# Chapter 7. Predation, monopolisation, and other abusive practices

**Massimo Motta**
European University Institute, Florence,
Universitat Pompeu Fabra, Barcelona, and CEPR, London
e-mail: massimo.motta@iue.it
FIRST AND INCOMPLETE DRAFT

*Competition Policy: Theory and Practice*
Cambridge University Press, 2003

This draft: 16 December 2002

**Abstract**

# Contents

# 1 Introduction

This chapter deals mainly with exclusionary practices, that is practices carried out by an incumbent with the aim of deterring entry or forcing exit of rivals. By and large, such practices correspond to the legal concepts of monopolisation in the US and abuse of dominance in the EU (see chapter 1).

The identification of exclusionary behaviour is one of the most difficult topics in competition policy, as often exclusionary practices cannot be easily distinguished from competitive actions that benefit consumers. For instance, suppose that following entry into an industry a dominant firm is reducing considerably its prices: should this low price considered an anti-competitive strategy aimed at forcing the new entrant out of the industry (after which prices will be raised again, damaging consumers in the long-run), or is it instead just the a competitive response that will be beneficial to consumers? Most of this chapter will be devoted to understanding how to answer this question.

Exclusionary practices by incumbents are certainly not a new phenomenon, but there are at least two reasons why there should be a renewed attention on such practices. The first is that in many countries there have been processes of liberalisation, privatisation, and de-regulation that have resulted in several sectors having an incumbent facing potential entrants. This asymmetric structure creates strong incentives for potential exclusionary behaviour. The second is that a growing share of today's advanced economies is composed of sectors (for example computer software, internet and telecommunications) that exhibit network and lock-in effects. In such environments, entrants might find it very difficult to compete with incumbents, and particular care should be devoted to possible exclusionary practices.

Section 1 focuses on pricing strategies, and section 3 on non-pricing strategies, such as over-investment, tying and bundling, and incompatibility choices. (Other non-price exclusionary practices focusing on vertical restraints, such as exclusive dealing and refusal to supply, have already been analysed in chapter 6.)

Section 4 deals with price discrimination in general, although only some forms of price discrimination can be thought as exclusionary.

# 2 Predatory pricing

Throughout this book we have seen that low prices are generally associated with higher consumer and social welfare. It might therefore seem surprising at first sight that competition authorities might be concerned with situations where a firm charges "too low" prices. Yet, although rare, there are circumstances where a dominant firm might set low prices with an anti-competitive goal: forcing a rival out of the industry, or preempting a potential entrant. In these cases, low prices improve welfare only in the short-run, for the time predation lasts; once the prey has succumbed, the predator will increase its price. The final effect of this predatory behaviour (if successful) will be to worsen welfare in the long-run, because it gets rid of competition in the industry.

Predatory pricing therefore occurs when a firm sets prices at a level that implies the sacrifice of profits in the short-run in order to eliminate competition and get higher profits in the long-run. This definition, for the moment still vague, contains the two main elements for the identification of predatory behaviour in practice: first, the existence of a short-term loss; second, the existence of enough market power on the part of the predator so that it reasonably expects that after a rival (or more rivals) has been driven out of the market it will be able to raise prices so as to increase profits in the long-run.

The very nature of predatory pricing, which involves low prices for a period, makes it difficult to deal with. To distinguish low prices due to a genuine and lawful competitive response to rivals from low prices due to a predatory and unlawful behaviour is far from an easy task in practice. Furthermore, a very cautious approach by antitrust agencies and courts is needed to avoid the risk that firms endowed with market power keep prices high to avoid being charged with predatory behaviour. Suppose for instance that in a certain jurisdiction a low standard of proof is accepted for a finding of predatory pricing. Anticipating possible antitrust problems, a firm will have a lower incentive to cut prices, even though this would be due to normal competitive behaviour. As a result, prices will be higher than otherwise could be, causing an allocative efficiency loss, and inefficient competitors might feel encouraged to enter the market, adding a productive inefficiency to the welfare loss.

This does not mean, of course, that predatory pricing should be eliminated from the possible set of anti-competitive actions, but it does suggest that it should be dealt with caution. In the rest of this section I will try to give some indications on how to build a cautious but rigorous policy towards it.

## 2.1 Predation: search for a theory

Allegations of predatory pricing are certainly not a new phenomenon. Indeed, as seen in chapter 1, one of the reasons behind the Sherman Act was the small entrepreneurs' complaint that large firms acted predatorily, setting low prices to drive them out of the market.[1] Of course, some allegations were (as they are today) unfounded: a large firm often charges lower prices than rivals simply because it enjoys stronger scale and scope economies and it is therefore more efficient. But the point is that predatory pricing cases, although relatively rare, are as old as antitrust laws themselves.[2]

[1] Section 2 of the Sherman Act, prohibiting monopolisation or attempts to monopolise an industry, and later the Clayton Act, are the legal instruments to protect the interest of firms that feel victim of predatory pricing. In Europe, it is article 82 of the Treaty.

[2] Or even older: see the *Mogul Steamship Co. v. McGregor, Gow and Co. et al.*, a classical case of predation, which started in 1885. It concerned a conference of shipowners that excluded competition from non-members in the China-England trade (see Yamey, 1972) by a variety of practices among which the use of "fighting ships" which had the task of undercutting freight rates of competing vessels whenever they tried to get business on the China-England route.

Two famous early cases, which have kept busy researchers even in recent years, are *Standard Oil* and *American Tobacco*, with Supreme Court decisions taken as early as 1910 and 1911

Although findings of predatory pricing have not been uncommon in the US and, later, in the EU, a convincing economic theory of predation has not appeared until recently. The main explanation for predation was probably the "long purse" story. A large firm might drive out of the market a small competitor by waging a price war that gives losses to both. But the small competitor has limited resources (a "small purse") and will therefore be unable to survive such losses for a long time. Sooner or later, it will have to give up and leave the industry, allowing the large firm to increase prices and recoup losses. Unfortunately, however, a solid theory to support this story has appeared only very recently (see below), and skeptics had pointed out the weak points of predation arguments.

McGee (1958), in a very influential article, criticised the idea that a firm could drive out competitors by using predatory pricing on four main grounds, that I loosely summarise as follows. First, due to its larger market share, a large firm will usually have to suffer greater losses than a small firm: other things being equal, the same unit loss will be multiplied by a larger number of units (McGee, 1958: 140). Second, predation makes sense only if the large firm will increase prices when the prey leaves. But, McGee (1958: 140-141) argues, the assets and plants of the small firm will not disappear, and as soon as prices rise the small firm can re-enter, or its assets might be bought and used by somebody else, reducing the profits the predator can expect to make. Third, the predation theory assumes that the predator has a long purse and the victim a short one, while this should rather be explained than assumed (McGee, 1958: 139). In this perspective, one should understand why a small firm, even if financially constrained, could not explain the situation (including the fact that the predator is making more losses than it does, and cannot sustain them forever) to its creditors, thereby obtaining funds until predation will end. Fourth, for predation to be rational, it must be not only feasible but also more profitable than alternative instruments. If a large firm would like to get rid of a competitor, this criticism goes, predation is an inefficient tool because it destroys industry profits for the time it lasts. Merging with the rival would be a more profitable strategy, as it would allow to preserve high profits in the industry.

The first two arguments above can be taken care of relatively easily. Indeed, the first point does not hold if the large firm could price discriminate and decrease prices selectively only in those markets or for those clients where the small firm is competing. This allows the predator to preserve high margins on most of the units it sells, therefore reducing the cost of the predation strategy.[3]

As for the second point, it relies on the idea that entering and re-entering the industry does not entail sunk costs. But as we have seen throughout the book, fixed sunk costs are pervasive. A firm that leaves a sector will probably not be able to recover more than a small fraction of the fixed costs it has incurred to

(see also below).

[3] However, in his detailed analysis of the Standard Oil case, McGee argues that there is no evidence that supports the claim that local price cutting was used as a discriminatory predatory pricing strategy.

start production and sales, and a firm cannot close down its plants, firing its workers, ceasing to supply its product one day and returning costlessly the day after.

Furthermore, the very fact that the incumbent has successfully preyed once will probably have an influence over other firms that are considering entry into the same market. A potential entrant will not rush into the industry after seeing the end of its predecessor. This is one of the important counter-objections made by Yamey (1972), who pointed out that predation will discourage further entry into the industry. If an incumbent develops a reputation for reacting toughly and aggressively towards entry, potential competitors might be discouraged from entering the industry at all. Although it has taken game theorists quite a long time to prove formally this reputation argument, it is now rigorously established, as we shall see in section 2.2 and in technical section 2.3.2 below.

Perhaps the most challenging point made by McGee is the third. Suppose that the incumbent is indeed endowed with a lot of financial resources and a small rival is not, although they are equally efficient. Why should the small firm not be able to get further financing from banks or other lending institutions? After all, they should understand that predation could not be successful if they gave unlimited funding to the prey, and anticipating that, predation would not take place at all. Again, it is only recently, with the developments in corporate finance, that a convincing story of why predation might make tighter the financial constraints of firms has emerged, as I shall discuss in section 2.2 and, more technically, in section 2.3.6 below.

Finally, note that the fourth point made by McGee stresses an important general issue, namely that predation must not only be feasible but it must also be more profitable than alternative options available to the incumbent. On the particular point that a merger would be more profitable than predatory prices, three counter-objections can be made. First, buying out a competitor might encourage new ones to enter the industry with the aim of selling out to the incumbent at a profit: if it gains the reputation that new competitors will be bought out, a merger might not be a cheap option. Second, under some antitrust laws, taking over rivals might not be allowed to dominant firms. Third, as both Telser (1966) and Yamey (1972) argued, predation and mergers are not necessarily mutually excluding options: aggressive price behaviour might well result in the prey being ready to sell out at lower prices. The merger strategy is therefore not necessarily in contradiction with a predation strategy.

Indeed, Burns (1986) looks at the expenditures made by American Tobacco to take over 43 competing firms between 1891 and 1906, and finds econometric evidence that predation substantially decreased the acquisition prices. Aggressive price behaviour helped both directly (by reducing the price of acquiring a victim) and indirectly (by establishing a reputation for being a predator, that persuaded other rivals to sell out before any predatory episode would start).[4]

[4] The fact that predation might depress profit expectations of competitors, persuading them to sell out at lower prices, has been modeled by Saloner (1987) and is discussed in technical section 2.3.4.

This discussion of McGee (1958)'s arguments and their possible counter-objections has brought up the main issues related to predatory pricing. In what follows, I briefly summarise how economic theory has addressed such issues, providing convincing stories of why predation might indeed take place.

## 2.2 Recent theories of predatory pricing

There is a common thread behind all the recent models of predatory pricing: predation is a phenomenon that can be fully explained only in a context of *imperfect information*, that is a situation where players have some uncertainty.[5] In all cases, the predator will try to use the imperfect knowledge of the entrant (or of the outside investors that finance it), and behave so as to make them believe that the entrant would not make high profits in the industry. As a result, the entrant will exit, or its lenders will not be willing to provide it with more funding.

This manipulation of beliefs can only exist if some uncertainty exists. In a world where all the firms (and other active agents in the economy, such as outside investors) knew perfectly what are the technologies and financial resources available to each, their preferences and those of consumers, and their ability to behave rationally, predation would never be observed: either it is clear that a dominant firm will have an incentive to fight entry, and in this case the entrant would not dare enter in the first place (or the small firm would exit immediately); or the dominant firm knows that predation will not be successful, and therefore would not prey at all. Either way, predatory pricing would not be observed.

Within this set of recent (game theoretic) predation models of imperfect information, there are three main types that can be identified: (i) reputation models, (ii) signaling models, (iii) financial market models of "long purse" predation.[6]

### 2.2.1 Reputation models

The discussion of McGee's critique pointed out that the behaviour of an incumbent firm towards a current competitor is likely to have an impact on future (potential) competitors as well. A price war today might therefore find its rationale in the attempt to create a reputation of being a strong and aggressive incumbent to discourage entry (in other markets by the same competitor, or

[5] More precisely, in game theory a player has *imperfect information* when it does not know the moves that its opponents have taken beforehand; it has *incomplete information* when it does not know the payoff or the set of actions available to its opponents. However, it has been showed that a game of incomplete information can be re-written as one of imperfect information, which is therefore a more general concept (the equilibrium concepts of Perfect Bayesian Equilibrium and Sequential Equilibrium apply to both types of game).

[6] The distinction between reputation and signaling models is done mainly for exposition purposes, and it is to some extent arbitrary. Both types of models are incomplete information games that use sequential equilibrium or perfect Bayesian equilibrium as solution method.

in the same market by others) tomorrow. To understand how economic theory explains this reputation based model of predation, consider the following example.

Suppose that there is an incumbent monopolist that is active in a number of identical markets, where it has the same technology and products (e.g., a "chain-store"). In each of these markets, it faces a potential entrant. Entrants can enter one at a time. The game is as follows. In the first market, first the potential entrant decides whether to enter or not, and if entry occurs the incumbent decides whether to fight or accommodate it. Then this same game repeats, one by one, for all the markets.

Call now "weak" incumbent one that has costs as high as the entrants and that, if the game was played only once, would not fight entry, because it would be unprofitable: fighting amounts to setting a low price that causes losses to both the entrant and the weak incumbent. Selten (1975)'s insight is to show that the same result - the entrant enters and it is accommodated - applies also when the game is played for (finitely) many times, as long as it is *certain* that the incumbent is weak. Consider for instance the case where there are two entrants. Whatever might have happened in the first market, it is clear that the second and last entrant will be accommodated, since the incumbent would incur losses from fighting and would have no reason to build a reputation to be strong if the game ends. But then, since the only reason to fight entry could be to deter future entrants, in the first period there is no incentive to fight either: both the incumbent and the first market entrant correctly anticipate that the following period the incumbent will not fight, and entry will occur. In other words, fighting the first entrant would not deter second period entry. Hence, the incumbent has no incentive to fight and the first entrant knows it and will enter.[7]

Selten himself was puzzled by the result (that he thought "paradoxical") that predation would never be observed. He was convinced that in reality there would be a strong reason for the incumbent to prey on entrants to build up a reputation to deter further entry.

The main reason behind this result comes from the fact that the entrants know with certainty (i.e., have perfect information) that the incumbent has an incentive to accommodate if the game was played just once. Kreps and Wilson (1982) show that if some uncertainty is introduced, predation will occur.[8] Suppose that when the game starts entrants believe that with some (possibly very small) probability the incumbent might be not weak as described above, but rather "strong". In other words, it might be a very efficient firm whose costs are so low that it could make profits (rather than losses) if it charged a price below the costs of the entrant.

[7] With more than two periods, the same logic is applied repeatedly: see section 2.3.1.

[8] Kreps and Wilson's *incomplete information* model is presented technically - albeit in a much simpler two-periods version - in section 2.3.2. Predation by an incumbent facing successive entry can also be explained in an *infinite horizon* model with perfect information, as shown in exercise 1. Both models are a reaction to Selten's chain-store paradox model, which is based on perfect information and assumes a *finite* stream of successive entrants.

Clearly, a strong incumbent will always fight entry, but this will not be predation: simply, it is so efficient that it can set prices below costs of the entrant. The interesting issue is another, that is that a weak incumbent might exploit the entrants' uncertainty and fight entry to make them believe it is strong instead.[9] Indeed, Kreps and Wilson (1982) prove that a weak incumbent would fight entry at the beginning of the game, to establish a reputation for being strong and thus discourage further entry. It would be only towards the last periods of the game that the weak incumbent will accommodate entry, as the closer to the end of the game the lower the expected gain from pretending to be strong. In general, in any period, the weak incumbent's decision to fight reinforces its reputation to be efficient, but involves the sacrifice of current profits in order to deter entry and earn higher future profits. At the beginning of the game, the future is long enough and the trade-off is in favour of fighting, whereas at the end of the game there is less to be gained from deterring further entry (in the limit, in the last period there is no future gain at all), and the trade-off is in favour of accommodating.

### 2.2.2 Signaling models

Signaling models of predation are based, like reputation models, on imperfect information. Again, the potential entrant does not know whether the incumbent is low cost (strong) or high cost (weak), and the incumbent will try to exploit this uncertainty to deter entry. The first signaling model is due to Milgrom and Roberts (1982b) and it can be roughly summarised as follows (see section 2.3.3 for a formal presentation).

Before taking its entry decisions, a potential entrant observes the price set by the incumbent when it is still a monopolist. If it was certain that the incumbent is weak, entry would be profitable. If it was certain that the incumbent is strong, entry would entail a loss. But the entrant cannot tell them apart. It thinks it will face a strong incumbent with some probability, but it can only revise this probability by observing the monopoly price of the incumbent (if it enters, instead, it will immediately learn if the incumbent is weak or strong). In this context, it is clear that a weak incumbent might want to mimic a strong one, to try and deter entry. However, a strong one would not like to be mistaken for a weak one, because it would attract entry, which lowers its profits.

There are two possible equilibria in the game. In the first (called "separating equilibrium"), the efficient incumbent will set a price lower than its normal monopoly price in the first period (when it is the only active firm), and this price is so low that no weak incumbents would like to set it, because it would involve

[9] Note that uncertainty precludes the same reasoning as in Selten's perfect information game. Consider for instance the last entrant's problem. Under perfect information, it is sure that entry will be accommodated, and will accordingly enter, no matter how many times before the incumbent has fought entry. But under incomplete information, things change. Suppose for instance that entry has always been fought so far: the last entrant will have revised its beliefs about the incumbent, and start to think that the probability it is strong is much higher than it thought at the beginning of the game! Accordingly, it will not necessarily enter.

too high losses. Since there is no scope for mimicking the efficient incumbent, the inefficient one will instead choose its normal monopoly price. The entrant will immediately learn which incumbent it faces: if the price is low, it can only be the efficient one, and it will stay out. If it is high, it will face the inefficient incumbent, and will enter.

Note that in this equilibrium one could say that there is predation, in that the low cost incumbent is acting "strategically" and sacrifices current profits to deter entry and gain more in the future. But, interestingly, its behaviour does not hurt welfare. To see why, note that in a perfect information world the entrant facing the low cost incumbent would never enter (by assumption of the model), and consumers would have to pay the normal monopoly prices in both periods. In this equilibrium, instead, the low cost incumbent charges a much lower price than it would otherwise do, to signal it is efficient. Therefore, while in the second period the sales price is the same, consumers will be better off in the first period. In a sense, by signaling its true nature through low prices the low cost incumbent is providing a service that enhances social efficiency.

In the second equilibrium (called "pooling equilibrium"), instead, there is no price at which the low cost incumbent can profitably sell and be distinguished from the high cost one. As a result, it will simply set its normal monopoly price and the high cost incumbent will imitate it in order to deter entry.[10]

In this case, we observe predation from the inefficient incumbent, who sets a lower price than it would otherwise set in the first period (even though, it is important to notice, that price might be above or below the incumbent's costs), but it can act as a monopolist in the second: it sacrifices current profits to increase the future ones. The impact on welfare is more likely to be negative in this case.[11]

Milgrom and Roberts' signaling model is reminiscent of the old concept of "limit pricing" proposed by Bain (19xx) and Sylos-Labini (19xx), very popular in pre-game theory industrial organisation. Limit pricing refers to the possibility that an incumbent monopolist sets a low price to deter entry, the rationale of this practice being that observing a low price a potential entrant would also expect lower margins in the industry, and therefore lower profits. If we read today those early works we would not find them very convincing, since they rely on some strong assumptions (one of them being that a firm commits to a certain price for a time, while we know that prices can be easily changed in

[10] The entrant does not learn anything from the observation of the first period prices, and decides on whether to enter or not on the basis of its ex-ante probability of facing a weak incumbent. For the pooling equilibrium to exist, this probability must be low enough: the entrant will stay out only if it expects a high likelihood to face an efficient incumbent. If it expected to meet a weak incumbent with high probability, it would enter. But then, it could not be an equilibrium as the high cost incumbent would have no reason to sacrifice current profits if it knows it will not deter entry.

[11] To be precise, the net effect is ambiguous a priori, since it involves a gain in the first period and a loss in the second. In section 2.3.3 I show for a specific example that the net effect on consumer surplus is negative, but this need not always be the case. Incidentally, one should recall that entry might in some circumstances involve a productive inefficiency. If this was the case, there would be an additional reason for entry deterrence not to be detrimental.

the short-run), but Milgrom and Roberts (1982b) have cast in rigorous terms the theory of limit pricing, with a low price being a signal that expected profits from entry might be low.

However, signaling models of predation are not inherently associated with the incumbent setting a low price. In the cost signaling model described above, the costs of the entrant are not correlated with the one of the incumbent, so a low cost of the incumbent is bad news for the entrant, and it makes sense for the incumbent to pretend to be low cost by setting a low price. However, consider a situation where the entrant - new to the industry - does not really know what costs it will have itself, and expects them to be identical (or highly correlated) to those of the incumbent. Further, note that in most cases where two firms with identical costs compete, each firm's duopoly profits decrease with costs.[12] In this situation, the incumbent might deter entry by setting a *high* price, because this would signal the existence of high costs in the industry for both (see Harrington, 1986).

**Predation for mergers** An extension of the signaling model above allows to explain why predation might be used to lower the price of taking over rivals, a strategy that has been discussed in section 2.1 above. Saloner (1987) changes slightly Milgrom and Roberts' model, to allow for the possibility that firms merge after the first period (also, in his model, entering when facing a low cost incumbent would not give rise to losses, but just lower profits). In this case, setting a lower price than would otherwise be optimal signals to the entrant whether it should expect to make high or low profits after entry, and therefore whether it should be willing to sell out to (to merge with) the incumbent at a high or at a low price.

