Bachelor's Programme in 2024

Price dispersion in the used-car market

Aapo Joensuu

Bachelor's thesis
Spring 2024

Aalto-yliopisto
Aalto-universitetet
Aalto University

Author Aapo Joensuu

Title of thesis Price dispersion in the used-car market

Programme Bachelor of Science in Economics and Business Administration

Major Economics

Thesis supervisors Mitri Kitti & Tanja Saxell

Thesis advisor Prottoy Akbar

Date 21.05.2024 **Number of pages** 28 **Language** English

Abstract

What is the mechanism that produces variation in prices for the same good? Some economic theories propose that incomplete, asymmetric information between the buyer and the seller could capture this variation the best. Most notably, I discuss the applicability of information-driven models (e.g., Burdett and Judd, 1983; MacMinn, 1980; Reinganum, 1979) and imperfect information as a source of price dispersion in the used-car market. Another fundamental talking point overlapping with price dispersion has been the concept of price discrimination which implies a systematic effort to charge different consumer segments different prices for the same good. The literature review section seeks to shed light on the most prominent theories and empirical findings on price dispersion in various markets and applies that knowledge to the used-car market which has unique characteristics that make valuation mechanism for the good quite tricky. Additionally, I utilize that knowledge in the empirical work about the used-car market in Finland and work to distinguish some of the key components that influence price variation in used cars.

Keywords Asymmetric information, market power, price dispersion

Contents

1 Introduction

Pricing is a fundamental component in understanding buyer and seller behaviour in various markets. For sellers, knowing what price to charge for a given product or service determines, to a large extent, the profitability and sensibleness of their businesses. However, sellers do not typically set their prices in unison nor charge just a one price themselves, even if the differences between the products were unnoticeable. Past empirical research suggests that the "law of one price" does not hold in the long run (e.g., Ardeni, 1989; Haskel and Wolf, 2001; Isard, 1977) which leads to the obvious conclusion that we are expected to see some variation in prices in a particular market. Such variation, also known as price dispersion, influences buyer's behaviour as well as their spending decisions. From a market's perspective, the magnitude and range of price dispersion is a good measure of its efficiency.

This text consists of literature review and an elementary and descriptive empirical work on price dispersion in the used-car market. The literature review sections discuss the two important sources of price dispersion: information asymmetry and price discrimination, while the empirical work attempts to capture those as well as other reasons for price dispersion in the Finnish used-car market. Most notably, the body of this thesis relies heavily on George Akerlof's paper, *The Market for "Lemons": Quality Uncertainty and the Market Mechanism* (1970) related to information asymmetry and the adverse selection in the market for used cars.

Price dispersion in the automobile market is a well-studied phenomenon. The differences in prices seem to be amplified across countries. Before the introduction of economic and monetary union of the European Union (EMU), the pre-tax prices of some cars varied by over 90 % across selected European countries (Verboven, 1996). Goldberg and Verboven (2001) found solid evidence of significant price dispersion between selected European countries. These observations were based on panel data on car prices in five major European markets (Belgium, France, Germany, Italy, and United Kingdom). Between 1980-1993, the price dispersion for a quality adjusted car was as high as 30 % of the car price against the average price in these selected countries. Some of these differences in prices were attributed to differences in local costs and some to variation in markups where the latter is a clear sign of deliberate price dispersion, that is, price discrimination. It is to be noted, however, that price dispersion could arise when prices interact with exchange rates. The interplay, namely correlation, between nominal exchange rate volatility and price dispersion has been studied ex-

tensively. Naturally, high exchange rate differentials imply differences in production costs, import costs and purchasing power which could result in price dispersion. Regardless, price dispersion cannot fully be explained by these kinds of macroeconomic forces.

After the inauguration of the European Union, these regional price disparities diminished and converged (Goldberg et al., 2004), as the researchers and policymakers predicted. These predictions stemmed from a set of assumptions where the free flow of goods, similar regulation and in most cases the common currency, Euro, would heavily restrict cross-border arbitrage, which is way for firms to differentiate, to charge different prices in different markets. Despite the large magnitude of market integration and regulatory uniformity in EU, the convergence of car prices stopped in the year 2003 (Dvir and Sasser, 2017). Dvir and Sasser (2017) extended the analysis of cross-border price dispersion by exploring the impact of different customer preferences and systematic price differentiation on car price dispersion. One of the key findings from that paper states that majority of the price dispersion not explained by common economic principles, such as exchange rates, is attributable to systematic price differentiation, amplified by regional heterogeneity in preferences, managed by firms. This concludes the brief and broad overview of evolution of price dispersion in the European car market. The macroeconomic themes and interplay across countries are not that relevant given the narrower scope of this thesis but give an important insight into the European car market.

Fundamentally, Finnish automobile market is characterized by high volume of transactions and large number of sellers which makes it a sensible reference market for the purposes of this thesis. The intensity of the car market makes the industry important from economics point of view. Large number of observations makes it easier to understand and evaluate how the various economic factors effect buyers' and sellers' decisions. Since the car is usually the most expensive tradeable good that households purchase, one could think that the prices are also intensely scrutinized. This thesis attempts to clarify whether consumers are informed, uninformed or something in-between with respect to those prices. According to data from 2023 provided by Finnish Information Centre of Automobile Sector (2024), 679 406 passenger cars were sold in Finland, of which 87,1 % were sold as used and 12,9 % were new registrations. Similar numbers were found in previous research in the used-car market of the United States (Gavazza et al., 2014). Thus, the large market share of the Finnish used-car market allows for a meaningful and representative study.

The thesis continues with a literature review, illustrating different sources of price dispersion and explaining the economic theory behind these phe-

nomena. Section 3 is devoted to empirical work where I measure the magnitude of price dispersion in the Finnish car market using the data provided by Statistics Finland. Section 4 illustrates and discusses the results. Section 5 concludes.

2 Sources of price dispersion

Many supply and demand models rely on the assumption that for identical products sold in competitive markets where the same currency is used, the same price would always be charged. However, extensive research and real-life data deviate from this assumption (see e.g. Dahlby and West, 1986; D'Haultfœuille et al., 2018; Kaplan and Menzio, 2015). In some markets the prices for a homogenous good do not converge to a singular value even in the long run. The Law of One Price (LOOP) states that those deviations would eventually be eliminated along with the arbitrage opportunities arising from price disparities between the sellers. In another words, if some market participants recognize that an identical product is cheaper in some region A, they would gain risk-free profit from selling the good in the more expensive region B. According to LOOP, this would ignite a positive demand shock for the product sold in A which would make the price converge to an equilibrium between the regions.

Price dispersion is a pervasive economic phenomenon in many retail markets. The disparity between prices, depending on the context, is usually indicated by the range of prices, variation of price distribution or standard deviation of price distribution. The existence of price dispersion usually involves some kind of deliberate effort to discriminate between buyers. Doing so, sellers can arrange different kinds of pricing schemes to make more profits. In the used car market, this kind of discrimination is common due to the special feature of some secondary markets where the car prices are usually negotiated individually. Price discrimination will be discussed in detail in section 2.1, for example using the teachings of Varian (1989).

Additionally, section 2.1 considers the buyer-specific attributes that influence the selling prices in the used-car market. Extensive literature has discussed those characteristics and the correlation between those characteristics and price dispersion. For example, race (Charles et al., 2008), gender (Ayres and Siegelman, 1995) or buyer's location (Goldberg and Verboven, 2001) have been shown to have varying impact, ranging from insignificant to meaningful, on the price distribution for a homogenous good. Usually, these differing demographic characteristics are prone to price discrimination and provide interesting talking points about fairness.

