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Abstract

It has been established for a long time that there is significant dispersion in prices charged for seemingly homogeneous goods. This may happen in competitive markets because the world is not frictionless, and certainly in other markets where price discrimination is carried out by firms with oligopolistic power. This paper is the first survey of the economic literature on price dispersion that addresses the following three key issues: i) its characteristics as a result of optimizing search behavior; ii) its relevance as a reflection of price discrimination and its consequences for social welfare and policy intervention; and iii) the empirical evidence of price dispersion. By contributing to a better understanding of price dispersion, this survey may help in the design and implementation of competition and anti-trust policies.

I. Introduction

Empirical research has established for a long time that there is significant dispersion in prices charged for seemingly homogeneous goods. For the last six decades, the literature on price dispersion has had two strands: price dispersion occurs in competitive markets because the world is not frictionless; and price dispersion is a consequence of price discrimination by firms with market power and thus a source of concern and intervention by antitrust authorities. In his classical paper, George Stigler noted that "it is important to emphasize the fact that dispersion is ubiquitous even for homogeneous goods… In both the cases of consumer and producer goods, the range of prices is significant on almost any criterion. Price dispersion is a manifestation and, indeed, it is the measure, of ignorance in the market. Dispersion is a biased measure of ignorance because there is never absolute homogeneity in the commodity if we include the terms of sale within the concept of the commodity… But it would be metaphysical, and fruitless, to assert that all dispersion is due to heterogeneity" (Stigler, 1961). This paper briefly surveys the economic literature that addresses those three issues: price dispersion as a result of optimizing search behavior; price dispersion as a reflection of price discrimination and its consequences for social welfare and antitrust intervention; and the empirics of price dispersion.

II. Price dispersion as a reflection of price discrimination

The economy is replete with price differences, different prices paid by different buyers for seemingly identical or, at least, similar products. Such price differences are most observed in markets for intermediate inputs, goods exchanged between manufacturers. Under some circumstances these price differences cause antitrust authorities to be concerned and, in others, they do not.

Strictly speaking, any instance of different prices charged for the same commodity is an instance of price discrimination. [1] However, there are myriad reasons why apparently identical products may actually differ in subtle and sometimes unobserved ways. For example, identical physical commodities may be sold to different customers at different prices because some customers have a history or reputation for paying promptly while others are systematically tardy. [2] Price differences do not qualify as price discrimination that gives rise to antitrust concern unless there is accompanying evidence of market power and, even then, there may be no antitrust intervention to mandate uniform pricing. Indeed, the reaction of antitrust authorities to price differences does differ across jurisdictions.

Market power is defined as the ability of an individual business enterprise (a "firm") or of a group of firms to set price or prices above competitive levels for a significant period of time throughout a well-defined antitrust market (a relevant market). For homogeneous products, single-firm or dominant-firm market power requires that the alternative suppliers of the homogeneous product have, in the aggregate, a limited capacity to supply the market; only then can a single enterprise unilaterally set price above marginal cost. In such homogeneous-product cases, the breadth of the product market is based on the ability of a hypothetical monopolist to raise price above marginal cost, which ability is in general disciplined by alternative supply sources for substitute products. Without capacity limitations, the 'law of one price' (LOP) obtains and there is a single price equal to marginal cost, the so-called perfectly competitive price: each supplier perceives a perfectly elastic demand curve and effectively has no ability to alter market price; even though it has, of course, the power to set its own price, if that price exceeds the market price sales fall to zero.

[1] We abstract from all the information/search issues previously considered.

[2] It is always useful to establish the physical and chemical differences between different brands to compare apples to apples.

When products are heterogeneous, each supplier has some degree of latitude over the price it charges customers, whose preferences are most closely satisfied by the specific product offerings of individual suppliers. That is, each supplier perceives a less-than-perfectly-elastic demand curve and is thus able to choose a price within a range of prices associated with non-zero sales. In such instances, antitrust markets are defined based on viewing actual market price, which may exceed marginal cost depending on own demand price elasticity, as the competitive benchmark. In antitrust economics, "price discrimination" is typically not used to describe different prices for similar but heterogeneous products. Strictly speaking, though, a firm's decision to differentiate its product offerings is impelled by the same motives associated with price discrimination, that is, to exploit consumer surplus more fully. In general, a differentiated-product supplier with the ability to price its product above marginal cost is not considered a monopolist unless it has the ability to raise the prices of similar products throughout a well-defined antitrust market (Klein, 2007, Baumol and Swanson, 2003, Murphy, Snyder and Topel 2015).

The present survey addresses monopolistic and competitive or, oligopolistic price discrimination separately principally because monopolistic price discrimination is simpler to analyze and thus provides a useful benchmark when applying the more complex welfare analysis that arises under imperfect competition. Thus, in the next section, the presumption is that a dominant firm supplies a single product in a single antitrust market containing multiple buyers or in several separate antitrust markets containing one or more buyers.

Economists presume that prices are set either through take-it-or-leave-it pricing or through negotiation between the seller and its buyers. In the former case, the seller chooses prices (or, perhaps, quantities) based on its knowledge of the buyer's or buyers' demands and its marginal cost. In the case of bilateral negotiations, there is a range of prices that would satisfy the seller and each of its buyers, and the pair negotiates privately a transaction outcome. The Nash bargaining model is the principal basis for predicting the equilibrium outcome in instances of bilateral negotiations. The present survey first summarizes economic analysis of take-it-or-leave-it price discrimination; and then it addresses, separately, bilateral negotiation and its implications for price discrimination.

In general, prices are either linear or non-linear. Linear prices refer to the common notion of a certain number of dollars per unit which applies regardless of the number of units purchased by the buyer. Non-linear pricing assumes many forms, the most familiar being quantity discounts. [3] Another example of non-linear pricing is two-part tariffs: cases when the price of a product consists of a lump sum and a per-unit charge.

Price discrimination may be intrapersonal or interpersonal. As the terms suggest, intrapersonal price discrimination occurs when a single individual pays different average unit prices depending on the number of units purchased. Thus, for example, the common practice of offering quantity discounts on higher volume sales qualifies as price discrimination in the first instance though there may be no enhanced exploitation of consumer surplus involved. Some price discrimination of this sort simply reflects the relative costs of supplying product in bulk relative to small quantities. Antitrust authorities are particularly concerned when a dominant firm offers quantity discounts that do not reflect cost differences, especially in the European Union.

Interpersonal price discrimination refers to instances in which different individuals pay different prices for an otherwise identical product. "Identicality" refers here to more than the physical attributes of the product so a commodity delivered to separate geographic locations constitutes two separate products. Interpersonal price discrimination however is often implemented by segmenting the market and assign buyers to different groups the delineation of which suggests separate products as in the case of different prices for daytime and nighttime theatre tickets. Clearly, consumer preferences determine whether these two products are identical, not product characteristics.

In each situation of price discrimination described in the present survey, the emphasis is placed on the welfare implications of uniform *vs*. discriminatory pricing. The welfare criterion adopted is defined

[3] Price-volume schedules in which the per-unit charge declines with the volume purchased.

in terms of consumer surplus, not total welfare or "economic efficiency." The latter is based on the sum of consumer and producer surplus and, with very few exceptions, is not the welfare standard used in antitrust law and economics. [4] In general, business firms are in possession of greater information about their customers and are better able to devise efficient prices that reflect more accurately heterogeneous preferences if they are unconstrained by public policy from conditioning their pricing on such knowledge. But socially efficient prices are not the goal of antitrust law; instead, pricing practices are judged on the basis of consumer welfare. Thus, in each illustrative analysis below, the principal issue is whether or not there is an unambiguous relation between consumer welfare and price discrimination. That is, does price discrimination make consumers worse off than they would be if uniform pricing were mandatory? To telegraph the answer, based on economic theory alone, in most instances predicting the welfare consequences of price discrimination is highly uncertain. This means that unless courts or antitrust authorities are willing to discount or ignore the attached uncertainty, substantial economic analysis —theoretical and empirical— is necessary to get it right.

