	(0.0435)	(0.1211)	(0.0435)
Brand	-0.6935	-0.3438	-2.8085**	-1.1888**
	(1.4379)	(0.5072)	(1.3740)	(0.4897)
Brand with Substitutes	-0.5554	-0.1583	1.4725	0.6585
	(1.5156)	(0.5346)	(1.4473)	(0.5157)
Number of Substitutes	-0.0586**	-0.0194**	-0.0404*	-0.0136*
	(0.0236)	(0.0083)	(0.0226)	(0.0080)
Average Cost	0.1080***	0.0403***	0.0933***	0.0365***
	(0.0121)	(0.0043)	(0.0118)	(0.0042)
Number of Manufacturers	0.2539	0.0932	0.2229	0.0937*
	(0.1641)	(0.0578)	(0.1555)	(0.0553)
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Constant	11.6892***	4.1807***	11.4952***	4.0278***
	(1.9429)	(0.6870)	(1.8899)	(0.6773)
Observations	370	370	370	370
R-squared within	0.2363	0.2459	0.1815	0.2057
R-squared between	0.4233	0.4476	0.2999	0.3458
R-squared overall	0.2567	0.2714	0.1827	0.2036
Rho	0.0292	0.0309	0.0425	0.0473

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

Table 20: Random Effects Models – Price Dispersion.

	Classes as Index including Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	-0.2673**	-0.0810*	-0.2239*	-0.0716*
	(0.1229)	(0.0435)	(0.1209)	(0.0434)
Brand	-0.6943	-0.3457	-2.8111**	-1.1913**
	(1.4369)	(0.5048)	(1.3695)	(0.4876)
Brand with Substitutes	-0.5486	-0.1478	1.4907	0.6673
	(1.5145)	(0.5320)	(1.4424)	(0.5135)
Number of Substitutes	-0.0585**	-0.0193**	-0.0403*	-0.0136*
	(0.0236)	(0.0083)	(0.0225)	(0.0080)
Average Cost	0.1080***	0.0404***	0.0935***	0.0366***
	(0.0121)	(0.0043)	(0.0118)	(0.0042)
Number of Manufacturers	0.2539	0.0931	0.2230	0.0936*
	(0.1639)	(0.0575)	(0.1549)	(0.0550)
Percent of Individuals in Poverty	-0.2448	-0.5911*	-0.5538	-0.6232**
	(0.8612)	(0.3016)	(0.8083)	(0.2864)
Percent of Population over 65	-0.5818	-0.6796**	-0.4654	-0.5856*
	(0.9176)	(0.3213)	(0.8612)	(0.3051)
Distance to Canada	-0.1344	-0.1757*	-0.2630	-0.1955**
	(0.2861)	(0.1002)	(0.2685)	(0.0951)
Constant	26.5094	26.6948**	32.6105	26.2529**
	(32.3280)	(11.3212)	(30.3449)	(10.7523)
Observations	370	370	370	370
R-squared within	0.2440	0.2614	0.1940	0.2196
R-squared between	0.4229	0.4460	0.2989	0.3444
R-squared overall	0.2639	0.2847	0.1949	0.2169
Rho	0.0296	0.0324	0.0437	0.0487

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

Table 21: Random Effects Models – Price Dispersion.

	Cities as Index excluding Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	-0.3385*** (0.0979)	-0.1121*** (0.0349)	-0.2941*** (0.0920)	-0.1089*** (0.0335)
Brand	-0.7867 (1.3637)	-0.3612 (0.4864)	-2.9230** (1.2824)	-1.1795** (0.4661)
Brand with Substitutes	-1.1997 (1.4406)	-0.4077 (0.5138)	0.5610 (1.3547)	0.2924 (0.4923)
Number of Substitutes	-0.0626*** (0.0217)	-0.0213*** (0.0077)	-0.0437** (0.0204)	-0.0157** (0.0074)
Average Cost	0.1014*** (0.0110)	0.0379*** (0.0039)	0.0861*** (0.0103)	0.0334*** (0.0038)
Number of Manufacturers	0.2530 (0.1593)	0.0949* (0.0568)	0.2212 (0.1498)	0.0974* (0.0544)
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Constant	13.0994*** (1.9940)	4.7244*** (0.6615)	12.9168*** (1.9491)	4.6737*** (0.6225)
Observations	370	370	370	370
R-squared within	0.2699	0.2806	0.1967	0.2130
R-squared between	0.0000	-	-	-
R-squared overall	0.2587	0.2738	0.1856	0.2082
Rho	0.0555	0.0276	0.0713	0.0211

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

Table 22: Random Effects Models – Price Dispersion.