Another source of price dispersion is related to information economics. Specifically, imperfect, or asymmetric information between buyers and sellers plays an important role in explaining some of the price dispersion in a market for durable goods. In the Bertrand competition model, identical firms sell a homogenous good for a given price. A buyer receives all of price quotes and buys the product that is priced the lowest. This naturally incentivises firms to set their prices just below the former lowest price to capture the whole market. This process of undercutting goes on until all the firms set their prices at their (identical) marginal cost. The model relies on several extreme assumptions, but one assumption that in not consistent with empirical findings states that the firms have access to every price quote the buyers receive. In another words, the model exhibits perfect information symmetry between the sellers which inevitably leads to a situation where the firms sell the good for a price equal to their marginal cost. However, in many industries, including the used car market, these price quotes and distributions are hard to obtain due to costs and the absence of sufficient information which results in information asymmetry between the counterparties. In section 2.2 Stiglitz's seminal work (1961) on information inefficiencies in various market and those search-theoretical models that have expanded upon it (e.g., Burdett and Judd, 1983; MacMinn, 1980; Reinganum, 1979) will be discussed thoroughly.

The last subsection of the literature review, 2.3, discusses how the online market differs from offline market with relation to price dispersion. From economist's point of view, one of the most important features of online markets is the opportunity to find the price range for a given product quite easily and essentially without any costs. One could assume that the lower search costs and the full knowledge of prices online would lead to lower price variation for a homogenous good or even converge towards a singular price. However, the research on this causal relationship provides conflicting results (e.g., Baye et al., 2004; Baylis and Perloff, 2002; Brynjolfsson and Smith, 2000).

2.1 Price discrimination

Price dispersion and price discrimination are very similar concepts as they both essentially denote variation in prices. Only the origin of the variation and the chain of events that lead to that endpoint are ambiguous. However, the endpoint of price discrimination is always price dispersion, but the existence of the latter does not necessarily imply the existence of the former. According to Varian (1989), for a firm to be able to discriminate between buyers, three assumptions must hold. The firm must have some influence

on the market by, for example, constraining the level of supply, and thus operating without being forced to set the same price as other firms. In a theoretical competitive market, firms act as price takers and every firm charges the same price as indicated by LOOP whereas firms with market power, in an imperfectly competitive market, can set higher prices that exceed the level of their marginal cost and thus increase their profits. The second assumption concerns the capability of identifying the distribution of prices the individual customers are willing to pay. If a firm has that ability, it can charge the maximum price that each customer is willing to pay and capture all of the customer surplus, that is, the willingness to pay (WTP) less the equilibrium price in a competitive market. Figure 1 illustrates the consumer and producer surpluses when a monopoly pricing scheme takes place in an imaginary market. Figure 2 shows how the whole consumer surplus is captured by a seller when the first-degree price discrimination scheme is used. However, since it is extremely costly to acquire such a large number of price quotes, first-degree price discrimination does not occur in its most ambitious form in a real-life setting. However, in the used-car market, the negotiating process can result in a price close to WTP. Finally, the firm must be able to prevent the buyers that receive the product at a discounted price from reselling the product to buyers with a higher WTP. This assumption is not realistic in a used-car market but is more commonly seen in markets where the good is intangible or consumed instantly.

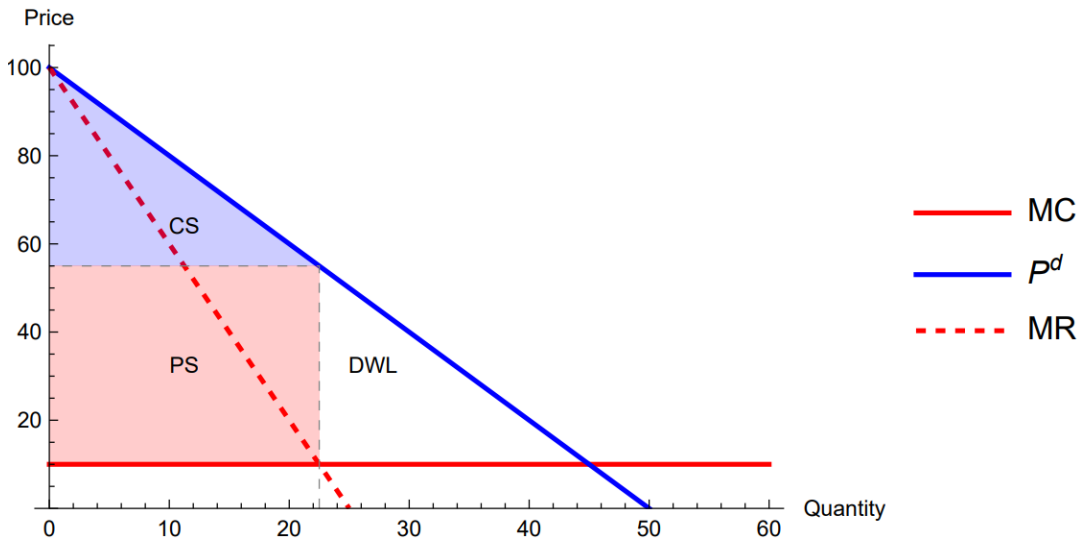

Figure 1. Supply and demand equilibrium under monopoly pricing. Consumer and producer surpluses and deadweight loss are denoted by CS, PS and DWL, respectively.

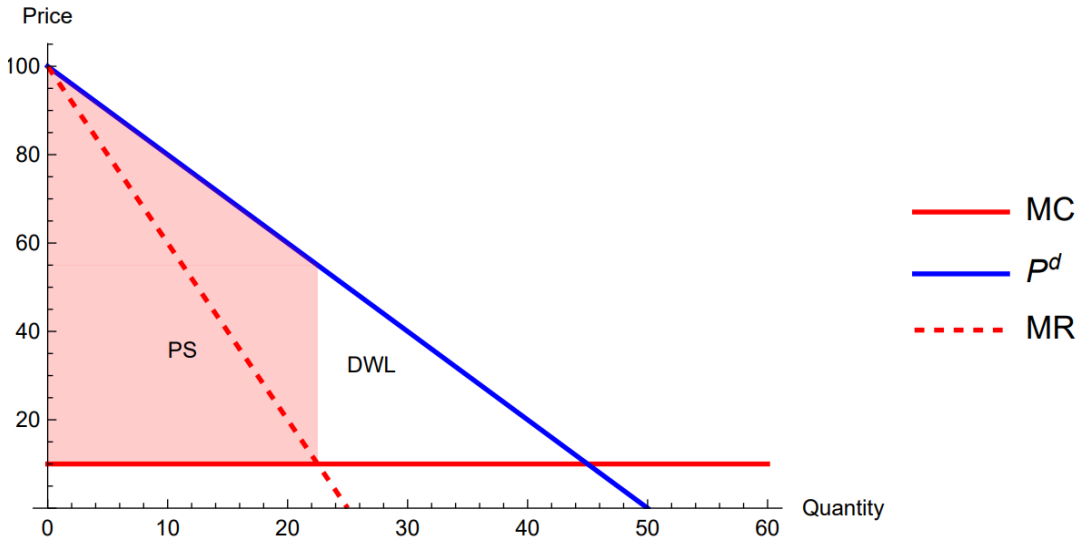

Figure 2. An example of first-degree price discrimination.