Across antitrust jurisdictions —notably the United States and the European Union— the presumptions about the consequences of price discrimination are different. Both jurisdictions distinguish between the potential exploitative and exclusionary effects of price discrimination. The former refers to the direct effects of price discrimination on consumer surplus while the latter considers the strategic effects of price discrimination on future buyer welfare. In the United States only exclusionary concerns are virtually ever raised, while in the European Union, some recent cases have been brought to promote uniform pricing to reduce exploitation of present consumer surplus (see Gal, 2004). Analysis of price discrimination as an exclusionary device is complicated by the fact that harm to competitors inevitably accompanies potential harm to consumers. Although antitrust authorities maintain that their goal is only to protect competition, they are sometimes lobbied to protect the competitors involved. Unfortunately, accurate evaluation of the effects of price discrimination on competition —i.e., consumer welfare— is much more difficult than an accurate assessment of its effects on rival firms.

As indicated at the outset, not all discriminatory pricing practices studied by economists are treated herein. For example, concerns that an integrated firm which transfers an input internally between divisions and also sells the input in external markets may charge higher prices in the so-called merchant market are not addressed. In addition, modern behavior-based pricing made possible through information gained from the Internet about final consumers' historical purchase decisions has raised antitrust as well as "privacy" concerns. Finally, price discrimination through bundling and other forms of non-linear pricing devised to sort consumers according to their willingness to pay are ignored, with the exception of the classical practice of metering which will be analyzed as part of second degree discrimination infra.

A. Monopoly

Monopoly refers to the case in which a single firm has substantial unilateral control over the price in the market. This situation can also arise when there are multiple firms but one of the firms is dominant. In the case of homogeneous products, dominance requires that rival firms face capacity limitations and that one of the firms possesses the lion's share of capacity. The "residual demand formula" made famous by Landes and Posner (1981) illustrates very concisely the issue: with a homogenous product, the residual demand facing the leading firm is market demand minus the supply from the rival firms in the aggregate, the so-called fringe supply.

Simple algebra and a bit of differential calculus makes clear that the elasticity of demand facing the largest firm is equal to market demand elasticity adjusted upward according to the reciprocal of its market share and further adjusted upward based on the fringe supply elasticity which is adjusted downward by the relative share of the fringe. A large firm is potentially a dominant firm in the homogenous product market when it is the largest firm, its share relative to the fringe is large and the

[4] In its beginnings the Mexican Competition Commission explicitly adopted the total welfare standard but has not applied it recently.

fringe is not capable of expanding production readily. Under these conditions a firm can impact adversely on the market price. Thus, whether the firm's share is 100% —a pure monopolist— or at some dominant-firm level less than 100% is immaterial for the application of the price-discrimination analysis, below.

In the context of take-it-or-leave-it pricing three separate types of price discrimination are described in the economic literature: price discrimination of the first, second or third degree. [5] Each of these is described in turn, and the welfare implications of mandatory uniform pricing are reported. In all cases, price discrimination is impossible unless the monopoly seller can prevent its customers from reselling the product or service to other customers, that is, unless the single seller can prevent arbitrage. For some products —in general services— there is a natural bar to arbitrage; for example, the resale of medical services is generally not feasible no matter how attentive an individual patient is while receiving care.

1. First-degree price discrimination

A single seller is presumed to know the demand curve of each potential buyer. If it can prevent profitable resale by making it prohibitively costly or preclude reselling outright; for example by limiting the volume of purchases of an individual buyer, the seller will be able to extract consumer surplus based on buyers' declining willingness to pay for greater quantities of the product through various means.

For example, the seller may offer quantity discounts so that the average price paid declines with volume purchased; or the seller may charge a fixed fee to consumers who wish to participate as customers who, once they are as members, are allowed to buy all they wish at marginal cost. In the first instance, the cumulative excess of the willingness to pay for each unit over the final or marginal willingness to pay is consumer surplus; in the second instance, the fixed fee is set equal to each consumer's surplus.

Thus, with perfect first-degree price discrimination, the monopolist extracts all of consumer surplus available. In contrast, a monopolist precluded from such price discrimination maximizes profit through a single price which exceeds marginal cost because maximum profit is achieved by equating marginal revenue, which is less than price, to marginal cost. At the margin, consumers' willingness to pay exceeds marginal cost, and their inability to buy more of the product is indicative of the inefficiency of simple monopoly pricing. If a monopolist can charge each consumer the maximum amount it is willing to pay, fully appropriating the area under the demand curve it faces through price discrimination, deadweight loss —the familiar welfare triangular area between a declining demand and a constant or increasing marginal cost— [6] is avoided. Thus perfect first-degree price discrimination is "efficient," even though consumers enjoy no surplus and hence, based on the consumer surplus welfare criterion, price discrimination is anticompetitive: it is exploitative.

An exception to this conclusion arises when some buyers are unwilling to pay the simple monopoly uniform price but are willing to pay an amount above marginal cost. Consumers of this type are priced out of the market under a regime of uniform pricing. This raises the question as to whether enforcing uniform pricing provides sufficient benefits to those who would buy the product at the simple monopoly price to justify excluding some buyers. With perfect first-degree price discrimination no consumer willing to pay more than marginal cost is excluded but ultimately each consumer enjoys no surplus. However, with less than perfect exploitation of consumer surplus or less customized intrapersonal price discrimination, some consumers who would choose not to buy at the simple monopoly price may benefit to a degree under a regime of first-degree price discrimination.

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[5] The analysis of the different types of monopolistic price discrimination is drawn principally from the following articles. Lars A. Stole, "Price Discrimination and Competition," Handbook of Industrial Organization, Vol. 3, M. Armstrong and R. Porter, eds., Elsevier B.V., 2007, pp. 2229-2231. Dennis Carlton and Jeffery Perloff, *Modern Industrial Organization*, 2nd ed., Harper Collins, 1994, pp. 437-442. Mark Armstrong, "Recent Developments in the Economics of Price Discrimination," *Advances in Economics and Econometrics: Theory and Applications, Ninth World Congress – Vol. 2*, Richard Blundell, Whitney Newey and Torsten Persson, eds., Cambridge University Press, 2006, pp. 97-141. Mark Armstrong, "Price Discrimination," *Handbook of Antitrust Economics*, Paulo Buccirossi, ed., MIT Press, 2008, pp. 433-468.

[6] See Harberger (1954).

Monopoly sellers rarely have sufficient information to perfectly exploit consumer surplus which would, of course, leave consumers indifferent between buying and not buying. In the real world, however, monopoly sellers imperfectly exploit consumer surplus by offering volume discounts to all buyers. As a matter of practice, antitrust authorities have rarely intervened to impose uniform intrapersonal pricing, principally because there are obvious pro-competitive aspects of volume discounts when the marginal costs of supplying larger quantities are factored in. Recently, however, with the advent of digital marketing via the Internet, some antitrust authorities have raised concerns about behavioral segmentation and purchase-history pricing. Firms are better able to exploit individual consumer surplus the more accurate and comprehensive the information is available to them.

There have been several famous antitrust cases associated with intrapersonal price discrimination achieved through so-called second-degree price discrimination which is described next.

2. Second-degree price discrimination

With second-degree price discrimination, the monopoly seller knows that buyers differ in their willingness to pay or that buyers can be categorized according to their sub-group demand elasticity but it is unable to identify to which group a specific individual belongs in terms of observable, verifiable characteristics. In these circumstances, the monopolist may increase profits by offering a "menu" of different contracts and allowing buyers to self-select their preferred group. Price discrimination works by inducing those with greater willingness to pay to pay more than those with less willingness to pay; thus, obviously, the menus must be designed so that those with greater willingness to pay will elect the option that charges them more.

