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1 Introduction

In broad terms, one can say that price discrimination exists when two "similar" products which have the same marginal cost to produce are sold by a firm at different prices.[1] This practice is often highly controversial in terms of its impact on both consumers and rivals. This chapter aims to explain some of the main economic motives for price discrimination, and to outline when this practice will have an adverse or beneficial effect on consumers, rivals and on total welfare.

Broadly speaking, there are three main reasons why competition policy may be concerned with price discrimination. First, a dominant firm may "exploit" final consumers by means of price discrimination, with the result that total and/or consumer welfare are reduced. Here, the question that needs to be addressed is: in what circumstances does price discrimination by a dominant firm have an adverse effect on welfare? The answer to this, as will be clear in this survey, often depends on the welfare standard that guides the application of competition law. However, in practice competition authorities hardly ever concern themselves with price discrimination as an exploitative device.

Second, and especially in Europe, it is sometimes a policy objective to attain a "single market" across the region. Arguably, one manifestation of a single market is that a firm does not set different prices in different regions, or at least it does not prevent arbitrageurs

*I am very grateful to Paolo Buccirossi and John Vickers for comments. More technical and detailed discussions of some of the material presented here is presented in Armstrong (2006). In preparing this survey I have benefited from consulting the two earlier surveys by Hal Varian (1989) and Lars Stole (2006).

[1] There seems to be no consensus on a precise definition. Stigler (1987) suggests a definition that applies to a wider class of cases: discrimination exists when two similar products are sold at prices that are in different ratios to their marginal costs. Which of these definitions we use makes no difference for the purposes of this paper.

reselling goods sourced in the low-price region to the high-price region. That is to say, firms are often prevented from segmenting markets with a view to engaging in price discrimination. In Europe, this concern has lead to a very hostile attitude by the authorities to attempts by firms to prevent "parallel imports", for instance.

Third, and perhaps most importantly from a competition authority's point of view, we may be concerned that price discrimination can be used by a dominant firm to "exclude" (or weaken) actual or potential rivals. The question is in which cases price discrimination can be an effective way to put the buyer's rivals (primary line injury) or the seller's rivals (secondary line injury) at disadvantage so as to force them to exit the market, or induce them to compete less aggressively.

The appropriate antitrust treatment of price discrimination may require consideration of more than one of these concerns. For instance, a form of price discrimination may potentially be an efficient way to supply services to final consumers, and yet it may also possess exclusionary effects. In such cases, competition law and policy needs to balance the risk of preventing firms from pricing their products efficiently with the risk of permitting conduct that leads to a less competitive market structure.

This chapter aims to explain some of the main economic motives for price discrimination, and to outline when this practice will have an adverse or beneficial effect on consumers, rivals and total welfare. The plan of the chapter is as follows. Section 2 outlines some of the principal methods of price discrimination. Section 3 shows how the ability to engage in price discrimination can sometimes lead to efficient (e.g., marginal cost) prices, which clearly leads to welfare gains. Section 4 discusses how price discrimination can open up new markets or shut down existing markets. Section 5 examines when price discrimination causes total output to rise or fall. Section 6 discusses when the introduction of price discrimination will cause some prices to rise and other to fall, while sections 7 and 8 focus on less familiar situations in which price discrimination causes all prices to fall or all prices to rise. Section 9 examines the impact of price discrimination on entry incentives. Section 10 introduces dynamic price discrimination, while section 11 outlines the impact of price discrimination in vertically-related markets.

The discussion throughout focusses on the underlying economics of price discrimination and its impact on profits, entry, consumer surplus, and welfare. Where relevant, though, particularly prominent anti-trust cases are mentioned as we go along.[2]

2 Forms of price discrimination

There are numerous business practices which fall under the heading of price discrimination. First, consider static situations in which consumers buy all relevant products in a single

[2]Section 3.7 of Varian (1989) summarizes the origins of the legal approaches to price discrimination in the United States, which initially focussed on protecting small retailers against large chain stores. For a survey on the application to price discrimination of Article 82 of the EC Treaty, see Geradin and Petit (2005).

period. In most markets, firms set the charge for purchase of their products by means of a simple price per unit for each product, where these prices do not depend on who makes the purchase. Such tariffs (i) are anonymous (they do not depend on the identity of the consumer), (ii) do not involve quantity discounts for a specific product (i.e., there are no "intra-product" discounts), and (iii) do not involve discounts for buying a range of products (i.e., there are no "inter-product" discounts). Various forms of price discrimination are found by relaxing restrictions (i)–(iii).

Non-anonymous price discrimination: This occurs when a firm offers a different tariff to identifiably different consumers or consumer groups. When the tariff also involves simple per-unit pricing (rather than nonlinear pricing or bundling), this is the familiar case of *third-degree* price discrimination. Examples of this practice include selling the same train ticket at a discount to senior citizens, selling the same car at different prices in two countries, or selling the same drug at difference prices for human and animal use. Unless arbitrage between consumer groups is very easy or competition between firms is almost perfect, we expect that any firm, if permitted to do so, would wish to set different tariffs to different groups. In antitrust cases this type of price discrimination can occur when the alleged abuse consists in "selective price cuts" or "geographic price discrimination".[3]

Another example of this form of price discrimination is *first-degree* price discrimination, where each consumer is charged exactly her willingness-to-pay for the product(s). In its purest form, the information needed for first-degree price discrimination makes it more of a theoretical benchmark than a realistic business strategy. However, it provides a transparent limit framework in which to discuss the possible efficiency gains from price discrimination, as well as its distributional impact on consumers.

Quantity discounts: This occurs when the per-unit price for a specific product decreases as the number of purchased units increases. A simple—and easy implemented—instance of this is a two-part tariff, whereby a buyer must pay a fixed charge in return for the right to purchase any quantity at a constant marginal price. There are two distinct motives to use nonlinear tariffs. First, nonlinear tariffs provide a more efficient means by which to generate consumer surplus. With linear pricing, the only way to make profit is to set prices above costs, which entails deadweight losses. With a two-part tariff, however, a firm can extract profit using the fixed charge, while leaving marginal prices close to marginal costs (which then maximizes the size of the "pie" to be shared between consumer and firm). This role for nonlinear pricing exists even if all consumers are similar. A second role emerges if consumers have heterogeneous tastes for a firm's products. In this case, a nonlinear tariff can be used to sort different types of consumers endogenously (so-called *second-degree* price

[3]Prominent antitrust cases in the European Union concerning selective price cuts and geographic price discrimination are *Irish Sugar* and *Compagnie Maritime Belge*, for the first category, and *United Brands* and *Tetra Pak II* for the second.

discrimination).[4] If some consumers gain higher utility from the product than others, then if the firm offers a tariff where the marginal price declines with volume, it will typically make higher profit than if it offers the same marginal price to all consumers.[5]

Pure quantity discounts are generally not challenged by competition authorities if they merely reflect cost efficiencies stemming from the larger volume of product sold (and are therefore not discriminatory). However, at least in Europe, there is hostility towards discounts offered by a dominant firm which do not reflect costs.[6] This approach, which seems to be overly rigid, does not recognize the efficiencies that may stem from the pricing method, independent of the cost efficiencies related to the scale of the transaction.

Bundling discounts: This occurs when the price for one product is reduced if the consumer also buys another product. Two variants of bundling exist: (i) *pure bundling* is where a consumer can only purchase the products as bundle and there is no scope for buying an individual item, and (ii) *mixed bundling*, where the firm sets prices for a bundle and also for individual items. In general, unless products have negligible marginal costs or are perfect complements, pure bundling is a rather inefficient business practice. The reason is that it forces some consumers to purchase products for which their willingness-to-pay is smaller than the cost of supply. Thus, we expect that "all inclusive holidays" will often be an inefficient way to market holidays, since efficiency requires that consumers only consume what they value. In addition, we will see that pure bundling can provide a means by which to deter entry by single-product firms. Mixed bundling (with two products) sorts consumers endogenously into three groups: those with a strong taste for both products (who buy the bundle from the firm), those with a strong preference for product 1 but weak preferences for product 2 (who buy just product 1), and those with the reverse tastes (who buy just product 2). Mixed bundling is closely related to two-part pricing: the "first" item from the firm is expensive, while the "second" is relatively cheap. Indeed, since it is often hard to pin down what it means for products to be "distinct", in practice it may be hard to distinguish (intra-product) quantity discounts from (inter-product) bundling discounts. (Should a season ticket for a concert series, say, count as a quantity discount for purchasing several units of the same product, or as a discount for purchasing several distinct items?)

Next turn to dynamic situations. There are several ways in which a firm can set different

[4] However, there are plenty of examples of second-degree discrimination that are not to do with nonlinear pricing. For instance, many retailers use coupons placed in newspapers to segment the market. It is plausible that those consumers who take the trouble to cut out and use a coupon will also have more elastic demand, and should therefore face a lower price. See Narasimhan (1984), for instance.

[5] See Tirole (1988, section 3.5.1), for instance.

[6] In its judgment in *Michelin II* the European Court of First Instance suggested that if discounts are not based on cost efficiencies they should be regarded as in beach of Article 82. For further discussion of competition law and policy towards quantity discounts and related practices, see Vickers (2005, section 2.4) and the "Syposium on Loyalty Rebates", *Competition Policy International*, volume 1, number 2, Autumn 2005.

prices for essentially the same product over time. If consumers wish to buy a single item at some point in time (e.g., a new novel), then a firm might be able to make those consumers with a higher reservation price pay more than other consumers by setting a price for the item which decreases over time. This *inter-temporal* price discrimination is essentially another form of second-degree discrimination. A crucial difference between static and dynamic forms of price discrimination is that, in the latter case, a firm may not have the ability to commit to future prices. That is to say, once a firm has sold its product to the initial (enthusiastic) pool of consumers, it typically has an incentive to reduce its price to extract profit from the remaining, lower-value consumers. Indeed, in simple models, it turns out that the firm would prefer not to have the ability to price discriminate in this way, but it cannot help but offer declining prices over time. This is the essence of the famous Coase (1972) problem faced by firms selling to forward-looking buyers. In these situations, policy which forbids price discrimination may have the effect of endowing the firm with commitment power, with the result that all prices can rise. Thus, it is perhaps not surprising that competition authorities have rarely investigated this type of dynamic price discrimination.