Again, predation takes the form of setting lower prices than a short-run calculation would imply, but this time its objective is not to deter entry but rather to improve the terms at which the rival will accept to be taken over.[13]

**Other signaling models** There are several other models where the incumbent might want to act strategically so as to make the entrant (or an existing competitor) expect lower profitability if it entered (or if it stayed in) the industry. Scharfstein (1984), for instance, analyses a model of "test-market predation", where the entrant has a new product and is uncertain about the demand for it. Given this uncertainty, it introduces the product in a test-market first to see how it would be received. The incumbent might engage in various predatory practices (for instance secret price discounts to consumers) to make the entrant believe demand for its product will be low, thus leading it to abandon the market or reduce its scale of activity.

Fudenberg and Tirole (1986) suggest that the incumbent might also engage in "signal-jamming predation", not to allow the entrant to improve its information.

[12] The reader can immediately check that this holds, for instance, in a duopoly with homogenous goods, linear demand $p = 1 - Q$, and Cournot competition. With a marginal cost $c$, a firm's profit is $\pi = (1-c)^2/9$, and therefore is the higher the lower the cost $c$.

[13] See section 2.3.4 for a technical presentation.

In a test-market model, for instance, the purpose of the entrant is to gather information about demand, and the predator defeats this purpose by openly cutting prices. The entrant knows that its demand is artificially low due to the incumbent's cut-throat prices, but it cannot have any information about what demand would be in normal competitive circumstances. In the absence of information, it will prefer to exit. A similar "signal-jamming" mechanism might also be used in other circumstances where there is imperfect information (for instance, in imperfect capital markets, see below).

### 2.2.3 Predation in imperfect financial markets

As we have seen above, a weak point of the long purse theory of predation is that it does not explain why the prey has limited access to funding. If capital markets were perfect, a profitable project would always find a financial sponsor.

Modern corporate finance theory, focusing on the imperfections existing in capital markets, provides an answer to these questions, leading to a long purse theory of predation where the prey's limited access to funding is endogenous, since predation affects the perceived risk of lending money, thereby reducing financial sources available to the prey.

The key point of this theory is the existence of imperfect information on the side of the lenders (be they banks, equity holders, or other financial institutions). Lenders do not have their hands on the industry and cannot have precise knowledge about it (or cannot observe some of the actions taken by firms). This characterises the relationship between the lender and the borrower. (In these principal-agent models, the bank is the "principal", and the borrower the "agent".) The bank cannot be sure that the money lent is used in an efficient and competent way rather than being used by the entrepreneur for its private benefit, or in an exceedingly risky way (there is a so-called "moral hazard" problem), and will accordingly have to devise a contract that protects its interests. For instance, it will give credit to a borrower only if it has a certain amount of internal assets (such as retained earnings). Because of credit constraints, therefore, a profitable project might not be financed.

Consider now the competition between an incumbent and a new firm. The incumbent is a well established firm that has accumulated enough resources in the past, whereas the new firm does not have enough own resources and needs to borrow heavily to compete on par with the incumbent. In such a situation, predation by the incumbent will reduce the possibility for the new firm to get funding, since it reduces its profits, its retained earnings and thus the own assets that are needed to obtain further funding. It is therefore the aggressive behaviour by the incumbent that endogenously reduces the funds available to the rival (see section 2.3.6 for a formalisation).

A possible objection to this predatory argument is that the lender, understanding that predation might occur, thus destroying its opportunity to make profits out of the loan, might have an interest in preventing it by announcing that it will finance the prey no matter what its performance in the market will be. However, it might not be optimal for the bank to do so because it would create the scope for further agency problems. If the firms' managers knew that whatever they do their firm will be refinanced, they would have an incentive to use the money lent by the bank to increase their salaries, embellish the firm's premises and so on, rather than making all the necessary effort to ensure that the venture will be competitive. The bank, anticipating this moral hazard problem, will therefore not be ready to commit to renew the loan independently of the repayment ability of the firm.[14]

To summarise, these models provide a convincing story of why predation takes place. Once again, aggressive market behaviour is used by the incumbent to modify the expectations of the profitability of the prey. In this particular case, predation affects the lender's evaluation that the firm they finance will be successful. As a result, the prey will have a lower ability to borrow and will be obliged to exit the industry or to reduce the scale of its operations.

## 2.3 Models of predatory pricing*

In this technical section I review the main models of price predation.

### 2.3.1 Selten's chain-store paradox*

Selten (1978) considers an incumbent firm which owns a chain of stores, one in each of $T$ different cities (with $T$ being a finite number). In each market in succession, the incumbent faces a local entrant, say firm 1 can enter market 1 in period 1, firm 2 can enter market 2 in period 2, and so on.

In each period $t$, the stage game between the incumbent and potential entrant firm $t$ is the same, and it is illustrated in figure 7.1.

INSERT Figure 7.1. Stage game at time $t$, chain-store paradox game

First, firm $t$ has to decide whether to enter or not; then, the incumbent has to decide whether it wants to fight entry (that is, choose an aggressive market action), or to accommodate it. If the entrant stays out, then the payoffs for the incumbent and the entrant are respectively $\pi^M$ and 0. If there is entry, and the incumbent chooses to accommodate it, then their respective payoffs are $\pi_I^A$ and $\pi_E^A$. If entry is followed by an aggressive reaction (or predation, or fight), payoffs are $\pi_I^P$ and $\pi_E^P$. Assume that the fight is costly for both players, in the sense that $\pi_I^A > \pi_I^P$ and $\pi_E^A > 0 > \pi_E^P$. Assume also that the incumbent gets highest profits under monopoly: $\pi^M > \pi_I^A$.

If the game was played just once ($T = 1$), it is clear that the threat of a fight in case of entry is not credible, and that entry would take place and be accommodated at the sub-game perfect equilibrium. Indeed, if entry occurs, the incumbent will prefer to accommodate than to fight it, as $\pi_I^A > \pi_I^P$. The entrant correctly anticipates the incumbent's choice, and in the first period it

[14] I shall discuss more formally this argument in section 2.3.6. There, I also show that a critical assumption for the unlimited lending contract to deter predation is that such a contract should involve a fully credible commitment and cannot be renegotiated.

knows that if it enters a soft market reaction will occur, so that it will get a payoff $\pi_E^A$, whereas if it does not enter its payoff is $0 < \pi_E^A$. Therefore, it prefers to enter.

Selten's insight is to show that nothing changes in this result if the same stage game is repeated a number of times, as long as this number is finite. To look for the sub-game perfect equilibrium when the incumbent faces $T$ entrants, we have to work by backward induction.

Consider what happens when the incumbent and the potential entrant play the game in the last market $T$. Whatever has happened before (if entry occurred or not, if it has been accommodated or not), the decisions to be taken in this market will not have any other effect than on the current payoffs, since it is the last play. Therefore, the firms will behave as if they were playing the game for the first and only time. The only equilibrium is therefore the one found above in the case where $T = 1$: the entrant anticipates that entry would be accommodated, and therefore entry occurs (and it is indeed accommodated: why should the incumbent prefer to have a payoff $\pi_I^P < \pi_I^A$ ?).

Consider now what happens at period $T-1$, where the incumbent and firm $T-1$ play the game on market $T-1$. Again, firms know that independently of what has happened in any period before and what they do today, in the next period $T$ entry will occur. Therefore, the play at period $T-1$ again does not have any bearing on future play, and the incumbent will play as if this was the only (or the last) period of the game. Firm $T-1$ knows that the incumbent does not have any reason to fight entry, and will accordingly enter; and, of course, entry will be accommodated.

The same reasoning will occur for the $T-2$ period and any other previous period, so that the only sub-game perfect Nash equilibrium of the game is one where each entrant will enter its respective market, and each entry will be accommodated.

Contrary to what one might expect, there is no effect of reputation building in this game, and predation will not occur.

### 2.3.2 A reputation model of predation**

In this section, I present a simplified two-period version of Kreps and Wilson's (1982) incomplete information model of predation. Consider the same model as the chain-store paradox for $T = 2$, but with a variant. Entrants do not know with certainty the per-period payoff of the incumbent. In particular, there is a small (prior) probability $x$ that firm $I$ is a *tough* ($\Pr(t) = x$), or low cost, incumbent, with profits $\pi_I^P > \pi_I^A$, whereas with probability $1-x$ it is a *weak* (or high cost) incumbent ($\Pr(w) = 1-x$), whose profits are $\pi_I^P < \pi_I^A$ as in the chain store game above. In other words, an entrant might face a tough opponent, that prefers fighting (predating) over accommodating even in a one period game.[15]

[15] The predatory strategy might be thought of as a low price, and the accommodating strategy as a high price. A tough incumbent is one that has such low costs that it would be optimal for it to set the low price regardless of strategic considerations.

This is a multi-stage game with incomplete information, and I look for the Perfect Bayesian Equilibrium (PBE) of the game. In this case, given the strategies of the players and the beliefs of the entrants, at the PBE each player chooses the optimal strategy given the strategy of the rival and the entrant's beliefs, and the beliefs are consistent (that is, they are derived using Bayes' rule). Note that the strategies might be stochastic rather than deterministic functions, i.e., there might be mixed strategy equilibria.

A game of this type admits three types of equilibria, two in pure strategies (*separating* and *pooling* equilibria) and one in mixed strategies (*hybrid* or *semi-separating* equilibria). We briefly indicate the conditions for each type of equilibrium, but then focus on the last one, which in this case is the most interesting.

**Separating equilibrium.** At a separating equilibrium a tough incumbent fights entry and a weak one accommodates it. The second period entrant has complete information after observing the behaviour of the incumbent in the first period: $\Pr(w \mid a) = 1$, $\Pr(t \mid f) = 1$, where $w, t$ stand for "weak" and "tough" respectively, and $a, f$ stand for "accommodate" and "fight". (So, $\Pr(w \mid a)$ is the probability that the incumbent is weak given that accommodation is observed in the first period, and $\Pr(t \mid f)$ is probability that it is tough given that fight is observed in the first period.) Accordingly, it will enter only if it observes that entry has been accommodated in the first period. At such an equilibrium there would be no predation: the tough incumbent is not behaving strategically, it just maximises its static payoff, and the weak incumbent is unable to deter entry.

A necessary condition for such an equilibrium to hold is that the weak incumbent prefers to accommodate rather than mimic the tough one, that is predate and deter entry:

$$\pi_I^A + \delta\pi_I^A \geq \pi_I^P + \delta\pi^M. \tag{1}$$

**Pooling equilibrium.** At a pooling equilibrium, both the tough and the weak incumbent fight entry. The entrant correctly understands it, and does not revise its beliefs when observing aggressive behaviour in the first period. The posterior belief coincides with the prior: $\Pr(t \mid f) = x$. For this to be an equilibrium, it must be that the entrant will not enter after observing a fighting episode:

$$x\pi_E^P + (1-x)\pi_E^A \leq 0. \tag{2}$$

To see that a pooling equilibrium cannot exist if condition (2) is violated, reason a contrario. If $x\pi_E^P + (1-x)\pi_E^A > 0$, the second entrant would enter after observing predation. But then it cannot be optimal for the weak incumbent to fight in the first period, since sacrificing profits would make sense only in order to deter entry. However, a pooling equilibrium of this type is not very interesting, since condition (2) means that the entrant would not enter the market in a static game.

**Semi-separating equilibrium.** Let us focus therefore on a situation where both condition (1) and (2) are violated, and assume that (1') $\pi_I^A + \delta\pi_I^A < \pi_I^P + \delta\pi^M$, and that (2') $x\pi_E^P + (1-x)\pi_E^A > 0$. I now show that there is a semi-separating equilibrium (i.e., an equilibrium in mixed strategies, since assumptions (1') and (2') rule out pure strategy equilibria) as follows.[16]

*Description of the equilibrium*

- (i.) The first potential entrant enters.
- (ii.a) The second potential entrant enters if the first was accommodated.
- (ii.b) The second potential entrant enters with probability $1 - (\pi_I^A - \pi_I^P)/[\delta(\pi^M - \pi_I^A)]$ if the first entrant was fought.
- (iii.) The tough incumbent fights in both periods.
- (iv.) The weak incumbent fights in the first period with probability $-x\pi_E^P/[(1-x)\pi_E^A]$.
- (v.) The weak incumbent accommodates entry in the second period, if it occurs.

*Proof*

First of all, note that actions (ii.a), (iii.) and (v.) are trivially optimal: if entry is ever accommodated, it is clear that the incumbent is weak (ii.a); a tough incumbent is by definition one whose payoff is higher from fighting even in a static game (iii.); in the last period of the game, a weak incumbent does not have any reason to fight entry (v.).

I now prove the optimality of the remaining actions as follows.

(iv) If entry has been fought in the first period, the second entrant will use Bayes' rule to revise its prior that it faces a tough incumbent. The revised probability that the incumbent is tough given a fight is observed is:

$$\Pr(t \mid f) = \frac{\Pr(f \mid t)\Pr(t)}{\Pr(f \mid t)\Pr(t) + \Pr(f \mid w)\Pr(w)} = \frac{x}{x + \Pr(f \mid w)(1-x)}. \qquad (3)$$

For a mixed strategy to be optimal, the second entrant must be indifferent between entering or staying out (that gives a zero payoff), that is:

$$\Pr(t \mid f)\pi_E^P + (1 - \Pr(t \mid f))\,\pi_E^A = 0, \qquad (4)$$

which after substituting and re-arranging can be rewritten:

[16] In this characterisation, I follow closely Ordover and Saloner (1989).

$$\Pr(f \mid w) = -\frac{x\pi_E^P}{(1-x)\pi_E^A}. \quad (5)$$

Note that $\pi_E^P < 0$, so this probability is positive, and by (2'), $\Pr(f \mid w) < 1$.

(ii.b) For the weak incumbent to randomise in the first period, it must be indifferent between fighting (which would be followed by entry with some probability $\Pr(Entry \mid f)$) or not:

$$\pi_I^P + \delta\left[\Pr(Entry \mid f)\pi_I^A + (1 - \Pr(Entry \mid f))\,\pi^M\right] = \pi_I^A(1+\delta). \quad (6)$$

By re-arranging, we find the indifference condition as:

$$\Pr(Entry \mid f) = 1 - \frac{\pi_I^A - \pi_I^P}{\delta(\pi^M - \pi_I^A)}, \quad (7)$$

which is lower than one by assumption (1').

(i.) The first potential entrant enters if its expected payoff is higher than staying out:

$$x\pi_E^P + (1-x)\left[\Pr(f \mid w)\pi_E^P + (1 - \Pr(f \mid w))\,\pi_E^A\right] > 0. \quad (8)$$

After substitution, this amounts to:

$$x\pi_E^P + (1-x)\pi_E^A - x\pi_E^P\left(\frac{\pi_E^P}{\pi_E^A} - 1\right) > 0. \quad (9)$$

Therefore, some restrictions on the payoff must be imposed for the previous condition to hold. As long as (9) holds, the semi-separating equilibrium we have described exists.

**Comment** The general case $T > 2$ is much more complex but also much richer. The main result is that if $T$ is large enough, in the earlier periods of the game even a weak incumbent fights with certainty, and anticipating this early entrants stay out. As the game proceeds, the optimal strategies are mixed ones, like in the $T = 2$ case.

The main insight of this model is that even a small departure from the perfect information setting might give rise to predation, if the horizon is finite but long enough: a weak incumbent will play at the beginning of the game as if it were a strong one, and this gives it the reputation of a fighter, that will convince entrants to stay out in early periods. Towards the end of the game, however, a weak incumbent will not find it convenient to fight, and anticipating it some entrants will try their luck (recall, there is always the possibility that the incumbent is a tough one).

Finally, note that Milgrom and Roberts (1982a) examine an extension where there is two-sided uncertainty (the incumbent does not know the payoff of the entrant), and confirm that predation might arise also in this more complex incomplete information game.

### 2.3.3 Milgrom and Roberts' limit pricing model**

Here I present a simplified version of Milgrom and Roberts (1982b). Consider an industry with an incumbent (firm 1) and a potential entrant (firm 2), and demand for the homogenous good is given by $p = 1 - Q$.[17] The potential entrant has a marginal cost $c$ and, if it enters, a fixed sunk cost $F$. Its costs are common knowledge. The incumbent's marginal cost, instead, might be low ($c_l = 0$) or high ($c_h = c < 1/2$). This cost is private information: the incumbent knows it, but the entrant believes that it is low with a probability $x < 1$: $\Pr(c_1 = 0) = x$, and high with a probability $\Pr(c_1 = c) = 1 - x$.[18] I also assume for simplicity that if the entrant actually enters the industry, it will immediately learn the true cost of the incumbent.

The game is as follows. In the first period, firm 1 chooses its output. In this period, it is a monopolist. In the second period, firm 2 decides whether to enter or not; if it does, it sinks its cost $F$; if it does not, it gets a zero payoff. Active firms choose outputs. For simplicity, I assume no discounting across periods: firm 1 just maximises the sum of its payoff.

I look for the Perfect Bayesian Equilibria of the game. In this case, given the strategies $(s_1, s_2)$ of the players and the beliefs $p$ of the entrant, the PBE consists of a triple $(s_1^*, s_2^*, p)$ such that each player chooses the optimal strategy given the strategy of the rival and the entrant's beliefs, and the beliefs are correct.

In such a game, there are two possible types of equilibrium in pure strategies. In a *separating equilibrium*, the low cost incumbent chooses a large enough output, and the entrant correctly infers the incumbent's type by observing its first-period output. In a *pooling equilibrium*, both the low and the high cost incumbent choose the same output. If the entrant has a high enough ex-ante probability to meet a low cost incumbent, it will not enter. It knows that the output observed in the first period does not carry any additional information about the incumbent's type, and its posterior beliefs are accordingly the same as in the first period.

(The fact that the low cost incumbent in a separating equilibrium and a high cost incumbent in a pooling equilibrium set a low enough price to make the entrant stay out makes the model resemble the so-called *limit pricing* arguments of entry deterrence.)

Before characterising these equilibria, let me briefly summarise the first-

[17] I will focus for simplicity on the case of Cournot competition in the second stage, but this is just to have simpler payoff functions. The type of competition in the second stage does not play any role in the analysis.

[18] In this specific example, where demand is linear and there are marginal costs, the model could be re-interpreted as one where uncertainty is on the demand intercept, rather than on the incumbent's costs.

and second-period outputs under the different possibilities. Firm 1's optimal quantities if there was no potential entrant would be:

$$q_{1h}^m = \frac{1-c}{2}; \quad q_{1l}^m = \frac{1}{2}, \tag{10}$$

where labels $h$ and $l$ stand for high- and low-cost incumbent respectively, and $m$ stands for monopoly. Under duopoly, equilibrium quantities in the Cournot game are:

$$q_{1h}^d = q_{2h}^d = \frac{1-c}{3}; \quad q_{1l}^d = \frac{1+c}{3}, \; q_{2l}^d = \frac{1-2c}{3}, \tag{11}$$

where $d$ stands for duopoly (the first pair refers to the case of a high-cost incumbent, the second of a low-cost incumbent). All equilibrium profits are given by $\pi_{ij}^k = (q_{ij}^k)^2$. To make the analysis interesting, I assume that in a full information context the entrant would never enter if it faced a low-cost incumbent ($\pi_{2l}^d - F < 0$), but would always enter if it faced a high-cost one ($0 < \pi_{2h}^d - F$), or:

$$\frac{(1-c)^2}{9} > F > \frac{(1-2c)^2}{9}. \tag{12}$$

Finally, denote by $\pi_{1j}^m(q_{1l})$ the profit obtained by an incumbent of type $j = h, l$ when selling an output $q_{1l}$ (not necessarily coinciding with the monopoly output of type $j$).

**Separating equilibrium** I shall now show that the following is an equilibrium:

$$\begin{cases} q_{1l}^* = \; q_{1l} > \; q_{1l}^m \\ q_{1h}^* = \; q_{1h}^m \\ s_2^* = \mathit{Enter}, \text{ if } \; q_1^m < \; q_{1l}; \; \mathit{Not\ Enter}, \text{ if } q_1^m \geq \; q_{1l}, \\ x' = 0, \text{ if } \; q_1^m < \; q_{1l}; \; x' = 1, \text{ if } q_1^m \geq \; q_{1l}, \end{cases} \tag{13}$$

where $x' = \Pr(c_1 = 0 \mid q_1^m)$ is the entrant's belief of facing a low-cost incumbent given the observed first-period output $q_1^m$.

At this equilibrium, the low-cost incumbent sets a higher output than its monopoly output (that is, the output set if it were in a monopoly unthreatened by entry) in the first period, and the high-cost incumbent sets its own monopoly output, thereby revealing its type. The entrant correctly infers the incumbent's type and behaves accordingly, entering only when if faces a high-cost firm 1.

For this to be an equilibrium, no firm should have an incentive to deviate. Given its beliefs and firm 1's strategies above, it is clear that the entrant cannot do better than that: entering with a low cost firm would entail losses, and not entering with a high cost one would imply foregoing positive profits.