One familiar contract of this sort which has arisen in many instances and given rise to antitrust litigation beginning with the famous International Salt case facilitates price discrimination through "metering". [7] As an example, consider a single seller which has a monopoly in the sale of a durable good, such as a 3-D printer or, in the past, a copier. Use of the durable good requires the complementary use of consumables, which are available in a so-called "aftermarket." In the case of the 3-D copier, resins are consumed; in the case of the traditional copiers, paper is consumed. Under these circumstances, a seller may increase its profit by tying the sale of the consumable to the use of its durable good. By selling the durable at marginal cost and selling the consumable at a premium above marginal cost, the seller can effectively charge higher prices for the machine to those with higher willingness to pay. Buyers of the machine services effectively self-select as between intense and occasional users depending on whether they use a lot or a little of the tied good. In this way, imperfect intrapersonal price discrimination is practiced. Note, however, that price discrimination of this sort cannot be prohibited by imposing uniform pricing. This is a common occurrence: price discrimination is accompanied by a different practice —here, tying— which may have exploitative or exclusionary effects.

There have been several famous U.S. antitrust cases over the years in which metering is critical to the theory of harm: IBM, Xerox, and Kodak. In most instances, the concern was not the direct exploitation of consumers —in fact, many economists would maintain that these cases were based on bad economics— but, instead, on implicit exclusion of competitive suppliers of consumables through tying. On occasion, the courts in the United States have erred on the side of protecting competitors more than protecting competition.

There are other examples of second-degree price discrimination in which price differences are interpersonal. Leisure/vacation airline travelers can flexibly determine when they wish to travel and thus their demand for travel at specific times is elastic compared to business travelers who have unpredictable, more-urgent demands for travel on specific dates. The airlines offer menus of tickets: tourist-class tickets which offer less comfort and must be booked in advance; and the last-minute business class tickets which provide more seat room and other amenities. Travelers self-select whether

[7] See Int'l Salt Co. v. United States, 332 U.S. 392 (1947) and Grill (2006).

they belong in the high or the low willingness-to-pay groups. [8] As another example consider the coupons in newspaper inserts offered by supermarkets. Those consumers with higher value of time (presumably correlated with higher willingness to pay) do not take the time to cut out coupons, while those with lower value of time and more elastic demand cut out coupons and thereby pay a lower price. These examples of price discrimination through self-sorting are found in competitive markets as well as in those with market dominance.

As in the case of imperfect first-degree price discrimination the welfare consequences of second-degree price discrimination are ambiguous. Put simply, uniform pricing rules may have the effect of denying elastic demanders access to the service altogether.

3. Third-degree price discrimination

With third-degree price discrimination, the monopoly seller knows that buyers' demand elasticities differ, and the seller can categorize consumers into groups with commensurate elasticities based on observable characteristics (such as different classes of movie theatre patrons senior/adult/student) and, the seller can prevent arbitrage: for example, a modest degree of screening prevents adults from gaining theatre access with student tickets.

Under these circumstances, even when the marginal costs of serving customers in the different groups are identical, the seller earns more profit selling to the inelastic demanders at a price higher than that charged to the relatively elastic demanders. The welfare effects of these practices are ambiguous in general.

Different prices to different groups of people for the same product assures that some individuals who pay these different prices are receiving some consumer surplus, and it is reasonably likely that in the absence of such price discrimination some would not agree to purchase at the uniform monopoly price. Relative to uniform pricing, third-degree price discrimination harms those who pay the higher prices —those with the relatively inelastic demands— and benefits those who pay the lower prices on account of their greater demand elasticity. Those with greater willingness to pay or urgency subsidize buyers with more elastic and less urgent demands.

Ambiguity in the welfare effects of price discrimination also arises when gains and losses are aggregated, specifically, when gains from price discrimination to elastic demanders is offset against losses to inelastic demanders. In this case, economic analysis has demonstrated that a necessary condition for price discrimination to raise consumer welfare overall is that price discrimination result in larger output. A volume increase is only a necessary condition for welfare-enhancing price discrimination however; consumer surplus may still decline with price discrimination that raises volume but it will never increase from price discrimination that reduces output or leaves output unchanged. That said, the overall output effect of price discrimination depends on the concavity of the demands in the different markets.

Joan Robinson (1933) demonstrated that a measure of demand denoted "adjusted concavity" —a concept related to the curvature of demand— determines whether price discrimination raises or lowers output. [9] Whenever the adjusted concavity of demand in the inelastic demand market is less than the adjusted concavity of demand in the elastic demand market (evaluated at the uniform monopoly price), the losses to inelastic demanders from price discrimination are lower than the gains to elastic demanders; that is, price discrimination causes total output to increase. Notably, linear demands have zero adjusted concavity and, thus, in the case of linear demands, price discrimination never raises output. In the case of linear demands, price discrimination reduces aggregate consumer welfare. That is, when demands are linear and the consumer surplus realized by losers from price discrimination is weighted equally with the consumer surplus realized by the beneficiaries, price discrimination reduces consumer welfare.

[8] Of course, in the case of airline travel, the seller is rarely a monopolist; thus, strictly speaking, this example of second-degree price discrimination belongs in the category of oligopolistic price discrimination addressed below in this survey.

[9] Joan Robinson, *The Economics of Imperfect Competition,* Macmillan, 1933.

In some instances in which the monopolist must cover its fixed cost-fixed avoidable cost in the short run and fixed, sunk cost in the long run-price discrimination may be necessary for the monopolist's viability. In the case of two markets or market segments based on differences in demand elasticities, the higher price from the inelastic demanders may be necessary to allow the monopolist to cover its total costs. Forced to charge uniform prices in this case may shut down both markets. If the very existence of active participation depends on price discrimination then, clearly, uniform pricing reduces consumer welfare.

Apart from differences in demand elasticity across geographic markets, an important factor affecting price differences across regions is differences in competitive conditions. More competition in a specific market typically drives price towards marginal cost. As a result, if there are natural or artificial barriers to arbitrage across geographic jurisdictions prices among areas are likely to differ simply because the degree of competition differs by geographic area. In the European Union, which is intent on establishing a "single European market," efforts by suppliers to limit "parallel imports" have been prohibited.

Absent artificial barriers to arbitrage, prices may differ across geographic areas because the specific areas constitute separate geographic markets. This is easily demonstrated by considering a simple example of two regions with two suppliers in Region 1 and with three suppliers in Region 2. The hypothetical monopolist test for market definition applied to Region 1 asks whether joint pricing by the two suppliers there would be profitable given the prospect that the product would be imported from Region 2. There are only two sources of imports, buyers in Region 2 who engage in resale and the third supplier there. Depending on transportation cost and the investments required to establish distribution, there may be insufficient imports to defeat the hypothetical monopoly price in Region 1 regardless of supplier restrictions on resale. In this case with two separate geographic markets, prices are likely to differ because the degree of competition in the two markets differs; specifically, predictably, price would be higher in Region 1 than in Region 2. In the case of geographically distinct markets, the amount of competition varies among locations. Depending on the relative sizes of the regional markets, forcing a single price across regions may result in suppliers abandoning the more competitive markets which would reduce consumer welfare.

Antitrust enforcement mandating uniform pricing is rare, perhaps because the ambiguous welfare effects noted above caution against prohibitions. As indicated, mandatory uniform pricing may actually harm consumers. That said, there probably is another more important reason that antitrust enforcement is light on price discrimination, which is that price differences typically reflect product or service differences that entail cost differences, or that price differences reflect sellers' means of introducing their products to rivals' customers or of protecting their customer base from poaching by rivals. In other words, when the competitive process is described more realistically than is done by the textbook models of monopoly, price differences become the natural result of the competitive process in which information is costly, preferences are variegated and competition is imperfect (see Klein, 2007).