	Cities as Index including Market Characteristics			
Variable	**Range**	**Standard Deviation**	**Residual Range**	**Residual Standard Deviation**
Purchase Frequency	-0.3385***	-0.1121***	-0.2941***	-0.1089***
	(0.0979)	(0.0349)	(0.0920)	(0.0335)
Brand	-0.7867	-0.3612	-2.9230**	-1.1795**
	(1.3637)	(0.4864)	(1.2824)	(0.4661)
Brand with Substitutes	-1.1997	-0.4077	0.5610	0.2924
	(1.4406)	(0.5138)	(1.3547)	(0.4923)
Number of Substitutes	-0.0626***	-0.0213***	-0.0437**	-0.0157**
	(0.0217)	(0.0077)	(0.0204)	(0.0074)
Average Cost	0.1014***	0.0379***	0.0861***	0.0334***
	(0.0110)	(0.0039)	(0.0103)	(0.0038)
Number of Manufacturers	0.2530	0.0949	0.2212	0.0974*
	(0.1593)	(0.0568)	(0.1498)	(0.0544)
Percent of Individuals in Poverty	-0.2448	-0.5911	-0.5541	-0.6235
	(3.6136)	(0.7157)	(3.6896)	(0.5892)
Percent of Population over 65	-0.5818	-0.6796	-0.4658	-0.5859
	(3.8500)	(0.7625)	(3.9310)	(0.6278)
Distance to Canada	-0.1344	-0.1757	-0.2632	-0.1956
	(1.2003)	(0.2377)	(1.2256)	(0.1957)
Constant	27.9347	27.2612	34.0816	26.9285
	(135.4256)	(26.8255)	(138.2732)	(22.0878)
Observations	370	370	370	370
R-squared within	0.2699	0.2806	0.1967	0.2130
R-squared between	0.1733	0.5609	0.2205	0.6120
R-squared overall	0.2659	0.2874	0.1980	0.2218
Rho	0.1839	0.0567	0.2114	0.0392

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

Table 23: Random Effects Models - Price Determination Models.

	Drug Effects		Drug and Pharmacy Effects	
Variable	**Class**	**City**	**Class**	**City**
Purchase Frequency	-0.1966* (0.1075)	-1.0965*** (0.0880)	-0.2414** (0.1083)	-1.0961*** (0.0877)
Brand	25.1607*** (1.0614)	39.7821*** (1.2264)	26.2640*** (1.0721)	39.7897*** (1.2228)
Brand with Substitutes	-8.5564*** (1.1335)	-34.9593*** (1.3024)	-10.4431*** (1.1430)	-34.9992*** (1.2989)
Number of Substitutes	-0.0322* (0.0164)	-0.0802*** (0.0195)	-0.0356** (0.0167)	-0.0804*** (0.0195)
Average Cost	1.0308*** (0.0118)	0.6767*** (0.0099)	1.0012*** (0.0117)	0.6767*** (0.0099)
Number of Manufacturers	1.1086*** (0.1099)	1.0435*** (0.1435)	1.1074*** (0.1116)	1.0426*** (0.1431)
Chain*Brand	-	-	-	-
Chain*Brand with Substitutes	-	-	-	-
Percent of Individuals in Poverty	-	-	-	-
Percent of Population over 65	-	-	-	-
Distance to Canada	-	-	-	-
Distance to Canada^2	-	-	-	-
Pharmacies per 1000 People	-	-	-	-
Constant	-22.9997*** (3.3599)	6.4280*** (1.6268)	(dropped)	-6.3831 (10.2791)
Observations	2775	2775	2775	2775
R-squared within	0.8386	0.8083	0.8436	0.8107
R-squared between	0.6909	0.0266	0.7002	0.5914
R-squared overall	0.7570	0.8072	0.7652	0.8104
Rho	0.3532	0.0032	0.1968	0.0000

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

Table 24: Random Effects Models - Price Determination Models.

	Drug, Pharmacy, Drug & Pharmacy Effects		Drug, Pharmacy, Drug & Pharmacy, and City Effects	
Variable	**Class**	**City**	**Class**	**City**
Purchase Frequency	-1.0966**	-1.0966***	-1.0964***	-1.0964***
	(0.0877)	(0.0877)	(0.0876)	(0.0876)
Brand	37.8457***	37.8457***	37.8593***	37.8593***
	(1.8229)	(1.8229)	(1.8211)	(1.8211)
Brand with Substitutes	-34.1385***	-34.1385***	-34.1833***	-34.1833***
	(2.2449)	(2.2449)	(2.2427)	(2.2427)
Number of Substitutes	-0.0803***	-0.0803***	-0.0803***	-0.0803***
	(0.0195)	(0.0195)	(0.0195)	(0.0195)
Average Cost	0.6768***	0.6768***	0.6767***	0.6767***
	(0.0099)	(0.0099)	(0.0099)	(0.0099)
Number of Manufacturers	1.0426***	1.0426***	1.0433***	1.0433***
	(0.1431)	(0.1431)	(0.1429)	(0.1429)
Chain*Brand	2.9291	2.9291	2.9230	2.9230
	(2.0371)	(2.0371)	(2.0350)	(2.0350)
Chain*Brand with Substitutes	-1.3019	-1.3019	-1.2571	-1.2571
	(2.7180)	(2.7180)	(2.7154)	(2.7154)
Percent of Individuals in Poverty	-	-	0.8079	0.8079
			(0.8179)	(0.8179)
Percent of Population over 65	-	-	0.8856	0.8856
			(0.8031)	(0.8031)
Distance to Canada	-	-	0.1712	0.1712
			(1.9731)	(1.9731)
Distance to Canada^2	-	-	0.0021	0.0021
			(0.0364)	(0.0364)
Pharmacies per 1000 People	-	-	-6.8475	-6.8475
			(10.0395)	(10.0395)
Constant	(dropped)	3.9415	(dropped)	-20.1929
		(11.4594)		(39.0743)
Observations	2775	2775	2775	2775
R-squared within	0.7704	0.8108	0.7718	0.8111
R-squared between	0.8503	0.5920	0.8502	0.9822
R-squared overall	0.8106	0.8106	0.8113	0.8113
Rho	0.0000	0.0000	0.0000	0.0000