Let us now check that the high cost incumbent has no incentive to deviate. If it plays the candidate equilibrium strategy it will get its monopoly profit in the first period but would attract entry: $\pi_{1h}^m + \pi_{1h}^d$. Alternatively, it could set $q_{1l}$ thus mimicking the low cost incumbent and deterring entry: under this deviation, it would get $\pi_{1h}^m(q_{1l}) + \pi_{1h}^m$. Its incentive constraint (IC) therefore amounts to:

$$\pi_{1h}^m + \pi_{1h}^d \geq \pi_{1h}^m(q_{1l}) + \pi_{1h}^m, \text{ or: } \frac{(1-c)^2}{9} \geq (1 - q_{1l} - c)q_{1l}. \tag{14}$$

As for the low cost incumbent, by playing the (candidate) equilibrium strategy it would get a lower profit than by setting its monopoly output in the first period, but it deters entry: $\pi_{1l}^m(q_{1l})+\pi_{1l}^m$. This strategy involves a sacrifice in the profits earned in the first period; the alternative could be to set the monopoly output in the first period (since any output lower than $q_{1l}$ would attract entry, choosing $q_{1l}^m$ is clearly the best deviation output) but this would not deter entry, and would therefore give duopoly profits in the second period. This deviation gives the payoff $\pi_{1l}^m + \pi_{1l}^d$, giving rise to the following incentive constraint:

$$\pi_{1l}^m(q_{1l}) + \pi_{1l}^m \geq \pi_{1l}^m + \pi_{1l}^d, \text{ or: } (1 - q_{1l})q_{1l} \geq \frac{(1+c)^2}{9}. \tag{15}$$

It is easy to check that the high cost IC (14) is satisfied for $q_{1l} \geq 1/2 + \sqrt{5}(1-c)/6$ and that this is bigger than $1/2$ for $c < (3\sqrt{5}-5)/4 \simeq .4271$ (for values of $c$ higher than this threshold, separating equilibria would exist where the low cost incumbent simply sets its monopoly output and is not mimicked by the high cost incumbent).

The low cost IC (15) is satisfied for $q_{1l} \leq 1/2+\sqrt{5-8c-4c^2}/6$.[19] Therefore, there exists an interval of values which satisfies both ICs as long as $1/2+\sqrt{5}(1-c)/6 \leq 1/2 + \sqrt{5-8c-4c^2}/6$, or $c \leq 2\sqrt{5}/3 - 1 \simeq .49$.

Note also that the best possible equilibrium for the incumbent corresponds to the output that makes the high cost IC's bind: $q_{1l} = 1/2 + \sqrt{5}(1-c)/6$ (any output larger than this would decrease the first period profit without changing the second period profit).[20]

**Pooling equilibrium** I shall now check if the following is an equilibrium:

$$\begin{cases} q_{1l}^* = \ q_{1h}^* = \ q_{1l}^m \\ s_2^* = \textit{Enter}, \text{ if } \ q_1^m < \ q_{1l}^m; \ \textit{Not Enter}, \text{ if } q_1^m \geq \ q_{1l}^m, \\ x' = 0, \text{ if } \ q_1^m < \ q_{1l}^m; \ x' = x, \text{ if } q_1^m \geq \ q_{1l}^m, \end{cases}$$

[19] The lower root of the second order equation is discarded because it is lower than 1/2.

[20] Since the high cost incumbent would have the same payoff anyway, this equilibrium would be selected if the criterion of Pareto dominance (for the active players, that is the firms) is used.

At this equilibrium, the high cost incumbent imitates the low cost incumbent. Since the potential entrant understands that it cannot infer the incumbent's type from the first period play, it decides on the basis of its ex-ante beliefs, which say that the incumbent is a low cost one with a probability $x$. Accordingly, the pooling equilibrium can exist only if the entrant's expected payoff (which is the same before and after observing firm 1's first period choice) is negative:

$$x(\pi_{2l}^d - F) + (1-x)(\pi_{2h}^d - F) < 0, \text{ or } \; x > \frac{(1-c)^2 - F}{2-3c}. \qquad (16)$$

In other words, the ex-ante probability that the entrant will meet a low cost incumbent must be high enough if the pooling equilibrium is to exist.[21] Otherwise, since at a pooling equilibrium first period play does not lead to a revision of beliefs, the entrant would always enter. In turn, the fact that entry will not be deterred implies that the high cost incumbent had better play its monopoly output rather than bluffing.

As for the incentive constraints of firm 1, the high cost incumbent must prefer to imitate the low cost firm and deter entry rather than reducing its output and attracting entry:[22]

$$\pi_{1h}^m + \pi_{1h}^d \leq \pi_{1h}^m(q_{1l}^m) + \pi_{1h}^m, \text{ or: } \frac{(1-c)^2}{9} \leq (1 - 1/2 - c)/2, \qquad (17)$$

which holds for $c < (3\sqrt{5} - 5)/4 \simeq .4271$.

As for the low cost incumbent, it is clear that it prefers to play the candidate equilibrium output, where it deters entry by choosing its monopoly profit: any other output would lower first period profit and possibly (if setting an output lower than 1/2) also trigger entry.

**Conclusion** The analysis shows that by setting a low enough price (a large enough output) and pretending to be an efficient producer, an incumbent would be able to deter entry. In the example above, this is possible whenever the high cost incumbent is not too inefficient ($c < (3\sqrt{5} - 5)/4$) and the ex-ante probability that the entrant attaches to the incumbent being low cost is high enough.

Note, however, that the policy implications of the model are far from straightforward. First of all, predation here occurs without the high cost incumbent selling below its cost: in the pooling equilibrium, entry is deterred by setting $q = 1/2$, that corresponds to a price $p = 1/2$ higher than the cost of the inefficient incumbent. Second, suppose, for the sake of the argument only (as such a

[21] Note that, other things being equal, as $c$ increases condition 16 is less likely to hold. In other words, the more inefficient the high cost incumbent the less likely it can deter entry by mimicking the low cost incumbent.

[22] Since, given the entrant's belief, any output below $q_{1l}^m$ would trigger entry, the high cost optimal deviation would entail setting its monopoly output. Note also that the IC for the high cost is basically the opposite condition as (14).

policy would be based on unobservables), that a competition authority imposed a rule which prevents a firm from "acting strategically" and selling at a price lower than the one it would set if there was no threat of entry. Such a rule would eliminate entry deterrence by the high cost firm, and might therefore increase welfare.[23] However, it would also for sure reduce welfare if the incumbent was low cost. Indeed, in such a case, by acting strategically the efficient incumbent would decrease price below the myopic monopoly level in the first period, and consumers would be better off.[24]

### 2.3.4 Predation to merge**

The Chicago School's critique to predation maintained that mergers would be a more profitable strategy than predation. The argument was criticised by Yamey (1972) who pointed out that even with a view to take over a rival, predation might be profitable because it would have the effect to decrease the price at which the rival is bought. Saloner (1987) gives formal support to this argument. In what follows, I present a very streamlined version of his model.[25]

Consider the same incomplete information model as in the previous section 2.3.3, but with some differences. First, assume that $F = 0$, so that the entrant always finds it profitable to enter (to focus on predation to merge at more convenient terms). Second, modify the game so as to introduce a stage where firms can merge, as follows. In the first period, the incumbent (that, as above, might be a low cost or a high cost firm) is alone in the market and chooses its output, that is observed by the potential entrant. In the second period (the novelty with respect to Milgrom and Roberts' analysis) there is bargaining over the merger terms. For simplicity, assume that all the bargaining power is on the incumbent, that makes a take-it-or-leave-it merger offer to the potential entrant. In the third period, active firms set outputs.[26]

Note that third period equilibrium quantities and profits are already known from section 2.3.3 above. In case a merger has taken place in the second period, the incumbent simply becomes a monopolist in the third.[27]

[23] Under a pooling equilibrium, consumers would buy a total of $1/2 + (1 - c)/2$ units in the two periods. If strategic behaviour was prevented, they would buy $(1-c)/2 + 2(1-c)/3$ units. The deadweight loss would therefore be reduced, but only for $c < 1/4$.

[24] Under a rule that excludes strategic behaviour the entrant would observe that the low cost sets $q = 1/2$ and correctly infer that it is efficient, and therefore would not enter. In both periods, there would be a monopoly with $1/2$ units sold. Under the separating equilibrium, instead, the output would be $1/2$ in the second period, but higher than $1/2$ in the first one.

[25] A similar presentation can be found in Tirole (1988: 374-376).

[26] In Saloner (1987) there is product market competition in the first period as well, so predation to make rival firm 2 exit, rather than to deter entry, takes place. He also considers an extension where a third firm (more efficient than firm 2 but not efficient enough to compete with a low cost incumbent) could enter the market. Therefore, the extended model is one where both predation for mergers and entry deterrence can occur. Indeed, there exist separating equilibria where a low enough ("limit") price is chosen by the low cost firm 1 so as to take over firm 2 more cheaply, and deter entry of firm 3. There also exist pooling equilibria where a high cost incumbent imitates the low cost one, thus both predating for merger and for entry deterrence.

[27] Goods being homogenous, this can only be a very stylised model of a merger, where assets

As for the merger process at period two, the price $Q$ at which firm 2 is willing to be bought will depend on whether it expects to face a high or a low cost incumbent. In the former case, it expects to make a profit $\pi_{2h}^d$ and in the latter a lower profit $\pi_{2l}^d$. Therefore the takeover will take place for $Q \geq \pi_{2h}^d$ and $Q \geq \pi_{2l}^d$ respectively. One can see immediately that the incumbent has an interest in being believed to be low cost. Since the bargaining power is all on the incumbent side, firm 2 will sell out at a price equal to its reservation price. If firm 2 believes it faces an efficient incumbent, the merger occurs at a price $Q_l = \pi_{2l}^d$. If it believes it faces an inefficient incumbent, the price will be $Q_h = \pi_{2h}^d > Q_l$.

I can now turn to the characterisation of the separating equilibria, whereas pooling equilibria are studied in exercise 2.

**Separating equilibrium** Let me focus on the following equilibrium, where the low cost incumbent sets an output larger than its monopoly output in the first period to signal it is efficient and buy firm 2 at a lower price, whereas the high cost incumbent simply sets its monopoly output and it is recognised as inefficient (and therefore has to pay a higher price for the takeover):

$$\begin{cases} q_{1l}^* = q_{1l} > q_{1l}^m;\ Q^* = Q_l = \pi_{2l}^d \\ q_{1h}^* = q_{1h}^m;\ Q^* = Q_h = \pi_{2h}^d \\ s_2^* = \begin{cases} \text{if } q_1^m < q_{1l}\text{: } \mathit{Sell},\ \text{if } Q \geq Q_h;\ \mathit{Reject},\ \text{if } Q < Q_h \\ \text{if } q_1^m \geq q_{1l}\text{: } \mathit{Sell},\ \text{if } Q \geq Q_l;\ \mathit{Reject},\ \text{if } Q < Q_l \end{cases} \\ x' = 0,\ \text{if } q_1^m < q_{1l};\ x' = 1,\ \text{if } q_1^m \geq q_{1l}. \end{cases}$$

Given its beliefs, it is clear that the entrant cannot do better than selling out at the high price $Q_h$ if $q_1^m < q_{1l}$ and at the low price $Q_l$ otherwise.

As for the high cost firm 1, playing according to the candidate equilibrium strategy is optimal if it is better to have the monopoly profit in the first period but having to pay a high price for the merger, rather than pretending to be a low cost incumbent, which entails a lower initial payoff but a higher later gain due to saving on the takeover price:

$$\pi_{1h}^m - \pi_{2h}^d + \pi_{1h}^m \geq \pi_{1h}^m(q_{1l}) - \pi_{2l}^d + \pi_{1h}^m. \tag{18}$$

This can be rewritten after substitution as $\pi_{1h}^m - \pi_{1h}^m(q_{1l}) \geq \pi_{2h}^d - \pi_{2l}^d$, or:

$$\frac{(1-c)^2}{4} - (1 - q_{1l} - c)q_{1l} \geq \frac{(1-c)^2}{9} - \frac{(1-2c)^2}{9}, \tag{19}$$

which simplifies to $q_{1l} \geq (1-c)/2 + \sqrt{(2-3c)c}/3$,[28] with $q_{1l} = (1-c)/2 + \sqrt{(2-3c)c}/3$ being the natural equilibrium among all the possible ones.

of the taken over firm simply disappear. See chapter 5 for a proper analysis of mergers with asset-based models.

[28] Note that $(1-c)/2+\sqrt{(2-3c)c}/3$ is bigger than $1/2$ for $c < 8/21$. Therefore, for $c \geq 8/21$, the low cost incumbent does not need to set a lower price (a higher output) than its monopoly price (output) to separate from the high cost incumbent.

The low cost firm 1 will find the candidate equilibrium strategy optimal if it is better to sacrifice first period monopoly profit to pay a lower price for the merger, rather than getting its monopoly profit in the first period but having less convenient terms for the takeover (as the entrant would mistake it for a high cost firm):

$$\pi_{1l}^m(q_{1l}) - \pi_{2l}^d + \pi_{1l}^m \geq \pi_{1l}^m - \pi_{2h}^d + \pi_{1l}^m. \tag{20}$$

This can be rewritten after substitution as $\pi_{1l}^m - \pi_{1l}^m(q_{1l}) \leq \pi_{2h}^d - \pi_{2l}^d$, or:

$$\frac{1}{4} - (1 - q_{1l})q_{1l} \leq \frac{(1-c)^2}{9} - \frac{(1-2c)^2}{9}, \tag{21}$$

which simplifies to $q_{1l} \leq 1/2 + \sqrt{(2-3c)c}/3$, always satisfied for $q_{1l} = (1-c)/2 + \sqrt{(2-3c)c}/3$.

### 2.3.5 Deep pocket predation*

For a very simple model of long purse predation, due to Benoit (1984), consider the following *perfect information* game that lasts for $T+K$ periods with $K > 1$. In the first period, an entrant firm $E$ decides whether to enter or not a given sector, and the incumbent firm $I$ decides whether to prey (fight) or accommodate entry. In each of the following periods, firm $E$ decides whether to stay or exit, and firm $I$ whether to prey or accommodate. (As an alternative, firm $E$ is already in the market, and decides whether to continue or not from the first period.) If it preys, both firms have a per-period payoff $\pi^P < 0$, if it does not prey, they have $\pi^A > 0$.

The two firms are perfectly symmetric in their technologies and products, but differ in their assets. The entrant has lower assets than the incumbent: $A_E = -T\pi^P < A_I$.[29] In other words, the incumbent can survive longer in the event of a price war, that is it has a deeper pocket (a longer purse).

Under this set of assumptions, at the only sub-game perfect equilibrium the entrant will not enter (or will immediately exit). It is easy to see this result by backward induction. Figure 7.2 illustrates the game in the simple case where $T = 1$ and $K = 1$, that is the entrant has resources only for one period fight, and the firms meet in the marketplace only twice. I first solve the model for this two-period case, and then for the general case.[30]

INSERT Figure 7.2. Deep pocket predation, with $T = K = 1$

[29] For simplicity, disregard here the possibility that firms borrow funds. As an alternative think of assets as the maximum financing they can obtain. This raises of course the crucial question of why a firm can raise more funds than another, a point that is dealt with in section 2.3.6.

[30] See also the slightly more difficult exercise 3 for a two-period game of predation.

**Solution for the two-period case:** $T = K = 1$ The game is solved by moving backwards. Let us start by the second period. If the entrant has entered and has been fought, in the second period it has to exit. If entry has been accommodated, it will decide to stay. This is because the entrant anticipates that - if it stays - the incumbent prefers to accommodate and get $\pi^A$ rather than fight and make a loss $\pi^P$. Therefore, in the second period, it prefers to stay and get $\pi^A$ rather than exiting and getting 0.

In the first period, if the entrant has entered, the incumbent knows that by fighting it will induce exit (and get monopoly profits $\pi^M$), whereas by accommodating it will not (we have just seen that if it is not fought, the entrant will stay). The former strategy is preferred if

$$\pi^P + \delta\pi^M > \pi^A(1+\delta). \tag{22}$$

Let us now move to the very first decision. If the above condition holds, the entrant knows that its entry will be followed by a fight and it will lose all its assets: it will thus prefer to stay out. If the condition is violated, the entrant will enter since it anticipates that the threat of predation is not credible.

**Solution of the general case** At period $T+1$, if firm $E$ has always been fought, it will go bankrupt and will have to exit, and firm $I$ will get monopoly profits forever, $\pi^M + \sum_{j=1}^{K-1} \delta^j \pi^M$. Else, predation in this period by the incumbent would not be credible: by accommodating it would get $\pi^A + \sum_{j=1}^{K-1} \delta^j \pi^A > \pi^P + \sum_{j=1}^{K-1} \delta^j \pi^A$.[31] Anticipating it, firm $E$ would stay, and they would both earn $\pi^A$ forever.

At period $T$, if the entrant is still in the industry and it has always been fought, the incumbent knows that by fighting the entrant one more time it would make it exit. Therefore, it would prefer to fight as long as:

$$\pi^P + \sum_{j=1}^{K} \delta^j \pi^M > \pi^A + \sum_{j=1}^{K} \delta^j \pi^A. \tag{23}$$

If this condition is satisfied, the entrant anticipates that it will be preyed upon once more and would prefer to exit immediately, in order to save $\pi^P$.

At period $T-1$, if the incumbent fights one more period it knows that it will induce exit in the next period, giving a payoff $\sum_{j=1}^{K+1} \delta^j \pi^M + \pi^P$. By accommodating, it will get $\sum_{j=1}^{K+1} \delta^j \pi^A + \pi^A$. Clearly, fighting is more profitable as long as condition (23) holds. Anticipating this, the entrant will prefer to exit immediately to avoid the losses caused by a period of fighting.

The argument then continues backwards in the same way until the first period, where the entrant prefers to exit immediately (or not enter at all) rather than incurring any losses.

[31] Since there is discounting, if the incumbent wants to fight entry for $T$ periods, it would fight the first $T$ periods. In other words, it would not make sense for it to restart predation after a period of accommodation.

**Comments** This simple model illustrates why the deep pocket arguments of predation might work. In a situation where a firm is financially stronger than another, the former can use its deeper pockets to force the latter out of the industry. Note also that there need not be any relationship between financial strength and efficiency: a more efficient firm might have - for several reasons, some to be seen in the following section 2.3.6 - cash constraints and be forced out of the market by a richer but less efficient rival (see exercise 3 ). If this is the case, predation is twice harmful for welfare: first, because it eliminates one firm where instead two could co-exist; second, because it eliminates the most efficient firm, adding a productive inefficiency to the allocative inefficiency.

None the less, the model has some limits. First, note that the information requirements for predation to work are quite strong, with the incumbent that should know not only the costs of the entrants but also the precise amount of funds available to it, and the entrant who should know that the incumbent does not have any cash (or credit) constraint (and there must be common knowledge of these elements). Second, the model is somewhat unsatisfactory in the sense that along the equilibrium path predation would never be observed: given perfect information and common knowledge, the entrant will never enter the industry (or, if already in, would leave it immediately), without any price war being observed. However, Benoit (1984) shows that predation would still occur under incomplete information (where some uncertainty exists about how long a firm's purse is), and that - similarly to the reputation model of section 2.3.2 - a price war might well be observed along the equilibrium path.[32] The third, and most important limit of this simple model is that it exogenously assumes that a firm is not able to raise outside funds. This leads us to the models that endogenously explain why predation might reduce the ability to borrow of an entrant firm, which is the object of the next section.

### 2.3.6 Deep pocket predation with imperfect financial markets**

To understand why predation might occur when an incumbent has financial strength, one has to understand why an entrant or a smaller firm is vulnerable when it does not have enough financial means. The key issue is to recognise that if capital markets are imperfect, then the assets (such as cash and retained earnings) owned by a firm matter and determine its ability to raise external funds. Once this point is established, it will be easy to understand why predation might occur: by behaving aggressively in the marketplace, the incumbent will reduce the assets available to the smaller firm, reducing its ability to raise capital, and therefore obliging it either to exit or to reduce its ambitions in the industry.

This section, based on Holmström and Tirole (1997) and Cestone (2001), formalises this point.[33]

[32] Note that the same remark applies also to the financial models of predation seen below. There as well the introduction of incomplete information would allow for predation to be observed at equilibrium.

[33] Cestone (2001) provides a nice survey of the literature on the interaction between capital

**Financing investments in an imperfect capital market** Consider first the financing problem of a risk-neutral entrepreneur, abstracting from product market competition. The firm needs to invest a given amount to enter a certain sector, or to continue operations in that sector, and that entails the payment of a fixed cost $F$. The firm has own assets for a total of $A$, so it needs to borrow from a risk-neutral bank the amount $D = F - A > 0$ to finance the investment.

If the investment is financed, the entrepreneur decides whether to work diligently on the project or shirking. If he works diligently, the business project will succeed with probability $p$ and will give a revenue $R$, and it will fail with a probability $1 - p$, giving a revenue 0. If he shirks, the project will fail with certainty, but he will get a private benefit $B$. The private benefit can also be interpreted as the disutility of effort saved when shirking, for instance, as the time the entrepreneur can spend reading newspapers or calling its family and friends rather than working on the project.

Effort is not observable (or, if observable, it is not verifiable), so it is not possible to write a financing contract that directly fixes its level. This creates an information asymmetry (with moral hazard) between the outside investors and the entrepreneur, that is the reason for capital market imperfection in this example.

Assume that if the entrepreneur had enough assets to finance the project itself, or if there was no information asymmetry (that is, if effort was objectively verifiable and it was possible to write a contract contingent on it), the investment will always be made:

$$pR > F. \tag{24}$$

But the outside investor will finance the investment only if it is sure that it is going to elicit diligent work from the entrepreneur. Otherwise, it will lose $D$. (Assume that there is limited liability: the investor (or bank) cannot recover the amount it lent by seizing the personal assets of the entrepreneur.)