Other issues arise if consumers wish to purchase a product repeatedly (e.g., from a supermarket or an online retailer). In this case, a firm may be able to base its price today on whether (or how much, or what) a consumer has purchased from it in the past. This *behaviour-based* price discrimination is becoming increasingly prevalent due to the improved technological ability to track consumer behaviour by means of the internet, loyalty cards, and so on. This kind of price discrimination is a dynamic variant of nonlinear pricing, and one which raises interesting and subtle issues. However, one difference with static nonlinear pricing is that, in many cases, a firm does not announce its discounting strategy. Partly this is because it would often be too complicated to describe its strategy—for instance, a supermarket's personalized vouchers to a particular consumer will depend upon his history of purchases, and this will be impractical to communicate in detail. But partly there is the commitment problem again. For instance, a supermarket may notice that a past customer appears to have starting shopping elsewhere (his loyalty card has not been used, for instance), and it may then decide to mail the consumer a financial inducement to return to the shop. It is unlikely that the supermarket will wish to publicize such a strategy. In sum, information about shopping habits presents firms with an ability to set "personalized" (i.e., discriminatory) prices. It is intrinsically hard to commit to such personalized prices.[7]

The final class of discriminatory pricing discussed involve the pricing of inputs to downstream firms. An issue of frequent anti-trust concern is the wholesale price a vertically-integrated firm should be permitted to charge a downstream rival. When the firm sets too high a wholesale price (relative to its own retail price), the firm might be said to "discrim-

[7]However, the information and commitment problems are sometimes less severe when the buyers are downstream firms with which the seller has long-term relationships. In these cases the dominant seller may offer what in the antitrust jargon are sometimes referred to as "target rebates". This practice conditions the rebate to the meeting of a threshold based on the past purchases of the buyer. Target rebates have been investigated in the cases *Michelin I* and *II*, *British Airways* and *Irish Sugar*.

inate" against its rival. The interpretation of "too high" is not obvious, however, and this issue is discussed later in the chapter. A second issue is whether a vertically-separate upstream supplier should be able to discriminate in its wholesale contracts among downstream buyers. A major difference between supplying an input to downstream firms and supplying a product to final consumers is that, in the former case, the contracts are often much more complex and "personalized" than those typically offered to final consumers. As such, the contract with one downstream firm might not be known to a rival downstream firm. This "secret deals" problem again raises the issue of credibility. We will see that if the upstream supplier can offer discriminatory deals to downstream firms, it may be forced to offer generous deals which ultimately benefit final consumers. But if public policy forbids such discriminatory behaviour, this may restore the monopolist's ability to set high prices to its downstream buyers.

Regardless of the method of price discrimination, it is necessary that consumer arbitrage not unravel the discriminatory prices. For instance, if a firm wishes to set a lower price in one country it is important that consumers in higher-price countries not be able easily to import the same product from the low-price country. (Prominent examples of price discrimination by country include cars and pharmaceuticals.) Similarly, a season ticket holder should not be able to let others use the season ticket, or consumers should not easily be able to pretend to be new customers at a firm in order to take advantage of its introductory offers. Therefore, when policy makers wish to discourage price discrimination, they will often take the indirect route of ensuring that consumer arbitrage is as easy as possible. For instance, as mentioned earlier, European competition law is very hostile to firms preventing parallel imports of their products when those firms are dominant or enter into anti-competitive agreements with other firms.[8]

3 Price discrimination can lead to efficient prices

In many cases, the welfare problems caused by firms exploiting their market power are due to firms having insufficient information about their consumers' preferences, or being constrained (by public policy, for instance) in their ability to condition prices on their information about consumers. In some circumstances, allowing firms to engage in price discrimination can implement efficient prices. In these cases, total welfare is unambiguously improved, although the impact on consumers may be negative.

One familiar example of this is first-degree discrimination, where a monopolist has perfect

[8] An important recent case is case C-53/03 *Syfait v GlaxoSmithKline* before the European Court of Justice. This involved a pharmaceutical company wishing to prevent its products, which are sold at a low price in Greece, from being re-imported into high-price countries. Advocate General Jacobs issued an opinion in October 2004 that such constraints on parallel imports in this case should not necessarily be considered abusive since the price differentials stemmed from state intervention in the prices for drugs in each country.

information about each consumer's willingness-to-pay for its product(s).[9] To be concrete, suppose there is a population of consumers, each of whom wishes to consume a single unit of the firm's product. Willingness-to-pay for this item is denoted v and this varies among consumers according to the distribution function $F(v)$. Thus, if a consumer has valuation v and faces the price p, he will buy if $v \geq p$. Suppose the firm has unit cost c. If price discrimination is not permitted (or is otherwise not possible), the firm will choose its single price p to maximize profit $(p-c)(1-F(p))$. Clearly, the chosen price will be above cost, and total surplus is not maximized. (It is efficient to serve all those consumers with $v \geq c$, but only those with $v \geq p > c$ are served.) If the firm can somehow observe each consumer's v and is permitted to discriminate on that basis, it will charge each consumer the maximum possible (i.e., $p = v$) provided this price covers its cost of supply. In other words, an efficient outcome is achieved. However, the firm appropriates the entire gains from trade and consumers are left with nothing. Thus, the benefits of allowing first-degree price discrimination depend on the chosen welfare standard: with a total welfare standard such discrimination is beneficial, whereas with a consumer standard it is not. Since it is rather common that the impact of price discrimination on consumers is the opposite to its impact on overall welfare, this issue—that policy towards price discrimination depends on the chosen welfare standard—appears repeatedly in the price discrimination literature.

Another example of first-degree price discrimination involves two-part tariffs. Suppose that the monopolist knows the utility each consumer gains from its product. Specifically, suppose that a particular consumer has surplus $u(q) - T$ if she consumes q units of the product in return for a payment T. Consumers must receive a non-negative surplus if they are to buy from the firm at all. If the firm has a unit cost c its profit-maximizing strategy is to maximize $T - cq$ subject to the consumer's participation constraint $u(q) - T \geq 0$. This entails choosing q to maximize $u(q) - cq$ so that total surplus from the interaction is maximized. This outcome can be implemented by means of a two-part tariff: the firm sets the marginal price equal to marginal cost c and sets the fixed charge to extract all the consumer's surplus. (This fixed charge will differ from consumer to consumer, depending on their preferences $u(\cdot)$.) Again, this results in the efficient level of consumption, while consumers are left with no surplus.[10]

Monopoly first-degree price discrimination is merely an extreme form of a fairly common situation. Lack of information about consumer tastes, in combination with market power, leads to welfare losses as a firm faces a trade-off between volume of demand and the profit it makes from each consumer. In many cases, if the firm can price discriminate more finely it

[9] Armstrong (1999) and Bakos and Brynjolfsson (1999) show how a monopolist supplying *many* products can sometimes be in a position to practise (approximate) first-degree price discrimination, even if it does not know the precise willingness-to-pay for any individual item.

[10] Price discrimination can also lead to efficient supply to *some* consumers, if not all. For instance, in standard models of nonlinear pricing, a profit-maximizing monopolist will ensure that those consumers with the strongest tastes for its product will face a marginal price equal to the firm's marginal cost. See Willig (1978), for example.

will be able to extract consumer surplus more efficiently, and this will often lead to greater overall welfare. However, it is consumers' private information that protects them against giving up their surplus to a monopoly. Therefore, when a price-discriminating monopolist has improved information about its consumers this will often lead to a reduction in consumer surplus.

Competition between suppliers is another means by which consumers are protected against surplus extraction. Therefore, even if firms know everything about a consumer's tastes, competition ensures the consumer will still be left with surplus. In competitive environments, whether consumers are better or worse off when firms can practice price discrimination is a subtle question, as we will see throughout this survey.

Consider for example the effects of firms offering two-part tariffs instead of linear prices. (This discussion assumes that consumers buy all supplies from one firm or the other, i.e., there is "one-stop shopping".) With linear pricing, firms' prices will be close to their marginal costs if the market is competitive, and prices will be higher when the firms have more market power. When firms offer two-part tariffs their marginal prices will usually be lower than when linear prices are employed. For instance, in the special case where all consumers have the same demand function, firms will sets marginal prices exactly equal to marginal cost, since that is the most profitable method for a firm to deliver a particular level of consumer surplus. Total welfare often increases if two-part tariffs are used instead of linear prices, since the marginal price falls to cost. With more intricate analysis one can also show that profit increases with this form of price discrimination, while consumers are typically worse off.[11] Thus, this competitive setting resembles the monopoly setting with two-part tariffs just discussed: welfare and profits increase but consumers are harmed by the use of two-part tariffs. The main effect of competition here is that consumer surplus is no longer driven down to zero when two-part tariffs are used. To confuse the issue, though, we will see alternative situations in section 7 where the reverse happens: when competing firms know everything about consumer tastes and price accordingly, firms are harmed and all consumers are better off.

Finally, in the context of *regulated* monopoly, socially optimal prices almost always exhibit price discrimination. Ramsey prices—the prices which maximize welfare subject to the regulated firm covering its costs, including fixed costs—depend on demand conditions in much the same way as an unregulated monopolist's prices do. For instance, when the firm serves a number of independent markets, each with the same marginal cost of supply, Ramsey principles suggest that the most efficient way to cover the firm's production cost is to set a higher price in those markets where consumer demand is less elastic, exactly as would be the case with an unregulated profit-maximizing firm. In sum, socially optimal prices are discriminatory whenever the regulated firm has fixed costs of operation which need to be funded by price-cost markups.

[11] See Corollary 1 in Armstrong and Vickers (2001) and Yin (2004). Armstrong and Vickers (2006) show that these results extend to many situations where consumers have heterogenous demand functions.

4 Price discrimination can open (or shut) markets

It is possible that permitting price discrimination will open markets that would otherwise not be served at all. For instance, suppose a monopolist faces two independent markets, one of which is "high value" and the other is "low value". When discrimination is allowed, suppose the discriminatory price in the high-value market is significantly higher than the choke price which causes demand in the low-value market to fall to zero. Then, if the size of the high-value market is sufficiently large compared to the low-value market, when discrimination is not allowed the monopoly will choose to serve only the high-value market. In such cases, granting permission to discriminate results in a Pareto improvement: the strong market's price is unchanged while the weak market is served, which increases the surplus of consumers in the weak market as well as the firm's profit.[12]

A simple example of this phenomenon is the following. There are two kinds of consumer: consumers in market 1 each wish to consume a single unit of the product and are willing to pay up to 4 for this unit, while consumers in market 2 each wish to consume a unit and are willing to pay 2 for this unit. Suppose the monopoly has no cost of production. In this case, if the firm must charge the same price to both markets it will choose to set the price 4 and serve only market 1 whenever there are more consumers in that market than in market 2. (If there are more consumers in market 2 then the firm will prefer to set the price 2 and serve all consumers.) If price discrimination is possible then the firm will set a price 4 in market 1 and a price 2 in market 2, and this results in a Pareto improvement.[13]

Another aspect of this issue is that the higher profit which price discrimination generates can provide a more effective way for a firm to cover its fixed costs. In some cases, a monopoly might be profitable overall if it can price discriminate but unprofitable if it cannot. A broadcaster, for instance, might only be profitable if it can bundle its channels together, or a rail operator might only be able to break even if it can discriminate between low income and other travellers. In such cases, *all* markets would be shut down if price discrimination were not allowed.

Further examples of how the introduction of price discrimination might open or shut a market involve nonlinear pricing. Suppose there are two groups of consumers, high-value users and low-value users, and the firm cannot distinguish between the two groups directly.

[12] See Layson (1994) for formal analysis along these lines. We follow the literature and say that a market where the price rises with discrimination is a "strong" market while a market where the price falls is a "weak" market.