There exists number of definitions for price discrimination. In the context of price dispersion, one might want to look the range of prices or the standard deviation of the price distribution. However, price discrimination can also arise when the costs of offering certain goods or services are not equal. Stigler (1987) argues that price discrimination occurs when the ratio of price to the marginal production costs for two identical products are not equal. Alternatively, Phlips (1983) suggests that the absolute differences between price and marginal cost should be compared when assessing whether a firm is price discriminating or not. While these definitions best serve the intention of comparing prices of non-differentiated products or services in primary markets, there are also some cost variation in various secondary markets as well which can help to track down some of the variation in prices. For example, before selling a car, a used-car dealership must purchase the car. The most common option for a car dealership is to buy the car from an auction. Some cars are also purchased from trade-ins or from other dealerships. However, one can easily infer that the various strategies related to auctioning and negotiating become important as a source of costs for individual dealerships. Additionally, some used cars require maintaining or repairing and if the dealerships expect the additional work and costs nested in those procedures to not be significant enough compared to the better quality and price for a more appealing car, they will engage in those activities. Those procedures can create some cost variation which can result in moderate price dispersion.

In classifying the forms of price discrimination, I use the three classic categories presented by Pigou (1938). These three categories measure the firms'

ability to accurately know the WTPs assigned to individual consumers. When a firm engages in first-degree price discrimination, it knows the WTPs of every potential consumer. This way the firm can charge the maximum price from every customer, as previously discussed. Pigou does not see the first-degree price discrimination as a viable option in practice but rather suggests that the firm should segment the market into customer groups. Preferably, these groups should be similar in their WTP. This form of market segmentation is quite common and is called third-degree price discrimination. For example, students and children are eligible to discounts in most forms of public transportation in Finland. Second-degree price discrimination, a form of non-linear pricing, occurs when the prices vary with the quantity that is purchased. Usually, the relationship between price and quantity is inverse. Bundling and quantity discounts are examples of second-degree price discrimination. It is important to note that none of these perfectly capture the form and magnitude of price discrimination in the used-car market. Second-degree price discrimination can be ruled out since quantity discounts in these kinds of durable good markets are irrelevant to most consumers. Thus, one is expected to see a certain mix of both the first and third-degree price discrimination in the used-car market since acquiring information about the customers is imperfect and does not usually result in a scenario where firms want to segment the market into broad groups (indicated by the following passage).

In the used-car market, learning about buyer's characteristics is a key component in pricing since the deals are often negotiated individually. Sagl (2023) describes how firms apply buyer-specific information about demographics, such as gender, income, and race, in their pricing decisions in the secondary market for pickup trucks. One of the most informative findings regarding price dispersion is that 25 % of that dispersion is explained by those differences in demographics. Additionally, the firms that leveraged more sophisticated information beyond broad buyer attributes were able to increase their profits by 20 % compared to uniform pricing, that is, charging every buyer the same price. Third-degree price discrimination, that is, discriminating groups rather than individual buyers was shown to be inefficient from a sellers' perspective as it decreased the profits relative to uniform pricing. These findings highlight the desirability of price discrimination and use of consumer data for sellers in some used-car markets. It is to be noted, however, that the set of attributes observable to a used-car seller vary by geographical location and the results are not necessarily applicable to, for example, the Finnish used-car market. An extensive literature on the relationship between price discrimination and buyers' demographic features sees the relation as significant. (e.g., Ayres and Siegelman, 1995; Chandra et al., 2017). However, some studies have found contradictory results. (e.g., D'Haultfœuille et al., 2019). Despite the conflicting results, the

potential for third-degree or even first-degree discrimination can be seen as a significant feature and a potential source of price dispersion in the used-car market.

Despite the many attractive features of price discrimination, uniform pricing might be preferred in some instances. As discussed before, gathering sufficient information about the customers is necessary if a firm wants to engage in personalized pricing scheme. However, a great body of research suggests that information alone does not guarantee a successful outcome. Fairness, as most notably presented by Kahnemann et al. (1986), can play an important role in explaining the reluctancy towards differently prices for homogenous goods. Kahnemann illustrates how the behaviour of consumers constraints the firms' ability to set personalized prices. The prospect of antagonizing customers is also a fundamental element of Keynesian economics with relation to sticky prices. The theory states that firms are reluctant to increase or decrease their nominal prices as that could generate a sense of uncertainty and instability in their customers. Thus, price discrimination could be against the interests of sellers when there are clear signs of hostility towards price changes among customers. This kind of hostile behaviour could arise if a buyer wanted to buy a certain golf club for a given price and observed that her friend had purchased the same golf club for a lower price. Leibbrandt (2020) finds that many firms strategically avoid personalized pricing when the differences between their customers' WTP are low. According to the same study, one factor that significantly discourages some firms from price discriminating exists when the information is symmetric. The probability of a personalized pricing scheme drops enormously when a firm learns that the customers are aware of personalized pricing.

2.2 Asymmetric information

In his seminal paper, Akerlof (1970) considers a market where used cars are traded under information uncertainty. Sellers are assumed to know whether their cars are qualified as "peaches" or "lemons". Peaches are good quality cars and lemons are poor quality cars. However, buyers are not able to distinguish between peaches and lemons. Since there exist an informational asymmetry between the agents, the cars are traded at a price that indicates buyers' average valuation for a car knowing that q proportion of the cars produced are good and $(1 - q)$ proportion are bad cars. Eventually, sellers of above average quality cars are driven out of the market by sellers of bad quality cars. In the most extreme scenario, the whole market seizes to exist.

2.2.1 Search-theoretical models

Despite the imperfect information in the used-car market, the trade volumes are large, and good, well-maintained cars have not been driven out of the market. Nonetheless, the availability and perfectness of information constitutes a major source of price dispersion as indicated by many research papers and empirical examples (i.e., Janssen and Morage-Gonzalez, 2004; Stigler, 1961; Zhao, 2006). Stigler (1961) was one of the first to acknowledge the relationship between information and price dispersion. In his seminal paper *The Economics of Information* Stigler (1961, p.3) argues that the price dispersion in certain markets for homogenous goods in not completely attributable to differences in service. Instead, at least some of the dispersion could be explained by the differences in buyers' search strategies and costs. Since the time of Stigler's writing, economic literature on information and search costs has expanded considerably. The opportunity cost of time is relevant when defining the composition of search costs. For example, a customer wanting to purchase a used car incurs search costs when he, for example, loses leisure time, wages, or utility as the result of visiting various car dealerships. One of the central motives of the literature has been the rationalization of price dispersion with the use of search models. The buyers in those models make purchase decisions that align with the optimal solution of weighing the search cost against the benefit of sampling another, ideally lower price quote. The significant feature of search-theoretical models where the customers differ by their search efficiency is the fact that those customers that are disadvantageous relative to their search efficiency, i.e., those customers who have higher search costs, are also charged higher prices. At the same time, the dispersion allows some sellers with market power to price discriminate between low and high search cost customers if the sellers face inelastic demand from the more search-inefficient subset of the market (Salop, 1977). Burdett and Judd (1983) demonstrate that price dispersion can exist as an equilibrium state even with ex ante identical agents. The theoretical paper also states that given sufficiently low search costs c, a fraction θ of customers only sample one seller while the other customers sample two or more sellers. However, the model also presents an equilibrium where all firms charge the monopoly price when the search costs are sufficiently high.

A common way of dividing these search models is to decide whether the consumers use sequential or nonsequential search strategy. If a customer uses the former strategy, he will continue sampling the sellers one at a time as long as he finds a price that is lower (or equal) to his reservation price.