Consider now the following contract between the bank and the firm. The bank lends $D$ to the firm, and if the project is successful, the former receives a payment $R - S$, where $S$ is kept by the firm. The entrepreneur's net expected utility is given by $U = pS$ in case of high effort, and $U = B$ in case of low effort. Therefore, $S$ must be chosen to satisfy the following incentive constraint:

$$pS \geq B. \tag{25}$$

So, if the contract is to elicit high effort, the entrepreneur must receive at least $S = B/p$ or, which is the same, the firm could not promise to repay more than $R - B/p$ to the bank ($R - B/p$ is called *pledgeable income*).

The bank will finance the project if and only if its expected value (subject to the entrepreneur making high effort, that is subject to condition (25) being satisfied) is higher than its cost (that is, the funds lent):

and product markets.

$$p(R - S) \geq F - A, \quad (26)$$

that is, if the expected pledgeable income is higher than the cost of the investment:

$$p(R - \frac{B}{p}) \geq F - A. \quad (27)$$

This clearly shows that the firm's financial position, summarised by the assets $A$ it owns, plays a key role in the bank's lending decision: the larger $A$ the more likely that the firm's project will be financed. [34] Indeed, (27) can be re-written as:

$$A \geq B - (pR - F) \equiv \overline{A}, \quad (28)$$

which makes clear that a project with positive net present value will not be financed (the firm is credit constrained) if the firm has assets below a certain threshold $\overline{A}$.

If involved in a price war that reduces its assets, a firm's likelihood to get further financing from banks will be jeopardised. This is the key insight from recent long purse models of predation, as I now show.

**A long purse model of predation** Let us now introduce product market competition in the financing model seen above. There are two firms: firm $I$ is the incumbent, and firm $E$ is a recent entrant into the industry (or the predator and the prey). The firms are perfectly identical in their technologies and products, but they differ in that $I$ has a long purse whereas $E$ has limited assets, in a sense to be specified below.

Assume that both firms have already incurred their fixed recurrent cost $F$ for period 1, but still have to pay it to continue production in period 2.[35] The game is as follows (see figure 7.3 for an illustration).

INSERT Figure 7.3. Time line: a (financial) long purse model of predation

At stage 1, firm $I$ decides on whether it preys or accommodates entry. If it preys, both firms get (first-period) profits $\pi^P$; if it does not, they get profits $\pi^A > \pi^P > 0$. At stage 2, each firm either pays $F$ or goes out of business; a firm

[34] There are different alternative models that lead to similar results. For instance, Fudenberg and Tirole (1985) look at a contract where either the firm repays its debt augmented by an interest rate $(D + rD)$, or it goes bankrupt (such a contract is showed to be optimal by Gale and Hellwig (1985)). Again, the final result is that the higher the assets owned by the firm the more likely the project is financed.

[35] Alternatively, one can think that entering the industry does not involve any cost, but then a new superior technology which requires paying a cost $F$ becomes available. This is a drastic innovation: a firm that does not adopt it will be excluded from the market.

that does not own enough assets has to find a bank to finance the investment. At stage 3, each entrepreneur has to make effort decisions, and then second (and last) profit realisation occurs. Conditional on making high effort, if both firms have invested they will earn $\pi^A$ with the same probability $p$,[36] whereas if only one firm has invested it will earn monopoly profits $\pi^M > 2\pi^A$ with probability $p$.

Assume that $p\pi^A > F$: this implies that the investment would always be financed if capital markets were perfect. Assume also that firm $I$ has own assets $A_I > F$, so that it will always be able to finance the investment, whereas firm $E$'s assets in the first period are $A_E = 0$; therefore, its second period assets coincide with its first period retained earnings (I abstract from discounting). Assume that:

$$F - \pi^A < p(\pi^A - \frac{B}{p}) < F - \pi^P. \tag{29}$$

It is now easy to look for the sub-game perfect Nash equilibrium of this game. Note that from stage 2 onwards, the game is exactly the same as the basic model studied in the previous subsection, where $\pi^A$ replaces $R$ and where assets $A$ are equal to either $\pi^A$ in case of accommodation or $\pi^P$ in case of predation. Therefore, condition (29) tells us that firm $E$'s investment would be financed only if firm $I$ does not prey.

So far, this proves that predation would indeed make firm $E$ exit the industry. However, I also have to prove that firm $I$ does have an incentive to predate. This is the case if and only if:

$$p\pi^M + \pi^P > p\pi^A + \pi^A. \tag{30}$$

Therefore, predation will occur if the future prospect of higher profits, $p(\pi^M - \pi^A)$, outweighs the current losses from predation, $\pi^A - \pi^P$.

**Some comments** First, note that I have assumed the entrant to have less financial means than the incumbent, but this might not always be the case. An interesting implication of this model is that large or financially strong entrants should be welcome. In an industry where a strong incumbent is present, a small firm might never be able to survive, whereas a large multinational company or a dominant firm in another sector that wishes to diversify into a new sector will not run the risk of being preyed upon by the incumbent. At present, I have the impression that whenever a large firm, possibly dominant in some market, plans to enter in a new market, this is regarded with suspicion. Such a suspicion might be warranted in many cases, but not always, as the long purse model teaches us.

[36] I assume that there is perfect correlation between the probability of success of the two firms. This will happen, for instance, if $p$ is the probability that market demand exists for the good.

Second, note that a strong market position is a necessary condition for predation. Predation involves monetary losses that a firm can hope to recoup in the future only if it enjoys enough market power.

Third, it should be noticed that exit of the rival is not strictly necessary for predation to be profitable, as showed in exercise 4: predation might not force a smaller firm to exit, but might prevent it from adopting innovations or to grow.

**Extensions: Renegotiation and Bolton and Scharfstein's model** A critique moved to this model is that predation could be avoided by the bank's agreement to finance the entrant independently of first period payoff realisation. In other words, if the bank and firm $E$ signed a long-term contract whereby the bank *commits* to finance firm $E$ whether or not there is predation, in exchange of a repayment $\pi^A - B/p$. Two important points should be stresses in this contract: first, it should be observable to the incumbent; second, it must be non-renegotiable, that is, the bank cannot withdraw from its commitment to finance firm $E$.

If both conditions are satisfied, then it is easy to see that predation will not occur. This is because firm $I$ knows that no matter what it does in the first period, that is no matter what assets are available to firm $E$ at the moment of investing, the bank will finance the investment. Hence, it would be pointless to engage in predation which involves foregoing profits that cannot be recovered later.

First, note that this reasoning hinges on firm $I$'s observing the contract between the bank and its rival, not necessarily a weak assumption (consider also that firm $E$ has all interest in having firm $I$ believe that it enjoys an unconditional line of credit).

Second, it also hinges on the credibility of the commitment of this long-term contract. If it were impossible for the bank to commit to such a contract, that is if the bank could renegotiate it at a zero or small cost, predation would not be avoided. Indeed, consider what happens if the contract is renegotiable after observing the first period payoff realisation. Suppose predation has occurred. Then firm $E$ has insufficient assets for the bank to be willing to finance its second period investment (since $p\pi^A - B < F - \pi^P$), and will not be able to borrow. Anticipating this, the incumbent will prey in the first period.

**The trade-off between moral hazard and deterring predation** Considering all the possible uncertainties of the market, it seems unlikely that a bank wants to commit to continue to finance operations of a firm no matter how its business is developing. Bolton and Scharfstein (1990) add the following argument to explain why it might not be wise for the bank to give such a long-term contract to the firm. If an entrepreneur knew its firm will be financed in the future independently of its results, it would not have the right incentives to make effort. To see why such an agency problem might arise following a long-term contract with the bank, consider an extension of the model where after the contract is signed but before first period market realisation firm $E$'s entrepreneur should decide whether to make a high or low effort.

To repeat, the model, illustrated in figure 7.4, is as follows (to stress the agency problem, disregard renegotiation issues and assume that the bank fully commits to the long-term contract).

INSERT Figure 7.4. Time line: Bolton-Scharfstein's model

At stage $i$, the bank and firm $E$ sign a long-term contract, whose details we shall see below. At stage $ii$, each entrepreneur takes effort decisions, which leads to success with a probability $q$ (success rates being perfectly correlated across firms).[37] First-period shirking gives private benefit $b$ (with $b < qB$). At stage 1, firm $I$ decides on whether to prey or accommodate, (first-period) profits being respectively $\pi^P$ and $\pi^A > \pi^P$. At stage 2, each firm either pays $F$ or exits. At stage 3, each entrepreneur has again to make effort decisions (success rate, again perfectly correlated, is $p$), after which, second (and last) profit realisation occurs, with payoffs $\pi^A$ if both firms invest, and $\pi^M > 2\pi^A$ if only one does.

We know from the sub-section above that firm $E$ will be able to borrow if its assets at the beginning of the second period are $A_E = \pi^A$ (recall that we assume $F - \pi^A < p\pi^A - B < F - \pi^P$). But the long term contract also establishes that the bank will finance the fixed investment $F$ with a probability $x < 1$ in case firm $E$'s second period assets are $A_E = \pi^P$, in exchange of a repayment $\pi^A - B/p$.

The optimal contract corresponds to the value of $x$ that maximises the value of firm $E$ subject to two incentive constraints to be satisfied: first, the incumbent does not prey ($\text{IC}_{I,NP}$); second, firm $E$'s entrepreneur makes high effort in the first period ($\text{IC}_{E,1}$). In other words, the programme is:

$$\max_x V = q\pi^A + [q + (1-q)x]\,(p\pi^A - F), \text{ subject to:} \tag{31}$$

$$\text{IC}_{I,NP}:\; q\pi^A + [q + (1-q)x]\,p\pi^A + (1-q)(1-x)p\pi^M \geq q\pi^P + xp\pi^A + (1-x)p\pi^M, \tag{32}$$

$$\text{IC}_{E,1}:\quad [q + (1-q)x]\,p(B/p) \geq xp(B/p) + b. \tag{33}$$

$\text{IC}_{I,NP}$ says that the incumbent prefers to accommodate entry than to prey. By accommodating, it earns $\pi^A$ in the first period, and in the second period $\pi^A$ if the rival has been successful or has been refinanced, and $\pi^M$ if it has not been successful and not refinanced (which happens with probability $1-x$), of course weighted by own probability of success. By preying, it gets $\pi^P$ in the first period, and in the second period $\pi^A$ if firm $E$ receives funding (which occurs with probability $x$) and $\pi^M$ otherwise (again, all payoffs are expressed in expected terms).

$\text{IC}_{E,1}$ says that the entrepreneur prefers to exert high effort than shirking in the first period (the IC in the second period is already taken care of under

[37] I introduce an effort decision for firm $I$ as well to preserve symmetry, but this is of course not necessary.

the stipulated contract that guarantees firm $E$ a payoff $B/p$ in case of success). The first-period effort does not give an immediate payoff to the entrepreneur, but increases the likelihood of financing in the second period. Financing occurs with probability $[q+(1-q)x]$ under high effort, and with probability $x$ under low effort.

After re-arranging, the two ICs can be re-written as:

$$x \geq \frac{p\pi^M + \pi^P - \pi^A(1+p)}{p\pi^M} \equiv x_{I,NP}, \tag{34}$$

where the numerator is positive because of condition (30), and

$$x \leq 1 - \frac{b}{qB} \equiv x_{E,0}. \tag{35}$$

These two conditions show that predation might be deterred at the cost of reducing the entrepreneur's incentive to exert effort. For instance, in the extreme case where $x=1$, that is firm $E$ is financed no matter what firm $I$ does, the entrepreneur's incentive constraint is always violated. More generally, the two ICs are simultaneously satisfied only if $x_{I,NP} \leq x_{E,0}$, that is if:

$$\frac{b}{qB} \geq \frac{\pi^A(1+p) - \pi^P}{p\pi^M}. \tag{36}$$

In such a case, the optimal probability of refinancing will be $x^* = x_{E,0}$ (the higher $x$ the larger the present value of the firm). But if condition (36) is violated, then predation can only be deterred at the cost of having low effort in the first period.

## 2.4 Practice: How to deal with predatory pricing allegations?

One clear lesson from section 2.2 is that incumbent firms might indeed use aggressive pricing strategies in order to deter entrants and/or to force competitors out of their industry, by relying on different mechanisms: they can build a reputation for being tough, so as to scare potential entrants out of the business, they might want to set low prices to signal entrants or smaller competitors they should not expect high profits, or they might want to erode a rival's resources to make it more difficult for it to get funding. No doubt, antitrust agencies should watch out and expect some incumbents to use such predatory practices to strengthen or create a dominant position.

However, we should also try to get something more from economic theory, not just the result that predatory pricing might occur. In what follows, I give my interpretation of the policy implications from the theory.

In all theories of predatory pricing there is a common mechanism: the predator sets low prices for a period, thereby sacrificing short-run profits, in order to make a rival (or its lenders) believe that it should not expect high profitability. When the rival revises its plans (or its lenders stop financing it) and exits, or abandons the project of entering, or reduces the scale of its operations, the incumbent will increase its prices and reap high profits, that in the long-run outweigh early losses.

Two elements should be stressed from this mechanism: (a) the sacrifice of short-run profits; (b) the ability to increase profits in the long-run by exercising market power once predation has been successful. It is on these two elements that the legal treatment of predatory pricing should be built. Accordingly, it makes sense to have a two-tier test of predation, as follows:[38]

1. Analysis of the industry to determine the degree of market power of the allegedly dominant firm. If the firm is not dominant, dismiss the case; if the firm is dominant, proceed with:

2. Analysis of the relationship between price and costs:

   - A price above average total costs should definitely be considered lawful, without exceptions.
   - A price below average total costs but above average variable costs should be presumed lawful, with the burden of proving the opposite on the plaintiff.
   - A price below average variable costs should be presumed unlawful, with the burden of proving the opposite on the defendant.

Note that the test reverses the logical order (a) and (b). This is because the analysis of the industry might in many cases turn out to be simpler to carry out than the price-above-cost test, and would allow to screen out some cases (those where the alleged predator is clearly not dominant) saving time and resources. In what follows, I discuss the proposed test.

### 2.4.1 Ability to increase prices (is there dominance?)

A necessary element for predation is the ability to more than compensate after the exclusion of the competitor the minor profits made during the predation episode. Clearly, this requires the existence of market power on the side of the firm, and the stronger its market power the more likely for it to gain in the long-run from the exit (or down-sizing) of the prey. Since market power is a matter of degree, the issue is where to set the line above which a firm might be accused of predatory behaviour: can an oligopolistic firm, among many in its sector that can exercise some market power, be accused of predation?

[38] Joskow and Klevoric (1979) were probably the first to suggest a two-tier test for predatory pricing. Relative to their test, the one I propose is probably more stringent in the first part (I would require dominance) and less stringent in the second part (I would presume prices below average total costs as lawful - provided they are above average variable costs).

In EU law, this is not an issue, since predation would fall under the category of abuse of dominant position. Accordingly, an oligopolistic firm that does not have a dominant position would not be found guilty for predatory behaviour. In current practice, this means that a firm with a market share below 40% would probably not be accused of predation.

In the US, the issue is much less clear, and courts have found firms guilty of predation even when they held relatively small market shares. A case in point is *Brooke Group*, although the final Supreme Court decision eventually dismissed the predation allegations, after an initial guilty verdict. In that case, a small cigarettes producer, Liggett & Myers (later to be part of the Brooke Group) had filed suit against Brown and Williamson - which held 12% of the cigarettes market - accusing the latter of having entered the generic and private label segment of the market and of selling below cost to drive Liggett - the main firm in that segment - out of the market.[39]

A high market power standard is needed to avoid the risk of jeopardising competition in oligopolistic markets. It would be paradoxical if antitrust authorities put hurdles to practices used by non-dominant firms to increase their market power. Suppose for instance that a firm with a sizeable market share (say, 20%) in an oligopolistic industry where there is a much stronger firm (say, one with 60% of the market) tries to increase its custom by decreasing its price. Suppose also the lower price allows it to steal customers both to the market leader and a smaller competitor, one that, say, has 5% of the market. The latter might then accuse the price cutting firm of predatory pricing, and - if the price is found to be below some specific measure of cost (see following sub-section), the court would indeed find predation. Yet, rather than behaving predatorily, the alleged non-dominant predator is just trying to increase its market shares through an aggressive but lawful behaviour.

There are many reasons why a non-dominant firm might price below costs as part of a normal competitive process. Consider for instance an industry characterised by *switching costs* (see also chapter 2): most consumers would be locked-in with the dominant firm, and only a significant price cut might convince many of them to address another seller instead. The same argument holds for markets with *network externalities* (see also chapter 2): if they are important enough, a substantial price cut might be necessary for a firm to win enough customers and reach critical mass. Or think of industries characterised by steep *learning curves* or important economies of scale: rather than being confined to be a niche player, a firm might want to sharply decrease prices and increase its output so as to go down the cost curve and increase its efficiency.[40] Finally, a firm might charge a price below cost if there is some *product complementarity*

[39] For discussions of this case, see Burnett (1993), Bolton et al. (2000), and Elzinga and Mills (2002).

[40] In this last example, the firm might defend itself by showing that its price is below current costs, but not below expected future costs. For this reason, whatever measure of costs is adopted, it is important that "reasonably anticipated" costs are considered, as discussed by Areeda and Turner (1974). See also below.

with another market.[41] If the latter is more important for the firm, it is short-run profitable (and good for consumers as well) that it decreases prices in the market at stake to increase demand in the complementary market.

Note also that the same arguments (with the exception of the complementarity defence) would *not* apply to a dominant firm. A dominant firm cannot claim that it needs promotional pricing to increase its sales, since it is already well established in the market: its consumers are already locked-in by switching costs and network effects, and presumably it has already reached the miminum efficient scale of production and benefited from learning effects.

Therefore, the market power test should catch only dominant firms, and not just any oligopolistic firm that has some market power. Admittedly, in exceptional circumstances there might be a non-dominant predator, and such a test would left it unpunished. Yet, this would be a small price to pay compared with a test that sets a lower barrier. The latter would create higher legal uncertainty, as most oligopolists might be the target of a predatory action. As a result of it, the normal competitive process would be damaged, since firms might fear predatory actions if setting too low prices. Further, it would invite many more predatory litigations, that would absorb energy and resources of the antitrust authorities and would distort the attention of both plaintiffs and (above all) defendants away from productive activities and into legal ones.

Finally, note that the existence of dominance should refer to the period when the first allegedly predatory episode starts, not at some later dates. Otherwise, one might find predation where instead two or more firms are fiercely competing in a market characterised by switching costs, network effects or scale economies, and they are initially competing on equal terms but only one is successful ex-post. (See also section 2.4.3 below.)

### 2.4.2 Sacrifice of short-run profits

In the predatory price models analysed above, sacrifice of short-run profits means that the incumbent-predator is not choosing the price, say $p^*$, that it would optimally choose were it taking as given the presence of the rival-prey, but rather a lower price, say $p'$, at which it will make lower current profits.[42] However, there is no necessary relationship between the price $p'$ chosen to exclude the rival and any measure of costs of the incumbent (for instance, $p'$ could be above or below the incumbent's marginal costs). In other words, theory just says that the incumbent chooses a price at which it makes less profit than it could otherwise make in the short-run, but it does not say whether such profit

[41] In chapter 8 I show that a multi-product monopolist charges lower prices when it produces complementary goods than two independent firms that monopolise those same markets, a result due to Cournot (1838), and already seen in chapter 6 as well. This result carries over to oligopolistic firms. It might also involve below-cost pricing on one good.

[42] To be sure, Harrington (1986) has showed that in some circumstances the incumbent might manage to exclude by using a higher price than would be optimal in the short-run, but I will focus on the more likely case where predation involves low prices. The considerations that follow will lead me to propose a rule whereby a necessary element of predation is pricing below (some measure of) cost. Hence, any predation through *high* prices would be undetected.

is negative or not.

If one wanted to apply literally the theory, one should be ready to enter into very troubled waters, where one of the necessary steps of the predation investigation would be the calculation of the optimal price $p^*$, and a proof that the actual short-run price $p'$ is lower than that. Clearly, this would not be feasible in practice. However sophisticated the managers of a firm might be, it is unlikely that they could have a notion of what *the* optimal price is: a fortiori, antitrust agencies and courts would find it impossible to establish that profits have been sacrificed in the sense that the price actually set by the incumbent is below the one it would have set had it not tried to force a rival out of the industry.

However, there is an alternative route to establish the sacrifice of current profits. This is to re-interpret the concept and define it not as making lower profits than otherwise possible, but making *negative* profits. In other words, the sacrifice of short-run profits is established if the alleged predation price $p'$ is lower than (some appropriate measure of) costs.

This way, one introduces a clearer benchmark: during the alleged predation episode, the predator's profits should be lower than zero, or its price below costs. Unfortunately, however, this rule is still far from being easily implementable in practice. But before discussing the practical implementation of the rule, let me make some additional remarks.

This rule is nothing else than what most courts have done and antitrust commentators have suggested to do, for a long time: a necessary (although not sufficient) condition for proving a predatory allegation of monopolisation (or abuse of dominance) is that the predator makes losses during the predation period. This rule makes a lot of sense. A firm that makes profits should be excluded from predatory charges because nobody could prove that it could have made even more profits had it acted differently. A firm that makes negative profits, instead, *might* be a predator, although there are other reasons why a firm might want to charge below costs, such as selling perishable products that would otherwise be unsold - thus causing even greater losses -, making promotional offers, stimulate sales of complementary products and so on (see more below).