[13] Note that a variant of this example shows that price discrimination can sometimes cause markets to shut down. Suppose there is a third intermediate market where consumers have a valuation of 3 for a unit. Suppose 50% of consumers are in market 1, 10% are in market 3 and 40% are in market 2. Without price discrimination, one can show that the best strategy for the firm is to set a price of 2 and to serve all consumers. Suppose next that the firm can distinguish only two groups of consumers, those in market 1 and those who are in either market 2 or 3. One can show that the optimal strategy for the firm is set a price of 2 to those in market 1 and to set a price of 4 to those in market 2/3. Thus, permitting price discrimination causes the firm to abandon market 3, and this causes welfare to fall.

Both types of consumer potentially wish to consume up to two units of the product. Low-value users have utility of 2 from their first unit and further utility of 1 from the second unit. High-value users have utility twice as high: their utility is 4 from the first unit and 2 from the second unit. The fraction of high-value users among the consumers is λ, say. If production is costless, when the firm sets a linear price the profit-maximizing price is $p = 2$ (regardless of the fraction λ). With such a price, the low-value users consume a single unit while the high-value users consume two units. Suppose next that the firm sets a nonlinear tariff, and say its price for a consumer's first unit is p_1 while its price for a subsequent unit is p_2. Then one can show that the profit-maximizing nonlinear tariff is $p_1 = 2$, $p_2 = 1$ if $\lambda < \frac{1}{2}$ and $p_1 = 4$, $p_2 = 2$ if $\lambda > \frac{1}{2}$. Thus, when low-value users are more numerous, the introduction of nonlinear pricing causes the low-value users to consume two units, which is efficient. This results in a Pareto improvement compared to linear pricing. However, when high-value users are more numerous, the optimal strategy for the firm is to exclude the low-value users completely so as to fully extract the high-value surplus. Total welfare decreases in this case compared with linear pricing, and all consumers are weakly worse off. In particular, this simple example shows that nonlinear pricing has an ambiguous effect on welfare relative to linear pricing.

While a consideration of when markets open or shut due to price discrimination does offer some insights—in particular, the possibility of Pareto improvements is an uncontroversial benefit of price discrimination—this analysis does not take us very far. For instance, the welfare difference between a market being shut down and being open a tiny bit is not significant. Moreover, in practice markets are rarely completely shut down when price discrimination is banned. (In virtually all countries, there is someone who is willing to pay almost any price for a luxury car or a pharmaceutical product.) For this reason, in the next section we discuss the effect of price discrimination on total output.

5 The effect of price discrimination on output

A focus of earlier work on price discrimination has been on its effect on output. If different products have different (marginal) prices when those products have the same marginal cost, then total output is sub-optimally distributed from a social welfare perspective. However, it might be that output increases when firms are permitted to engage in price discrimination, and this effect might be sufficient to outweigh the undesirable "unequal marginal utilities" effect. Using this insight one may deduce that if price discrimination does *not* lead the firm(s) to expand output, it will cause welfare to fall.[14] However, this does not tell us much in the event that discrimination causes total output to rise, since welfare might then be higher or

[14] The effect of discrimination on total output was perhaps first studied by Robinson (1933). Schmalensee (1981) shows that if demands for the products are independent and marginal costs are constant, then if welfare increases with discrimination it must be that total output increases. Varian (1985) extends this argument to allow for cross-price effects, and Schwartz (1990) extends the argument to nonlinear cost functions.

lower. Thus, using changes in output as a test for the welfare effects of price discrimination is capable only of delivering bad news. Moreover, outside some classroom examples, it is rarely easy to find conditions that characterize when output rises or falls with discrimination, and very detailed knowledge of consumer demand is needed to formulate accurate public policy.[15] However, if the firm is *regulated* the comparison is sometimes easier. For instance, Armstrong and Vickers (1991) and Armstrong, Cowan, and Vickers (1995) show that with common forms of average price regulation, total output necessarily increases if the firm is permitted to engage in price discrimination. As already emphasized, however, this does not imply that price discrimination will be welfare improving.[16]

Another insight is that if the strong market is also the large market, then allowing price discrimination is often good for output and welfare. To see this, consider the following example.[17] Consumers each wish to purchase a single unit of a monopolist's product. Consumers either have a high valuation v_H for the unit or a low valuation $v_L < v_H$. There are two markets, 1 and 2, and the fraction of the consumers in market i who have a high valuation is λ_i. Suppose that $\lambda_1 \geq \lambda_2$, so that market 1 has the greater proportion of high-value consumers. Suppose that production is costless. If the firm is able to practice third-degree price discrimination across the two markets, it will set a high price v_H in market i if $\lambda_i v_H \geq v_L$, and otherwise it will set the low price v_L. If the firm cannot discriminate, it will base its price on the overall fraction of high-value consumers across the two markets. If a fraction β of all consumers are in market 1, the overall fraction of high-value consumers is $\bar{\lambda} = \beta\lambda_1 + (1-\beta)\lambda_2$. If the proportion of high-value consumers is similar in the two markets, so that the discriminating firm would like to set the same price in the two markets (either both high or both low) then clearly policy toward discrimination has no impact on prices. However, if the distribution of consumers is quite asymmetric, in the sense that

$$\lambda_1 > \frac{v_L}{v_H} > \lambda_2 \ ,$$

the discriminating monopolist would set a high price in market 1 (the strong market) and a low price in market 2 (the weak market). In this case, policy which prohibits price discrimination will certainly have an effect on prices. If the weak market is the larger market,

[15] When consumer demands are linear, and if no markets are opened as a result of price discrimination, it is well-known that output is not affected by price discrimination, and hence that discrimination causes welfare to fall. Schmalensee (1981, p. 245) concludes "If all demand functions are strictly concave or convex and the p_i's [the discriminatory prices] are not nearly equal, there is apparently no simple, general way to tell if monopolistic discrimination will raise or lower total output." However, see Cowan (2006) for more progress in this direction.

[16] An interesting case involving price discrimination and total output is Competition Commission (1999). In 1999, the supply of milk in the UK was fixed by European quotas. One distributor, *Milk Marque*, held nearly a 50% market share, and was heavily engaged in price discrimination to its buyers. Since its total output was fixed via the quota arrangements, this discriminatory pricing was likely to harm welfare. This factor was an important part of the Competition Commission's case against *Milk Marque.*

[17] This is taken from Hal Varian, "A Big Factor in Prescription Drug Pricing: Location, Location, Location", *The New York Times*, 21 September 2000.

in the sense that $\bar{\lambda} < v_L/v_H$, the non-discriminating firm will choose to set a low uniform price. This will increase consumer surplus and total welfare relative to the situation with price discrimination. On the other hand, if the strong market is the larger market, in the sense that $\bar{\lambda} > v_L/v_H$, the firm will respond to a ban on discrimination by setting a high price to everyone. This will harm consumers in the weak market, and lower total welfare. In sum, when a weak market—a market with relatively few high-valuation consumers—is also a relatively small market, then price discrimination is likely to help consumers in this market and improve overall welfare. This suggests that a *per se* ban on price discrimination by country is too blunt a policy.

Extending this monopoly analysis to situations of oligopoly does not usually make the effect of price discrimination on output easier to predict, since one must consider firm-level elasticities as well as market elasticities.[18] One exception to this occurs in Armstrong and Vickers (2001, section 4). Here the focus is on the competitive limit where prices are close to marginal cost, and it is shown that if the weak market is also the market with lower market elasticity then total output falls with discrimination, and hence so does welfare. In competitive environments, firms might be forced to set a lower price in the "wrong" market (i.e., in the less elastic market) since firm-level elasticities might differ drastically from market-level elasticities. By contrast, with monopoly the firm generally sets high prices in the correct (inelastic) markets.

6 When does price discrimination cause some prices to rise and others to fall?

It is intuitive in many situations that when a firm is permitted to engage in price discrimination some of its prices will fall while others will rise. That is to say, the non-discriminatory price is some kind of "average" of the discriminatory prices.

Consider first the case of monopoly supply. Suppose a monopolist serves two markets, 1 and 2, which have independent consumer demands. The firm's profit in market i when it sets the price p_i in that market is denoted $\pi_i(p_i)$. Then the profit-maximizing discriminatory prices are characterized by $\pi_i'(p_i) = 0$, while the profit-maximizing uniform price p satisfies $\pi_1'(p) + \pi_2'(p) = 0$. Except in the fluke case where there is no gain from discrimination, it follows that in one market i we have $\pi_i'(p) < 0$ and in the other market $\pi_j'(p) > 0$. Assuming profit functions are single-peaked it follows that if the monopoly can price discriminate it will lower its price in market i and raise its price in market j.

Matters are more complicated when there are competing suppliers. As emphasized in Corts (1998), the chief difference with monopoly is that a market might be strong for one firm but weak for its rival. In such cases price discrimination can cause *all* prices to fall, as discussed in section 7 below. However, when firms do not differ in their judgement of which

[18] See Holmes (1989), for example.

markets are strong, Corts shows that when price discrimination is permitted, prices will rise in the market which both firms view as strong and prices will fall in the market which both firms view as being weak. (Corts uses the term "best-response symmetry" when firms agree about which market is strong and which is weak.) Armstrong and Vickers (2001, section 4) and Armstrong (2006, section 3.2) provide simple examples of best-response symmetry where price discrimination causes some prices to rise and other to falls. In both examples, industry profit rises when discrimination is permitted, while consumer surplus falls.

The discussion in this section has considered only the case of third-degree price discrimination so far. Consider next a monopoly bundling example.[19] There are two products, 1 and 2, provided by a monopolist. Consumers are characterised by their valuations v_1 and v_2, where v_i is a consumer's valuation for product i. Suppose that her valuation for consuming both products is just the sum $v_1 + v_2$. In general, the firm sets three prices: p_1 is the firm's price for product 1 alone, p_2 is the price for product 2 alone, and p_{12} is the price for the bundle of products 1 and 2. Figure 1 shows the resulting pattern of demand (when $p_{12} < p_1 + p_2$).

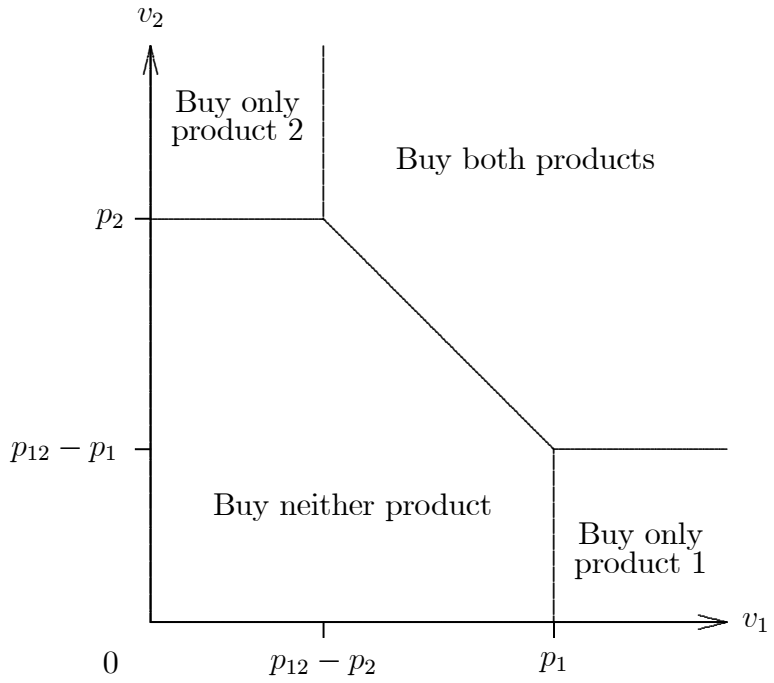

Figure 1: Pattern of Consumer Demand with Monopoly Bundling

Suppose the marginal cost of supplying either product is zero and consumer valuations (v_1, v_2) are uniformly distributed on the unit square $[0, 1]^2$. If bundling is not possible (i.e.,

[19] Two key papers on monopoly bundling are Adams and Yellen (1976) and McAfee, McMillan, and Whinston (1989).