Given a price distribution $F(p)$ and assuming geometric price distribution the expected number of searches with a reservation price r, is

$$E[n] = \frac{1}{F(r)}$$ (Baye et al., 2006)

The latter strategy assumes that the consumer commits to n searches before the purchase decision and eventually pick the lowest offering. Clearly, sequential search is a viable option when the desirable price is found early on. In that case, the customer does not have to bear the costs of additional search. However, nonsequential search allows for quick information gathering. If a buyer was searching for a used car to commute to a remote location for work, ideally, she would want to see a list of the used cars rather than spend valuable timing visiting various dealerships one at a time. Price comparison websites, or "information clearinghouses" in economic literature, such as used-car price comparison website Nettiauto in Finland, allow for such speedy information gathering with negligible search costs. However, the increasing popularity of online retailing has not eliminated price variation in most markets. (Baye et al., 2006).

One important feature of these search models is the fact that the conclusions relative to price dispersion are highly sensitive to the assumptions used in those models. For example, MacMinn's (1980) search model relies on the assumption of non-sequential search. Additionally, the firms are not able to observe other firms' marginal costs and buyers have unit demand (as in most search models). The model arrives at three economically interesting conclusions. First, as in Burdett and Judd's (1983) model, sufficiently low search costs lead to dispersed price equilibrium. Second, the variance in firms' marginal costs amplifies price dispersion. Third, as the search costs decrease, the price dispersion increases. The third result is perhaps the most interesting finding of the three since it is intuitive to think that lower search costs would improve the perfectness of information and thus, make it easier for consumers to select the lowest price available which would incentivize high-price sellers to either lower the prices or exit the market if the marginal costs were too high. The inverse relationship is explained by the heterogenous marginal costs and increased competition due to lower search costs and consequently more sampling. Simply put, if the search costs are lower, customers sample more stores which in turn implies that firms have more competition. Since consumers are sampling more stores, firms might want to adjust and differentiate their prices relative to their new rivals. This results in a wider range of prices and more price dispersion than before. Reinganum's (1979) search model is quite similar to MacMinn's but uses sequential search. Reinganum comes to conclusion that, unlike in the non-sequential search model, search costs and price variation are not inversely related. In another words, lowering search costs would

lower the variation in prices. This emphasizes how differently the reduction in search costs affects price dispersion depending on the model.

2.2.2 Clearinghouse models

Albeit giving insights to pricing dynamics in varying market conditions, the search-theoretical models are limited in certain market environments. The applicability of those models is greater in situations where consumer do not have immediate access to all price information of a given good. As discussed before, information clearinghouses fill that void by making some customers more informed about the range of prices charged by different sellers. Information clearinghouses are particularly relevant when consumers compare prices of a durable good, usually but not always such where even small price differences constitute a major expenditure. Thus, examining price comparison websites, such as Nettiauto, which was a market leader in the Finnish used-car market in 2020 (AIM Group, 2020), becomes economically important in the context of used-car market. Luckily, economic literature has expanded the knowledge of imperfect information by including information clearinghouses in search models. Most of these models share similar assumptions about the market participants (Baye et al., 2006). In this general clearinghouse model developed by Baye et al., (2006) firms are not obliged to share price information via the clearinghouse. Firms also incur costs, equal to ϕ when posting their prices through the intermediary. Consumers have unit demand with WTP of v. However, not all consumers observe prices using the clearinghouse. A certain number $N > 0$ of the consumers gets the list of prices from the clearinghouse and if the lowest price does not exceed v, buys the lowest-priced product. If the lowest price is higher than v, the consumer observes one price at random and if the product is priced lower than v, buys it. Otherwise, the consumer does not buy anything. If some portion $qN > 0$ of the consumers make the purchase or $\phi > 0$ (but low enough to warrant a profitable sale by a firm), the general model results in equilibrium price dispersion (Baye et al., 2006). Again, this highlights the fact that imperfect information can constitute a significant source of price dispersion in the Finnish used-car market where information clearinghouses are prevalent.

In some clearinghouse models, consumers vary in their level of informedness. In the Varian model (1980), I number of consumers are "informed" and the mass M are "uniformed consumers". In another words, some consumers, denoted by M, choose not to acquire or are not capable of acquiring relevant price information while a mass I are fully informed about the range of prices for a given product. For instance, some people use price comparison websites and some do not. Clearly, this is not entirely realistic in the

real world since most people are not fully informed nor uninformed about the selection of prices. However, for the sake of a relatively simple demonstration of equilibrium price dispersion, this binary assumption is good enough. Contrary to the general model, a firm can post its price at the clearinghouse without a cost ($\phi = 0$). As Baye et al. (2006) assumed in their general model, a firm decides to use the intermediary with a probability of

$$a = 1 - \left(\frac{\frac{n}{n-1}\phi}{(v-m)S} \right)^{\frac{n}{n-1}}$$

Where n, m, s and v are number of firms ($n \geq 1$), marginal cost, the number of consumers per firm $\left(S = \frac{I}{n}\right)$ who consult the clearinghouse and WTP, respectively. While $\phi = 0$, every firm decides to use the intermediary. Additionally, a proportion of uniformed customers per firm is denoted by $L = \frac{M}{n}$. Varian deduced that if the costs to "become" informed between the subsets of customer, S and L differ, an equilibrium price dispersion exists. One can notice that the costs of becoming informed are hidden in this model since it is unrealistic to think that some subset of people would just deterministically be able to become informed without a cost. Varian assumes that the hidden costs to the customer groups are such that,

$$C_S < C_L$$

One way to illustrate Varian's result is to assume that the cost benefit of accessing the clearinghouse is equal to expected price paid by uninformed customers less the expected price paid by informed customers. Thus,

$$B = E[p]_L - E[p]_S$$

Varian argues that if the costs to uniformed exceeds the benefit as follows,

$$C_s \leq B < C_L$$

the equilibrium price dispersion emerges from the model. Intuitively, informed customers are better off than the uniformed. Optimally, from a customer's perspective, all the customers would be fully informed. This would lead to an equilibrium where the firms would engage in a Bertrand competition pricing at a marginal cost. However, if the price of accessing the clearinghouse is high enough, no customer chooses to become informed. According to Diamond (1971), provided that the profit-maximizing firms are aware of such market condition, the firms will collude and charge the monopoly

price. This puts emphasis on the varying welfare effects that the level of search costs and equivalently the perfectness of information can produce.

The models discussed highlight the importance of search as a source of price dispersion. Both the intensity and cost of search are parameters that greatly affect the magnitude of equilibrium price dispersion. Stigler (1961, p. 219) anticipates several outcomes influenced by search in his hypotheses. One of those that is particularly relevant to used-car buyers is the hypothesis where Stigler ties households' budgets to search benefits and search intensity. According to the hypothesis, the search intensity and the benefits of search are higher when a larger portion of a household's budget are used on the good. Since negative correlation between search intensity and price dispersion is one important conclusion of Stigler's (1961) model, the hypothesis implies that the more budget-depleting products have exhibit levels of price dispersion. Following the same logic, a used-car buyer has significantly higher propensity to search and gains more utility from search than a buyer looking to purchase milk. To summarize, Stigler states that the magnitude of equilibrium price dispersion is strongly dependent on the average amount of search, and search, in turn, is greatly dependent on the "nature of the commodity" (Stigler, 1961, p. 219).