4. Bilateral contracting

Inderst and Valletti (2009) analyze the case in which a single monopolist, which faces some competition, sets take-it-or-leave-it linear prices in supplying an input to competing downstream duopolists. [10] The duopolists choose quantities in a homogeneous final goods market based on (possibly) different marginal costs. In this model input prices are observable but because of the downstream firms' asymmetry the monopoly input supplier, when able to price discriminate, charges a higher price to the buyer with the more inelastic demand, here, to the relatively inefficient buyer. The larger buyer gets a discount, and the discount is larger the greater the value to the buyers of the outside alternative, which in their model is indicated by the magnitude of a factor denoted by F. In the simple case with linear demand and no outside alterative (i.e., F = 0), price discrimination and uniform pricing result in the same total output; thus, consumer welfare is unaffected by banning price discrimination. However, when there is a

[10] The Inderst-Valletti model is included here under monopoly pricing because the authors do not explicitly include rival suppliers in their model but, instead, capture such competitive discipline through an assumption about the value magnitude of the downstream producers' demand-side alternative.

demand-side substitute worth F > 0, discriminatory input prices amplify the effects arising from efficiency differences between the downstream firms, and banning price discrimination generally raises consumer welfare. In contrast, Inderst and Shaffer (2009), analyze a similar situation in which two-part tariffs are used instead of linear pricing, with opposite welfare consequences. That is, in their model, banning price discrimination reduces consumer welfare.

In both of the forgoing models, the downstream firms are presumed to observe the wholesale prices set by the monopoly supplier. In contrast, Rey and Tirole (2007) compare price discrimination and uniform pricing in a model in which the monopolist's two-part tariffs cannot be observed directly by the competing downstream producers. In their model, unobservability and the inability of the monopolist to commit to prices in the first instance causes competition to be more intense. Because buyers do not observe the input prices charged their rivals, the monopolist has incentives to offer selective discounts which allow selected buyers to divert sales from their rivals. In the absence of the monopolist's ability to promise not to engage in selective discounting, all buyers anticipate such behavior and, as a consequence, are only willing to pay marginal cost for the input. Under these circumstances, banning price discrimination restores the ability of the monopolist to commit, which raises prices overall and reduces consumer welfare. These findings are confirmed in a related specification by McAfee and Schwartz (1994).

B. Third-degree price discrimination and oligopoly

The analysis of third-degree price discrimination with imperfect competition —i.e., oligopoly— introduces additional complications. As explained above, a monopolist sets prices according to the relative market demand elasticities across markets and, thus, inelastic demanders —or high-value users— pay more than elastic demanders or low-value users. This outcome makes predicting the welfare effects of third-degree price discrimination feasible, albeit complicated in general. In contrast, when competitors price discriminate the elasticity of substitution among rivals plays a critical role, not simply overall demand elasticity. In effect, price may be higher in the "wrong" market; that is, higher in the market where the overall elasticity of demand is actually higher. These circumstances complicate predicting the welfare effects of price discrimination and probably explain why antitrust authorities world-wide have to date shied from intervention except, as indicated, when there is a potential for anti-competitive exclusion (see Gyselen, 2005).

Price discrimination by competing oligopolists may, under some circumstances, increase consumer welfare. There are two general price-determination models adopted by economists to analyze the welfare effects of price discrimination under oligopoly: 1) quantity setting among Cournot rivals each producing identical physical products sold to consumers in separate geographic markets, and 2) Bertrand price setting among suppliers of differentiated products. [11]

1. Quantity setting: The Cournot model [12]

In the Cournot model, each supplier chooses the profit-maximizing quantity to offer the market given the supplies anticipated from its rivals, and market price clears the market (i.e., equates demand with the aggregate supply thus forthcoming). Products are physically identical but supplied to demanders which are assumed to be located in separate autonomous areas. Equilibrium quantities supplied to the separate markets obtain when the suppliers choose quantities that match those anticipated by their rivals.

In the simplest case, there are two independent homogeneous product demands, one for market A and one for market B, and in each market two firms with equal and constant marginal costs. Under these circumstances, with price discrimination, price is higher in the market with the more inelastic demand. Whether price discrimination enhances consumer welfare relative to uniform pricing (specifically, whether price discrimination increases output relative to uniform pricing; a necessary condition for

[11] Recall that a welfare analysis of price discrimination means that consumer welfare with price discrimination is compared to consumer welfare with uniform pricing.

[12] Severin Borenstein, "Price Discrimination in Free-Entry Markets," RAND Journal of Economics, 1985.

pro-competitive price discrimination) depends on relative adjusted concavities of demand just as in the case of monopoly described above. Moreover, as in the case of monopoly, with linear demands total output is the same with and without price discrimination and, therefore, price discrimination always lowers consumer welfare unless only one of the markets would be served under uniform pricing. In general, with non-linear demand curves, output is higher with price discrimination when the output reduction experienced by the high-price buyers is less than the output increase experienced by the low-price buyers, which is related to the relative adjusted concavities. As indicated in the discussion of monopoly price discrimination, an increase in output is only a necessary condition for welfare-enhancing price discrimination. The bottom line here is that when products are physically homogeneous and the Cournot model of output determination (and, indirectly, price determination) applies, the predictions for oligopolistic and monopolistic price discrimination are the same. Greater uncertainties arise when products are differentiated, which situation is typically analyzed in the context of price setting according to the Bertrand model.

2. Price setting: The Bertrand differentiated product model

In the Bertrand model, each supplier produces and sells products with different characteristics from the perspective of buyers. For example, when the source of differentiation is location, physically identical products are heterogeneous from the perspective of buyer preferences if buyers are located at various distances from the point of sale and transportation is costly. Alternatively, similar products may be differentiated in terms of specific consumption attributes exemplified by the market for ready-to-eat breakfast cereals. In the latter instance, for example, consumers who prefer crunchy, sweet breakfast cereal will be located "closer" to some particular brands than those who prefer soft breakfast cereal without sugar. In Bertrand models, each supplier confronts a demand for its product (or products) which depends on its own price and the prices of the alternative, related products. Suppliers choose own prices given the prices anticipated from their rivals, and market equilibrium prices obtain when all expected prices mesh with those actually chosen.

Within the set of price-setting or Bertrand models, there are high-demand and low-demand markets, and firms either agree in their rankings of high-and low-demand markets, or they disagree in their rankings. (For the sake of simplicity the analysis reviewed below assumes two different markets, one "strong" and one "weak"). With symmetric rankings, the welfare effects of price discrimination depend on the relative competitiveness of the strong and weak markets. In the case of asymmetry, welfare analysis of price discrimination is yet more complex.

With differentiated products a key to predicting the effects of price discrimination on consumer welfare is whether the rivals agree on their rankings of the relative strengths of the different markets involved (see Corts, 1998). For simplicity and with no sacrifice of generality, only two markets are considered herein. Thus, one market is strong and one market is weak, and a key issue is whether the firms agree on the identification of the strong market for themselves. Defining weak and strong markets requires a bit more analysis than in the case above with homogeneous products. Specifically, market 1 is weak from the perspective of firm A when, given uniform prices charged by its rival in each of the two markets, A would choose —if allowed to price discriminate— a lower price in market 1 than in market 2. Similarly, the weak and strong market from firm B's perspective can be defined. Given these delineations, there is "best-response symmetry" when the two firms agree on the rankings of the strengths of the two markets; otherwise there is "best-response asymmetry."

Roughly speaking, when there is best-response asymmetry, price discrimination may cause all prices to fall; in contrast, when the rivals agree on the ranking of market strengths, price discrimination causes prices to rise in the strong market and to fall in the weak market and, for the most part, consumer welfare is reduced.

a) Best-response symmetry

In contrast to the case of monopoly or to the homogeneous product case, above, the evaluation of the effect of price discrimination on aggregate output involves additional information beyond the concavity of the various demand curves. Specifically, knowledge of the relative sensitivities of the respective strong and weak markets to competition is necessary. The cross and own elasticities of demand in the

separate markets, respectively, reflect the degree of competition within the market between the rival substitutes and the extent of competition between the market product and outside alternatives. "Sensitivity to competition" is measured by the relative magnitudes of 'within' and 'without' competition as measured by the ratio of the cross-price elasticity to the market own elasticity. [13]

To illustrate an application of the analysis, assume that demands are linear, which means as indicated above, that adjusted concavities are zero. In this case, the effect of price discrimination on total output is entirely explained by the sensitivity of the strong market relative to the weak market. When the strong market exhibits greater sensitivity to competition than the weak market, price discrimination will result in a smaller reduction in output in the strong market than the output increase in the weak market. That is, price discrimination under these circumstances tends to enhance consumer welfare (see Holmes, 1989 and Armstrong, 2008).