$p_{12} = p_1 + p_2$), the profit-maximizing price for each product is $\frac{1}{2}$ and the firm makes profit of $\frac{1}{2}$. If the firm is able to price discriminate by means of offering a discount for joint purchase ($p_{12} < p_1 + p_2$), one can show the profit-maximizing prices are $p_{12} = \frac{4}{3} - \frac{1}{3}\sqrt{2} \approx 0.862$ for the bundle of two products and $p_1 = p_2 = \frac{2}{3}$ for each stand-alone product. Thus the price for joint consumption is lower than with unbundled pricing, while the price for a single item is higher. In this example at least, then, the market for joint consumption is the weak market, while the market for individual consumption is the strong market. This pricing policy results in profits approximately equal to 0.55, which is 10% higher than the profit without bundling. One can calculate that aggregate consumer surplus with this mixed bundling policy is given by 0.255, which compares to 0.25 with independent pricing. Thus, aggregate consumer surplus also increases (slightly) when mixed bundling is used, although those consumers with strong taste for one product but not the other are worse off with the bundling policy since they constitute the strong market. Again, then, we see that price discrimination is not necessarily harmful to consumers or welfare, even in a monopoly context.

7 How price discrimination can intensify competition

Perhaps surprisingly, there are several situations where permitting firms to engage in price discrimination causes *all* prices to fall, so that competition is intensified. The examples discussed here fall into two categories: models where firms discriminate on the basis of consumer brand preferences, and models of competitive bundling. We discuss these in turn. (Further situations in which price discrimination leads to tougher competition are found in the dynamic context presented later in section 10.)

Following the analysis of the previous section, consider cases where firms differ in their view of which markets are strong and which are weak. Corts uses the term "best-response asymmetry" for these cases.[20] Take for example the model of Thisse and Vives (1988). There are two firms in a Hotelling market. Suppose first that firms can observe each consumer's location (or brand preference), and can price accordingly. A firm will then set a relatively high price to nearby consumers in order to exploit those consumers' unwillingness to travel so far to the other firm, so that its nearby consumers constitute a firm's strong market. In particular, one firm's strong market is the other's weak market. In equilibrium, consumers purchase the product from the preferred firm, which is efficient, and those consumers who are almost indifferent between the two brands will obtain the best deal. If firms must set a uniform price to all consumers, however, Thisse and Vives show that this uniform price can be above all the discriminatory prices. Thus, when there is best-response asymmetry it is possible that all prices decrease with price discrimination. In this model, price discrimination

[20] Nevo and Wolfram (2002) present evidence consistent with the hypothesis that price discrimination via coupons in the breakfast cereal market exhibits best-response asymmetry, and that the introduction of coupons leads to a fall in all prices. They also document how firms allegedly colluded to stop the use of coupons.

has no impact on total welfare since all consumers just wish to buy a single unit, and they buy this unit from the closer firm with either pricing regime.[21] All consumers clearly benefit from price discrimination. Firms, however, make lower profits when they engage in this form of price discrimination compared to when they must offer a uniform price.[22] As Thisse and Vives (1988, page 134) put it:

> "denying a firm the right to meet the price of a competitor on a discriminatory basis provides the latter with some protection against price attacks. The effect is then to weaken competition, contrary to the belief of the proponents of naive application of legislation prohibiting price discrimination like the Robinson-Patman Act."

The fact that firms might be worse off when they practice price discrimination is one of the key differences between monopoly and competition. Ignoring issues of commitment for now (see section 10.1 below), a monopolist is always better off when it can price discriminate: the firm is free to choose a uniform price when discrimination is permitted but in general it is better off setting different prices. In the same way, an oligopolistic firm is always better off if it can price discriminate compared to when it cannot, for *given* prices offered by its rivals. However, as in many instances of strategic interaction, once account is taken of what rivals too will do, firms in equilibrium can be worse off when price discrimination is permitted. Firms then find themselves in a classic prisoner's dilemma.

We turn next to examples concerning bundling. The first such example is taken from Matutes and Regibeau (1992), where two symmetric firms each offer a version of two products. Consumers wish to purchase one unit of both products. (These two products could be purchased from the same firm or from two different firms.) In a specific example, Matutes and Regibeau show that when firms are able to offer a discount for joint consumption, the firms' prices are uniformly below the equilibrium prices without bundling. Of course, each firm's profit then falls when bundling is employed. Clearly, consumers are all better off as a result of the price reductions caused by price discrimination. However, there is *excessive loyalty*: because of the bundle discount too many consumers buy both products from the same

[21] As ever, one should be wary of reaching policy conclusions on the basis of these unit demand models since price levels have little role to play in welfare terms. If consumers had elastic multi-unit demands, price reductions have a beneficial welfare impact. In addition, if firms have imperfect information about brand preferences, price discrimination may induce some consumers to buy from their less preferred supplier. For instance, Bester and Petrakis (1996) consider a model where firms only know whether a consumer prefers it to its rival, but not by how much. In this model, firms set lower prices to those consumers who are known to prefer the rival brand, with the result that those consumers who are almost indifferent between the two brands will prefer to buy from the (slightly) less preferred supplier in return for the reduced price. A similar feature appears in dynamic models of price discrimination in section 10.

[22] Cooper, Froeb, O'Brien, and Tschantz (2005) use a variant of this model to argue that mergers are less likely to be detrimental when firms practice spatial price discrimination than when they do not.

firm than is efficient, and so welfare falls with this form of discrimination.[23,24] The economic reason why mixed bundling acts to intensify competition is rather subtle, and awaits further clarification. (It cannot be anything to do with best-response asymmetry, since firms do not view the various kinds of consumer as strong or weak in different ways.)

The final examples in this section involve a multi-product firm facing a *single*-product rival. I discuss two such examples. The first one involves pure bundling and the second involves third-degree price discrimination. Consider first this bundling example.[25] Suppose there are two products, 1 and 2, and each consumer potentially would like a unit of each product. Firm A supplies both products and holds a monopoly over product 1, while firm B supplies a variant of product 2. Suppose consumers have additive utility for the two products. Suppose consumers have homogeneous preferences for product 1, and all have the same reservation value, v_1, for this item. The two firms supply imperfectly substitutable versions of product 2, and if firm A sets the (unbundled) price p_2^A while B sets the price p_2^B, firm A's product 2 demand is $q_2^A(p_2^A, p_2^B)$ and B has demand $q_2^B(p_2^A, p_2^B)$. Firm A has marginal cost $c_1^A < v_1$ for product 1 and marginal cost c_2^A for its product 2, while B has marginal cost c_2^B for its product 2. Then A's profit from product 2 is $(p_2^A - c_2^A)q_2^A(p_2^A, p_2^B)$ and B's profit is $(p_2^B - c_2^B)q_2^B(p_2^A, p_2^B)$. Given that A sets unbundled prices, its most profitable response to B's price p_2^B is denoted $p_2^A = R_{SEP}^A(p_2^B)$ and similarly B's best response to A's price p_2^A is denoted $p_2^B = R_2^B(p_2^A)$. When firm A sets unbundled prices for its two products, the prices for product 2 are determined by the intersection of these two reaction functions, as depicted by γ on Figure 2. (Firm A sets the monopoly price $p_1^A = v_1$ for product 1.)

Next, suppose firm A commits to sell its two products as a pure bundle, while prices are determined in a second stage. Say that firm A's price for the bundle is p_{12}^A. A consumer deciding whether to buy from firm A or firm B knows that when she buys from A she obtains an extra utility v_1 due to the additional consumption of product 1. Therefore, firm A's "effective price" for product 2 is $p_2^A = p_{12}^A - v_1$, and the demand for A's bundle is just $q_2^A(p_{12}^A - v_1, p_2^B)$. Firm A's total profit is

$$(p_{12}^A - c_1^A - c_2^A)q_2^A(p_{12}^A - v_1, p_2^B) = (p_2^A - [c_2^A - \{v_1 - c_1^A\}])q_2^A(p_2^A, p_2^B) \ .$$

[23] A variant of this model involves the two firms having to choose between separable pricing and *pure* bundling. In this case, firms' profit also falls in many cases when firms choose to sell their products only as a bundle, and typically if falls by more than when mixed bundling is employed. See Matutes and Regibeau (1988) and Economides (1989) for this analysis.

[24] The example analyzed in Matutes and Regibeau (1992) is extended in Armstrong and Vickers (2006) to allow for asymmetric products, non-uniform distributions, correlation in brand preferences, and shopping costs for purchasing from more than one supplier. They show in this more general framework that mixed bundling continues to harm profit and welfare, and to boost consumer surplus, relative to linear pricing. However, they also extend the bundling model to allow for elastic, multi-unit demand for each product, in which case the impact of price discrimination on profit, welfare and consumer surplus is shown to be ambiguous.

[25] This is essentially Example 2 in Whinston (1990). For more detailed discussion of the Whinston model and the literature that follows, see Neven (2007).

This is similar to its profit from product 2 when there is unbundled pricing, except that its cost c_2^A is shifted down by $\{v_1 - c_1^A\}$. Therefore, firm A's most profitable effective price p_2^A, given B's price p_2^B, which is denoted $p_2^A = p_{12}^A - v_1 = R_{BUND}^A(p_2^B)$, is shifted *downwards* compared to the case of unbundled pricing. The (effective) prices for product 2 are now located at β on Figure 2, which are lower for both firms. Typically, both firms' profits fall when firm A offers its products as a bundle. Therefore, when there is an existing firm in market 2—so that entry deterrence is not an issue—in this particular model we would not expect the multi-product firm to choose to sell its products as a bundle.