To test that hypothesis empirically, Stigler (1961) compared the prices of anthracite coal and automobiles. Coal purchases were purchased by the US government and automobiles were purchased by ordinary households, both in 1953. Naturally, the coal purchases constitute insignificant fraction of the government budget whereas a car constitutes a large expenditure for a household. For the coal purchases, the average price was \$16.90 and the standard deviation was \$1.15. Automobile purchases had an average price of \$2436 and a standard deviation of \$42. As such, these number are not particularly informative about the level of price dispersion. However, using other measures of price dispersion, for example coefficient of variation, $CV = \sigma/E[p]$, reveals that the price dispersion is comparatively higher in the case of coal purchases. Coefficients of variation were 6,8 % and 1,7 % for coal purchases and car purchases, respectively. Pratt et al. (1979) provide empirical evidence of the fact that the coefficient of variation decreases as the price of the product increases. On the other hand, as the results are often sensitive to the measure of price dispersion used, the standard deviation tends to increase as the price of the product increases according to the same model.

The positive correlation between search intensity and the level of price dispersion does not always hold if other search-theoretical or clearinghouse models are used. Pennerstorfer et al. (2020) measure price dispersion using a clearinghouse model developed by Stahl (1989) in an environment where

commuters and noncommuters purchasing gasoline in Austria differ in their informedness. Furthermore, it is assumed that commuters have access to the information clearinghouse since they can practically sample a significant number of gasoline price quotes along their commuting path without any additional costs. On the contrary, noncommuters do not possess that knowledge and must select a gasoline station from fewer number of options. The study shows robust evidence of a non-monotonic relationship between consumers' level of information and equilibrium price dispersion as theorized by Stahl (1989) and Baye et al. (2006). The empirical evidence of the study also supports the fact that consumers tend to acquire lower price quotes, search more intensively and benefit more from search when their level of informedness increases. In another words, originally the price dispersion function increases as the fraction of the informed consumers increases but begins to decrease after a certain upper boundary. In general, assessing consumers' level of informedness is quite cumbersome. In the used-car market, clearinghouse websites could be used as proxies for perfect informedness. Moreover, used-car buyers that exclusively visit car dealerships and those who do not utilize, should be assumed to vary in their level of informedness. However, the data in my empirical work only allows for the scenario where all of the consumers use an information clearinghouse, hence they exhibit perfect informedness.

All in all, information is a major resource for both consumers and sellers. Most empirical studies and theories suggest that as the fraction of informed consumers increases, prices converge, price dispersion decreases and consumers benefit. It is clearly visible that the interpretation of the level price dispersion is dependent on the theoretical model's assumptions. For example, search-theoretical models such as MacMinn's (1980) are useful when measuring price dispersion in an industry such as real estate, where buyers generally cannot gather all the sufficient information of the property just by browsing through a price comparison website. For the used-car market, both search-theoretical and clearinghouse models are viable options for the purpose of measuring price dispersion. In the next section, the elements of search and search costs are further discussed with the general and intuitive assumption that search costs are lower in online markets compared to offline markets.

2.3 Price dispersion online

Generally, online environments make it easier and less expensive for buyers to gain information about products and services. For example, a buyer can acquire the whole price range for a given product by using a price comparison website. Thus, intuitive premise for comparing price dispersion be-

tween online and offline markets is that search costs are virtually non-existent in the former and considerable in the latter. However, as discussed in section 2.2, economic search models propose various outcomes regarding the level of information availability and intensity. This ambiguity also holds true empirically since economic literature finds that price dispersion is at a similar level or even higher for some products sold online (Aparicio et al., 2024, Baylis and Perloff, 2002; Brynjolfsson and Smith, 2000; Zhuang et al., 2018).

There are many theories that try to rationalize what causes most online markets to not obey the law of one price. Clearly, online markets are more symmetrical regarding information and the barriers of entry are lower online. Additionally, in many markets such as the used-car market, competition is more intense online than offline. For example, running a car dealership comes with various fixed and variable costs such as storage costs, wages, licenses, and advertising costs whereas a one-time seller in online marketplace incurs very little costs. Consequently, it is reasonable to assume that online markets would ideally be more inline with the model of perfect competition than offline markets.

What are the potential explanations for the counterintuitive results regarding price dispersion online? One can rule out some obvious ones such as shipping and handling costs. Ancarani and Shankar (2004) compare prices of books and CDs across three different seller types; traditional (offline) sellers, multichannel sellers and pure online sellers. The study shows that when shipping costs are accounted for, there still is considerable variation in the online market for both product categories. The range of prices posted by pure online sellers is higher than those other two price ranges. However, the variation in prices is slightly lower across online sellers than traditional sellers (Ancarani and Shankar, 2004, p. 185). Moreover, the results of the study align with those of Bjyrnjolfsson and Smith (2000); average prices are lower in online markets than in offline markets, even with shipping costs.

One explanation for online price differences considers maturity of the market environment. In the wake of organized internet retailing, some academics, such as Bjyrnfolsson and Smith (2000) suggested that price dispersion in online markets is only temporary and random, and the prices should converge as the market matures. Since then, internet retailing has become increasingly more popular and the Internet users more sophisticated. Despite this, in many markets, prices have not converged and price dispersion remains a persistent feature of online retailing (Zhuang et al., 2018).

A common way of rationalizing online price differences is to measure heterogeneities in service quality. For example, used-car dealers are generally seen as more trustworthy than individual sellers. This is because most dealers are professionals and have incentives to offer good service. If they offer subpar service in the form of poor-quality cars, the dealership's reputation eventually becomes poor as well and affects the individual dealer negatively. A one-time seller cares a lot less about his reputation than a dealer who participates in car selling daily. Biglaiser et al. (2020) find that even though used-car dealers charge higher average prices than sellers in unmediated market, the quality of their service is superior. In other words, one can think that price dispersion arises from the fact that some consumers are willing to pay extra for a reduced risk related to car condition in a market full of imperfect information.

As Stigler (1961, p. 214) noted, heterogeneities in service do not fully explain the existence of price dispersion. Numerous empirical studies recognize that online sellers' pricing power extends far beyond than what could be attributable to their level of service (see, e.g., Pan et al., 2002). In some markets, the price differences could arise from product differentiation (Ba et al., 2012, Pan et al, 2002) such as brand recognition but that factor is not applicable to markets selling homogenous goods.

Once again, there is not clear consensus of the roots of price dispersion in the online environment. However, some general guidelines, particularly interesting for the purposes of my thesis, could be drawn from previous research. First, online market participants are not that different from their offline counterparts. Information and differences in information availability contribute to price differences. Even though gathering price information is generally easier online, the absence of concreteness in the purchase decision, especially when one buys from pure online sellers, creates an additional layer of smokescreen which amplifies the asymmetry of information. Moreover, some sellers are equipped with risk-alleviating qualities such that are attractive to risk averse buyers who are ready to pay premium for that insurance. This aspect is quite relevant to car market where the condition and longevity of the car is a major factor in forming a purchase decision. The significant expenditure that comes with purchasing a car highlights the importance of information and risk.

Second, it is important to distinguish between listed prices (or ask prices) and transaction prices. Zhao et al. (2015) study price differences for purses purchased from Chinese online shopping platform Taobao and find that listed prices exhibit three times more price dispersion than transaction prices. This feature is prevalent in the car market, both online and offline, since the market allows for price cutting through the process of negotiation.

Lastly, the element of price dispersion does not cease to exist in an online environment. Empirically, price dispersion could be lower, similar or higher online than in offline market even though many theoretical models or intuition could suggest otherwise.

