Price Dispersion

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Abstract

A brief survey of the economics of price dispersion, written for the New Palgrave Dictionary of Economics, 2nd Edition.

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Price dispersion occurs when different sellers offer different prices for the same good in a given market. Thus, it differs from price discrimination under which a single seller offers different prices to different groups of buyers or in different geographical locations. A simple explanation for price dispersion is that it arises from imperfect information on the part of consumers who do not all buy from the lowest price seller because some at least do not know who the lowest priced seller is. It is an important topic in the field of the economics of information in that there is considerable empirical evidence that price dispersion is widespread and significant. Yet, it has proven surprisingly difficult for economists to derive satisfactory models that support price dispersion as an equilibrium phenomenon.

The rise of electronic commerce at the end of the 20th century gave new impetus to empirical studies of pricing behaviour. Baye et al. (2004) analyse detailed information on prices of 1000 items collected from a price comparison site. Price dispersion is found to be significant and persistent. Baye et al. finds the an average coefficient of variation of about 9% for goods being sold online. This is comparable with the results of Lach (2002) for conventional retailers who finds a lower coefficient for the price of refrigerators, but higher variation for grocery items such as coffee or flour.

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Such empirical work on price dispersion is often disputed on the basis of two arguments, both of which claim that any apparent price dispersion is largely illusory. First, variance in prices might be explained by hidden heterogeneity in the good being offered for sale. For example, a retailer that charges high prices might survive not because of consumer ignorance of cheaper sellers, but because it offers superior service, something not captured by evidence on prices alone. A second line of scepticism is that dispersion in posted prices may not be inconsistent with uniformity in prices actually paid. Those who post high prices may not in fact sell anything. Certainly, one would expect low priced sellers to sell more than those charging high prices, so that prices weighted by market share will be less dispersed than if all sellers are given equal weight.

The first criticism is addressed by Baylis and Perloff (2002) who find that, in fact, some online sellers persistently offer both high prices and poor service. The second is answered at least in part by Baye et al. (2004) who in their empirical study concentrate on the difference between the lowest and second lowest price, rather than the difference from lowest to highest or standard deviation, as their measure of dispersion. Furthermore, their data comes from a price comparison site where listings are costly for sellers. Why pay to list a price at which you think there will be no sales?

In any case, it is certainly possible to construct theoretical models in which prices are dispersed and yet high prices yield positive sales. Such theory is recent, however. In an influential survey, Rothschild (1973) identified serious difficulties with the then existing models of price dispersion. At that time, no-one had produced a model where price dispersion was shown to be the result of equilibrium behaviour. The challenge was to show that charging a range of prices could be a rational response by sellers to the search behaviour of consumers, and vice-versa.

It took some years for this challenge to be met. The difficulty in doing so is illustrated by the earlier work of Diamond (1971) who found that once one introduces imperfect information for consumers, a natural outcome is not price dispersion, but monopoly pricing by sellers. The essence of Diamond's result is the following. Suppose there are a large number of identical buyers who each want to buy one unit of a good from one of a large number of identical sellers, provided it costs no more than a maximum price p^*. The buyers know the distribution of prices but each only knows the price currently being charged by one seller. Each must then must decide whether to learn the price of one more seller at a fixed cost (imagine searching on foot, or by phoning a succession of sellers). The optimal search policy in this situation of sequential search is to buy the first time one sees a price that is equal or below a reservation level r, which varies with the unit search cost s and distribution of prices $F(p)$. Now, if all consumers have the same unit search cost, then for a given distribution of prices, they will have the same reservation price r. The optimal price for all sellers must then be r. But if there is no dispersion in prices, it cannot be optimal to learn more than one price. Thus, the only equilibrium is where all sellers charge p^* and all buyers do not search, even when the unit cost of search is arbitrarily small. Ironically, this equilibrium satisfies Rothschild's criteria. Consumer behaviour is optimal as, when prices are identical, paying to learn additional prices is a waste of effort; pricing at the monopoly level is optimal as, when there is no search, there is no incentive for sellers to cut prices to increase sales.

Not surprisingly, therefore, many of the earliest successful equilibrium price dispersion models (Salop and Stiglitz, 1977; Varian, 1980) take a different route from Diamond and do not assume sequential search. Instead, they are what have been called "clearinghouse" models by Baye et al. (2004). By buying a newspaper or by visiting a price comparison website, a consumer can obtain information about the prices of a number of sellers all at once. The simplest clearinghouse assumption is that it is possible for consumers to become informed of all current prices. Suppose a proportion q of consumers remain uninformed and hence pick at a seller at random. The other $1-q$ consumers are informed and only purchase from the lowest priced seller. All consumers wish to buy one unit of the good if the price does not exceed a common maximum price p^*. Then, given n sellers and L consumers, if one seller charges a price strictly lower than all others, she sells to both informed and uninformed, a total of $qL/n + (1-q)L$. The other sellers sell only to the uninformed and expect sales of qL/n. That is, demand is decreasing but discontinuous in price.