If, market sizes differ across locations and big markets are more likely to be weak markets than small markets, forcing a single price across regions will likely bring about consumer welfare losses at the national level because the possible gains in small strong markets will be less than the losses in large weak markets.

Clearly, even in the simple example with two suppliers and two markets, predicting whether price discrimination reduces aggregate output —much less, predicting its effect on consumer welfare— requires substantial information about market and rival firm demands, including their second-order (i.e., curvature) properties. It is little wonder that principled antitrust policy is unlikely to ban price discrimination based on concerns about its direct exploitative effects. The possibility that price discrimination may actually promote competition in situations of best-response asymmetry lends further support to such light-handed treatment.

b) Best-response asymmetry

A simple example is provided in Thisse and Vives (1988). In their model, two firms are located at different ends of one-dimensional space, consumer locations are distributed uniformly along this line (with length 1), and there are linear transportation costs. A consumer located at distance d from the firm at the left end must pay t *d in transportation cost to have the physically homogeneous product delivered to him by the left-end firm, and would pay (1 – d)*t to have it delivered by the firm at the right end. In this framework, the right-side customers are in the right-end firm's strong market and the left-side customers are in the right-end firm's weak market, and the two firms rank these markets in terms of strength in opposite ways. That is, the weak market for one firm is the strong market for the other: there is best-response asymmetry.

With uniform pricing and constant and equal marginal costs, c, the market price is t + c. This result is contrasted with that with price discrimination. Price discrimination here means that the firm closest to a particular customer located, for illustration, at distance, d from the left end, will charge a delivered price just a minimal amount below the cost of serving the customer from the firm that is further away. Thus, consumers at the ends pay price, p = c + t and prices decline towards the middle where the marginal customer pays c + t/2. Clearly, except for the consumers at the end of the lines, price discrimination results in lower prices to all consumers than uniform pricing does. In this model, antitrust intervention that required uniform pricing would impose harm on consumers. Notably, firms' profits are lower with price discrimination than with uniform pricing. The firms find themselves on the horns of a Prisoners' Dilemma (Armstrong, 2008). Each would realize more profit through price discrimination if its rival chose a uniform price, but when both firms price discriminate they are worse off than with uniform pricing. Collectively, the firms would choose to have price discrimination prohibited and would support antitrust efforts to mandate price uniformity. When left to choose pricing

[13] In a differentiated product market with two products, in the simple demand function for product 1, lnQ1 = A1 + B11 lnP1 + B12 lnP2, B11 is the own elasticity for product 1 holding constant the price of product 2; its magnitude reflects inter-product substitution or competition. When both prices change simultaneously, the substitution occurs between the products combined —the product more broadly defined— and outside alternatives. The "market" demand elasticity is thus, B11 + B12, which is less than B11 in absolute terms. That is, the individual firm demand is more elastic than the market demand. Sensitivity to competition means that B12 is large relative to – B11.

independently, however, they wind up electing to discriminate based on price to consumers' benefit. Antitrust authorities are likely to be especially vigilant regarding rivals' attempts to establish pricing methods jointly.

c) Dynamic price discrimination with switching cost and best-response asymmetry

Chen (1997) analyzes competition between two rival suppliers in a two-period context. In the first period, the firms' products are perfect substitutes but, because of switching costs, in period two the market for present customers is strong for the incumbent and weak for the rival, and vice versa. In light of switching costs and the best-response asymmetry in the second period with price discrimination the rivals choose high prices for their past customers (their strong market) and, seeking to poach their rivals' customers, they set low prices in their weak markets. (By assumption, the firms cannot commit to second-period or future prices in the initial period.) As in the previous illustration of best-response asymmetry, prices are lower in the second period with price discrimination than they would be were the practice banned. Also, as in that illustration, the firms would benefit from a ban on price discrimination; however, in this case unlike the former, consumers may or may not benefit from such a prohibition.

3. Entry deterrence

Price discrimination allows a firm to target price reductions more accurately at market segments where competition is most intense (Armstrong and Vickers, 1993). Pricing in this manner can harm rivals and deter entry and, as such, can harm consumers compared to the case where discrimination is banned. However, here, as in many instances of competitive price discrimination, the effects on consumer welfare of restricting price discrimination are ambiguous in direction and magnitude. This proposition is demonstrated with an analysis of selective price discounts.

Often a seller supplies several different markets. For example, a dominant firm may supply several different geographic regions with competition from a rival in only a few of them. If the firm were required to charge equal prices across regions it would be discouraged from meeting competition from a rival's lower price in a specific region because the price reduction would have to be granted in all areas even those without a rival. If, instead, the firm were permitted to charge discriminatory prices, it would be incented to lower price to meet a rival's competition in a specific region which would benefit all consumers in that region. Clearly, an antitrust ban on price discrimination in these circumstances would make consumers worse off.

In contrast, bans on selective discounting can be pro-competitive when the dominant firm uses price discrimination to exclude rivals not yet in the market. In the prior example, the rival may refer to an entrant planning to sell in a region for the first time. In this case, the ability of the dominant firm to price discriminate which enables it to meet or undercut the entrant's price without lowering prices throughout the rest of its geographic markets may serve to exclude the entrant, which protects the incumbent firm's ability to exact super-competitive prices. Under such conditions, uniform pricing would soften the incumbent firm's response to entry by forcing the incumbent to lower price across all regions in order to meet the new competition.

Exclusionary selective discounting of this kind appears to be the principal concern of the European Commission with selective price cuts. The welfare effects of price discrimination through selective discounting are ambiguous, and antitrust intervention can have deleterious welfare effects if not approached wisely and with attention to the specific facts of the case (Gyselen, 2005 and Gal, 2004).

There is another aspect of selective price cuts that is relevant when prices are set through bilateral contracts and are unobservable ex post contracting (McAfee and Schwartz, 1994). In intermediate goods markets, prices are often set with the seller (or sellers) making take-it-or-leave-it offers within bilateral transactions. This sales situation contrasts to that in final goods markets in which retailers post the same price or prices for all consumers. With bilateral contracting and competition among buyers, an individual buyer is unlikely to be able to observe the prices agreed to by the seller and the buyer's rivals. Moreover, inferring price cuts from own market share changes would be imperfect in the face of uncertain demand. As a consequence, buyers would justifiably fear opportunistic contract "renegotiation". In this situation,

without some means of commitment to uniform prices, the seller would be forced to offer a marginal-cost price to all buyers. To avoid such outcome, sellers will seek to include non-discrimination clauses in their contracts with buyers. A common example is the so-called "best price offer": the seller agrees to extend to any buyer a lower price verifiably offered by the seller to a competing buyer.

4. Price matching

Finally, another way in which price discrimination might harm competition is when price-matching contracts are used, i.e., when a firm promises consumers it will match a lower price of a rival firm if consumers can find evidence of such a price. Such contracts are a form of price discrimination since the price a consumer pays differs according to their knowledge of other firms' prices and their willingness to go to the trouble to provide evidence of a lower price.

If consumers are well informed about all rivals' prices and there are no costs associated with verifying the lower prices, there is a possibility of collusion. As demonstrated by Salop (1986), there is no incentive for one firm to undercut another since the low-priced firm will not obtain greater market share and will simply lower all prices. Under these conditions, such price-matching contracts or MFNs facilitate collusion. Antitrust intervention to prohibit such contracts or pricing policies would be pro-competitive. However, if consumers face costs of searching for price offers or verifying low-price offers, the threat of collusion is reduced, and consumers may gain from this form of price discrimination, which serves to sort consumers on the basis of their value of time (akin to the use of discount coupons described above in the section on second-degree price discrimination).