3 Data and research methodology

I am using car registration data illustrating the sales of used-cars bought from Finnish used-car marketplace and price comparison site Nettiauto. The data is provided by Statistics Finland. Most importantly, the data unveils posted prices for given car models. Some other relevant attributes consist of mileage, engine size, model year and whether the car was sold by a private seller or a dealer.

Unfortunately, records of transaction prices are only available for years 2007, 2020 and 2022 which makes comprehensive historical price comparison unfeasible. Due to these limitations, one can only obtain an aggregate and broad picture of the level of price dispersion. I decided to focus on car sales in 2022 since the results did not have significant differences across the years.

The car models selected for the study, listed in a descending order based on aggregate sales, are Volkswagen Golf, Opel Astra, Ford Mondeo, Volkswagen Passat, Ford Focus, Audi A4, Skoda Octavia and Nissan Qashqai. These 8 car models represent the market activity in used-car market comprehensively in the measurement year 2022.

I use individual-level (FOLK) data showing three characteristics of the buyers: after-tax income, municipality of residence and age. Initially, I merged FOLK data merged with data from The Finnish Transport and Communications Agency (TRAFI) to match the personal identification numbers of those two datasets. Moreover, I merged transaction data from Nettiauto with that mixed dataset. This is done to study differences between broad customer segments to assess the level of price discrimination faced by those groups. Additionally, I use a dummy variable that shows whether the buyer is from Helsinki capital region (HCR) consisting of four municipalities: Helsinki, Espoo, Vantaa and Kauniainen.

I use two estimation models to clarify the sources of price variation. The first omits buyer-specific variables and is expressed as follows:

$$P = \beta_0 + \beta_1 \times \text{Mileage} + \beta_2 \times \text{Engine size} + \beta_3 \times \text{Dealer type} + \epsilon$$

Where Dealer type is a dummy variable taking the value 1 if the car sold by a dealer and 0 if it was sold by a private seller. ϵ is the error term. The second model takes buyer-specific factors into account and takes the following form:

$$P = \beta_0 + \beta_1 \times \text{Mileage} + \beta_2 \times \text{Engine size} + \beta_3 \times \text{Dealer type} + \beta_4 \times \text{Income} + \beta_5 \times \text{Age} + \beta_6 \times \text{From HCR} + \epsilon$$

Where Income is buyers' after-tax annual income and From HCR is a dummy variable taking the value 1 if the buyer lives in HCR and 0 if he does not. For the sake of simplicity and better results, I removed the observations that were manufactured before or after the mode value of model year for a given model. Furthermore, I restricted the engine size to be at most 0.5 litres off from the mode value of engine size. Restricting these heterogeneities ensured that the observations were more comparable to each other.

Table 1 presents summary statistics, such as price range, average asking price and standard deviation, illustrating the shape of price distribution. These are very coarse and ambiguous results that do not account for car or buyer-specific heterogeneities. Figure 3 presents price distribution graphs. Table 2 shows the estimation results with and without buyer-specific variables.

4 Results

Table 1 establishes coarse picture of the price-related characteristics for each car model. Without accounting for heterogeneities within the models, the price ranges and other price dispersion statistics are substantially large. As discussed before, the cleaned dataset exhibits controls for model year and engine size. However, after selecting the model value (the most sold car) for each car model in 2022 and removing the obvious outliers, large price dispersion remains.

This observation becomes even more apparent in figure 3. For example, Astra model manufactured in 2016 and sold in 2022 has a price range of over 7000 €. I observed even more extreme values and deviation from the mean than can be seen from the graphs. However, these values were too scarce to be presented since it would be a violation of Finnish data protection law. Overall, these descriptive statistics show the magnitude of price dispersion without controlling enough for heterogeneities that have a significant effect on the price.

Descriptive price statistics 2022

	A4	Astra	Focus	Golf	Mondeo	Octavia	Passat	Qashqai	Total
N	1283	1032	1335	2111	732	1849	1299	1529	11170
Percent	11.5 %	9.2 %	12.0 %	18.9 %	6.6 %	16.6 %	11.6 %	13.7 %	100.0 %
Range	63510.00	41410	50130	49580	45790	53904	51600	46171	
Mean	13327.2	11789.5	11825.9	11951.4	10089.4	13727.3	12987.1	16855.5	
Standard deviation	11398.4	7198.2	9075.7	9038.3	8727	9940.9	10557.3	8615.5	

Descriptive price statistics 2022 (cleaned)

	A4	Astra	Focus	Golf	Mondeo	Octavia	Passat	Qashqai	Total
N	196	204	262	385	167	268	181	340	2003
Percent	9.8 %	10.2 %	13.1 %	19.2 %	8.3 %	13.4 %	9.0 %	17.0 %	100.0 %
Range	12290	10980	9590	10000	9600	9800	6620	10990	
Mean	6097.7	13643.2	3352.6	3949	3535	5823.8	2945.3	19564.5	
Standard deviation	1939.1	2083.6	1793.1	1869.2	1864.4	1920.7	1552.1	2036.2	

Table 1. Descriptive price statistics using uncleaned and cleaned data from 2022.