This rule, however, admittedly leaves some possible predation cases uncovered, as we have seen that - in theory - a firm might choose prices strategically to exclude rivals even without going as low as selling below costs.[43] Given the difficulty of proving that price has been lower than some optimal price, there could still be another possibility, which is to find documents at the alleged predator's premises that show that there has indeed been the managers' willingness to sacrifice profits in the short-run to exclude rivals.

Such evidence should not be the replacement of an objective proof, though. Statements like "let us decrease prices so as to signal to them that we are efficient", or "...so as to make them exit", or even the existence of a business plan aimed at reducing prices to make life difficult to competitors can be comple-

[43] In other words, this approach reduces type-I errors but not type-II errors.

mentary evidence, but they should not be taken as independent and objective proof of sacrifice of short-run profits, if at those prices the incumbent is making profits. After all, if an inefficient rival enters the industry, an efficient incumbent might well be entitled to reduce its prices in response to entry, and it might well know that this is going to determine the rival's exit. Yet, this is simply part of the competitive process that antitrust agencies should stimulate: exit of an inefficient firm does not harm welfare.

In a similar vein, if an incumbent causes a rival to exit by reducing prices but at a level at which it still makes profits, this means that the rival is likely to be much less efficient than the incumbent. Hence, it is unlikely that there is a great welfare loss from its exit.

To summarise, a price below cost test might not allow to catch all the possible instances of predation. Yet, it would probably not cover just some very special cases. The cost of making such errors seems small.

Compare it instead with the error that we would make if we allowed to find predation at prices above costs. The absence of an objective rule based on observables ("optimal" prices are not observable) would introduce an element of legal uncertainty and arbitrariness. This might not only have an effect to the particular cases at hand (firms might be found guilty of monopolisation while they are not) but would have serious consequences across the economy, as firms endowed with market power would hesitate in decreasing their prices lest they are accused to force smaller competitors out of the industry or to preempt the entry of new rivals. Since low prices improve consumer surplus and welfare, and it should be an objective of any competition policy to create circumstances favourable to low prices, the risk of deterring firms from setting low prices is simply too high.

**Which definition of cost in a "price below cost" test?** Determining whether at a certain price a firm is making positive profits or not (i.e., is selling above or below cost) is a very hard task. First of all, one should decide which measure of cost to use in this assessment exercise.

Areeda and Turner (1974), in an article that has influenced antitrust practice worldwide, argue that the best measure from a conceptual point of view would be that of *marginal cost*,[44] since a firm that sets price below marginal cost would clearly not maximise short-run profits. However, they suggest to use in practice *average variable cost* - defined as the sum of all variable costs divided by output - as a surrogate for marginal cost, given "the difficulty of ascertaining a firm's marginal cost. The incremental cost of making and selling the last unit cannot

[44]Marginal cost is "the increment to total cost that results from producing an additional increment of output. It is a function solely of variable costs, since fixed costs, by definition, are costs unaffected by changes in output". "[Variable costs] typically include such items as materials, fuel, labor directly used to produce the product, indirect labor such as foremen, clerks and custodial help, utilities, repair and maintenance, and per unit royalties and license fees." Of course, such a concept leaves out fixed costs, that do not vary with output, and that "[...] typically include most management expenses, interest on bonded debt, depreciation (to the extent that equipment is not consumed by using it), property taxes, and other irreducible overhead." (Areeda and Turner, 1974: 700).

readily be inferred from conventional business accounts, which typically go no further than showing observed average variable cost. Consequently, it may well be necessary to use the latter as an indicator of marginal cost".[45]

Hence, Areeda and Turner (1974: 733) suggest that:

> "(a) A price at or above reasonably anticipated average variable cost should be conclusively presumed lawful.
>
> (b) A price below reasonably anticipated average variable cost should be conclusively presumed unlawful."

There are probably not enough cases on predatory pricing to say what courts in different jurisdictions would currently deem a predatory price. However, according to Bolton, Brodley and Riordan (2000):

> "Under current US law, a price above average total cost (ATC) is conclusively lawful, while a price below average variable cost (AVC) is at least suspect. A price between AVC and ATC is sometimes held unlawful, depending on other factors. But judicial decisions are not consistent and courts have increasingly relied on the AVC benchmark as the main criterion for illegality."[46]

Not only courts, but also some scholars would rule out predatory pricing only if price is above average *total* cost (that is, if the firm is able to recover its fixed costs as well), rather than above average *variable* cost. Joskow and Klevoric (1979) suggest that it would be more appropriate to deem any price below ATC as predatory (provided that the structural part of their test is met, that is if the alleged predator does enjoy enough market power), since a situation where a firm has losses cannot be an equilibrium. However, a problem with using ATC is that it would require a firm to cover all the fixed sunk costs, which is a very stringent standard. Suppose for instance that an incumbent firm makes some fixed expenditure that it expects to recover through monopoly profits. Soon afterwards, a new firm unexpectedly enters the market, with normal competition leading the incumbent to decrease its price at a level where the fixed sunk investment cannot be recovered. In this case, a price below ATC rule would find predation even if there is none.

This drawback is avoided by the concept of *average incremental costs* (AIC), defined by Bolton et al. (2000) as "the per unit cost of producing the added output to serve the predatory sales. AIC differs from average variable cost in at least two ways. First, it is not measured over the firm's whole output, but only over that increment of output used to supply the additional predatory sales. Second, incremental cost includes not only variable cost, but any fixed

[45] Areeda and Turner (1974: 716). Using average variable cost instead of marginal cost is clearly an imperfect proxy (as Areeda and Turner themselves recognise) and has been criticised in the literature, giving rise to alternative measures of costs to be used in predatory tests. Some will be mentioned below. For a review of predation tests, see Ordover and Saloner (1989).

[46] Average total costs are all costs (including fixed costs) divided by output.

costs incurred in expanding to serve the new sales. Incremental cost is a better standard than either average variable cost or full costs because it most accurately reflects the costs of making the predatory sales."[47] Accordingly, these authors would presume illegal a price below AIC and lawful one above ATC, with a grey area in between.

To sum up, a number of different cost standards have been proposed in the literature. In particular, both average variable cost and average incremental cost are reasonable standards. Perhaps AIC better matches the concept of predation, but it might not be always easy in practice to identify precisely the costs that are sustained for a given output, and/or isolate the predatory output from total output.

However, I would be cautious in finding predatory behaviour in cases where the price is above average variable cost (or average incremental cost): the possibility that a firm is charged with predatory pricing if it sets a price that allows it to recover variable cost but not total fixed costs (that is, a price above average variable cost but below average total cost) seems too strict and might encourage firms to keep prices higher than they would otherwise be.

Accordingly:

1. A price above average total costs should definitely be considered lawful, without exceptions.

2. A price below average total costs but above average variable costs should be presumed lawful, with the burden of proving the opposite on the plaintiff.

3. A price below average variable costs should be presumed unlawful, with the burden of proving the opposite on the defendant.

For the cases where average incremental costs can be calculated, they might be used instead of average variable cost.

It would obviously be very important, to safeguard legal certainty, that antitrust agencies express the criterion they want to follow in clear guidelines.

### 2.4.3 Testing predatory pricing: further discussion

This section comments upon further elements that might be raised during a predatory pricing case: intent, proof of recoupment, proof of anti-competitive effects and matching competitors' prices as a defence. It also deals with predatory pricing allegations in high-technology markets, an issue that has recently been debated. Finally, it criticises recent laws and regulations adopted in some EU countries, that forbid firms to sell at prices below costs.

[47] AIC is a concept that is very close to the measure of *average avoidable cost* suggested by Baumol (1996).

**Intent (existence of a predatory scheme)** In many predation cases, there is evidence from internal documents that the alleged predator's managers intended to exclude a new entrant, or force a competitor out of the industry. How should one treat these documents?

On the one hand, e-mail, minutes and other internal papers where one or more managers adopt a very strong language against competitors and state they want to eliminate them, "kill" them or the like, should not be given much importance, as they are probably to be found in any company's headquarters and - right or not - are part of the usual business language. (I would be much more suspicious of managers who say they want to be nice to their competitors, and would suggest to open immediately a collusion investigation!)

On the other hand, it would be hard to dismiss evidence that there is an articulated plan to try and exclude smaller rivals, at the cost of temporary sacrifice of profits. If there is a proof that a coherent business strategy has been put in place with exclusionary purposes, and especially if those documents reveal the intention to produce at a loss to achieve that aim, then the burden of proving that there was no predation after all should be on the shoulders of the alleged predator.

**No need to prove recoupment or success of predation ex-post** The proposed test suggests to look at the existing market power of the alleged predator to see if there is the ability to recoup losses in the long-run. Note that this is very different from assessing whether there has actually been recoupment of losses, or whether this is under way. This assessment should be in any case done from an ex-ante, rather than ex-post, vantage point, and the firm could not defend itself showing that after all it did not manage to recoup losses. In other words, the predator should not benefit from the fact that it has miscalculated the opportunity to recover losses, or that the prey has turned out to be a "tougher cookie" than initially thought, or that prompt antitrust action has led to conclusion of the predatory episode before it could achieve its aim.

Likewise, if the market power and price above cost tiers of the test are both satisfied, one should not admit as a defence the fact that predation has not been effective and exclusion has not happened.

**No need to prove ex-post damage to consumers** Antitrust policy aims at protecting competition, not competitors. So, it might appear strange that there is no explicit requirement of harm to consumers in a predation test. However, predatory pricing as established by the proposed test will result in lower consumer surplus in the vast majority of cases. Sure enough, it is possible to conceive models where predation occurs without consumer surplus being harmed (this might happen, for instance, in signaling models). However, the fact that the predator expects to recover losses from raising prices after exclusion points to a horizon long enough for (future) high prices to have a higher weight than (current) low prices. Consequently, one should expect a negative effect on net consumer surplus, leading to a presumption of anti-competitive effects.[48]

In particular, it should not be accepted as a defence that consumers have ex-post turned out to benefit from the alleged predatory episode, for the reasons expressed in the previous sub-section: the fact that low prices have not been followed by high enough prices might be due to the predator's miscalculations, antitrust action, or stronger than expected resistance from the prey.

Conversely, the alleged predator might conceivably have an efficiency defence for its below-cost prices (for instance, when it is active in complementary markets). If it has a convincing case in this respect, and the burden of proving it should be on it if prices are found to be below average variable costs, then this would exclude anti-competitive harm.

**Meeting prices of a competitor as a defence** It is part of the normal competitive process that entry by a competitor would trigger a response by the incumbent firms, leading them to decrease their prices.[49] Therefore, observing that a dominant firm's price decreases following entry is per se no proof of strategic behaviour. Clearly, a rule which dictates otherwise, and obliges a dominant firm not to react to entry would harm the competitive process and lead to market distortions (any inefficient firm would be invited to enter).

However, matching a rival's price should not be accepted if it leads the incumbent to price below average variable costs.[50] As we have seen above, there exist many reasons why an entrant, or a less established firm, might want to set prices below costs for a period in order to gain new customers and overcome the competitive disadvantage created, for instance, by switching costs, network effects, and scale economies. In such situations, as we have seen in chapter 2, a very aggressive price might be the only instrument available for a new firm to win customers away from the incumbent. While some initial losses for a new firm are perfectly justified and are part of the normal competitive process, the same is not true for an incumbent which enjoys a dominant position. Accordingly, matching a competitor's price should not be an accepted defence if it implies prices below average variable costs for the incumbent. Conversely, a price above average total costs is lawful even if it implies undercutting a smaller competitor or a new firm.

**Predatory prices in high-technology markets** In recent years, there have been a stream of high profile cases involving high technology firms, such as IBM, Intel, and Microsoft. Microsoft in particular has been the object of several investigations in both the US and the EU. These cases are very complex and comprehend several allegations of anti-competitive behaviour, among which the possibility that Microsoft aimed at excluding a competitor, Netscape, from the browser market as a way to avoid being challenged in the OS (Operation System) market.

[48] Note that this presumption applies only to predatory pricing. I will argue in section 3.1 below that quite a different approach should be taken for allegations of predatory investments.

[49] The reader can check that this would happen in most, if not all, oligopolistic models.

[50] See also Areeda and Turner (1974: 715).

Without discussing the merit of these allegations here, some commentators have argued that traditional antitrust analysis is not well suited for high-technology markets such as the computer software markets.[51] Such markets are characterised by extremely high fixed costs and very low - if not nil - marginal costs (as well as average variable costs). Think for instance of software, where R&D is the main expenditure firms incur to develop a new software package, and where the cost of producing and selling an additional unit of it, whether in the form of CDs or downloads, is next to zero. They are also characterised by very important network externalities, either direct (the more other people use my same software the happier I will be because the more likely I can exchange files with them) or indirect (the more people use my same OS the happier I will be because the more likely that software developers will write applications that will run on my OS).[52] This means that we should expect very intense competition in the early stages of the market, until the market tips in favour of one firm, which will then become dominant and use its market power to recover the losses incurred in the initial periods, until a new technology will appear that will replace the old one, bringing to an end the previous leadership.[53]

While I agree that caution should be used in dealing with predatory charges, (1) neither do these markets present unique features unknown to industries in the pre-information technology age, (2) nor is a "new antitrust" necessary to deal with them. As for the first point, examples of industries with very strong fixed sunk costs and relatively low variable costs can be found everywhere: think for instance of consumer products characterised by heavy advertising outlays and industries such as chemicals, pharmaceuticals, engineering characterised by heavy R&D outlays.[54] Nor are new information technology industries the only ones where network effects are at play, of course. Network effects can be seen in such traditional industries as toys, shoes, and design for instance, that is whenever fashion and fads play a role (whereas some people are happier to buy unique pieces, the vast majority seems to want what other people have), and of course network externalities play a role in electricity appliances, fixed telephones, railways, records and so on.

As for the second point, note that the proposed test for predatory pricing above (which is a variant on a long tradition dating from Areeda and Turner, 1974) allows to cope with many of the fears expressed by, for instance, Ahlborn et al. (2001). A firm that is charging below average total costs (which can easily

[51] See Ahlborn et al. (2001) and Schmalensee (2002).

[52] Computer OS, like many other markets characterised by network externalities, are *two-sided* markets, that is markets where the success of a product depends on it being accepted by two different groups of consumers. Another examples of two-sided market is the market for credit cards (shop-keepers and consumers). For an analysis of pricing strategies and competition effects of such markets, see Rochet and Tirole (1999, 2001), Schmalensee (2002) and Evans (2002).

[53] See Shapiro and Varian (1999) for an interesting and accessible analysis of information technology markets, and Shy (2001) for a simple analysis of network industries. Breshanan (1998) presents a theory of successive monopolies in a dynamic context.

[54] Sutton (1991, 1998) provides a detailed analysis - rich also of case studies - of industries with high fixed sunk costs and low variable costs.

be the case when fixed costs are important) is not necessarily found guilty even if it has a dominant position. And, most certainly, if two or more firms are competing for the market in a particular sector and none of them has a dominant position at the outset, the fact that they charge below costs to win the market (and that they do have intent to exclude, since each of them is struggling to become the firm which wins the race and becomes the monopolist) should not lead to any charge since the first tier of the test (no dominance) is not satisfied. In other words, if there is no ex-ante dominance, the case for predation should be dismissed.

The existence of network effects and important R&D outlays should be no excuse for a dominant firm that tries to keep its market power through anti-competitive means. The rules should apply to high-technology markets as well as traditional ones, and if a dominant firm tries to preserve its position by predatory pricing, it should be punished for it.

Another interesting case is the one where a firm dominant in one product tries to enter a new market for a complementary or independent product, which is often the case in high technology markets (think for instance of Microsoft, that has moved progressively into internet browsers, audio and video software, instant messaging services, software for hand-held devices and so on). How should it be treated? Obviously, there is no a priori answer to this question, but a couple of observations seem worth making. First, if the products are complementary, recall that a firm will have an (honest) interest in charging lower prices than two separate firms would, in order to stimulate demand, and that this is to the advantage of consumers as well. As we have seen repeatedly (see also chapter 6), being served two products by the same monopolist is usually better than being served those same products by two different monopolists!

Second, people are generally concerned about large and well endowed firms extending their power from one market to the other. However, if markets are complementary we have seen that this is more likely than not to be beneficial for consumers. If markets are independent, this is not necessarily bad news either. In markets characterised by important network effects and other attritions, it might be very difficult to leapfrog the current leader, and a firm that can rely on important R&D, marketing and financial assets might manage to achieve what a small firm might not.[55]

Therefore, it might not necessarily be always bad news when a large firm tries to enter a new product market.

**Price below average variable cost: not a general rule** In most EU countries, there exist laws and regulations that apply to specific sectors or are economy-wide, and that forbid below cost pricing, promotional sales, free gifts, "two-for-one" offers, retail discounts above a certain threshold. Retailers are

[55] Cestone and Fumagalli (2001) show that the allocation of financial resources within a business group (even when it is not observable to outsiders) affects the business' units probuct market behaviour. Being affiliated to a well-endowed business group might facilitate entry in a market relative to a stand-alone firm; however, an incumbent firm which is part of a business group might also deter entry more easily.

not entitled to sell goods at a loss in France, Spain, Italy, Ireland, Luxembourg, Belgium, Portugal and Greece (*Financial Times*, August 22, 2002: 1, 3). In general, these laws are the result of lobbying from shopkeepers and small businesses that regard aggressive price cuts by national supermarket chains or large firms as predatory and unfair. However, the resulting obligation to charge above costs apply to any firm, regardless of the market power it holds and the reasons why the price cut is made.

There is no justification for such a regulatory approach, that protects competitors (for political or social reasons) rather than promoting competition. To repeat, there are many reasons (switching costs, network externalities, price promotions, complementary products) why firms might want to sell at a loss temporarily, and they are part of a normal competitive process. Forbidding them a priori and on a generalised basis has the effect of hampering competition and decreasing consumer welfare.[56] If there are reasons to believe that, say, a supermarket chain is selling at a loss to force small shop-keepers out of business, a specific antitrust action should be started. If instead the concern is the survival of small shops, small peasants, and small firms in general, then, as I have argued also in chapter 1, this might well be the objective of a public policy, but should be addressed with different means (for instance, income tax rebates) that are less distortive of competition.

# 3 Non-price monopolisation practices

There are a number of instruments other than price that a dominant firm might use to try and force exits of smaller rivals or to deter entry into the industry. They include strategic investments (section 3.1), tying (section 3.2), and incompatibility decisions (section 2.1); other instruments, such as exclusive dealing and refusal to supply, have already been analysed in chapter 6.

## 3.1 Strategic investments

We have seen that when a dominant firm reduces prices, first it is very difficult to understand whether this is due to genuine, lawful competition or to anti-competitive behaviour; second, since low prices are something that consumers like, one has to be extra careful in not discouraging firms from decreasing prices. This basic problem re-appears when one looks at investments in capacity, R&D, advertising, product quality, new brands and so on. Theory shows that - like for price decisions - a dominant firm might use its investment decisions in a strategic way, in order to drive competitors out of the industry, or to persuade them not to enter at all.[57] However, first it is difficult to recognise in practice whether a

[56] Compare with the following statement by the European Parliament's internal market committee: "the prohibition of loss-making sales...is a useful instrument that not only serves consumer interests but also helps to prevent unfair trade practices". (*Financial Times*, 22 August 2002: 1).

[57] See for instance the classic papers by Spence and Dixit on investments in capacity; and the more recent papers by Choi (1996) and Farrell and Katz (2000) on R&D investments in

certain investment level is the fruit of the "honest" attempt of a firm to be more competitive and more appealing to consumers, or instead it is driven only by the desire of attaining or reinforcing a monopolistic position. Second, since most investments have a positive effect upon welfare, a very cautious approach has to be taken not to discourage firms from undertaking projects that should be welcome. I will argue that because of these difficulties, only in truly exceptional cases it might make sense to accuse a firm of over-investments; further, the burden of proof should be on the plaintiff, not on the defendant.

The basic mechanism behind anti-competitive choice of investments is similar to predatory pricing: an action is taken that involves the sacrifice of current profits, to be outweighed by future profits. In other words, for a period, a firm invests more than is profitable in the short-run, with the expectation of increasing profits in the long-run, when the rival has left (or a potential competitor abandons plans of entering the market).

To fix ideas, consider a situation (analysed formally in section 3.1.1) where an incumbent monopolist has to decide how much to invest in process R&D, knowing that a firm is considering entry into the industry. Suppose for the simplicity of the argument that the R&D outcome is not stochastic, for instance because there are technologies already available elsewhere and the incumbent has to decide which ones to adopt. Facing competition, it makes sense that the incumbent wants to improve its technology and abate its production costs. Indeed, we would all say that such an investment in R&D is one of the welcome effects of increased competition. Let me call $x^i$, where "i" stands for innocent, the optimal investment level chosen by the incumbent firm when it takes for given that the new competitor will be in the market in the following period.

However, the incumbent might also act strategically, and try to discourage the new firm from entering at all. For instance, it might choose to invest in a particularly costly and efficient technology, so costly and efficient that the new entrant would not expect to be sufficiently profitable when the incumbent adopts it. In other words, investing in the more efficient technology represents a credible commitment to be a fierce competitor in case of entry. Call $x^p$, where "p" stands for predatory, the investment level (higher than $x^i$) that would make the entrant re-consider its entry decisions.[58] When the rival observes that the incumbent has invested (or committed to invest) $x^p$, it will withdraw.

Clearly, $x^p$ is higher than short-run profitability would require, since it is the lower investment level $x^i$ that the incumbent would choose if it did not try to affect the entry decisions of the potential rival. None the less, the expectation of continuing monopolistic profits (due to entry deterrence) might make the more costly investment profitable.