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with Random Effects GLS model. Both models exclude dummy variables for different categorized drugs. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for 23 different categorized drugs. Class models have the classes as the group. City models have the cities as the group.

APPENDIX E

PHARMACY HETEROGENEITY VARIABLES

Table 25: Pharmacy Effect Variables.

Non-Prescription Items Missing	Of the 38 non-prescription (NP) items surveyed, the number of NP items that the pharmacy does not carry.
Delivery	Dummy Variable. If the pharmacy has a delivery service = 1.
Free Delivery	Dummy Variable. If the pharmacy has a free deliver service = 1.
Chain	Dummy Variable. If the pharmacy is part of a chain =1.
Hospital	Dummy Variable. If the pharmacy is within a mile of a hospital =1.
Grocery	Dummy Variable. If the pharmacy is attached to a grocery store = 1
Department	Dummy Variable. If the pharmacy is attached to a department store = 1
Hours Open	Total hours a pharmacy is open.
Open Saturdays	Dummy Variable. If the pharmacy is open on Saturdays =1.
Open Sundays	Dummy Variable. If the pharmacy is open on Sundays =1.

Table 26. Pharmacy Heterogeneity Variables on Price Level.

	Price Determination Model: No Class		
Variable	**Drug and Pharmacy Effects (2)**	**Drug, Pharmacy, and Drug & Pharmacy Effects (3)**	**Drug, Pharmacy, Drug & Pharmacy, and City Effects (4)**
Non-Prescription Items Missing	0.0700	0.0700	0.0233
	(0.1417)	(0.1419)	(0.1726)
Delivery	-0.1296	-0.1261	-4.1320
	(3.4089)	(3.4074)	(3.9871)
Free Delivery	-2.3749	-2.3768	1.9207
	(3.3015)	(3.2989)	(4.0358)
Chain	1.0656	-0.5478	0.3589
	(2.4354)	(2.4299)	(3.1186)
Hospital	-3.4879**	-3.4881**	-1.0784
	(1.7403)	(1.7401)	(2.3923)
Grocery	0.7889	0.7882	1.5803
	(1.3077)	(1.3082)	(1.8897)
Department	-2.4654	-2.4678	-1.6267
	(1.8752)	(1.8755)	(2.6262)
Hours Open	0.0623	0.0624	-0.0482
	(0.1271)	(0.1271)	(0.1488)
Open Saturdays	4.5957	4.5572	3.2577
	(3.8631)	(3.8629)	(4.3251)
Open Sundays	-5.6362*	-5.6354*	-3.6225
	(3.0769)	(3.0771)	(3.6008)
Observations	2775	2775	2775
R-squared	0.8104	0.8106	0.8113

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.

Table 27. Pharmacy Heterogeneity Variables on Price Level.

	Price Determination Model: Class		
Variable	**Drug and Pharmacy Effects (2)**	**Drug, Pharmacy, and Drug & Pharmacy Effects (3)**	**Drug, Pharmacy, Drug & Pharmacy, and City Effects (4)**
Non-Prescription Items Missing	0.0661	0.0660	0.0184
	(0.0962)	(0.0965)	(0.1174)
Delivery	-0.5474	-0.5530	-4.6827*
	(2.2919)	(2.2895)	(2.6883)
Free Delivery	-1.9707	-1.9634	2.3932
	(2.2298)	(2.2266)	(2.7376)
Chain	1.4458	-0.3055	0.7841
	(1.6660)	(1.7922)	(2.2109)
Hospital	-3.5857***	-3.5859***	-1.2267
	(1.1840)	(1.1834)	(1.6332)
Grocery	0.7634	0.7621	1.5013
	(0.8804)	(0.8806)	(1.2661)
Department	-2.4792**	-2.4820**	-1.7146
	(1.2319)	(1.2317)	(1.7605)
Hours Open	0.0665	0.0666	-0.0482
	(0.0857)	(0.0856)	(0.0998)
Open Saturdays	4.8358*	4.8097*	3.5905
	(2.5940)	(2.5901)	(2.9126)
Open Sundays	-5.9521***	-5.9522***	-4.0123*
	(2.0899)	(2.0898)	(2.4150)
Observations	2775	2775	2775
R-squared	0.9133	0.9134	0.9142

The estimated coefficient is presented above with the standard error in parenthesis below it. All regressions are done with robust standard errors. ***, **, * show significance at 1%, 5%, and 10% levels, respectively. Class models include dummy variables for sixteen different categorized drugs.