C. Bargaining

Even when there is a single or dominant-firm seller, prices are not always set through take-it-or-leave-it offers in which sales transactions only involve implicit contracts. In some markets, particularly intermediate goods markets, price and non-price terms are negotiated. There are even instances in which buyers define the customized product they wish to buy —i.e., the terms of sale and the attributes of the product demanded are specified by the buyer— and buyers invite bids from rival suppliers sometimes committing to the outcome of an auction and, in others, allowing for post-bid negotiations. In these cases, the prices are private knowledge of the buyer and seller, and are likely to differ across buyers when there is a single seller. These price differences reflect the different products broadly defined and different sales terms agreed to, as well as the relative bargaining strengths of the buyers and the sellers and the fact that negotiations are private. That is, price discrimination is more or less inherent in the nature of the bargaining competition and, as such, is rarely regulated through antitrust intervention.

Antitrust intervention is rare in part because economists do not have comprehensive theories of competitive bargaining. Given a specific product definition which is often the result of negotiation, the price resulting from bargaining is indeterminate in the absence of a specific bargaining model. This can be seen in the classic case of bilateral monopoly, when a single seller supplies a single buyer. In general, the buyer has a maximum willingness to pay for the product or for a specific volume of the product, and the seller has a minimum acceptable price. Absent a theory of bargaining, the resulting price will lie in the range between the most the buyer will pay and the least the seller will accept.

At present, most economists adopt the Nash bargaining model to explain price determination in bilateral bargains. The model defines two critical measures for each party to the negotiation: a so-called "disagreement payoff" —the profit realized by the party in question when no agreement in the bilateral negotiation is reached— and the maximum surplus or profit that can be realized when the parties agree to transact. In the simple case of equal bargaining abilities, the Nash solution to the negotiations is that each party receives his disagreement payoff and, in addition, the excess of the total surplus above the sum of the disagreement payoffs is divided equally between the parties. In general, the equilibrium price will be closer to the best price for the seller when the seller's disagreement payoff is larger than that of the buyer and the seller and the buyer will divide the surplus in accordance with their bargaining ability. This is a reasonable result, as the disagreement payoffs represent the value of the alternatives to agreement that are available to the parties.

In contrast to the bilateral monopoly, there may be a situation with a single seller and several competing buyers. This is the case first analyzed by Horn and Wolinsky (1988). They defined a Nash-in-Nash equilibrium, essentially, a non-cooperative equilibrium in bi-lateral bargaining outcomes. In their simple model, a monopoly input supplier negotiates bilaterally and independently with two downstream producers competing in quantities facing differentiated-product demands. [14] The authors assume symmetric demands, marginal costs and bargaining strengths, which greatly simplifies the analysis but, predictably, yields uniform bargaining solutions. They then define a Nash-in-Nash equilibrium that presumes that both partial equilibrium conditions are simultaneously satisfied. The bargaining solution in one instance is predicated on a given outcome in the other and vice versa. Price differences across customers would naturally result if these assumptions were relaxed. Thus, depending on the asymmetries between the downstream producers —the nature of the demand system they face, their respective marginal costs and disagreement payoffs and their bargaining abilities— the equilibrium bargaining outcome yields different input prices for the two downstream producers. In this case, price discrimination reflects the differences in willingness to pay for the input, which ultimately depends on individual differences of one sort or another. The Horn/Wolinsky model involves a single supplier (or, virtually equivalently, two suppliers negotiating separately and exclusively with two downstream producers). Only recently have economists generalized their original model to account for competition among suppliers negotiating bilaterally with competing buyers (see Inderst and Wey, 2003 and de Fontenay and Gans, 2013). Intuitively, models of bargaining in an oligopolistic setting will yield equilibrium predictions about different prices and terms depending on the underlying differences among buyers and sellers and the nature of competition. Antitrust intervention to force uniform pricing in such instances would be rare when both the buyers and the sellers (whether monopolists or oligopolists) are simply exploiting their knowledge of the individual differences, including differences in demand elasticities. When price discrimination is practiced by a dominant firm in the context of bargaining, antitrust intervention is more likely, however, as suggested above; in such instances, the principal source of concern is likely to be a specific exclusionary practice in which price discrimination is ancillary.

Moreover, enforcing price uniformity in the context of secret bilateral bargaining would require very intrusive actions, including banning price negotiations. Some recent empirical work indicates that uniformity is likely to be anticompetitive in any event. Grennan (2013) estimates asymmetric differentiated product demands by hospitals for cardiac stents, which are supplied by only a few manufacturers, in the context of bilateral bargaining. Through simulations he demonstrates the buyer consolidation through group purchasing organizations ("GPOs") which naturally creates price uniformity has two opposite effects: price competition is softened which is harmful to the hospital buyers while hospital bargaining power is enhanced. Generally, the greater bargaining strength does not offset the adverse effects of higher prices from reduced competition among manufacturers.

1. Abuse of dominance under European Union Article 82

As indicated above, price discrimination by a dominant firm can be either exploitative or exclusionary. Exploitative discriminatory pricing is conceptually straightforward: the dominant firm charges discriminatory prices when feasible to exploit consumer surplus more fully. In the United States, "monopoly pricing, as such, is not regulated. In contrast, under European Community (EC) law, excessive pricing is considered an abuse of dominance and is punishable by fine and subject to prohibitory order". [15] Notwithstanding several Commission decisions, the European Court of Justice has found an abuse of dominance through excessive pricing in only one instance: British Leyland. [16] Practicably, treatment of excessive pricing has been much the same in the U.S. and in Europe. [17] In Mexico, although monopolies

[14] Normally, quantity setting models are applied when products are homogeneous; in the Horn/Wolinsky set up, product homogeneity would lead to a trivial bargaining result with only one downstream producer being supplied. To avoid this result while maintaining the simplicity inherent in the Cournot model, they specify differentiated product demands and negotiation over quantities.

[15] See M. Gal, "Monopoly Pricing as an antitrust offense in the U.S. and the EC: two systems of belief about monopoly?" *Antitrust Bulletin*, Spring-Summer, 2004, p. 345.

[16] *British Leyland Plc. v. Commission* (1986) E.C. R. 3263 (1987) 1 C.M.L.R. 185.

[17] See also OFT Guidelines in Relation to Chapter II Prohibition Under the UK Competition Act 1998 (OFT 402, March 1999).

are prohibited, the law does not deal expressly with monopoly as such or with abuse of dominance; in particular, the law does not address high pricing. [18]

In contrast, exclusionary conduct does receive antitrust scrutiny in the United States, in the United Kingdom and in the European Union (Gal, 2004 and Gyselen, 2005). When a dominant firm engages in price discrimination which has the effect of foreclosing a significant share of the market for its product or products, the United Kingdom's OFT and the Commission as well as the European courts —the Court of First Instance and the European Court of Justice— have been especially vigilant. [19] The issues raised in several prominent Commission decisions and subsequent judicial reviews regarding exclusionary conduct are described below. In Mexico, unlawful conduct is defined in terms of exclusionary practices at the expense of competitors or other firms in the chain of distribution, and not in terms of exploitative practices at the expense of consumers. Exploitation of market power by charging supracompetitive prices is expected to be self-correcting, as such conduct will normally attract new entrants. [20]

In general, a dominant firm risks inviting antitrust intervention for pricing too high and for pricing too low. Here, the focus is on instances in which the concern is with price discounting by a dominant firm that benefits customers receiving the selectively lower prices, at least, in the short run, but which has the potential to exclude equally efficient rivals unable to match the dominant firm's prices to the detriment of future competition. In this regard, the Commission has focused its attention on "fidelity (or, loyalty) discounts," in contrast to standardized volume discounts. The latter are not challenged when they reflect lower transactions or production costs of supplying customers with larger volumes and the volume targets are not individualized. By their nature, fidelity discounts restrict individual customers' ability to choose other suppliers and, as a result, may substantially foreclose rivals from access to these buyers.