Some remarks are at stake here. First, it is not said that the entry deterrence level of investment would always be chosen. Even if it was *feasible* to deter entry (for instance, because it is known that the rival would drop its entry plans after

complementary markets.

[58]For the sake of simplicity, I am assuming that the entrant cannot use the same technology, for instance because the size of the market is not large enough for two firms to recover such important (endogenous) sunk costs. See also chapter 2 on endogenous sunk costs.

observing $x^p$), it is not necessarily *profitable*. For instance, the sunk cost required by technology $x^p$ might be so high that it is more convenient to co-exist with the competitor.

Second, the focus is on protecting competition, not competitors. In other words, even in the unrealistic case where we could establish that $x^p$ has been decided only to preempt entry, from the above example we could not conclude that the over-investment is anti-competitive, for two reasons:[59] The first reason is that the lower its costs the lower the price a monopolist charges, so it is conceivable that consumers might gain from the more efficient technology (in the period prior to the planned entry date of the other firm, prices would be lower; prices might also be lower under an efficient monopolist than under less efficient duopoly).

The second and most important reason, it would be very difficult to identify predation for strategic motives such as the one described above in practice, as there are no observable variables and no evident benchmark levels that one could look at to decide whether there has been strategic over-investment or not. Imagine a court having to evaluate a complaint by a competitor that there has been strategic over-investment by the incumbent in order to deter entry. The only observable variable here is the actual investment level made by the incumbent, $x^p$. How can it be proved that had it not wanted to deter entry, the incumbent would have chosen another, and lower investment level? The incumbent will say that it has chosen an investment that makes it competitive vis-a-vis an entrant, and in any case in the real world it could never be sure whether after observing $x^p$ the rival would call off its entry plans or not.

The very notion that a court or an antitrust authority could find a firm guilty of anti-competitive behaviour because it has "invested too much" would create a dangerous precedent: firms might refrain from investing fearing that they could be investigated for abuse of dominance or monopolisation.

Similar considerations also applied to predatory pricing, but with two differences. Firstly, for allegedly predatory prices a possible benchmark exists: if a firm sets a price below average variable costs, a presumption that the firm is taking an anti-competitive action exists. But no such benchmark exists when it comes to investments.

Secondly, low prices are reversible, whereas most investments are not. And indeed, a full commitment is crucial for the strategic entry deterrence argument (if the investment decision was reversible, the entrant would enter, regardless of the announcements of the incumbent). As a result, consumers will benefit from the investment even after "predation" ends, whenever the incumbent's action involves the installation of new capacity, investments in R&D (think for instance of the creation of a new laboratory and the hiring of related personnel and scientists), the introduction of new brand if supported by specific advertising and marketing expenses (provided they are specific to the new brand), and so

[59] An additional argument, that I will not consider here, is that entry might not always be welfare enhancing, because of duplications of fixed costs. Accordingly, it is in principle possible that welfare is higher when the incumbent acts strategically than otherwise.

on.[60] Other things being equal, this argument indicates that the loss from anti-competitive investment would be lower than under predatory pricing.

Overall, therefore, while it is theoretically possible that an incumbent over-invests in advertising, R&D, or capacity; or that it introduces new brands, or engages in product proliferation for the purpose of strategically deterring entry or forcing exits of smaller rivals, it would seem difficult to suggest any rule that allows to identify such behaviour in practice.

### 3.1.1 Strategic investments to deter entry*

There are a number of variables that could fit the analysis carried out in section 3.1, and indeed many works have showed that a firm might preempt entry by investing strategically. Spence (1977) and Dixit (1980) are the classical references in this respect: they show that a monopolist can strategically accumulate capacity so as to deter a potential entrant. Here I present a slightly different (and perhaps simpler) model that gives similar insight.[61]

There is an incumbent, firm 1, that faces a potential entrant, firm 2, in the market for a homogenous good whose demand is $p = 1 - q$. The game they play is as follows. In the first stage, firm 1 decides how much it wants to invest in a cost-reducing technology. Absent any investment, the incumbent produces at a marginal cost $c$; by investing $x_1$ it can become more efficient, with total cost of production given by $C(x_1, q_1) = (c - x_1)q_1$. Assume a quadratic cost for the investment, $F(x_1) = x_1^2$. For simplicity, assume that firm 2 cannot invest in R&D prior to entry and that if it enters, it will have a constant marginal cost $c$. (Exercise 5 studies the case where firm 2 can also invest in R&D, and shows that the main results obtained here carry over to that case.) In the second stage, firm 2 decides whether to enter or not, after observing the investment of firm 1. If it does, it has to pay a fixed sunk cost $F$. In the last stage, active firms choose outputs.

To look for the sub-game perfect Nash equilibrium of the game, start by the Cournot game at the last stage.

If there is a duopoly, firm $i = 1, 2$ will choose the output $q_i$ so as to maximise $\Pi_i = (1 - q_i - q_j - c_i)q_i$, where $c_1 = c - x_1$ and $c_2 = c$. Re-arranging the FOCs $d\Pi_i/dq_i = 0$, one obtains the reaction functions:

$$R_1 : \; q_2 = 1 - 2q_1 - c + x_1; \qquad R_2 : \; q_2 = \frac{1 - q_1 - c}{2}. \tag{37}$$

Their intersection gives the usual Cournot outputs, prices and profits:

[60] Judd (1985) analyses a model where an incumbent might use product positioning to deter entry, and he shows that if the incumbent could later withdraw the brand at a low cost, it might want to do so. Accordingly, the commitment of the investment is reduced and the entrant will not be deterred.

[61] For a textbook presentation of entry deterrence models of capacity see for instance Tirole (1988).

$$q_i^c = \frac{1 - 2c_i + c_j}{3},\ p^c = \frac{1 + c_i + c_j}{3},\ \Pi_i^c = \frac{(1 - 2c_i + c_j)^2}{9}. \tag{38}$$

If there is a monopoly, firm 1's optimal values are: $q_1^m = (1 - c_1)/2$, $p^m = (1 + c_1)/2$, $\Pi_1^m = (1 - c_1)^2/4$.

Going backwards, we find two different cases, according as to whether firm 1 behaves innocently or strategically.

**Innocent behaviour** The first case is the one where firm 1 takes as given firm 2's entry. Its programme will be:

$$\max_{x_1} \pi_1 = \frac{(1 - c + 2x_1)^2}{9} - x_1^2. \tag{39}$$

From $d\pi_1/dx_1 = 0$, and further substitutions, we obtain:

$$x_1^{inn} = \frac{2(1-c)}{5}; q_1^{inn} = \frac{3(1-c)}{5}; q_2^{inn} = \frac{(1-c)}{5}; p^{inn} = \frac{1+4c}{5}; \tag{40}$$

corresponding profits for firms 1 and 2 respectively are:

$$\pi_1^{inn} = \frac{(1-c)^2}{5};\ \pi_2^{inn} = \frac{(1-c)^2}{25} - F. \tag{41}$$

Therefore, firm 2 would enter the market as long as $F \leq (1-c)^2/25$. In the words of Bain (19xx), if $F > (1-c)^2/25$, entry would be blockaded: there would be no need for firm 1 to behave strategically in its technology choice: firm 2 would not enter.

**Strategic behaviour** Observing firm 2's profits one can notice that they decrease with the investment of firm 1: $\Pi_2^c(x_1) = (1 - 2c - x_1)^2/9 - F$. Call $x_1^p$ the level of investment such that $\Pi_2^c(x_1^p) = 0$. It is easy to see that:

$$x_1^p = 1 - c - 3\sqrt{F}. \tag{42}$$

For a level of investment slightly above $x_1^p$, firm 2 will prefer to stay out of the market, as it would not be able to recover its fixed costs if it entered.

To see the intuition behind the existence of such a level of investment at which entry is deterred, consider figure 7.5.

INSERT Figure 7.5. Entry-deterring R&D investment

The solid lines represent the reaction functions of the two firms absent investments by firm 1. Expressions (37) reveal that they are negatively sloped and that an increase in $x_1$ shifts firm 1's reaction function to the right. The figure also draws the iso-profits of firm 2: the closer to the vertical axis (where $q_1 = 0$) the higher firm 2's profits. By appropriately selecting its investment levels, firm 1 can therefore move the equilibrium to the right, up to the point where firm 2's profit is just a shade short of covering its fixed cost $F$. In other words, if firm 1 chooses the investment level $x_1^p$, it will move its reaction function from $R_1$ to $R_1(x_1^p)$ and firm 2 will prefer not to enter.

So far, I have just proved that entry deterrence is *feasible*: by choosing a level slightly above $x_1^p$ firm 2 would be deterred from entering. But is such a strategy *profitable*? To see if this is so, note first that by investing $x_1^p$ firm 1 would be a monopolist. Therefore:

$$q_1^p = 1 - c - \frac{3\sqrt{F}}{2}; p^p = c + \frac{3\sqrt{F}}{2}; \pi_1^p = \frac{12(1-c)\sqrt{F} - 25F}{4}. \tag{43}$$

The question is then whether by behaving strategically (that is, preying) firm 1 will obtain higher profits than by accommodating firm 2. This happens if $\pi_1^p > \pi_1^{inn}$. By re-arranging, one has that:

$$\pi_1^p - \pi_1^{inn} > 0 \Leftrightarrow 125F - 60(1-c)\sqrt{F} + 4(1-c)^2 < 0. \tag{44}$$

By setting $\sqrt{F} = \phi$, one has a standard second-order equation which is solved for $2(1-c)/25 < \phi < 2(1-c)/5$, or $4(1-c)^2/625 < F < 4(1-c)^2/25$. Note that the second root is beyond the interval we are considering. Therefore, we can conclude the analysis by saying that:

- $F \leq 4(1-c)^2/625$, there is accommodated entry.
- $4(1-c)^2/625 < F \leq (1-c)^2/25$, there is deterred entry.
- $F > 4(1-c)^2/25$, there is blockaded entry.

**Is entry deterrence anti-competitive?** There is still an important point to be clarified. Suppose that $4(1-c)^2/625 < F \leq (1-c)^2/25$, so that incumbent firm 1 does engage in entry deterrence behaviour by strategically over-investing in process innovation. Does such behaviour harm consumers? Is the price under entry deterrence higher than under accommodated entry? This is not the case if $p^p \leq p^{inn}$, or $F \leq 4(1-c)^2/225$. For low enough values of the fixed cost $F$, entry deterrence is possible and profitable, but firm 1 has to invest so much to preempt entry that it becomes so efficient that consumers are better off than if the entrant was accommodated. To summarise:

- $F \leq 4(1-c)^2/625$: accommodated entry.

- $4(1-c)^2/625 < F \leq 4(1-c)^2/225$: deterred entry; but consumer surplus is higher.
- $4(1-c)^2/225 < F \leq (1-c)^2/25$: deterred entry; consumer surplus is lower.
- $F > 4(1-c)^2/25$: blockaded entry.

Note that here I am looking at the impact on prices (i.e., consumer surplus) rather than on total welfare. This is just to avoid unnecessary calculations: looking at total welfare would give similar results: for some values of $F$, entry would be deterred but this turns out to be welfare improving.

## 3.2 Bundling and tying

In many situations, a product is offered by a seller under the condition that another product is also bought, a phenomenon which is called *tie-in sales*. For instance, a travel agent might sell a plane ticket only together with the purchase of a hotel accommodation, a car manufacturer sells a car as a whole, and does not sell separately tyres, air-conditioning, engine, seats and car body, shoes are sold with strings, computers might include both OS and application software, and so on. All these are instances of *bundling* (or *package tie-in*): different goods are sold together in *fixed proportions*.[62]

A different class of examples pertains to so-called *requirements tying*, that occurs when a seller requires to purchase not only a certain good, but also all the units a consumer wishes to buy of another good: here the two goods are sold together in *variable proportions*. For instance, a mobile phone company might want to sell you the mobile telephone set only at the condition that you make all the phone calls from it and not from other operators, or a photocopier might sell a copy machine only if one accepts to buy toner only from it.

This section analyses why firms might want to use tie-in sales (I use indifferently the terms tying and tie-in sales), and what are the likely effects of such business strategies. Section 3.2.1 shows that tying often has a very natural efficiency rationale (and therefore has pro-competitive effects). But there are two possible reasons why tying might decrease welfare. The first (section 3.2.2) is that it allows firms to price discriminate across consumers with different preferences (this is true for both bundling and requirements tying). Unfortunately - like for price discrimination in general (see section 4), the welfare effects of tie-in practices are ambiguous. The second (section 3.2.3) deals with the old contention that by tying sales of two products, a monopolist in one product might be able to extend its monopoly onto a second product market. Chicago School thinking maintained that this would be unprofitable, but recent models of tying indicate strategic reasons why tying might allow monopolisation. Section 3.2.4 tries to identify the main policy conclusions from the analysis.

[62] To be more precise, these are instances of pure bundling. *Mixed bundling* occurs when a firm offers consumers the choice between bundle and separate products or components. For instance, a restaurant might offer both a fixed menu and the possibility to order *à la carte*.

### 3.2.1 Efficiency reasons for tying

In some cases, selling components together has obvious efficiency justifications. For instance, assembling all the different bits and pieces that compose a computer is much more costly for a typical consumer than for a computer maker that can rely on specialised personnel and appropriate machines; it would be time-consuming to buy separately shoes and laces, or a car and its different parts, and having to assemble them. Therefore, in many cases the principles of *division of labour* and *scale economies* imply that it is more efficient that certain components are marketed together rather than separately.

In other cases, tying different components or products together might also be an efficient response to *asymmetric information*. Imagine for instance that a computer would work at its best only with certain components, or that driving a car without a specific set of tyres might become dangerous, or a copy machine would give poor copies without a specific type of toner. Then firms might wish to incorporate the right components or parts into the final product, to overcome possible reputation problems that would arise if the consumers did not combine them properly. Such a practice would be profitable for the firm but would also be efficient: consumers enjoy the highest possible quality of the products they buy.

Of course, when assessing efficiency gains, one should take into account that tying might not always be the only available way to overcome information problems. For instance, a car manufacturer could specify which types of tyres can be installed on its cars, the computer maker could warn what are the components that can be put into its computer, and the copy producer the toner that can be used in its photocopy machine. Sometimes this would solve the problem, in others they would not, it depends on the specific cases.

In a widely cited US case on tying in the old-generation computer sector, *International Business Corporations v. US*, IBM claimed that its requirement that customers should use only IBM punch-cards for IBM computers was justified on quality grounds: poor cards might have led to malfunctioning and jamming of its computers, with a loss in its reputation. However, the Supreme Court found that IBM could have solved the possible quality problem by either properly publicising the higher quality of its cards, or making leases conditional on a minimum standard requirement for cards to be used with IBM machines.[63]

### 3.2.2 Tying as a price discrimination device

Even if none of the previous technological or informational justifications exists, firms might still have other reasons to use tie-in sales. In particular, both bundling and requirements tying allow firms to increase profits by working as a price discrimination device, as explained in what follows.

[63] For more on this case and other examples of tie-in sales, see Scherer and Ross (1990: 562-569).

**Bundling** Consider a very simple example where a monopolist sells two goods, call them A and B, to two consumers, 1 and 2. Consumer 1 has a maximum willingness to pay for good A of 7 and for good B of 5. Consumer 2 has a maximum willingness to pay for good A of 4 and for good B of 8. Assume also that the monopolist knows their willingness to pay but it cannot charge different prices to them (for instance, because it is illegal), that consumers buy at most one unit of each good, and the monopolist's production cost is zero for simplicity.

| | 1's willingness to pay | 2's willingness to pay |
|---|---|---|
| good A | 7 | 4 |
| good B | 5 | 8 |
| goods A and B | 12 | 12 |

If the monopolist sells separately the two products, it will choose the price of A to equal 4 and sell to both consumers, making a profit of 8 on good A (if it sold at 7, it would sell only one unit and have a profit of 7); and it would sell B at 5, making a profit of 10 on B (by selling at 8, it would sell only one unit and make lower profits). In total, it would gain 18.

If instead the monopolist sold the two products as a bundle, it could charge a bundle price of 12, and since both consumers would buy, its total profits would be 24. Clearly, bundling allows it to extract more surplus from consumers and increase profits.

There have been several contributions in the economic literature trying to understand under which conditions firms have an incentive to bundle. More interestingly for our purpose, however, is to notice that the welfare implications from such a bundling practice are ambiguous:[64] one can devise examples where bundling increases welfare and others where it decreases it.[65]

**Requirements tying as a metering device** Sometimes consumers use a certain product in a more or less intensive way. For instance, some might use a copy machine very often, while others use it only occasionally, which would reflect in different willingness to pay for the photocopier.[66] When this happens, a firm might want to have a metering device, that is a way to sort consumers according to their intensity of use (and therefore willingness to pay), and make them pay accordingly, so as to extract as much surplus as possible from them. Ideally, the firm would like to measure intensity of use directly. However, if the copy producer requires consumers to buy from them all toner they need, this would effectively work as a measure of intensity of demand, since the more often one makes copies the more frequently one needs to replace the toner cartridges. The firm can then keep the price of the copy machine low (so as to attract people with lower intensity of demand to buy it) and charge a higher price on

[64] Bundling here works very much like price discrimination (see section 4), whose welfare impact is also a priori unclear.

[65] See Adams and Yellen (1976). One reason why more insightful conclusions on the welfare effects of bundling are not available is that it is difficult to analyse bundling with general hypotheses on consumers' preferences.

[66] Scherer and Ross (1990, chapter 15) use the same example.

each unit of the complementary good (the toner cartridges) so as to extract surplus according to the willingness to pay of consumers.[67]

While it is clear that tie-in sales benefit the firm, the welfare effects are ambiguous. It can be showed that if all consumers buy both when there is tying and when it is banned, then welfare will be lower under tying. However, the tying strategy might allow to sell to some consumers who would not otherwise buy the good (that is, it might increase demand), and cause a net positive effect on welfare. (See technical section 3.2.5 for a formal analysis.)

So far, in view of both the fact that tying might well have important efficiency effects, and that even in the absence of an efficiency rationale its impact on welfare is a priori ambiguous,[68] there would be little economic ground for a harsh treatment of tying. Before drawing any conclusion, however, we should look into the possible exclusionary effects of tying.

### 3.2.3 Exclusionary tying in recent models

The first author to offer a convincing explanation on why exclusionary tying might be profitable is Whinston (1990) (see section 3.2.6 for a formal analysis). He shows that an incumbent monopolist in a market for product A that commits to bundling it with an independent product B can exclude a competitor from the latter market. This is because the commitment to sell the two products together effectively acts as a commitment to be more aggressive in market B: the incumbent knows that every consumer who prefers to buy the rival's version of product B is also a consumer who will not buy its product A (on which there are high margins since it is a monopolist).[69] In turn, fiercer competition in the market will decrease the rival's profits with respect to the case where the incumbent does not bundle its sales, and might force it to leave the industry if the reduced profits are not large enough to cover fixed costs. (Note also that more aggressive competition would decrease the incumbent firm's profits as well, if the rival continued to be active: I shall come back to the implication of this point.)

Note, however, that the exclusion of the rival is not necessarily profitable for firm 1: if it has committed to sell the products as a bundle, it might well be that some consumers who would have bought A only in combination with the rival's variety of B would not buy the bundle at all; this might happen, for instance, if they do not value A too high, and if they much prefer the rival's

[67] This is a very similar price discrimination mechanism as that used by a seller which offers two-part tariffs (in turn equivalent to quantity discounts): by using a fixed fee and a variable component in its price, it manages to extract surplus from consumers with different intensities of demand. See section 4.1.

[68] Note that, so far, tying works in a very similar way as price discrimination (see section 4 below). However, an efficiency defence might possibly exist for tying, but is less likely for price discrimination (quantity discounts might be associated with savings in transaction costs and scale economies).

[69] Although under bundling the incumbent just sets a single price for the two products sold together, everything works as if it sold product B independently but it had a lower cost, that is the true unit cost of producing B minus the unit margin on product A sales. And a lower cost implies a more aggressive market behaviour.

version of product B. In other words, if the incumbent is selling a poor quality version of product B, it seems unlikely that - even if it can exclude the superior quality rival's product - the incumbent would find it profitable.

It is important to stress that the exclusionary effects of this mechanism take place as long as the bundle has commitment value, that is if the incumbent can irreversibly commit to sell the two products together, for instance by product design or in the technological process. Otherwise, exclusion would not occur: the rival knows that, if it entered or it stayed in the market, the incumbent would reverse its bundling decision, as it also earns lower profits when both firms are active (remember, bundling implies more aggressive competition, and this destroys profits if both firms are in the market).

Note also that in this model tying does not have by assumption any efficiency role (this is done to stress the possibility of anti-competitive effects). When assessing welfare in practice, however, one should keep in mind that tying might have efficiency effects that enhance consumer's utility directly, and that might outweigh its exclusionary effect. In other words, an efficiency defence should be allowed to the incumbent monopolist that allegedly used tying to exclude competitors.[70]

Whinston also shows that when goods are complements, exclusion is in general not profitable. Continue the example above, but suppose now that products A and B are complements in fixed proportions: good A is a necessary product, and no consumer would buy good B alone. In this context, a commitment to bundling would trivially exclude the rival: if A is sold only in combination with the incumbent's variety of product B, nobody would buy rival's product B.