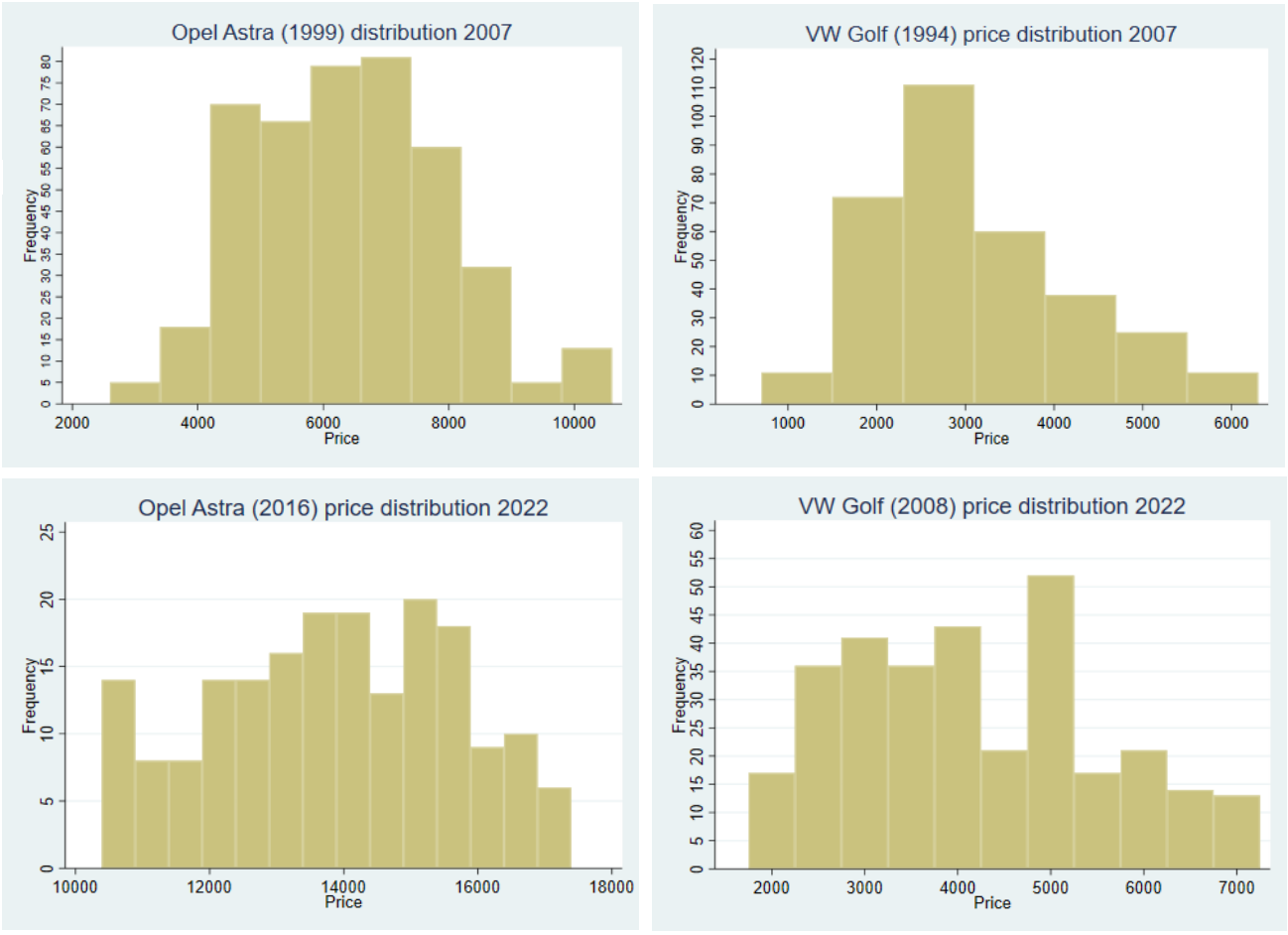

Figure 3. Price distribution graphs illustrating asking price distributions of Opel Astra and Volkswagen Golf in 2007 and 2022.

	(1)	(2)
	Ask price	Ask price
mileage	-0.0281	-0.0269
	(0.000932)	(0.000930)
engine size	-5827.3	-5447.3
	(360.0)	(357.6)
Dealer type	1833.3	1798.0
	(193.5)	(190.8)
Income after tax		0.00133
		(0.00362)
Age		43.31
		(5.392)
From HCR		347.7
		(249.5)
Constant	22134.3	19237.7
	(539.2)	(644.7)
Observations	2003	2003
R^2	0.675	0.686

Standard errors in parentheses

Table 2. Regression results using cleaned data from 2022.

The estimation results presented in table 2 tell more about the composition of price dispersion. Intuitively, mileage brings the price down and people living in HCR are charged higher prices. However, the regression results are weakened by the fact that the car models are not perfectly comparable to each other. Qashqai and Astra are in higher price group than the other models which could affect the results. For example, large proportion of high-income individuals live in HCR and are thus more likely to purchase

more expensive cars. However, buyers' income does not have a significant effect on the ask price. All in all, one can quite comfortably say that densely populated and economically active geographical areas tend to have larger demand for cars and the prices reflect that fact.

One surprising result considers the inverse relationship between engine size and price since larger engine require more materials and are thus more expensive to build. This counterintuitive result is, again, most likely explained by the differences between the models.

Finally, dealerships charge significantly higher prices for the same cars. As discussed before, dealerships are considered more trustworthy and professional among the buyers, and this could be reflected in the prices as a type of insurance against engine problems, scratches and dents. It is also possible that dealerships are actively price discriminating and this could be seen from the fact that older people are charged higher prices.

5 Conclusion

In this paper, I summarised the most significant sources of price dispersion. Price discrimination is a deliberate pricing scheme and a process that can result in different allocations of wealth but usually works in a favour of the seller and harms the buyer. Price discrimination is closely linked to economics of information. The level of information that the market participants possess largely explains the differences in prices and knowledge about customers' level of informedness greatly enhances the effectiveness of price discriminating practices.

Additionally, I showed that Finnish used-car market exhibits significant amount of price dispersion. I showed that the dispersion is linked to the condition of the car, demographic factors and location. However, the study could have benefited from utilization of more sophisticated models and availability of transaction price data as opposed to asking price data that was available.

The research on sources and implications of price dispersion needs to be expanded. Currently, price disparities and pricing schemes are important discussion and research topics from the societal point of view as many households in many countries are experiencing struggles related cost of living. Analysing potentially harmful pricing mechanics could pave the way for more optimal policies and improve consumer awareness.

6 References

Literature

Ancarani, F., Shankar, V. (2004). Price Levels and Price Dispersion Within and Across Multiple Retailer Types: Further Evidence and Extension. *Journal of the Academy of Marketing Science, 32*(2), 176-187.

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, *84*(3), 488–500. https://doi.org/10.2307/1879431

Aparicio, D., Metzman, Z., Rigobon, R. (2024). The pricing strategies of online grocery retailers. *Quantitative Marketing and Economics*, *22*(1), 1-21. https://doi.org/10.1007/s11129-023-09273-w

Ardeni, P. G. (1989). Does the Law of One Price Really Hold for Commodity Prices? *American Journal of Agricultural Economics*, *71*(3), 661–669. https://doi.org/10.2307/1242021

Ayres, I. (1991). Fair Driving: Gender and Race Discrimination in Retail Car Negotiations. *Harvard Law Review*, *104*(4), 817–872. https://doi.org/10.2307/1341506

Ayres, I., & Siegelman, P. (1995). Race and Gender Discrimination in Bargaining for a New Car. *The American Economic Review*, *85*(3), 304–321. http://www.jstor.org/stable/2118176

Ba, S., Stallaert, J., & Zhang, Z. (2012). Research Note: Online Price Dispersion: A Game-Theoretic Perspective and Empirical Evidence. *Information Systems Research*, *23*(2), 575–592. http://www.jstor.org/stable/23274440

Baye, M. R., Morgan, J., & Scholten, P. (2006). Information, Search, and Price Dispersion. [Working paper].

Baye, M. R., Morgan, J., & Scholten, P. (2004). Price Dispersion in the Small and in the Large: Evidence from an Internet Price Comparison Site. *The Journal of Industrial Economics*, *52*(4), 463–496. http://www.jstor.org/stable/3569859

Baylis, K., & Perloff, J. M. (2002). Price Dispersion on the Internet: Good Firms and Bad Firms. *Review of Industrial Organization*, *21*(3), 305–324. http://www.jstor.org/stable/41799125

Biglaiser, G., Li, F., Murry, C., & Zhou, Y. (2020). Intermediaries and product quality in used car markets. *The RAND Journal of Economics*, *51*(3), 905–933. http://www.jstor.org/stable/45380728

Brynjolfsson, E., & Smith, M. D. (2000). Frictionless Commerce? A Comparison of Internet and Conventional Retailers. *Management Science*, *46*(4), 563–585. http://www.jstor.org/stable/2661602

Burdett, K., Judd, K. 1983. Equilibrium price dispersion. *Econometrica* 51, 955-969. https://doi.org/10.2307/1912045

Chandra, A., Gulati, S., & Sallee, J., M. (2017). Who Loses When Prices Are Negotiated? An Analysis of the New Car Market. *The Journal of Industrial Economics*, 65(2), 235–274.