For simplicity, let us follow Varian (1980) and assume that sellers have constant marginal cost c. There is then no pure strategy equilibrium for sellers as long as there are both informed and uninformed consumers, that is if $q \in (0,1)$. To see this, note that if all sellers charged the same price, it would generally be profitable for an individual to undercut this price in order to attract the informed buyers. However, because of the presence of uninformed consumers who are not price sensitive, charging the monopoly price p^* gives a guaranteed minimum profit of $(p^* - c)qL/n$, and so when the prices of other sellers are close to c, the most profitable price may be p^*. There is a symmetric mixed equilibrium in which all sellers randomise according to the same continuous distribution. This mixed equilibrium is a dispersed price equilibrium, as since sellers randomise over the prices they charge, realised prices will vary over sellers.

However, to have an equilibrium that fully satisfies Rothschild's challenge, it is necessary to make the consumer's decision to become informed endogenous. Varian (1980) assumed differing information costs, with high cost consumers remaining uninformed, and low cost consumers paying for information. However, Burdett and Judd (1983) showed that it is possible to close a clearinghouse model even if all buyers have the same cost s to becoming informed. For example, given the symmetric mixed equilibrium described above, consumers who pay to become informed will buy from the lowest priced seller whose expected price is equal to the expected value of the lowest of n independent draws from the equilibrium price distribution. In contrast, those who remain uninformed expect to pay the simple expectation of the distribution. If q is zero or one, the equilibrium price distribution will collapse on c or p^* respectively. However, for interior values of q, the difference between the price paid by the informed and uninformed will be positive. Thus, it can be shown that for a value of s sufficiently low, there is at least one interior value of q such that the resulting equilibrium distribution of prices is sufficiently dispersed such that consumers are indifferent between paying or remaining uninformed.

That is, there is at least one internally consistent dispersed price equilibrium. The proportion of informed consumers generates exactly the right amount of expected price dispersion such that consumers are indifferent between being informed and uninformed. It is an elegant but delicate construction. In contrast, the Diamond outcome (no consumers pay to be informed, all firms charge p^*) is a simple pure equilibrium of this game that coexists with any dispersed price equilibria. Thus the Varian model and the similar models of Salop and Stiglitz (1983) and of Burdett and Judd (1983) have multiple equilibria (though the Bertrand outcome where all consumers pay to be informed and all firms charge marginal cost is not an equilibrium here, consumers have no incentive to pay to be informed if all prices are the same).

A reasonable question is whether introducing heterogeneity, either under sequential search or in clearinghouse models, makes dispersed price equilibria more robust. However, consumer heterogeneity does not remove the Diamond paradox as an alternative equilibrium. Even if consumers have a range of search costs, if there is no price variation at all, then there is no incentive to search (unless one makes the implausible assumption that a mass of consumers have zero search costs). That is, if all sellers share the same monopoly price, then all charging that price can be an equilibrium if consumer search is costly. But if instead there is sufficient seller heterogeneity, an outcome where all sellers charge their monopoly price may not be an equilibrium. Suppose no consumer searches, each seller would then charge her monopoly price. However, suppose all consumers have the same continuous increasing demand function (in contrast to the unit demand assumed up to now), then a dispersion of costs amongst sellers would lead to heterogeneity in monopoly prices. This could be sufficiently diverse so that consumers would have an incentive to search. Thus, in the equilibrium of Reinganum (1979), low cost sellers charge their monopoly price, but high cost sellers must charge less than their monopoly price to make sales.

Finally, when one has heterogeneity of both buyers and sellers, there are two advantages. First, by the above argument, a Diamond-type outcome cannot be an equilibrium and so uniqueness of the dispersed price equilibrium is possible (Benabou, 1993). Second, the dispersed price equilibrium can be pure and strictly monotonic: higher cost firms charge higher prices. This follows because sufficient buyer heterogeneity can make demand to be everywhere continuous in prices, unlike the discontinuous demand in Varian's clearinghouse model. For example, if there is a continuum of buyers who search sequentially and have a continuous density of unit search costs, then there is the possibility of a continuous density of reservation prices. So, demand will increase smoothly as a seller lowers its price.

What are the major conclusions that can be drawn from these equilibrium models of price dispersion? The first is that both social and consumer welfare typically are decreasing with search costs. A reduction in search costs for some consumers can have a positive externality on other consumers, as increased search brings down prices for all. Other predictions can sometimes be counterintuitive. For example, an increase in the number of sellers actually raises the average price charged in the Varian model. However, this result does not hold for all price dispersion models. Further, Baye et al. (2004) find empirically that both average prices and the degree of price dispersion fall with an increase in seller numbers. Finally, we have seen that models with homogenous sellers give rise to mixed equilibria, while models with bilateral heterogeneity can generate pure equilibria. Randomisation over prices would imply regular change in price order amongst sellers. That is, sometimes a given seller would have the highest price, sometime the lowest, and sometimes in the middle. A monotone pure equilibrium would give rise to a stable price ranking. Baylis and Perloff (2002) find that price ranking on online sales of electronic goods are very stable. In contrast, Lach (2002) finds that price ranking in data on prices charged by different Israeli supermarkets is highly variable.

One possibility is that the difference arises because Lach's data are for groceries that are purchased with greater frequency than the electronic goods in Baylis and Perloff's data set. But this highlights that the current theoretical literature on price dispersion has rarely addressed the related issues of repeat purchases, frequency of purchase and search patterns that depend on past experience, for example, returning to sellers which have had low prices before. This would seem the area that is in most the need of further research.

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