However, by not bundling the incumbent can only do better. Call $\widetilde{p}$ the optimal price of the bundle under monopoly. Suppose that when it does not bundle the incumbent chooses for market B a price $p_B$ equal to $c_B$, its marginal cost of producing B, and for market A a price $p_A$ equal to $\widetilde{p} - c_B$. Given this pricing policy, two cases might happen. Consider first the case where the rival is not active in the market. In this case, the only thing that matters for consumers is the sum of the prices of the two goods, and the incumbent will do just as well as with the bundle, since $p_A + p_B$ equals $\widetilde{p}$ (both price and demand are the same as under bundling).

Consider next the case where the rival is active when the incumbent does not bundle and uses the above pricing policy. In general, there will be two effects from the presence of the rival. (a) Some consumers who were buying from the incumbent will switch to the rival (others stay with the incumbent). But this does not reduce the incumbent's profits: it will still sell product A to all consumers (those who buy B from it and those who buy B from the rival), and

[70] Whinston (1990: 845) also points out that, even when it does exclude and it is profitable, tying is not necessarily welfare detrimental: consumers will lose from it (monopoly prices under bundling will probably be higher, and less variety of product B is on offer), but in principle this adverse effect on welfare might be outweighed by the saved fixed costs of the rival. This presumes, however, that there might be excess of entry in the market from a social welfare point of view: an occurrence that is theoretically possible but it has no clear application, as it is impossible to verify empirically.

make on them the same margin as $(\widetilde{p} - c_B) - c_A$ as when it sells under bundling. Lost demand on B's products does not amount to lost profits, though: B is sold at unit cost under the pricing scheme above, so profits on B are zero anyway. (b) Some consumers who were not buying from the incumbent under bundling will instead start to buy when an alternative choice of B exists. Clearly, this effect increases the incumbent's profits, since it attracts to product A additional demand (on which the incumbent makes positive profits).

Whinston (1990) finds two specific examples where an incumbent profitably uses tying to exclude competitors in a complementary market: one where product A is not essential, the other where an inferior alternative to product A exists. Overall, however, complementarity makes it less likely (albeit not impossible) that an incumbent will use tying for exclusionary purposes.

Choi and Stefanadis (2001) also consider complementary products (see technical section 3.2.7). In their paper, an incumbent firm is monopolising both components, and faces an entrant in each market. Each potential entrant can enter the market for one component if it has a successful innovation. However, innovating involves an initial fixed investment, and it is therefore risky. In this context, if the incumbent commits to bundling, entry in one component market is possible only if both innovations are simultaneously successful (when the incumbent is bundling, if one entrant only obtains the innovation it will have no demand since the goods are complements). Therefore, bundling reduces the incentives to invest and consequently it will be less likely that innovations will appear, and that entrants will oust the incumbent.[71]

Even in this model, however, it is not always clear that the incumbent will find it profitable to tie sales of the two goods. On the one hand, tying would avoid being forced out if both rivals were simultaneously successful; on the other hand, it would decrease the profit the incumbent makes were only one rival successful. In the latter case, indeed, it would gain from the rival's investment, since it will use the monopoly power it has on the other component to extract some of the rent created by the rival's innovation.

Carlton and Waldman (2000) present a similar mechanism whereby tying would allow an incumbent to deter entry in a complementary market B in order to protect its monopoly in market A.[72] Initially, the incumbent faces a potential entrant in market B; only subsequently can another firm decide on entering market A. By tying A and B, the incumbent could deter the first entrant in the B market (this happens as long as it is sufficiently uncertain that there will be future entry in market A), which in turn makes it less likely that the second entrant wishes to enter the A market (because the incumbent would be the only producer of the complementary product).

[71] Exclusionary tying in the presence of R&D investments is also considered in Choi (1996). Farrell and Katz (2000) look at incentives to invest, and resulting welfare effects, when a monopolist in a component is also present in a competitive complementary market (their analysis does not necessarily refer to tying).

[72] The model therefore tells a story which is reminiscent of the US v. Microsoft case, where Microsoft was alleged to tie Explorer, its internet browser, with its OS, Windows, to force exit of Netscape, a rival browser, supposedly because Netscape was supporting the language Java, that could have been used to jeopardise Microsoft's monopoly position in the OS market.

Both in Carlton and Waldman (2000) and in Choi and Stefanadis (2001) the basic mechanism of exclusion is the same, in that entry in one market is made dependent on the success of entry in a complementary market. In a way, this mechanism reminds us of the papers where exclusive dealing deters entry exploiting externalities among buyers (see chapter 6). Here there also externalities among the potential entrants, which begs the question of what happens when the entrants can coordinate (in Choi and Stefanadis the entrants can belong to the same firm, but probabilities of success in the two markets are still independent, a hard assumption to make. It would seem reasonable to expect that there exists correlation among the probabilities of success when it is the same firm to contest entry in both markets).[73]

In all these models, tying can have its strategic (exclusionary) effects only to the extent that it really involves a credible commitment, such as for instance bundling directly in the product design or in the way production is carried out. If bundling is obtained through marketing or packaging decisions that can be easily reversed, then the commitment effect is absent (and no strategic effect exists). For instance, these models could not have been invoked in two oft-mentioned US cases: *Times-Picayune Publishing v. US*, and *United Shoe Machinery v. US*. In the first case, a New Orleans publisher that had the only morning newspaper was tying sales of advertising space in that newspaper with advertising in an evening newspaper (where it faced other competitors). In the second case, United Shoe tied repair services with the leasing of its machinery. In both cases, it would be difficult to argue that there was a technological commitment to bundling (see also Whinston, 1990: 839).

In a more recent EC merger decision, *Boeing/Hughes*,[74] the merging entity would have produced two complementary products, geo-stationary satellite operations and services to launch satellites to their orbit. The Commission considered whether the new entity might have had an interest in engaging in exclusionary tying. It concluded that this was unlikely, among other things because a commitment to offer the two services only in a bundle was unlikely: customers seemed to have a strong preference for flexibility in the choice of launchers, and would not have liked incompatibility of their satellites with all launchers but Boeing's.

### 3.2.4 Practice: Assessment of tying practices

As the previous discussion has hinted at, the welfare implications of tie-in sales are far from unambiguous, and to deal with them in practice might be extremely complex. In most cases, tying will have efficiency effects that will benefit consumers; in a few (probably rare) cases, they might have harmful exclusionary effects that have in any case to be balanced with any possible efficiency effects. In some other cases, tie-in sales might be done to price discriminate, and when this is the case the immediate impact on consumer and total surplus is ambigu-

[73] See also Rey, Seabright and Tirole (2001) for specific criticisms to Carlton and Waldman's model.

[74] See NERA Competition Brief 18, July 2001 for a brief analysis of this case.

ous even in the absence of any efficiency effect; therefore, it is even less likely to be detrimental when efficiency considerations are present.

Traditionally, tying has been looked at very suspiciously by antitrust authorities and courts, and for a long time in the US it had a status very close to *per se* prohibition (see chapter 1). This harsh approach is not justified.

To start with, it would make sense to investigate tying practices only when they are carried out by firms endowed with considerable market power. Since it is the exclusionary effect of tying that one should fear the most, firms that do not have a dominant position should be free to use tie-in sales as they like. Accordingly, a safe harbour might be prescribed where firms with market shares of less than, say, 40%, in each product market involved will not be investigated.

This approach might seem generous at first sight, but it is justified by the number of possible efficiency effects that derive from tying: consumers gain in many cases where they do not have to bother assembling products themselves, or look for different suppliers to collect the different components they want, and so on. Tying might therefore allow a non-dominant firm to become more competitive, resulting in a positive welfare effect.

Particularly instructive in this respect is the *Ilford* case, where UK authorities denied Ilford to bundle sales of photographic films with their developments, speeding up its decadence with respect to Kodak. In the mid-60's, the colour film market was dominated by Kodak worldwide. In the UK, Kodak had around 80% of sales, with Ilford holding less than 15% market share. One of the reasons why Ilford found it difficult to catch up with Kodak was due to (indirect) network effects: Ilford used a processing system differing from the dominant Kodak's, and this represented an obstacle of its diffusion with independent processors. Ilford's response to this problem was to sell film with processing included. A customer would buy the film and after taking pictures would send back the exposed film to Ilford, which would process it in its laboratories and then send it back to the customer. Following a complaint by independent processors, the demand for whose services this practice would have reduced, the Monopolies and Mergers Commission found the tying of film and processing to be anti-competitive in 1966. As Sutton (1998, p.126) puts it, "[t]his finding greatly increased Ilford's problems. The independents could not easily process the company's film, and this appears to have been the last straw for Ilford's retail business. [...] Ilford withdrew its brand from the color film market in 1968."

When a firm does not pass the first screening test and it has market shares above that certain threshold, a full investigation should weigh possible anti-competitive effects against possible efficiency reasons behind the practice. Note that theory tells us that the higher the complementarity between the products the less likely tying will be used for exclusionary purposes, so allegations of monopolisation when a firm bundles two fully complementary products should be received with more skepticism. Theory also says that exclusionary effects are more likely when there is a credible commitment to bundling, such as when two previously separate components are combined in a new product design. Therefore, it is less likely to have exclusionary effects when, for instance, two products are sold together but this marketing decision is reversible. However, when such a commitment exists, it is far from automatic that it will have detrimental effects. Furthermore, extreme care should be taken in this case because stopping a tying practice amounts to intervene and modify the product design of a good.

### 3.2.5 Modeling tying, I: Requirements tying as a metering device*

In this section I show that a monopolist of an essential good A has an incentive to tie the use of a complementary good B, whose demand intensity differs across consumers.[75] The welfare consequences of tying will be ambiguous.[76]

A consumer of type $i = l, h$ who buys one unit of product A and $q$ units of product B has the following utility function:

$$U_i = q - \frac{q^2}{2v_i}. \tag{45}$$

Consuming the goods separately gives zero utility, and buying more than one unit of good A does not add to utility. Type-$l$ consumers have lower intensity of demand ($v_l < v_h$) and are a share $\lambda$ of the population (of size 1 for simplicity), $1 - \lambda$ being the share of type-$h$ consumers.

Good A is monopolized by firm 1, whereas several firms having identical technology - including firm 1 - are involved in the production of good B. The cost of producing one unit of the product are respectively $c_A$ and $c_B < 1$. There are no fixed costs.

To look at the effects of (requirements) tying first consider the case where firm 1 sells separately goods A and B. Assume that there is price competition in the B market.

**No tying (if all consumers buy).** Suppose first all consumers buy. Demand of type-$i$ consumers is obtained as $\max_q U_i - p_A - p_B q$. By setting $dU_i/dq = 0$, one has:

$$q_i = v_i(1 - p_B). \tag{46}$$

A type-$i$ consumer will then buy good A if its surplus $CS_i = U_i - p_A - p_B q_i$ is non-negative or, after substitution, if $CS_i = v_i(1 - p_B)^2/2 - p_A \geq 0$.

Price competition on the good B market implies that $p_B = c_B$. Therefore, in the case where firm 1 chooses prices so that all consumers buy, it must be:

$$p_A^{NT} = \frac{v_l(1 - c_B)^2}{2}. \tag{47}$$

[75] Note that complements here are not used in fixed proportions, unlike the case I analyse below in section 3.2.6.

[76] I follow here Tirole (1988: 142-148) quite closely, with a different utility function that gives rise to slightly simpler calculations.

In this case, type-$l$ consumers will have zero surplus, whereas type-$h$ consumers will have a surplus $CS_h^{NT} = (v_h - v_l)(1 - c_B)^2/2$.

Producer surplus equals firm 1's profits from good A: $\pi^{NT} = v_l(1-c_B)^2/2 - c_A$. Welfare will therefore be equal to:

$$W^{NT} = \frac{((1-\lambda)\, v_h + \lambda v_l)(1 - c_B)^2}{2} - c_A. \tag{48}$$

**No tying (only high types buy).** Firm 1 might prefer to serve only high type consumers, though, fixing a price that allows to extract all surplus from them and leaves consumers with lower intensity of demand unserved:

$$p_A^{NTh} = \frac{v_h(1 - c_B)^2}{2}. \tag{49}$$

In this case, both types will have zero surplus: $CS^{NTh} = 0$, and producer surplus is: $\pi^{NTh} = (1 - \lambda)\left[v_h(1 - c_B)^2/2 - c_A\right] = W^{NTh}$.

Selling only to high types is profitable as long as $\pi^{NTh} > \pi^{NT}$, which is the more likely the smaller the proportion of low-type consumers and the higher the difference in demand intensities. Formally, this strategy is profitable if:

$$\lambda < \frac{(v_h - v_l)(1 - c_B)^2}{v_h(1 - c_B)^2 - 2c_A}. \tag{50}$$

**Tying.** Consider now the case where firm 1 requires consumers who want to buy good A also to buy good B from it. Assume also, and it is a strong assumption, that it is endowed with some technology that allows it to monitor consumers' purchases of good B, and to prevent them from addressing competitors to buy good B after having bought one unit of good A with a symbolic quantity of B.

Recalling that demand of product B is given by equation (46), firm 1's profits are:

$$\pi = (p_B - c_B)\left[\lambda v_l(1 - p_B) + (1 - \lambda)\, v_h(1 - p_B)\right] + p_A - c_A. \tag{51}$$

From $d\pi/dp_B = 0$ one obtains:

$$p_B^T = \frac{(1 - \lambda)(v_h - v_l) + c_B\left[\lambda v_l + (1 - \lambda)\, v_h\right]}{2v_h - v_l - 2\lambda(v_h - v_l)}, \tag{52}$$

where it is easy to check that $p_B^T > c_B$. (Therefore, it is crucial that firm 1 is able to prevent consumers from buying good B from competitors.) As for the price of good A, note that profits increase with it, but consumers will buy as long as $CS_i = v_i(1-p_B^T)^2/2 - p_A \geq 0$. After replacement, one obtains the optimal price for good A:

$$p_A^T = \frac{(1-c_B)^2 v_l \left[\lambda v_l + (1-\lambda)\, v_h\right]^2}{2\left[2v_h - v_l - 2\lambda(v_h - v_l)\right]^2}, \tag{53}$$

which can be either bigger or smaller than $c_A$. Note that here tying works in a very similar way as a two-part tariff scheme $T + pq$ that segments consumers according to their intensity of demand.[77] Here, the fixed fee part of the tariff, $T$, corresponds to $p_A^T$, that is the price of one unit of the (essential) good A, whereas the variable part of the tariff corresponds to the price $p_B^T$ of one unit of good B. The lower the intensity of demand of a consumer the lower the number of units of good B he will buy from the monopolist, as $q_i = v_i(1-p_B^T)$, and therefore the lower the total amount paid to it.

Firm 1's profits under tying are:

$$\pi^T = \frac{(1-c_B)^2 \left[\lambda v_l + (1-\lambda)\, v_h\right]^2}{2\left[2v_h - v_l - 2\lambda(v_h - v_l)\right]} - c_A. \tag{54}$$

Type-$l$ consumers have zero surplus, whereas type-$h$ consumer surplus is:

$$CS_h^T = \frac{(1-c_B)^2 (v_h - v_l) \left[\lambda v_l + (1-\lambda)\, v_h\right]^2}{2\left[2v_h - v_l - 2\lambda(v_h - v_l)\right]^2}. \tag{55}$$

Welfare can be computed as:

$$W^T = \frac{(1-c_B)^2 \left[\lambda v_l + (1-\lambda)\, v_h\right]^2 \left[1 + (1-\lambda)\,(v_h - v_l)\right]^2}{2\left[2v_h - v_l - 2\lambda(v_h - v_l)\right]^2}. \tag{56}$$

**Comparisons of equilibria.** (a) Let us first consider the case where both types are served anyhow. One can check that tying is profitable:

$$\pi^T - \pi^{NT} = \frac{(1-c_B)^2 (1-\lambda)^2 (v_h - v_l)^2}{2\left[2v_h - v_l - 2\lambda(v_h - v_l)\right]} > 0. \tag{57}$$

This is not surprising, as it allows the monopolist to impose higher payments from consumers who have a higher intensity of demand, i.e., to price discriminate among the two types of consumers. It is also possible to check that tying is detrimental to welfare, as:

[77] For two-part tariffs as a price discrimination device, see section 4.2.2.

$$W^{NT}-W^{T}=\frac{(1-c_B)^2\,(1-\lambda)\,(v_h-v_l)^2\left[\left(1+\lambda-2\lambda^2\right)v_h+2\lambda^2 v_l\right]}{2\left[2v_h-v_l-2\lambda(v_h-v_l)\right]^2}>0. \tag{58}$$

Even without doing tedious calculations, one can notice that welfare should be lower under tying. Indeed, if there is no tying, consumers buy at marginal cost, and welfare is therefore the highest possible, whereas tying introduces a source of allocative inefficiency as good B is sold above marginal cost. We are therefore in the usual case where a higher price decreases consumer surplus (of high types, since low types have zero surplus in either regime) more than it increases producer surplus.

(b) The above comparisons have been made for the case where both types of consumers buy in the regime where there is no tying. If only high types buy, however, it turns out that tying *increases* welfare. To see that, notice that consumer surplus is positive under tying whereas it is zero when there is no tying and low types do not buy. Therefore, whenever tying is more profitable for firm 1 it will also be welfare improving.

To check that tying might indeed be profitable, and to save on tedious calculations, just consider a simple example where $c_A=c_B=0$, $v_h=2$, and $v_l=1$. For these values, under no tying firm 1 would serve only high types for $\lambda<1/2$. It is straightforward to check that $\pi^T-\pi^{NTh}>0$ for $\lambda>1-\sqrt{3}/3=.42265$: above this threshold, tying is profitable and it is welfare improving.

### 3.2.6 Models of tying, II: Tying, foreclosure, and exclusion in Whinston (1990)*

Consider two markets for *independent products* (see below for the complementary products case), A and B, and two firms, 1 and 2. Firm 1 is a monopolist in market A, where it is not challenged, and produces at constant marginal costs $c_A$. Both firms 1 and 2 are potential entrants in market B. To enter, they have to incur a fixed cost $F_1$ and $F_2$, and they can then operate at constant marginal costs respectively equal to $c_{B1}$ and $c_{B2}$.

The game is composed of three stages. In the first stage, firm 1 decides whether it wants to bundle good A and B1 together, or not.[78] If they are bundled, assume that this decision is irreversible (that is, it has full commitment value). In the second stage, each firm simultaneously decides whether to enter or not market B, and accordingly pays (or not) the fixed cost $F$. In the third stage, active firms simultaneously set prices: firm 1 either sets a single price $\widetilde{p}$ if it has committed to a bundle, or two independent prices $p_A$ and $p_{B1}$;[79] firm 2, if active, sets the price $p_{B2}$.

[78] Assume also that firm 1 cannot use a *requirements contract*, that is it cannot sell good A only under the condition that a consumer will not buy $B2$ (for instance because firm 1 is unable to observe what consumers buy).

[79] I exclude for simplicity the case where firm 1 does mixed bundling, that is it allows consumers to choose between the bundle or separate prices. However, this is never optimal in this model: the only reason to choose a bundle is for its strategic value: either the firm

**A simple example of exclusion with homogenous goods*** Assume first that consumers have mass one and have valuations (that is, a maximum willingness to pay) $v > c_A$ for product A, and $w > c_{B1} > c_{B2}$ (firm 2 is more efficient than firm 1 in market B) for products $B1$ and $B2$ that in this first example are assumed homogenous. Consumers buy one unit of goods A and B as long as prices are lower than their valuations; otherwise, they do not buy the good. Also assume that firm 1 has already sunk its fixed cost in market B (this is therefore a slight variation of the above-described game, since firm 1 is already active in both markets), whereas firm 2 has not, and that $c_{B1} - c_{B2} > F_2$ .

To look for the sub-game perfect Nash equilibrium we move backwards. Two cases should be studied, according to whether in the first stage firm 1 has bundled the goods or not.

*Independent pricing (no tying).*

Since market B products are perfectly homogenous, and firm 2 is more efficient, it will set a price equal to (a shade less than) the marginal cost of firm 1 and get all the market. It will make a profit $c_{B1} - c_{B2}$. Since this is higher than its fixed cost, it will enter the market. Market A is independent, and firm 1 will set $p_A = v$. It will therefore make a total profit $\pi_1 = v - c_A$.

*Tying.*

Suppose now that firm 1 has bundled the two goods A and B1 and sells them at a price $\widetilde{p}$. One can think of this price as $\widetilde{p} = v + \widetilde{p}_{B1}$, where $\widetilde{p}_{B1} = \widetilde{p} - v$ is the *fictitious* price set by firm 1 under bundling (and since it would not make sense to charge consumers in market A less than their valuation for it). Since there is Bertrand competition, consumers will buy the bundle from firm 1 if $\widetilde{p}_{B1}$ is a shade less than the marginal cost of firm 2: $\widetilde{p}_{B1} = \widetilde{p} - v = c_{B2} - \varepsilon$. Therefore, with $\widetilde{p} = c_{B2} + v$, no consumer would buy from firm 2.

Since firm 2 observes that firm 1 has bundled the two products (and since this is irreversible), it knows that if it entered it would not be able to recoup its fixed costs (since it would not sell anything). Hence, it stays out.[80]

Finally, note that under bundling and when firm 2 decides not to enter, at the last stage of the game firm 1 will set the bundle price at $\widetilde{p} = v + w$, therefore extracting all the surplus from the consumers, and making a profit $\widetilde{\pi}_1 = v + w - c_A - c_{B1}$.

*First stage.*

It is now easy to look at the decision between bundling or not at the first stage of the game. Firm 1 will prefer to commit to bundling and tying sales of the two goods if $\widetilde{\pi}_1 > \pi_1$, which is always satisfied since by assumption $w - c_{B1} > 0$.