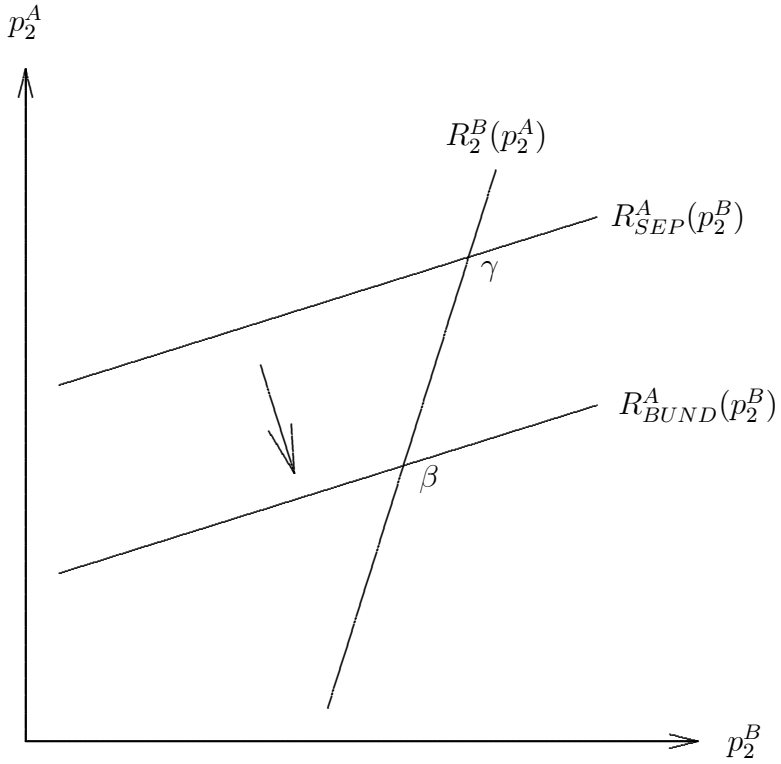

Figure 2: The Strategic Effect of Pure Bundling

Why does bundling by the multi-product firm lead to more intense competition? As explained by Whinston (1990, page 884), when firm A bundles its products, in order to make profitable sales of its monopolized product 1, it must also make sales of its product 2. This leads it to cut price in an effort to take sales away from firm B, an effect Whinston terms "strategic foreclosure". However, whether this strategic foreclosure effect operates or not depends on the details of the model, as we will see in section 8.

A closely related model, involving third-degree discrimination instead of bundling, is the following.[26] Suppose firm A serves two independent markets, 1 and 2. Market 1 is

[26] See Armstrong and Vickers (1993) for formal analysis. This paper also argues that the effect of allowing

monopolized by firm A, whereas in market 2 there is a rival firm B. If firm A can price discriminate in the sense that it may offer selective price cuts and set distinct prices in the two markets, it will set the monopoly price in market 1, while prices in market 2 will be determined by the competitive interaction between the two firms. On the other hand, if firm A cannot set different prices in the two markets it will have to trade off the benefits of setting a low price in the competitive market versus a high price in the captive market. In particular, if firm A prefers to set a higher price in the captive market than in the competitive market, so that the former is firm A's strong market, the effect of a ban on price discrimination is to reduce the price in the captive market and to raise prices in the competitive market. The profit of the single-product rival clearly increases when such a ban is imposed, while the effect on firm A's overall profit is not clear-cut.[27]

8 How discrimination can relax competition

There are a variety of ways in which price discrimination can act to relax competitive pressures in the markets, to the detriment of consumers.[28]

When a multi-product firm faces a single-product rival, it is possible that bundling can act to reduce the intensity of competition.[29] To see this, suppose again there are two products, 1 and 2. Firm A supplies both products while firm B can supply only product 2. The two firms here offer identical versions of product 2. A consumer has valuation v_1 for product 1 and v_2 for product 2 (and valuation $v_1 + v_2$ for both products). Suppose the firms' costs of supply are normalized to zero. For simplicity, suppose that (v_1, v_2) is uniformly distributed on the unit square $[0, 1]^2$. Then, if firm A sets unbundled prices for its two products it will set the monopoly price $p_1^A = \frac{1}{2}$ in its captive market. All profits are competed away for product 2, and that product's price is equal to zero. Therefore, with unbundled pricing firm A's profit is $\frac{1}{4}$, while firm B makes nothing.

Suppose instead that firm A commits to bundle its two products together, prior to the two firms choosing prices. Firm A sets a price p_{12}^A for its bundle, while firm B sets the price p_2^B for its product. Figure 1 depicts the pattern of consumer demand (where $p_1^A = \infty$). By calculating the areas in the figure, one can calculate the equilibrium prices are approximately

price discrimination on the intensity of competition is exacerbated when the multi-product firm is regulated and operates under an average-price constraint. (If it reduces its price in the competitive market it can then *raise* its price in the captive market.)

[27] Dobson and Waterson (2005) present a related model where a national retailer operates in a number of markets, in some of which it is the sole supplier and in the remainder of which it faces a single local competitor. They show that it is possible for the chain store to benefit if it commits to a national pricing policy (i.e., if it does not price differently depending on competitive conditions in each local market).

[28] See Buccirossi (2007) for a fuller account of "collusive" practices.

[29] This bundling example is taken from Section III.E of Nalebuff (2004). See section II of Whinston (1990), Carbajo, De Meza, and Seidman (1990) and Chen (1997a) for earlier analyses.

$p_{12}^A \approx 0.61$; $p_2^B \approx 0.24$. Therefore, all prices rise compared to the situation in which firm A sets unbundled prices. In effect, bundling helps to differentiate the two firms' offerings: firm A offers a superior "product" (by virtue of its additional product 1 in the bundle). The respective profits of the two firms are approximately $\pi^A \approx 0.367$; $\pi^B \approx 0.067$, which are also both higher compared to when firm A prices its products separately. This example, in combination with the discussion of the Whinston model in the previous section, indicates that the effect of bundling on a multi-product firm's incentive to be aggressive to single-product rivals is ambiguous and depends on the fine details of the model of consumer demand. Without very detailed data on consumer preferences, it is hard for an anti-trust authority to predict *a priori* whether bundling will relax or intensify competition.

Another way in which price discrimination might relax 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 effort costs involved in documenting the lower prices, there is a clear danger of collusion: 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 its and its rivals' prices. In this stark framework, public policy which prohibits the use of such "competitor-based" discrimination schemes would help restore normal competitive pressure in the market, to the benefit of consumers. However, if consumers face costs of searching for price offers or providing evidence of low prices, a more conventional price discrimination motive emerges: sorting consumers on the basis of their value of time (akin to the use of discount coupons). In such cases, the collusive impact of competitor-based discrimination is blunted, and consumers might sometimes be better off with this form of price discrimination is employed.[30]

A further way in which price discrimination might act to limit competition occurs when it leads to negative network effects. Consider an telecommunications market in which subscribers join one network or another. Public policy might or might not permit firms to price discriminate on the basis of the destination network. This form of discrimination is present if a subscriber on network A faces a different call charge if his call is made to another subscriber on network A or to a subscriber on a rival network B. If firms each make it *cheaper* to make calls to people on rival networks than to people on their own network, then negative network effects are present and, all else equal, a subscriber prefers to join a smaller network since they can then make a greater fraction of their calls at the cheap rate. It is well known that markets with negative network effects of this form will not be very competitive, since a firm which offers a low price will not attract many new subscribers. Therefore, this form of price discrimination can act to relax competition, to the detriment of consumers.[31]

[30] See Corts (1996), for example.

[31] I have skated over the means with which firms agree to set lower prices to make calls to subscribers on

9 Effects of discrimination on entry

The effects of price discrimination on entry is a central concern of competition policy. Three broad issues are discussed: (i) the effect on the equilibrium number of firms in a monopolistic competition framework; (ii) the effect on a monopolist's incentive to enter an adjacent market; and (iii) the effect on a potential entrant's incentive to enter a monopolized market.

9.1 Free entry

Price discrimination can raise or lower equilibrium profits in a market with a given number of firms, as seen in the previous sections. When there is free entry of firms, it follows that the equilibrium number of firms will rise with price discrimination in the former case, but will fall in the latter case when more intense competition will drive out some firms. In some common models of oligopolistic interaction—though by no means all—it is well known that free entry will result in too many firms entering from a total welfare perspective.[32] In those cases where price discrimination raises profits, the resulting greater entry will only exacerbate the welfare costs of excessive entry. By contrast, when price discrimination destroys profits, the excess entry problem will be mitigated (although typically not overturned).[33]

9.2 A monopolist's incentive to enter an adjacent market

The second topic in this section involves a monopolist in one market entering an "adjacent" market. The motives considered here are not necessarily anti-competitive—there need not be a motive to drive firms out of the adjacent market—but rather the firm wishes to engage in price discrimination, and in some situations the only way it can do this is by participating in the adjacent market.

Ability to offer quantity discounts: In this example, product 1 is monopolized by firm A, while product 2 is potentially supplied in a competitive market with price equal to cost. For simplicity, suppose all production is costless. Suppose product 2 is a complementary product

rival networks. In the telecommunications context, this could be done via low "call termination" rates. If firms agree to set their charge for delivering calls from rival networks below the associated cost, then firms will have an incentive to set low charges for calls made to rival networks. See Laffont, Rey, and Tirole (1998), Gans and King (2001) and Berger (2005) for further details.

[32] See Mankiw and Whinston (1986), for instance.

[33] See Borenstein (1985), Norman and Thisse (1996) and Bhaskar and To (2004) for further analysis of the effect of price discrimination on the free-entry number of firms. Ordover and Panzar (1982) investigate the effects of an upstream monopolist's use of two-part pricing on the number of downstream firms. They find that in general the monopolist will not set a socially optimal two-part tariff, despite the fact that it knows everything about its downstream customers. Thus, in this respect there is a contrast between selling to final consumers (when the use of two-part tariffs leads to an efficient outcome, as discussed in section 2 above) and selling to intermediate customers.

to product 1, but consumed in variable quantities by consumers. Consumers wish to buy just one unit of product 1, however. (The classical examples of this situation are computers and punch-cards, or photocopiers and toner.) Consumers differ in how much of the joint product they wish to consume. Suppose demand for the joint product by a consumer with demand parameter θ is $\theta - p_2$ if the marginal price for product 2 is p_2. Suppose θ is uniformly distributed between 0 and 1. If p_1 is the price for product 1, a consumer's net surplus is $\frac{1}{2}(\theta - p_2)^2 - p_1$. Therefore, a consumer will participate in the market if $\theta \geq \sqrt{2p_1} + p_2$, and total demand for product 1 and product 2 is respectively

$$q_1 = 1 - \left(\sqrt{2p_1} + p_2\right) \ ; \ q_2 = \tfrac{1}{2}(1 - p_2)^2 - p_1 \ .$$

If the monopolist for product 1 ties the purchase of its monopoly product to purchase of the potentially competitive product 2, it can set a price above cost for product 2. It will then choose the pair of prices (p_1, p_2) to maximize total profit $p_1 q_1 + p_2 q_2$, and this entails $p_1 = 0.08$ and $p_2 = 0.2$. This brings in profit of 0.08, while consumer surplus is approximately 0.043. In particular, the monopolist wants to set a price above cost for product 2.[34] If the monopolist did not tie product 2 with product 1, all active consumers will buy product 2 on the competitive market with price $p_2 = 0$. This will surely bring the monopolist less profit than the tying strategy (since it could choose $p_2 = 0$ under the tying regime, but preferred to set $p_2 = 0.2$). Therefore, the monopolist has an incentive to "leverage" its monopoly position for product 1 into the market for product 2. If such tying is not permitted (so $p_2 = 0$), the monopolist would significantly increase its product 1 price to $p_1 = 0.22$. Its profit is then 0.074, while consumer surplus is essentially unchanged at 0.044. In this example, then, total welfare is higher if the monopolist is permitted to tie its product, although in general the comparison is ambiguous.[35,36] Notice also that the monopolist would like to pursue this tying strategy even it incurred a slightly higher cost in supplying product 2 than did the competitive rivals. (This assumes that the monopolist

[34] The monopolist will do even better if its sets a fully nonlinear tariff, rather than just a two-part tariff, for consumption of the joint product.