Fidelity discounts include market share discounts and their equivalents and bundled loyalty discounts, including tying arrangements. Discounts or rebates that are offered on the basis of the dominant firm's share of individual buyers' purchases of like products are definitely considered to be violations of Article 82 when the target share approximates exclusive dealing (see Hoffman La Roche, British Plasterboard and Deutsche Poste) but, even when there is no explicit full requirements provision, the restraint may effectively require substantial loyalty. For example, the dominant firm may simply state target volumes for individual buyers, but when these are set with an eye to estimates of the buyers' potential requirements they are condemned as equivalent in effect to market-share discounts (see Michelin I and Virgin/British Airways).

Bundled discounts and tying are related. Hilti was a dominant supplier of nail guns which also sold nails for use in their nail guns. It offered rebates on nails purchases to loyal buyers, effectively conditioning the sale of nail guns on the purchase of nails from Hilti. The Commission condemned these discount practices designed to foreclose the aftermarket for Hilti-compatible nails to rival nail suppliers (see Hilti). These and several other fidelity discount cases emphasized several critical factors. [21] First, evidence of a dominant-firm market share in a relevant antitrust market was critical. After proof of dominance, evidence focused on whether the volume targets were individualized or standardized across buyers; on whether the dominant firm used monitoring mechanisms to enforce its rebate policies; on whether the target volumes were equivalent to market share requirements; on the length of the period over which fidelity was measured; on evidence of actual foreclosure or the potential for substantial foreclosure; and, finally, on the presence of objective justifications or quantifiable efficiencies.

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[18] Competition Law and Policy in Latin America PEER REVIEWS OF ARGENTINA, BRAZIL, CHILE, MEXICO AND PERU, OECD, 2006.

[19] See Gyselen (2005). The Commission has also been concerned about so-called "secondary-line" price discrimination in which foreclosure occurs in the buying market of a dominant firm, in contrast to "primary line" discrimination. Finally, abuse of dominance is regulated in the EU also through Article 102 TFEU ("Treaty on the Functioning of the European Union") which applies only to dominant firm conduct that affects trade between Member States; decisions pursuant to Article 102 regulation are not considered herein.

[20] OECD (2006), *Competition Law and Policy in Latin America peer reviews of Argentina, Brazil, Chile, Mexico and Peru*.

[21] See European Sugar Industry, Solvay, ICI, Irish Sugar, and Michelin II.

III. Information, consumer search and price differences

In a market in which there are positive consumer search costs, suppliers choose price distributions. In the simplest models, consumers demand a single unit for which they have a maximum, typically common, willingness to pay ("WTP"), and they choose to sample k price offers looking for the lowest price among those offers, with k determined by comparing the cost of search and the expected gain from search. The lower the cost of search, the larger the sample of offers searched: when the search cost is zero all outlets are searched and firms have no option but to charge the perfectly competitive price, assuming that suppliers set prices instead of quantities. However, when search cost is positive, firms realize that not all offers will be reviewed and they have incentives to choose a price randomly. In equilibrium, there is a distribution of prices in the market that confirms consumers' decisions about optimal search (see Varian, 1980 and Burdett and Judd, 1983). In such models, the lower the cost of search, the more search will be carried out thereby reducing both the average market price and its dispersion. Within such models, there are some differences: in some, price dispersion increases with the number of firms and, in others, it declines. In all of them, however, the average price is lower when the number of firms offering the product is larger.

Waldeck (2002) introduces market segmentation in the context of these models. Specifically, he assumes that the entire market is divided between buyers who have inelastic demand for a firm's product (i.e., they buy a single unit of the good for any price between zero and their maximum WTP) because they are uninformed about alternative price offers or otherwise captive to an individual supplier and those whose demand is elastic. Each supplier thus perceives that it has a captive demand and a contestable demand. With price discrimination, a supplier would charge captive buyers their maximum WTP thus exploiting fully potential consumer surplus, and it would compete in the contestable market as described by the search models with equilibrium price dispersion. However, Waldeck assumes that the suppliers are not permitted to price discriminate: a uniform price must be offered to all. Thus, the fraction of a supplier's potential market that is captive affects the price that is chosen. As in familiar models of third-degree price discrimination, the price ultimately selected is based on a balancing: the supplier could charge the maximum WTP and gain revenues from its captive buyers only, or it could elect a lower price in order to attract some of the informed buyers (buyers who search) at the cost of foregoing margin on sales to its captive buyers. Waldeck shows that reductions in search cost, which

raise the level of search, cause the expected profit to be earned in the informed sector to decline which has the effect of inducing the supplier to rely more on profits from its captive customers through a higher price. In this way, depending on the proportion of the whole market that is assumed to be captive, lower cost of search may result in a higher average price not a lower price as predicted by the traditional search cost models. This effect is not monotonic however; when the supplier's captive market is small relative to the market for buyers who search, reductions in search cost have the familiar implication of reducing average price and dispersion.

In a recent paper, Burdett and Menzio (2014) study the effects of menu costs in the tradition of Sheshinski and Weiss (1977) on the pricing behavior of sellers and on the cross-sectional distribution of prices in the search-theoretic model of imperfect competition. They find that when menu costs are not too large, the equilibrium is such that sellers let inflation erode the real value of nominal prices until it reaches some point when the seller pays the menu cost and changes its nominal price so that the real value of the new price is randomly drawn from a distribution. In that case, both menu costs and search frictions contribute to price stickiness but a calibrated version of the model reveals that the latter are more important than the former in explaining the duration of nominal prices.

IV. Empirical evidence

While the theoretical literature allows us to categorize the factors that may lead to price dispersion not attributable to price discrimination (non-homogeneity of sellers and products; search costs; imperfectly informed consumers and menu costs) it provides little insight into how big is small in a competitive environment. We review a few empirical papers below.

The search cost literature predicts that frequently purchased items will exhibit lower average prices and less price dispersion than infrequently purchased items. Clay and others (2001) test these hypotheses based on data from 32 online bookstores and 399 different books over a period of several months ending in January 2001. First they find no evidence of price convergence: measures of price dispersion range from 13% to 28% of average price and they were stable or rising during the period. Second they compare average prices and price variance for New York Times best sellers and randomly selected books. Their evidence supports the predictions when they restrict their focus to the big three booksellers (Amazon, Barnes and Noble, and Borders) who represent a large fraction of all Internet book sales.

Baye and others (2004) also study the effect of the Internet on price dispersion. Specifically, they investigate whether there is evidence that price differences are an equilibrium or a temporary phenomenon by analyzing 4 million price observations over an eight month time period for 1,000 of the best-selling consumer electronics products sold on Shoppers.com a price comparison site. If prices converge that would constitute evidence of the LOP; in contrast, if price dispersion is an equilibrium phenomenon, factors such as market structure and search costs and returns should explain persistent price differences. The authors define price dispersion in three ways: 1) the (percentage) gap between the lowest two price quotes; 2) the percentage range in prices; and 3) the coefficient of variation, which is the standard deviation of prices normalized by the average price. The authors find no evidence that prices converge: regardless of the measure used, price differences are an equilibrium phenomenon. On the other hand, as the number of suppliers increases, the gap between the lowest two prices decreases, which also holds for the coefficient of variation. Specifically, as the number of firms increases from 2 through 5 and, then, to 10 and beyond, the gap percentage drops as follows: 23%, 14%, 11%, 9% and 4%. The authors maintain that this evidence is consistent with all economic theories of price dispersion. In contrast, however, the range of prices increases with the number of quotes but only significantly up to

5 quotes. (The price range percentages associated with 2-5 firms are 23%, 30%, 35% and 42%, with insignificant increases for the number of firms beyond 5).

Kaplan and Menzio (2014) study the shape and structure of the distribution of prices at which an identical good is sold in a given market and time period using data from the Kilts-Nielsen Consumer Panel Dataset (KNCP), which contains price and quantity information for over 300 million transactions by 50,000 households for over 1.4 million goods in 54 geographical markets over the period 2004-2009. The data contain information on transactions for the same good at multiple stores, transactions for multiple goods at individual stores, and multiple transactions for the same good at individual stores. When they define goods by their UPC (barcode) they find that the average standard deviation of normalized prices is 19%. For the broadest definition of what constitutes a good which aggregates all products that are identical expect for their brand and size, the average standard deviation of normalized prices is 36%. They also find that price dispersion is a widespread phenomenon since for more than 90% of goods/markets/quarters the standard deviation of prices is greater than 10%.