Charles, K. K., Hurst, E., & Stephens, M. (2008). Rates for Vehicle Loans: Race and Loan Source. *The American Economic Review*, *98*(2), 315–320. http://www.jstor.org/stable/29730040

Dahlby, B., & West, D. S. (1986). Price Dispersion in an Automobile Insurance Market. *Journal of Political Economy*, *94*(2), 418–438. http://www.jstor.org/stable/1837411

Diamond, P. A. (1971). A model of price adjustment. *Journal of Economic Theory*, *3*(2), 156-168. https://doi.org/10.1016/0022-0531(71)90013-5

D'Haultfœuille, X., Durrmeyer, I., & Février, P. (2019). Automobile Prices in Market Equilibrium with Unobserved Price Discrimination. *The Review of Economic Studies*, *86*(5 (310)), 1973–1998. https://www.jstor.org/stable/26802785

Dvir, E. & Strasser, G. (2017). Does Marketing Widen Borders? Cross-country price dispersion in the European car market. *Journal of International Economics, 112*(5), 134-149. https://doi.org/10.1016/j.jinteco.2018.02.008

Goldberg, P. K., & Verboven, F. (2001). The Evolution of Price Dispersion in the European Car Market. *The Review of Economic Studies*, 68(4), 811–848. http://www.jstor.org/stable/2695910

Goldberg, P. K., Verboven, F., Morton, F. S., & Fingleton, J. (2004). Cross-Country Price Dispersion in the Euro Era: A Case Study of the European Car Market. *Economic Policy*, *19*(40), 485–521. http://www.jstor.org/stable/3601051

Haskel, J., & Wolf, H. (2001). The Law of One Price: A Case Study. *The Scandinavian Journal of Economics*, *103*(4), 545–558. http://www.jstor.org/stable/3441004

Hendel, I., & Lizzeri, A. (1999). Adverse Selection in Durable Goods Markets. *The American Economic Review*, *89*(5), 1097–1115. http://www.jstor.org/stable/117049

Isard, P. (1977). How Far Can We Push the "Law of One Price"? *The American Economic Review*, *67*(5), 942–948. http://www.jstor.org/stable/1828075

Maarten C. W. Janssen, & Moraga-González, J. L. (2004). Strategic Pricing, Consumer Search and the Number of Firms. *The Review of Economic Studies*, *71*(4), 1089–1118. http://www.jstor.org/stable/3700729

Kahneman, D., Knetsch, J. L., & Thaler, R. (1986). Fairness as a Constraint on Profit Seeking: Entitlements in the Market. *The American Economic Review*, *76*(4), 728–741. http://www.jstor.org/stable/1806070

Kaplan, G., & Menzio, G. (2015). The Morphology of Price Dispersion. *International Economic Review*, 56(4), 1165-1205. http://www.jstor.org/stable/24517949

Kessler, A. S. (2001). Revisiting the Lemons Market. *International Economic Review*, *42*(1), 25–41. http://www.jstor.org/stable/2648717

Lach, S. (2002). Existence and Persistence of Price Dispersion: An Empirical Analysis. *The Review of Economics and Statistics*, *84*(3), 433–444. http://www.jstor.org/stable/3211562

Leibbrandt, A. (2020). Behavioral constraints on price discrimination: Experimental evidence on pricing and customer antagonism. *European Economic Review*, *121*, [103303]. https://doi.org/10.1016/j.euroecorev.2019.103303

MacMinn, R. D. (1980). Search and Market Equilibrium. *Journal of Political Economy*, *88*(2), 308–327. http://www.jstor.org/stable/1837293

Mertens, Y., & Ginsburgh, V. (1985). Product Differentiation and Price Discrimination in the European Community: The Case of Automobiles. *The Journal of Industrial Economics*, *34*(2), 151–166. https://doi.org/10.2307/2098679

Moraga-González, J. L., Sándor, Z., & Wildenbeest, M. R. (2023). Consumer Search and Prices in the Automobile Market. *Review of Economic Studies*, *90*(3), 1394-1440. https://doi.org/10.1093/restud/rdac047

Nelson, R. A., Cohen, R., & Rasmussen, F. R. (2007). An Analysis of Pricing Strategy and Price Dispersion on the Internet. *Eastern Economic Journal*, *33*(1), 95–110. http://www.jstor.org/stable/20642333

Pan, X., Ratchford, B.T., Shankar, V. (2002). Can price dispersion in online markets be explained by differences in e-tailer service quality? *Journal of the Academy of Marketing Science, 30*(4), 433–445. https://doi.org/10.1177/009207002236915

Pennerstorfer, D., Schmidt-Dengler, P., Schutz, N., Weiss, C., & Yontcheva, B. (2020). INFORMATION AND PRICE DISPERSION: THEORY AND EVIDENCE. *International Economic Review*, *61*(2), 871–899. https://www.jstor.org/stable/48584471

Peterson, J. R., & Schneider, H. S. (2014). Adverse selection in the used-car market: evidence from purchase and repair patterns in the Consumer Expenditure Survey. *The RAND Journal of Economics*, *45*(1), 140–154. http://www.jstor.org/stable/43186450

Phlips, L. (1983).*The economics of price discrimination*. Cambridge [Cambridgeshire]: Cambridge University Press.

Pratt, J. W., Wise, D. A., & Zeckhauser, R. (1979). Price Differences in Almost Competitive Markets. *The Quarterly Journal of Economics*, *93*(2), 189–211. https://doi.org/10.2307/1883191

Reinganum, J. F. (1979). A Simple Model of Equilibrium Price Dispersion. *Journal of Political Economy*, *87*(4), 851–858. http://www.jstor.org/stable/1831011

Rosenthal, R. W. (1980). A Model in which an Increase in the Number of Sellers Leads to a Higher Price. *Econometrica*, *48*(6), 1575–1579. https://doi.org/10.2307/1912828

Sagl, S. (2023). Dispersion, Discrimination, and the Price of Your Pickup. [Unpublished manuscript]. Department of Economics, The Pennsylvania State University.

Salop, S. (1977). The Noisy Monopolist: Imperfect Information, Price Dispersion and Price Discrimination. *The Review of Economic Studies*, *44*(3), 393–406. https://doi.org/10.2307/2296898

Stahl, D. O. (1989). Oligopolistic Pricing with Sequential Consumer Search. *The American Economic Review*, *79*(4), 700–712. http://www.jstor.org/stable/1827927

Stigler, G. J. (1961). The Economics of Information. *Journal of Political Economy*, *69*(3), 213–225. http://www.jstor.org/stable/1829263

Varian, H. R. (1980). A Model of Sales. *The American Economic Review*, *70*(4), 651–659. http://www.jstor.org/stable/1803562

Varian, H.R. (1989). Chapter 10 Price discrimination. *Handbook of Industrial Organization, 1*, 597–654.

Verboven, F. (1996). International Price Discrimination in the European Car Market. *The RAND Journal of Economics*, *27*(2), 240–268. https://doi.org/10.2307/2555925

Zeithaml, V.A., Parasuraman, A. and Malhotra, A. (2002) Service Quality Delivery through Web Sites: A Critical Review of Extant Knowledge. *Journal of the Academy of Marketing Science*, *30*, 362-375. https://doi.org/10.1177/009207002236911

Zhao, K., Zhao, X., Deng, J. (2015). Online Price Dispersion Revisited: How Do Transaction Prices Differ from Listing Prices? *Journal of Management Information Systems*, *32*(1), 261-290. https://doi.org/10.1080/07421222.2015.1029397

Zhao, Y. (2006). Price Dispersion in the Grocery Market. *The Journal of Business*, *79*(3), 1175–1192. https://doi.org/10.1086/500673

Zhuang, H., Popkowski Leszczyc, P.T.L., Lin, Y. (2018). Why is Price Dispersion Higher Online than Offline? The Impact of Retailer Type and Shopping Risk on Price Dispersion. *Journal of Retailing, 94*(2), 136-153. https://doi.org/10.1016/j.jretai.2018.01.003

Other references

AIM Group. (2020). *2020 Automotive Marketplaces annual*. https://aimgroup.com/2020-automotive-marketplaces-report/