[35] See section 3.3.1.5 in Tirole (1988) for a clear account.

[36] In fact, the firm can also do well if it offers consumers an *optional* bundled tariff. Suppose that the firm offers consumers the profit-maximizing unbundled tariff ($p_1 = 0.22$, $p_2 = 0$). Suppose, in addition to this tariff, the firm offers consumers the option of another tariff which has a lower price for the monopoly component but a higher price for the competitive good. Such a tariff will be attractive to consumers with relatively low demands. Specifically, if the firm offers the optional tariff with $\hat{p}_1 = 0.037$ and $\hat{p}_2 = 0.272$ then those consumers with $0.54 \leq \theta \leq 0.82$ will use this new tariff. (Some of these are new consumers and some are "cannibalized" from the existing tariff.) Since consumers have the option of using the unbundled tariff, consumer surplus surely rises with the addition of this tariff. Also, the firm's profit with the new optional tariff is 0.081, which is higher than that generated by the unbundled tariff on its own, and also higher than that generated by the optimal single two-part tariff ($p_1 = 0.08$, $p_2 = 0.2$). Therefore, the introduction of this optional tariff represents a Pareto improvement compared to when the unbundled tariff is used on its own. See Nalebuff (2005) for related analysis (where the same model for consumer demand is employed).

cannot monitor a consumer's consumption of product 2 from rival suppliers.) In this sense, the monopolist has an incentive to exclude more efficient rivals.

Ability to offer bundling discounts: Since a multi-product monopolist typically gains when it can bundle its products—see the discussion in section 6 above—it follows that a multi-product monopolist makes greater total profit than if the same products were supplied by a series of single-product monopolies. (If the products were supplied by single-product firms, then prices would be product-by-product.) This is true even when the various products are neither complements or substitutes in the usual sense. In technical terms, there may be "informational economies of scope" involved in multi-product supply, even if more familiar economies of scope are not present.[37]

To illustrate, return to the example in section 6 where there are two products, 1 and 2, and consumers have valuations (v_1, v_2) for these two products individually and valuation $v_1 + v_2$ for joint consumption. If production is costless and the valuations are uniformly distributed on $[0, 1]^2$, the multi-product monopolist obtains profit of 0.55 by practising mixed bundling, while a pair of single-product monopolies each supplying one product make a combined profit of 0.5. To see how this affects a monopolist's incentive to enter an adjacent market, consider the following broadcasting scenario. There is an incumbent broadcaster who currently holds broadcasting rights to a particular sports event. The rights to a second, perhaps unrelated, sports event then become available for auction. Because the incumbent broadcaster will be able to engage in bundling if it obtains the second rights, but a new broadcaster will not, the incumbent will be willing to pay more for the new rights than a new broadcaster. (It will be prepared to pay up to 0.3 for the new rights, whereas a new broadcaster could only pay 0.25.)

Thus, even if for no other reason, this argument suggests that an existing rights holder is likely to win a bidding war for any new rights. Indeed, in a richer model where the entrant might offer a superior service (e.g., it has lower supply costs or a higher quality service), the incumbent might be prepared to pay more for the additional rights than the superior entrant. However, set against this is the fact that consumers often benefit from bundling. For instance, in this particular example, consumers are better off if the incumbent wins the new rights and practices bundling. Thus, if policy-makers are deciding whether to permit bundling, they may have to trade-off the possible consumer benefits of bundling against the possible foreclosure of more efficient entrants. The information required to implement accurate policy in this environment is formidable.

This provides a simple example of "conglomeration" effects (or "portfolio" or "range" effects), which have risen in prominence in anti-trust cases in recent years. See Neven (2007) for a more detailed account of such cases, which include the controversial *General*

[37] See Bakos and Brynjolfsson (2000) for further analysis of this issue. Of course, the argument does not apply to third-degree price discrimination, where there are several separate markets and each consumer wishes to purchase just a single product from the multi-market firm.

Electric/Honeywell merger. One reason why these cases are challenging for the competition authorities is that the standard approaches to market definition no longer always apply well.[38]

9.3 An entrant's incentive to enter a monopolized market

One of the most controversial aspects of price discrimination is the possible impact of an incumbent's ability to price discriminate on the incentives for entry. There are a number of ways in which price discrimination by an incumbent firm affects the incentives to enter its markets. Constraining the incumbent's freedom to choose its prices affects its response to entry, and hence the expected post-entry profits of the entrant.

This is illustrated in the context of the model of third-degree price discrimination based on Armstrong and Vickers (1993) discussed in section 7. There is a multi-market incumbent facing potential entry into one of its markets. If the incumbent is permitted to set different prices in its two markets, then it is plausible that it will react more aggressively to entry compared to when it must set the same price in the competitive and the captive market. We conclude that the post-entry profit of the entrant is likely to be lower when the incumbent can price discriminate than when it cannot. If the entrant has a fixed cost of entry, it will enter only if it expects post-entry profit to cover its entry cost. There are then three cases to consider. If the entry cost is large, there will be no entry regardless of whether the incumbent can price discriminate. In this case, the social desirability of price discrimination is exactly as in the standard monopoly case, and this is ambiguous in general. Similarly, if the entry cost is very small, entry will take place regardless of policy towards price discrimination. The interesting case is when the cost of entry lies in the intermediate range where entry is profitable only if the incumbent cannot price discriminate, so that a ban on price discrimination acts to induce entry. In such cases it is plausible that a ban on price discrimination will cause the prices in *both* markets to fall: if discrimination is possible, there will be no entry and the incumbent will charge monopoly prices in each market; if the incumbent must charge a common price in the two markets, this will bring in the entrant and force both of the incumbent's prices down from monopoly levels.

The general principle, as in the Thisse-Vives quote in section 7 above, is that denying an incumbent the right to meet the price of a competitor on a discriminatory basis provides the latter with some protection against price attacks. While the effect of a ban on price discrimination is indeed to weaken competition if the entrant is already in the market, once the *ex ante* incentives to enter are considered, the effect of a ban on price discrimination might actually be pro-competitive. However, the welfare effects of a ban on price discrimination

[38] Another way in which price discrimination interacts with market definition is that, (i) when a hypothetical monopolist is able to price discriminate between two or more consumer groups, these consumer groups will make up separate anti-trust markets, while (ii) when the monopolist cannot price discriminate, the whole market becomes the relevant market for anti-trust purposes. For instance, see the *Horizontal Merger Guidelines* issued by the United States Department of Justice and the Federal Trade Commission, 1992.

in this context are not clear cut. For instance, since the incumbent is reluctant to cut its profits in the captive market by meeting its rival's price in the competitive market, even a highly inefficient entrant might prosper. While preventing an incumbent from engaging in selective price cuts is likely to be a powerful means with which to assist entry, as with many forms of indirect entry assistance the danger of inefficient entry is never far away.

This question of whether to permit (above cost) selective price cuts is of substantial importance in practice. For instance, many network industry incumbents (such as privatized telecom companies) are required to offer geographically uniform retail tariffs, even though they face competition only in particular areas (such as cities). While such a policy will indeed act to encourage entry and to "bring the benefits of competition to the whole country" (as it is often put), it is also likely to induce inefficient, or excessive, entry into the attractive market segments. The question is also important in markets without a history of regulation. For instance, Vickers (2005, page F249) summarizes a recent anti-trust case involving shipping:

> "Above-cost price cuts were at issue in the case of *Compagnie Maritime Belge*, on which the ECJ gave judgment in 2000. The enterprise, which had a near-monopoly position on certain shipping routes between Europe and West Africa, had selectively cut prices to match those of its competitor, though not demonstrably to below total average cost. The Court saw the risk that condemning such pricing could give inefficient rivals a safe haven from the full rigours of competition, but in the circumstances at hand judged that there was abuse (albeit not abuse under the heading of predation) because the selective price cuts were aimed at eliminating competition while allowing continuing higher prices for uncontested services."

The situation in which a firm selectively lowers its prices in more competitive markets is closely connected to the situation in which a firm selectively offers low prices to customers of a rival. We will discuss this issue in more detail in section 10, albeit mostly in the context of competition between symmetric firms. When firms are symmetric, we will see that selective price cuts to a rival's past customers can reduce prices to all consumers.

A second way in which price discrimination might impede entry concerns (pure) bundling.[39] In section 7 we presented Whinston (1990)'s model where, if a multi-product firm bundles its two products, the equilibrium profits of the single-product rival are reduced. Therefore, if the multi-product incumbent can commit to bundle its products together before the entry decision has been made, this can act to deter entry. (Again, this will depend on the size of the fixed cost of entry.) Once entry is deterred, the incumbent can raise its bundle price to the monopoly level. There are a broad range of situations in which the incumbent finds

[39] The most prominent case relevant to this is the *Microsoft* case, and in particular the part of the case relating to the bundling of the *Internet Explorer* browser with its *Windows* operating system—see section 7.5 of Motta (2004) for some further details. An earlier relevant case from 1979 is *Berkey Photo v. Eastman Kodak*.

it privately profitable to deter entry in this way, but where total welfare would be higher if entry took place. Such instances provide a coherent case for a ban on bundling by an incumbent.

From the incumbent's point of view, one problem with the strategy is that, if entry *does* take place, the incumbent also makes lower profits with bundling than with unbundled prices. That is to say, its plan to bundle products might not be credible. The entrant might predict that the incumbent will renege on its promise to bundle if entry does take place, in which case the threat to bundle carries little weight. However, there are plenty of cases where the bundling decision is a long-term decision (if it is built into the product design, for instance), in which case it has credibility and the ability to deter entry.[40]

Another problem is that apparently minor changes to the model imply that bundling, even if credible, will not deter entry. For instance, in section 8 we saw that if consumers had heterogeneous valuations for the monopolized product, it might be that both firms' profits are higher if the multi-product firm bundles its products. In this case, bundling acts to *encourage* entry. Since the incumbent would still like to deter entry so it can set monopoly prices in both of its markets, if there is a fixed cost of entry the incumbent might well prefer to commit to unbundled pricing to deter entry (even though if entry did occur, the incumbent would prefer to revert to the bundling strategy which boosts both firms' profits). While a monopolist would prefer to bundle its products in this example, unbundled pricing with monopoly yields higher profit (0.5) than does bundling with entry in one market (which yields the incumbent profit of only 0.367).

This discussion of bundling so far has assumed the two products enter additively into consumer utility: the fact that a consumer has purchased product 1 has no impact on her willingness-to-pay for product 2. Many examples of bundling involve complements. In the extreme case of perfect complements, a consumer places no value on product 2 unless she also has product 1. The analysis changes somewhat when the two products are perfect complements. For one thing, a firm with a monopoly on one component clearly has the *ability* to foreclose entry into the complementary product market, simply by bundling its two components together. Whether it has the incentive to do this is another question. Whinston (1990, section III) shows in a benchmark model that the incumbent has no such incentive. Indeed, the incumbent generally benefits from the presence of a differentiated entrant in one component market. For instance, if the entrant provides an identical product 2 component but at lower cost, the incumbent will be able to extract all the entrant's profit by setting a product 2 price below its own cost, and raising its product 1 price accordingly. This is an instance of the Chicago School's insight that an incumbent has no incentive to prevent entry by a more efficient firm in a complementary product market.[41] Similarly, if the

[40] Nalebuff (2004) mainly considers a model in which the incumbent firm not only makes its bundling decision prior to entry, but decides on its prices before entry. Among other results, he shows that bundling is an effective way to deter single-product entry if the incumbent does not know in advance into *which* market the entrant will enter.