To understand the sources of price dispersion, Kaplan and Menzio decompose each transaction price into three components: i) a store component, defined as the average price of all goods at the particular store where the transaction took place; ii) a store-specific good component, defined as the average price of the particular good at that store, relative to the average price of all goods at that store; and iii) a transaction component, defined as the price of the good in that particular transaction relative to the average price of that good at that store. This decomposition allows them to conclude that price dispersion does not primarily arise because some stores are cheap and others are expensive but rather that price dispersion arises because even among equally expensive stores, the average price of a particular good varies substantially, and even at a given store, the price of a particular good varies across transactions. [22]

A. The law of one price in commodity markets

As we have argued, price dispersion can occur for two reasons: because the world is not frictionless and because firms with market power are able to discriminate. When goods are identical, competition will tend to equalize their prices through arbitrage. Even though commodities' characteristics may vary, for a given type and grade, the law of one price ("LOP") will apply to them in a more direct manner than in the case of differentiated retail products or customized intermediate goods. The LOP requires arbitrage and thus products that are similar. Arbitrage takes time because it is based on trade between geographically separated markets. Lags in physical supply responses are likely but, for like type and grade, the prices of a commodity in different locations will converge to a single level unless arbitrage is unfeasible or if there are barriers to interregional trade. Transportation and delivery costs do not prevent arbitrage per se but they drive a wedge between prices in import regions and prices in export regions. Thus, more generally, the LOP states that prices only differ by the amount of transport and handling costs. Buyers or sellers will not profit by shipping a commodity between regions to avail themselves of profitable price differences unless they commit to facilities for shipping from export regions and receiving and distributing in the import regions. Regions are effectively autonomous in the short run and price differences may exist for some period of time but, in the absence of barriers to interregional trade or restrictions on the ability of buyers to resell, price differences of substantial magnitude will not persist in the long run; they will only be limited by the cost of investments required to facilitate interregional trade. For example, consider the case of three producers of the same commodity: X and Y with production facilities in region A; and producer Z with production facilities in region B. All else the same, in the absence of exports from A to B, price in B is likely to exceed price in A because of greater competition in the former. On the other hand, firms X and Y are potential entrants into region B; if the price difference between the two regions were sufficient, they may consider operating a plant in region B

[22] 90% of the variance of prices is due, in approximately equal parts, to differences in the average price of a good across equally expensive stores and to differences in the price of a good across transactions at the same store.

or, alternatively, establishing facilities for exporting and for receiving and distributing their own imports from A. These two options will establish the LOP.

The LOP has been investigated by economists for agricultural commodities and financial assets in various contexts by collecting time-series price observations for identical products in separate locations or markets and studying the relationship between those prices to ascertain whether there is a long-run relationship between them such that their difference —if any— reflects only transportation or transactions cost and additional deviations are highly damped and are quickly eliminated.

Early empirical studies generally failed to support the LOP [23] but, since Engle and Granger's seminal paper (1987), cointegration techniques have become the method of choice to determine its prevalence because they can establish the existence of long-run relationships, even if the variables are not stationary, often the case for price time-series. By using cointegration methods, several papers have found evidence of the LOP in markets for agricultural commodities. Buongiorno and Uusivuori (1992) analyze data on United States exports of pulp and paper to European countries and Japan from January 1978 to December 1988 and find that in 52 of the 56 pairs of price series the LOP could not be rejected. Bessler and Fuller (1993) study average monthly price data for wheat from twelve regional markets in the US and the Houston port; and Jung and Doroodian (1994) investigate four softwood lumber regional markets in the United States during the period 1950-1985. More recently, Pippenger and Phillips (2008) use monthly prices in the United States and Japan for three different varieties of wheat in Japan for the period 1975-1981 [24] are cointegrated.

Lately, other methods have been used to find evidence of the LOP. Pippenger and Phillips (2007) show that half-lives for differentials for monthly spot prices (in dollars) for one variety of corn and three varieties of wheat in different ports in the US Gulf, the US Pacific, Rotterdam and Japan for different periods between 1974 and 2001 range from 3 to 8 weeks, much less than previous estimates that last quarters or years. Goodwin, Holt and Prestemon (2011) use Time-Varying Smooth Transition Autoregressions to study price dynamics for North American oriented strand board (OSB). This class of nonlinear, time series models allows for the possibility of gradual adjustments among price linkages and the possibility of structural change. Pippenger and Phillips's results show that all tested price pairs create stationary linear combinations, or cointegrated price pairs (some of which exhibit nonlinearities) but in all cases they provide confirmation of the Law of One Price, augmented to account for transactions costs bands and non-linearities. Interestingly, over the 10 years sample period there were a number of events that impacted OSB prices and could have influenced regional OSB price relationships, among them allegations of price fixing scheme among OSB manufacturers during the 2002-2006 period.

Goodwin and others (2014) develop copula-based models that consider the joint distribution of prices separated by space and, in some cases, national borders, and apply them to weekly prices for homogeneous OSB products at geographically distinct North American markets, to reveal nonlinear, spatial arbitrage relationships. The approach is analogous to the regime-switching and threshold models that are frequently applied in evaluating spatial and vertical market linkages. They consider price linkages among six regionally-separated OSB markets, including two Canadian markets and four U.S. markets. The results provide strong support for the LOP in North American OSB markets. In every case, the results correspond to an error-correction type of process for price differentials whereby deviations from parity conditions are temporary. In some cases, the responses tend to be highly nonlinear, likely reflecting transactions costs. In other cases, results are similar to those obtained for standard linear error-correction models. The half-lives range from 6-15 weeks.

[23] See, for example Isard (1977).
[24] Quoted in dollars to avoid the problems that may arise from exchange rate fluctuations.

V. Conclusions

The economy is rife with price differences: different prices that are paid for seemingly identical or, at least, very similar products. Such price differences are most often observed in markets for intermediate goods, where prices are often not take-it-or-leave-it but negotiated prices. Strictly speaking, any instance of different prices charged for the same commodity is an instance of price discrimination. However, there are myriad reasons why apparently identical products actually differ in many ways: identical physical commodities may be sold to different customers at different prices because some customers have a history for paying promptly while others are systematically tardy.

Under some circumstances price differences have been a cause for concern for antitrust authorities but price differences do not qualify as price discrimination that gives rise to antitrust concern unless there is evidence of market power and, even then, there may be no antitrust intervention to mandate uniform pricing.

This paper has surveyed the economic literature that addresses price discrimination and its consequences for social welfare and antitrust intervention. The conclusion is that, based on economic theory alone, in most instances, predicting the welfare consequences of price discrimination is highly uncertain. Eliminating price discrimination may not be competition enhancing or consumer welfare augmenting. Thus, unless the antitrust authority is willing to discount or ignore the possibility that the consequences of their measures is that consumers will be harmed, substantial economic analysis —theoretical and empirical— is necessary to get it right.

Some things do emerge as fairly certain:

- Price differences attributable to the fact that despite the appearances, the products are not identical will weaken suspicions that price differences translate in consumer harm. This includes all price differences attributable to different physical (chemical) differences and other costs of supplying buyers.
- On the contrary, the existence of a dominant firm with market power and/or the existence of barriers to entry will heighten the concern that price discrimination may harm consumer welfare.

- Finally, the existence of unused productive capacity by competitors is a strong mitigator of unease about price differences.

While the theoretical literature categorizes the factors that may lead to price dispersion not attributable to price discrimination it provides little insight into how big is small in a competitive environment. Several articles that have studied price formation in the Internet, thought to be one of the most competitive environments, find price dispersion that can be as high as 28%. A recent study using data from the Kilts-Nielsen Consumer Panel Dataset for brick and mortar stores find that price dispersion is a widespread phenomenon. Finally, while the LOP seems to prevail in many commodity markets, they are characterized by a significant dispersion in the distribution of prices.

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