[41] The Chicago argument relies on the integrated firm possessing accurate information about its rivals'

entrant offers a differentiated product 2 component which appeals more to some consumers than the incumbent's own product, the incumbent will make more profit by allowing the entrant to deliver its monopoly component to the entrant's own pool of consumers.[42]

Still in the context of perfect complements, Choi and Stefanadis (2001) examine the case where an entrant must innovate if it is to produce a successful substitute for one of the incumbent's components. If the incumbent bundles its two product, this implies that there is no scope for single component entry. Entry then requires successful innovation on *both* fronts. Bundling can therefore reduce the incentive to innovate and so can increase the probability that the incumbent retains its markets. However, it is not always optimal for the incumbent to bundle, since it benefits when an entrant successfully innovates on just one component (as in the previous paragraph). Carlton and Waldman (2002) present a model where entry into the monopolized market is more likely to occur if the entrant is first active in the competitive market. If the entrant offers a superior product in the competitive market, or if its costs are lower there, then entry there is socially desirable. If entry were to be limited to that market, the incumbent would also welcome entry (as in the previous paragraph). However, the incumbent might choose to bundle its products and prevent desirable entry into the competitive market in order to discourage subsequent entry into its captive market.

10 Dynamic price discrimination

A topic which has received much recent attention is dynamic price discrimination. A publisher sets a high price for a new (hardback) book, then subsequently the price is reduced. Or a retailer might use information it has obtained from its previous dealings with a customer to offer that customer a special deal (or, as we will see, sometimes a bad deal). As discussed in the introduction, it is plausible that these forms of price discrimination have proliferated in recent years, due to developments in information technology. The cases of monopoly and duopoly supply are discussed in turn.

10.1 Monopoly

Classical results demonstrate that (i) if a monopolist can commit to its future prices it often does not wish to engage in inter-temporal price discrimination,[43] and (ii) if the firm cannot commit to its future prices it will decrease its price over time, its total profit is lower

capabilities. Section 11 below discusses a model where the integrated firm is unsure about a rival's cost of supply, and here the firm does have an incentive to exclude a more efficient rival.

[42] Whinston shows that if the complementary products are not perfect complements, then the incumbent may again wish to exclude a rival by means of bundling.

[43] See Stokey (1979). If the model is modified so that either consumers have different discount factors or consumers as a whole have a different discount factor to the firm, then it can be optimal to commit to a decreasing time path.

than in (i) while consumers are better off compared to (i).[44] Therefore, a ban on price discrimination in this context, even if feasible, will act to boost the monopolist's profits and harm consumers, since it gives the firm commitment power.

In more detail, suppose the firm can sell its product over two periods. There are two classes of model that are relevant. First, there is the "single sale" (or durable good) model where a consumer wishes to buy just a single unit of the good over the time horizon. (An example of this might be a new novel.) Second, there is the "repeated sale" model, where a consumer potentially wishes to consume in both periods. (An example of this might be a supermarket or online retailer.)

Consider first the single sale model. Suppose that there is a diverse population of consumers, each of whom wishes to buy just a single unit of a monopolist's good. As in section 3, consumer's valuation for this item, v, varies among consumers according to the distribution function $F(v)$.

First suppose that consumers are myopic, and they will buy the good as soon as the price offered is lower than their valuation, v. In this case the firm can fully extract consumer surplus by offering a price which decreases over time. By moving down the demand curve in this way, first-degree price discrimination is achieved. Notice that there is no issue about the firm committing to a price path over time in this special case when consumers are myopic.

If consumers are forward looking, however, the firm will not be able to extract consumer surplus fully, even if it can commit to future prices. Moreover, the firm will lose profit if it cannot commit to a time path for prices. Initially, suppose the firm can commit to a price pair $\{p_1, p_2\}$, where p_t is its price in period $t = 1, 2$. For simplicity, suppose that v is uniformly distributed on $[0, 1]$ and production is costless. It is then straightforward to show that the profit-maximizing price pair is $p_1 = p_2 = \frac{1}{2}$. Therefore, there is no inter-temporal discrimination, and consumers buy either in the first period or not at all. This analysis changes if consumers are forward looking and the firm is able to "change its mind" in the second period. Once consumers with $v \geq \frac{1}{2}$ have purchased in the first period, the firm is left with a pool of less enthusiastic consumers. Given this, in the second period the profit-maximizing policy is to set $p_2 = \frac{1}{4}$. Of course, if consumers foresee that the firm will behave in this opportunistic manner, their first period choice will be affected, and some consumers will strategically delay their purchase in order to receive the discounted price next period. To counteract this effect, the firm will optimally set an initial price $p_1 < \frac{1}{2}$. In sum, when the firm has the freedom to set its second-period price only after the initial period, *both* prices decrease compared to the case where the firm can commit (when $p_1 = p_2 = \frac{1}{2}$). If, somehow, public policy prohibited inter-termporal price discrimination so that the firm was forced to set $p_2 = p_1$, this would restore the firm's ability to commit to future prices, and would boost profit and harm consumers.

Next, consider the repeated sale model, and suppose that an individual consumer has the same valuation v for a unit in each of the two periods. Now, the firm has potentially

[44] This point was first made by Coase (1972). See also Hart and Tirole (1988).

three prices to choose: p_1, the price for a unit in the first period; p_2, the price in the second period if the consumer did not purchase in the first period; and $\hat{p}_2$, the price for a unit in the second period if the consumer also purchased in the first period. When the firm can commit to its second-period prices, one can show that the profit-maximizing pricing policy is just to set $p_1 = p_2 = \hat{p}_2 = \frac{1}{2}$. Therefore, it is optimal not to price discriminate. When the firm cannot commit, one can show that the most profitable prices satisfy[45]

$$p_2 \leq p_1 \leq \frac{1}{2} \leq \hat{p}_2 \ .$$

Therefore, when the firm cannot commit to its future prices, it will set a relatively low first-period price ($p_1 \leq \frac{1}{2}$), and then a high second-period price for those (high-value) consumers who purchased in the first period ($\hat{p}_2 \geq \frac{1}{2}$) and an even lower second-period price aimed at those who did not purchase in the first period ($p_2 \leq p_1$).[46] In particular, the firm views its past customers as its strong market in the second period, and new customers as its weak market. (This ranking also holds in oligopoly settings below.) All consumers are better off when the firm cannot commit, while the firm is obviously worse off. Total welfare is also higher without commitment. Again, the effect of a ban on price discrimination is to give the firm commitment power, to the detriment of consumers.[47]

10.2 Oligopoly

In this section I mention two models, both of which are repeated sale models involving symmetric firms. Each model involves a firm learning about a consumer's brand preferences from her initial choice of firm. In one model, due to Fudenberg and Tirole (2000), consumers have a stable brand preference for one of the two firms. If a consumer buys from firm A in the first period, she will most likely prefer to buy from firm A in the second period as well, all else equal, and both firms will price accordingly. In the second model, due to Chen

[45] See section 2.2 of Armstrong (2006) for further details.

[46] Of course, this form of discrimination is not feasible if past consumers can pretend to be new customers, for instance by deleting their computer "cookies" or using another credit card when they deal with an online retailer.

[47] Taylor (2004) analyzes a related situation where one firm sells a product in period 1 and a separate firm sells a related product in period 2. The first firm is able to sell its information about which consumers purchased from it in the first period to the second firm. The second firm is willing to pay for this information, since it provides the basis for behaviour-based price discrimination towards its consumers. Since the first firm can fully extract the second firm's benefit from the information, the scenario is essentially the same as when an integrated firm supplies in both periods and cannot commit to its second-period price. Taylor distinguishes between sophisticated and naive consumers. If consumers are naive, in the sense that they do not foresee their decisions with one firm might affect their offers from the subsequent firm, the first firm has an incentive to raise its price above the monopoly level in order to boost the value of information to the second firm. Public policy towards privacy might prohibit the passing of consumer information between firms, and this would make naive consumers better off and reduce the level of industry profit. On the other hand, when consumers are sophisticated, a ban on information transfer will surely increase industry profit.

(1997b), consumers initially view the two firms as perfect substitutes, but in the second period they incur a switching cost if they change supplier, and firms price accordingly in the second period.[48]

In each model, firms set their second-period prices taking as given their first-period market shares, i.e., the framework is one where firms offer short-term contracts and there is no commitment to future prices. In both models, the second period resembles the static model of Thisse and Vives (1988) discussed in section 7: whenever such price discrimination is permitted, firms will price low to try to "poach" their rival's previous customers and price high to their own previous customers. Each firm regards its own previous customers as its strong market, and there is "best-response asymmetry" in the terminology of Corts (1998). Therefore, the models share the feature that second-period prices are all lower than they would be if behaviour-based discrimination were not feasible.[49] Moreover, both models predict there to be excessive switching in the second period, in the sense that some consumers will buy from their less preferred firm because they are tempted by the low poaching price. Therefore, in these simple models with unit demand, behaviour-based price discrimination causes welfare to fall.[50]

While the two models are similar in terms of their predicted prices in the second period, they differ significantly in their prediction for how initial prices are determined. In broad terms, when behaviour-based price discrimination is employed, the Fudenberg-Tirole model predicts that prices are initially high and then decline, while Chen's model suggests that prices are initially low and then rise. (This latter result is common to most switching cost models.) Fudenberg and Tirole show in a specific example that when firms practice price discrimination, profit (over the two periods) falls and consumers in aggregate are better off. In Chen's model firms are always better off when price discrimination is not possible, and it is ambiguous whether consumers are better or worse off. (As already mentioned, in both models total welfare falls when price discrimination is employed.)

The discussion so far has not considered the possibility within the Fudenberg-Tirole framework that consumer brand preferences might change over time. For simplicity, consider the opposite polar case, and suppose that second-period brand preferences are independent of those in the first period. In this case, the consumer's choice of firm in the first period gives no useful information to firms in the second period, and there is no motive for a firm to set discriminatory prices to its own past customers and its rival's past customers. Suppose now

[48] See Taylor (2003) for an extension to Chen's analysis in a number of important directions, for instance to more than two periods and more than two firms. When there are more than two periods, the fact that a consumer switched supplier in the second period indicates that the consumer has low switching costs, and this could generate more intense competition for him in future periods.

[49] Thus, even if it appears to be "unfair" to the firm's existing customers that the firm's new customers often obtain a better deal, it is quite possible that if this form of price discrimination were forbidden, the existing customers would be yet worse off.

[50] However, in a richer model where consumers had elastic, multi-unit demands each period, the low second-period prices would bring welfare benefits which might outweigh the welfare losses due to excessive switching.

that firms can commit to a dynamic pricing strategy, i.e., they can credibly announce the three prices—the initial price, the second-period price if the consumer did not buy in the first period, and the second-period price if the consumer did buy from the firm in the first period—at the start of period 1. (This setting, where firms commit to explicit loyalty schemes, seems broadly applicable to frequent flier programmes and the like.) In this case, the static model of competitive mixed bundling by Matutes and Regibeau (1992), discussed in section 7 above, can be applied. As such, the dynamic loyalty scheme causes all prices to fall compared to the case when firms did not make their second-period prices depend on whether the consumer purchased from them in the first period. This is clearly good for consumers, although social welfare is reduced since there is excessive loyalty. This provides an interesting contrast to the Fudenberg-Tirole model without commitment, where the inefficiency was due to *insufficient* loyalty to firms. It is important to recognize, though, that both forms of dynamic price discrimination—*ex post* discrimination to poach rival consumers and *ex ante* explicit loyalty schemes—are often pro-consumer in their impact.

The discussion so far has assumed the two firms are symmetric and that there is no possible exit of firms. By contrast, anti-trust scrutiny of price discrimination typically focusses on the case where one firm is dominant. There has so far been little work done on dynamic price discrimination when firms are asymmetric. Chen (2006) takes a first step, and shows that the use of behaviour-based price discrimination might induce a weak firm to leave the market. For instance, he shows that the stronger firm may price below cost when selling to the rival's past consumers, with the aim and effect of eliminating socially desirable competition. The use of this form of price discrimination to deter entry and induce exit deserves further scrutiny.

11 Price Discrimination in Vertically Related Markets

In practice, many of the most pressing antitrust concerns about price discrimination relate to the pricing of inputs. For instance, Article 82(c) of the EC Treaty states explicitly that a dominant firm is abusive if it applies "dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage." We divide the discussion into two parts to cover cases where the upstream monopolist is vertically integrated or vertically separated.

Consider first a vertically-integrated firm which supplies an essential input to a potential entrant. Suppose that the incumbent firm has marginal cost c_1 for supplying its service to final consumers and marginal cost c_2 for supplying the input to a potential entrant. The entrant needs one unit of the input for each unit of output it supplies, and it incurs marginal cost c for converting a unit of the input into a unit of the final product. (No firm incurs any fixed costs in this simple framework.) Suppose consumers view the final products of the two firms as perfect substitutes, and choose to buy from the lower priced firm. Suppose that the incumbent does not know the marginal cost c of the entrant at the time it sets its two prices

p and a, where p is the incumbent's price to final consumers and a is its (access) price for the input. Suppose the cost c is perceived to be a random variable with distribution function $F(c)$. If the incumbent sets the two prices p and a, the entrant can profitably enter if its own costs are lower than the maximum price it can charge, i.e., when $a + c < p$, in which case the incumbent will make its profit solely from selling the input to the entrant. Otherwise, the incumbent makes its profit solely from selling directly to final consumers. Therefore, the incumbent's expected profit is

$$\pi = F(p-a)q(p)(a-c_2) + [1 - F(p-a)]\, q(p)(p-c_1) \ .$$

If we write $m = p - a$ for the *margin* offered to the entrant, this profit can be written as

$$\pi = q(p)(p-c_1) + q(p)F(m)(c_1 - c_2 - m) \ .$$

Therefore, regardless of the incumbent's decision about its retail price p, if free to do so it will choose m to maximize $F(m)(c_1 - c_2 - m)$. In general, this entails $m < c_1 - c_2$, or

$$a > c_2 + [p - c_1] \ . \tag{1}$$

What does price discrimination (as broadly interpreted) mean in this context? Intuitively, as with Article 82(c), the integrated firm discriminates against the entrant when the entrant faces a different (higher) cost for its input than does the "downstream" part of the integrated firm. But what is the true economic cost to the integrated firm in supplying a unit of the input to the entrant? One naive answer is that it is the physical cost c_2. But this ignores the opportunity cost element, that when the integrated firm supplies a unit of input to the entrant it supplies one less unit to final consumers and foregoes a profit there of $p - c_1$. That is to say, the economic cost to the monopolist of supplying a unit of the input to the rival is $c_2 + [p - c_1]$, and so the non-discriminatory input price is

$$a = c_2 + [p - c_1] \ . \tag{2}$$

With this input price the potential entrant finds it profitable to enter only if this is the more efficient way to supply the product to final consumers. (With expression (2) the entrant will enter only if $c + c_2 < c_1$, i.e., when this is the lower cost method of delivering the product to consumers.) That is to say, if the input price is set as in expression (2) then an equally efficient entrant can just survive in the market. If the input charge satisfies (1), however, an equally efficient entrant cannot survive in the market.[51] The reason why an integrated firm wishes sometimes to exclude a more efficient rival in this case (in contrast to

[51] In anti-trust terminology, a vertically-integrated incumbent is sometimes said to practice a "price squeeze" (or "margin squeeze") if an equally efficient entrant makes a loss with the offered margin—see Vickers (2005, section 2.3) for further discussion and a summary of recent price squeeze cases. Grout (2001) and Bouckaert and Verboven (2004) discuss the implementation of price squeeze rules in richer settings than discussed here (such as when the entrant incurs a fixed cost of entry or when the incumbent incurs extra

the standard Chicago result) is that the entrant has private information about its cost, and the incumbent wishes to appropriate part of the entrant's efficiency advantage.[52] Therefore, an unconstrained integrated firm might be expected to show undue discrimination against a rival. In such circumstances, a ban on this kind of price discrimination will raise total welfare compared to a *laissez-faire* regime.[53]

Consider next an alternative scenario in which a vertically-separated upstream monopolist sells an essential input, again with cost c_2, to two competing downstream firms, A and B say. For simplicity, suppose that A and B compete in a Cournot fashion, given the input prices set by the upstream firm.[54] Suppose that the contract between the monopolist and a downstream firm i takes the form of a two-part tariff, with fixed charge f^i and per unit of input price a^i. First, note that by an appropriate choice of two-part tariff, the monopolist can ensure (i) the industry profit is maximized and (ii) it appropriates the entire industry profit. (This is done by setting a high per-unit input price a—above the cost c_2—which generates high retail prices downstream, and then extracting the downstream profit via the fixed charge f.) In many relevant cases, however, the fact that buyers are firms rather than consumers implies that these contracts for input prices will be negotiated bilaterally rather than simply announced by the monopolist. Indeed, it is plausible that each downstream firm's contract with the monopolist will not be observed by the rival downstream firm. In this situation of secret deals the monopolist finds it hard to avoid offering each downstream firm a cost-based two-part tariff, with $a^i = c_2$. Of course, if both A and B pay for the input at cost, then the industry outcome will correspond to the (moderately) competitive Cournot outcome rather than the industry profit-maximizing outcome. In effect, the monopolist cannot avoid "competing with itself".

Why is the monopolist forced to set $a^i = c_2$ in this framework? Since it is secret, the choice of contract between the monopolist and firm A, say, cannot affect the expected output from firm B (or its input choice). Therefore, the contract with A will maximize the combined

costs when it supplies the input to the rival than it does when it supplies itself). Although price squeezes share with predatory price the feature that a "price" (here, the margin) is below avoided cost (here, the opportunity cost), there is nothing necessarily predatory about them. For instance, in the example presented in the text, the integrated monopolist set a low margin not to drive out rivals with a view to subsequently raising a price, but to extract some of the potentially efficiency gains generated by entrant supply. (Indeed the monopolist is here better off when entry occurs.)

[52] If the monopolist did know the entrant's cost c, and was permitted to base its input charge on this cost (another form of price discrimination), it would set the input price which just ensured profitable entry by an equally or more efficient entrant. The result is productive efficiency, but the entrant is left with zero profit. This outcome corresponds closely with the case of first-degree price discrimination discussed in section 3.

[53] However, Armstrong and Vickers (1998) argue that from a social welfare perspective it is often better to require the incumbent to set its input price equal to its cost c_2 than to require it to satisfy condition (2), for the reason that this condition (2) provides no constraint on the incumbent's retail price p.

[54] The key papers relevant to this "secret deals" problem are Hart and Tirole (1990), O'Brien and Shaffer (1992) and McAfee and Schwartz (1994). See Rey and Tirole (2006) for a full account of this literature. In particular, the results reported in the text are also valid when the downstream firms compete in prices. I have largely taken this informal discussion from Vickers (1996).

profits of A and the monopolist, taking the contract with B as given. But the joint profit-maximizing contract will involve $a^A = c_2$, since in that way the downstream firm's incentives are in line with the monopolist's. A similar contract will be secretly agreed with firm B. The monopolist's market power is eroded by its inability not to negotiate efficient bilateral deals secretly with the downstream firms.

This effect is closely related to the Coasian problem for the inter-temporal monopolist which was discussed in section 10.1 above. In the dynamic context, the unconstrained monopolist cannot commit not to offer a good deal to the remaining (low value) consumers in the second period, and this acts to undermine its market power. And just as with the Coase problem, a policy to ban price discrimination in input prices will act to restore the monopolist's market power. If the upstream monopolist were not allowed to offer different terms to different downstream firms, then it cannot secretly negotiate efficient bilateral contracts, and it can implement the monopoly outcome. As in the Coase problem, then, a policy which bans price discrimination may end up being detrimental to (final) consumers.

12 Conclusion

The welfare effects of allowing price discrimination are ambiguous, both with monopoly and with oligopoly supply. There is of course no justification for public policies that prohibit price discrimination in general. Price discrimination can lead to efficient pricing, for instance (see section 3). Price discrimination can lead to more intense competition which benefits consumers (see sections 7 and 10). When firms have difficulty committing to prices, they often are forced to charge low prices. In such situations, a policy which forbids discrimination endows a firm with commitment power and prevents the firm competing with itself, to the detriment of consumers and welfare (sections 10.1 and 11). When firms offer different prices to their loyal customers and to their new customers this can make competition more intense, but it can also induce excessive switching between firms (section 10.2). By contrast, multiproduct firms might induce excessive loyalty by means of bundling discounts (section 7). Price discrimination can also lead firms to leave consumers with less surplus than they would enjoy in its absence (sections 3 and 8). In addition, the freedom of an incumbent firm to engage in price discrimination will typically have a discouraging effect on entry (sections 9.3 and 11).

Ideally, then, policy towards price discrimination should be founded on good economic understanding of the market in question. This survey has highlighted the formidable amount of information required to determine when price discrimination is likely to be welfare enhancing or decreasing. Since it is impractical, and undesirable, to require competition bodies to have a good economic understanding of all markets, some broad rules of thumb are needed. One possible such rule is to follow a presumption that price discrimination by dominant firms aimed at final consumers should be permitted. Obviously, there are many examples where such price discrimination harms consumers and welfare, but given the detailed information

required to decide on this, and given that rules against excessive pricing remain available in some jurisdictions for use with particularly egregious cases, it seems sensible to give firms the benefit of the doubt. On the other hand, continued detailed scrutiny of cases involving selective price cuts and cases involving margin squeeze—which can be broadly interpreted as price discrimination—is important.

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