This shows that tying might allow to exclude entry in a profitable way.[81]

---

commits to technologically bundle the products (in which case they cannot be sold separately any longer), or it does not, in which case selling them together is dominated by selling them separately.

[80] Note that this equilibrium occurs only if the bundle profit under duopoly is positive: $v + c_{B2} - c_A - c_{B1} > 0$, otherwise firm 1 would be better off not selling at all in case firm 2 entered.

[81] This example is not suitable to study welfare effects of tying, since it involves the spe-

Let us now look at a slightly more general case.

**The model with differentiated goods in market B**** Assume consumers are located on the $[0,1]$ line, where they are uniformly distributed with unit density. They can consume at most one unit of good A, for which they have a valuation $v > c_A$, and one unit of good B. The net utility they derive from buying variety $i = 1, 2$ of good B is given by $U_{Bi} = w - t_i \mid x - x_{Bi} \mid - p_{Bi}$, where $w > \max(c_{B1}, c_{B2})$ is the maximum valuation for good B, $t_i$ measures the disutility parameter of buying a variety located in $x_{Bi}$ for a consumer located in $x$.[82] I assume that $x_{B1} = 0$ and $x_{B2} = 1$. This is a simple Hotelling model (see chapter 8) where location should not necessarily be intended in physical terms.[83]

The game is the one described at the beginning of the section, and its solution is found by backward induction.

*Independent pricing (no tying).*

To find the solution of the price game, in the case where firm 2 has entered, one first has to derive the demand functions for goods B1 and B2 (in this case, A is sold independently, so it does not affect the game in market B). A consumer located at $x$ will prefer to buy product B1 if $U_{B1} \geq U_{B2}$, or: $w - t_1 x - p_{B1} \geq w - t_2(1-x) - p_{B2}$. Define as $x_{12}$ the consumer indifferent between buying from B1 or B2, and such that:

$$x_{12}(p_{B1}, p_{B2}) \equiv \frac{t_2 + p_{B2} - p_{B1}}{t_2 + t_1}. \tag{59}$$

All consumers located between 0 and $x_{12}$ will prefer variety B1. Those located between $x_{12}$ and 1 will prefer B2. Therefore, demand functions will be $q_{B1} = x_{12}(p_{B1}, p_{B2})$, and $q_{B2} = 1 - x_{12}(p_{B1}, p_{B2})$. Profit functions are:

$$\pi_{B1} = (p_{B1} - c_{B1}) \frac{t_2 + p_{B2} - p_{B1}}{t_2 + t_1}; \quad \pi_{B2} = (p_{B2} - c_{B2}) \left( \frac{t_1 + p_{B1} - p_{B2}}{t_2 + t_1} \right). \tag{60}$$

Set the first derivatives equal to zero ($d\pi_{Bi}/dp_{Bi} = 0$) and write the reaction functions of the two firms in the plane $(p_{B2}, p_{B1})$:

$$R_{B1} : p_{B1} = \frac{t_2 + c_{B1} + p_{B2}}{2}; \quad R_{B2} : p_{B1} = 2p_{B2} - c_{B2} - t_1. \tag{61}$$

cial case of perfectly inelastic demands. Exclusion just shifts the surplus between firms and between firms and consumers. Further, it has the beneficial effect of saving the fixed cost of entry of firm 2 (goods are perfectly homogenous, so consumers do not value variety here), so its overall impact is positive.

[82] For $t_1 = t_2 = t$ we have the standard Hotelling game.

[83] This model differs from the examples chosen by Whinston in his paper but it allows to reproduce his main results and shares a similarity with his examples.

From the intersection of the two reaction functions we find the equilibrium prices and (after substitution) profits in the no tying price game:

$$p^*_{Bi} = \frac{t_i + 2t_j + c_{Bj} + 2c_{Bi}}{3}; \;\; \pi^*_{Bi} = \frac{(t_i + 2t_j + c_{Bj} + 2c_{Bi})^2}{9\,(t_i + t_j)} \text{ (for } i, j = 1, 2,\, i \neq j). \tag{62}$$

As for market A, it is clear that firm 1 will set its price as to extract all the surplus from consumers in that market: $p_A = v$. The total profits under the independent pricing (no tying) game for firm 1 will then be $\pi^*_1 = (v - c_A) + \pi^*_{Bi}$.

*Tying.*

When firm 1 has irreversibly bundled the two goods A and B1, market A is clearly not independent from B any longer, as the firm chooses a unique price $\widetilde{p}$ for the whole bundle, rather than two separate prices. A consumer $x$ now has the choice between buying either the bundle A/B1, or variety B2 alone. (Note that if a consumer buys variety B2, this implies one lost sale of good A for firm 1.) She will prefer the bundle A/B1 if $\widetilde{U} \geq U_{B2}$, or: $v + w - t_1 x - \widetilde{p} \geq w - t_2(1-x) - p_{B2}$. In order to have both firms selling at a bundling equilibrium assume:

(A1) $0 < v - c_A < t_2 + 2t_1 + c_{B1} - c_{B2}$, and

(A2) $v - c_A > -2t_2 - t_1 + c_{B1} - c_{B2}$.

The consumer indifferent between A/B1 and B2 is:

$$\widetilde{x}_{12}(\widetilde{p}, p_{B2}) \equiv \frac{t_2 + p_{B2} + v - \widetilde{p}}{t_2 + t_1}. \tag{63}$$

Therefore, demand functions will be $\widetilde{q} = \widetilde{x}_{12}(\widetilde{p}, p_{B2})$, and $q_{B2} = 1 - \widetilde{x}_{12}(\widetilde{p}, p_{B2})$. Profit functions are:

$$\widetilde{\pi} = (\widetilde{p} - c_A - c_{B1})\frac{v + t_2 + p_{B2} - \widetilde{p}}{t_2 + t_1}; \;\; \pi_{B2} = (p_{B2} - c_{B2})\left(\frac{v + t_1 + \widetilde{p} - p_{B2}}{t_2 + t_1}\right). \tag{64}$$

From $d\pi_{Bi}/dp_{Bi} = 0$, the reaction functions are:

$$R_1 : \widetilde{p} = \frac{v + c_A + t_2 + c_{B1} + p_{B2}}{2}; \;\; R_2 : \widetilde{p} = 2p_{B2} - c_{B2} + v - t_1. \tag{65}$$

Solving the system we find the equilibrium prices under tying:

$$\widetilde{p}^* = \frac{t_1 + 2t_2 + c_{B2} + 2c_{B1} + v + 2c_A}{3}; \widetilde{p}^*_{B2} = \frac{t_2 + 2t_1 + c_{B1} + 2c_{B2} - v + c_A}{3}, \tag{66}$$

and by replacement the equilibrium profits:

$$\widetilde{\pi}_1^* = \frac{(t_1 + 2t_2 + c_{B2} - c_{B1} + v - c_A)^2}{9(t_1 + t_2)}; \widetilde{\pi}_{B2}^* = \frac{(t_2 + 2t_1 + c_{B1} - c_{B2} - v + c_A)^2}{9(t_1 + t_2)}. \tag{67}$$

*Profit comparisons, and interpretation of the results.*

First of all, it is straightforward to see that bundling by firm 1 hurts rival firm 2: $\pi_{B2}^* > \widetilde{\pi}_{B2}^*$, as $v > c_A$. However, note that bundling also hurts firm 1 if firm 2 enters the market. To see this, first check that:

$$\widetilde{\pi}_1^* < \pi_1^* \text{ iff } v - c_A < 5t_2 + 7t_1 + 2c_{B1} - 2c_{B2}. \tag{68}$$

Then, note that for inequality (68) to be compatible with assumption (A2), it must be $7t_2 + 8t_1 + c_{B1} - c_{B2} > 0$, which is always satisfied by assumption (A1).

To sum up, conditional on firm 2 being active, both firms would be worse off by bundling. Therefore, for bundling to be chosen by firm 1, it must be that it deters entry from firm 2. Before showing the conditions under which this occurs, let us interpret the results obtained: why does bundling depress profits of both competitors?

To see this, it is useful to think of $\widetilde{p}$ as composed of two fictional prices: the price on market A (that can only be equal to $v$, since firm 1 is monopolist on that market) and the price in market B:

$$\widetilde{p} = v + \widetilde{p}_{B1}. \tag{69}$$

By replacing this expression into the reaction functions (65), we can write them in the plane $(\widetilde{p}_{B1}, p_{B2})$, as:

$$\widetilde{R}_1 : \widetilde{p}_{B1} = \frac{t_2 + c_{B1} + p_{B2} - (v - c_A)}{2}; \; R_2 : \widetilde{p}_{B1} = 2p_{B2} - c_{B2} - t_1. \tag{70}$$

INSERT Figure 7.6. Strategic effect of bundling

As Figure 7.6 shows, and is easily checked from comparing expressions (61) and (70), bundling shifts downwards, from $R_{B1}$ to $\widetilde{R}_1$, the reaction function of firm 1 when it competes in market B. In other words, bundling represents a credible commitment for firm 1 to be more aggressive when it competes in that market, because it knows that any lost sale in market B is lost profit $(v - c_A)$ in market A. As a result, equilibrium prices and profits will be lower for both firms under tying.

*Entry decisions.*

Firm 2 will enter market B if and only if its profits offset its fixed costs. It is then straightforward to see that there are parameter values where it would enter if firm 1 did not use tying, but it would not enter if it committed to tying. This occurs if $\pi^*_{B2} \geq F > \widetilde{\pi}^*_{B2}$. This is also the case where firm 1 might find it profitable to bundle, as we show next.

*Bundling decisions.*

At the first stage of the game, firm 1 decides on bundling. The previous comparison between profits shows that if firm 2 is expected to enter, bundling is unprofitable. Therefore, when $F \leq \widetilde{\pi}^*_{B2}$, the equilibrium is such that firm 1 does not bundle, and firm 2 enters.

However, it is not a priori said that firm 1 necessarily wants to bundle when it expects firm 2 not to enter. Bundling is optimal only if the monopoly profit under bundling, $\pi_m$, (remember, the firm commits to bundling, so it cannot reverse the decision when firm 2 decides not to sink its entry costs) is higher than the duopoly profit when there is no bundling, $\pi^*_1$. To find the former profit, note that a consumer located in $x$ will decide to buy the bundle rather than not buying at all, if $U_m = v + w - t_1 x - \widetilde{p}_m \geq 0$. Therefore, the indifferent consumer will be $x_m = (v + w - \widetilde{p}_m)/t_1$. There are two cases according to whether $x_m < 1$ (the market is not covered) or $x_m \geq 1$ (the market is covered: all consumers buy the bundle):

$$q_m = \begin{cases} 1, \text{ if } \widetilde{p}_m \leq v + w - t_1 \\ \frac{v+w-\widetilde{p}_m}{t_1}, \text{ if } \widetilde{p}_m > v + w - t_1 \end{cases} \tag{71}$$

$$\pi_m = \begin{cases} \widetilde{p}_m - c_A - c_{B1}, \text{ if } \widetilde{p}_m \leq v + w - t_1 \\ (\widetilde{p}_m - c_A - c_{B1})\frac{v+w-\widetilde{p}_m}{t_1}, \text{ if } \widetilde{p}_m > v + w - t_1 \end{cases}. \tag{72}$$

One can then find the optimal price at the internal solution as $\widetilde{p}_m = (v + w + c_A + c_{B1})/2$, and check that it can apply only if $v + w < c_A + c_{B1} + 2t_1$ (else, $\widetilde{p}_m \leq v + w - t_1$ and the corner solution holds). Therefore, the equilibrium profits will be:

$$\pi^*_m = \begin{cases} v + w - t_1 - c_A - c_{B1}, \text{ if } v + w \geq c_A + c_{B1} + 2t_1 \\ \frac{(v+w-c_A-c_{B1})^2}{4t_1}, \text{ if } v + w < c_A + c_{B1} + 2t_1 \end{cases}. \tag{73}$$

The conditions obtained make sense: the higher the consumers' willingness to pay for the goods the more likely they will all end up buying. The higher the disutility from purchasing a variety B1 distant from the most preferred one (that is, from the consumer's location), the less likely they will all buy.

We can now proceed to compare monopoly profits under the bundling strategy with duopoly profits when products are sold separately. Rather than carrying out tedious calculations, let me focus on two very special cases, just to show that different outcomes can arise.

Suppose first that $c_A = c_{B1} = c_{B2} = t_2 = 0$, and that $v + w < 2t_1$: the market is not covered under monopoly. Then:

$$\pi^*_m - \pi^*_1 = \frac{(v+w)^2}{4t_1} - \frac{t_1}{9} - v. \tag{74}$$

Clearly, this expression decreases with $t_1$, which means that there exist parameter values such that the above expression is negative, that is, bundling would not be chosen even if it leads to the exit of firm 2.[84]

Suppose now that $c_A = c_{B1} = c_{B2} = t_2 = 0$, but that $v + w \geq 2t_1$: the market is covered under monopoly. Then:

$$\pi_m^* - \pi_1^* = -t_1 - \frac{t_1}{9} + w. \tag{75}$$

Here, it is easy to see that it would be enough to choose a high enough $w$ or a low enough $t_1$ for the monopoly with exclusion to be profitable.

To conclude, bundling in this model might lead to exclusion. However, this does not necessarily mean that it will be profitable for the incumbent to choose this option, as obliging consumers to buy the bundle or abstain may imply fewer sales on market A, and decrease the profitability of the monopoly solution.

*Welfare analysis*

There would remain one last item to check, and this is the effect of exclusionary bundling upon welfare. To keep things short, let me skip derivations and just recall Whinston's conclusions. He shows that the effects of bundling, even when it profitably excludes an entrant, are ambiguous. Under monopoly, consumers tend to suffer from lower variety (those located to the right of the interval, for instance, have to content themselves with a more distant specification than their ideal one, or give up buying the bundle altogether) and prices tend to increase; but a duplication of fixed costs can be avoided when firm 2 stays out. Overall, however, it seems sensible to expect that consumer welfare will decrease from exclusionary bundling (when it is profitable), and if one disregards the argument that there might be excess of variety under free entry, total welfare should decrease too.

**When goods are complementary*** I have so far looked at the case where products A and B are independent. Suppose now that they are complementary. More particularly, assume a one-to-one relationship between them, so good A is essential. Therefore, consumers derive zero utility from buying B alone. We shall see that bundling is not a profitable strategy for firm 1.

Assume that, like above, consumers are distributed uniformly on $[0, 1]$, and that their utility is given by $U_{A/Bi} = \theta - t_i \mid x - x_{Bi} \mid - p_{Bi} - p_A$, and keep the same assumptions as before.[85]

*Tying (and exclusion).*

If firm 1 commits to bundling, the very fact that A can only be sold in a bundle with B1, automatically implies that firm 2 is excluded from the market. Note first that we have already seen the case where firm 1 is a monopolist selling

[84] The most restrictive among the assumptions we have made above is (A1), which becomes in this case $v < 2t_1$. Therefore, $t_1$ can be made large at will.

[85] One can think of $\theta$ as $v + w$. Note that it does not make sense to give separate valuations to good A and B. Assume also for simplicity (but the results would not change otherwise) that $\theta$ is high enough for all consumers to buy when both firms are active.

a bundle. The market is covered ($q_m = 1$) if $\widetilde{p}_m \leq \theta - t_1$, and is not otherwise ($q_m = (\theta - \widetilde{p}_m)/t_1$ for $\widetilde{p}_m > \theta - t_1$). From the analysis above it follows that equilibrium prices and profits will be:

$$\widetilde{p}_m^* = \begin{cases} \theta - t_1, & \text{if } \theta \geq c_A + c_{B1} + 2t_1 \\ \frac{(\theta - c_A - c_{B1})^2}{4t_1}, & \text{if } \theta < c_A + c_{B1} + 2t_1 \end{cases} \quad (76)$$

$$\widetilde{\pi}_m^* = \begin{cases} \theta - t_1 - c_A - c_{B1}, & \text{if } \theta \geq c_A + c_{B1} + 2t_1 \\ \frac{(\theta - c_A - c_{B1})^2}{4t_1}, & \text{if } \theta < c_A + c_{B1} + 2t_1 \end{cases}. \quad (77)$$

*No tying.*

Suppose now that firm 1 decides instead to sell the goods separately. Regardless of whether firm 2 is active or not, suppose it sells at prices $\widehat{p}_{B1} = c_{B1} - \varepsilon$, and $\widehat{p}_A = \widetilde{p}_m^* - \widehat{p}_{B1}$. There are two possible cases.

(a) If firm 2 is not active, then this pricing policy will give exactly the same profits as bundling. Indeed, consumers will buy the system A/B1 if $U_{A/Bi} = \theta - t_1 x - \widehat{p}_{B1} - \widehat{p}_A \geq 0$. But then demand and profits will just depend on the sum of the prices, $\widehat{p}_A + \widehat{p}_{B1} = \widetilde{p}_m^*$, and therefore the total profits will be the same as under bundling.

(b) If firm 2 is active and sells at a price $p_{B2}$, consumers will choose B1 if $U_{A/B1} > U_{A/B2}$, or $\theta - t_1 x - \widehat{p}_{B1} - \widehat{p}_A \geq \theta - t_2(1-x) - p_{B2} - \widehat{p}_A$. The indifferent consumer is $x_{12} = (t_2 + p_{B2} - \widehat{p}_{B1})/(t_2 + t_1)$. The demand for B1 is given by $q_{B1} = x_{12}$, whereas demand for good A is given by all consumers. Firm 1's profits are then:

$$\pi_1 = (\widehat{p}_A - c_A + \widehat{p}_{B1} - c_{B1})x_{12} + (\widehat{p}_A - c_A)(1 - x_{12}) = \quad (78)$$

$$= (\widetilde{p}_m^* - c_A - c_{B1}), \quad (79)$$

which cannot be lower than under the monopoly with bundling: in both cases, the firm has the same unit profit ($\widetilde{p}_m^* - c_A - c_{B1}$), but under independent pricing total demand cannot be higher, since everybody buys.

In words, what happens here is as follows. If under monopoly with bundling all consumers were buying, then firm 1's profits cannot decrease when there is no bundling: some consumers might replace B1 with B2, but since under the chosen pricing scheme B1 is sold at (slightly below) marginal costs $c_{B1}$, and everybody continues to buy A, profits are not lower (they increase by $\varepsilon$).

If the market was not covered under monopoly, then the presence of firm 2 would allow to increase sales of A. Some consumers might switch from B1 to B2, but we have seen that this does not harm firm 1's profits, but some others will buy the system A/B2, thus increasing sales of A, and overall profits.

### 3.2.7 Models of tying, III: Tying to deter entry in complementary markets*

This subsection provides a variant of Choi and Stefanadis (2001). Consider two complementary products, A and B, that are combined in fixed proportions on a one-to-one basis and have value only if consumed together. Firm 1 is an incumbent in both products. It produces them (call them A1 and B1) at unit cost $c_h$ each. In each of the two markets there is a potential entrant, that can sell products which are perfect substitutes of A1 and B1: call them A2 and B2 respectively. By making an investment in R&D, $I_{i2}$, which costs $C(I_{i2}) = \gamma(I_{i2})^2/2$, with $\gamma > (c_h - c_l)$,[86] each potential entrant affects the probability $p(I_{i2}) = \varepsilon + I_{i2}$ (with $i = A, B$) that it will obtain a successful innovation, defined as an innovation that gives it a unit cost $c_l < c_h$. With probability $1 - p(I_{i2})$, the entrant's unit cost will be prohibitively high.

Consumers' utility is given by $U_{Aj/Bj} = \theta - p_{Bj} - p_{Aj}$, with $j = 1, 2$, and I normalise consumer size to one, without loss of generality.

Consider the following game. In the first period, firm 1 decides whether to commit to sell A1 and B1 as a bundle, or not. In the second period, firms A2 and B2 simultaneously take investment decisions. In the third period, active firms name prices (Bertrand competition). Let us solve the game backwards.

**Price sub-game** Consider the case of *no tying* first. If the incumbent only is active, it will extract all the surplus from the consumers by setting prices for its components such that their sum equals $\theta$, and earns $\theta - 2c_h$. If both entrants are active (i.e., their innovations have been successful), each will charge a price that equals $c_h$, and get the whole market for its product, making gross profits $c_h - c_l$. Less straightforward the case where only one entrant, say A2, is active, as it gives rise to a continuum of equilibria. The two extreme ones are as follows: (a) both the entrant and the incumbent set price $c_h$ in product A, with the entrant getting all demand and extracting the rent from the innovation, $c_h - c_l$,[87] and the incumbent sets price $\theta - c_h$ on product B. (b) both the entrant and the incumbent set price $c_l$ in market A, with the entrant still getting all demand but zero profits, and the incumbent setting $\theta - c_l$ in market B, thereby extracting all the rents from the innovation itself, through a price squeeze. All intermediate cases are also equilibria of the price game.

Following Choi and Stefanadis, assume that when only one entrant enters, the incumbent obtains a share $\lambda$ of the innovation rent, $c_h - c_l$, with the remaining part $1 - \lambda$ obtained by the entrant, with $\lambda \in [0, 1]$ being the measure of the price squeeze that the incumbent can exercise due to its monopoly position on market for the complementary product.

Next, consider the case of *tying*. If only the incumbent is active, it will extract all the consumer surplus, and earn $\theta - 2c_h$. If both entrants are active, at the symmetric equilibrium each entrant sets a price equal to $c_h$, and gets the whole market for its product, making gross profits $c_h - c_l$. If one entrant only

[86] One can check that this ensures at the same time that the equilibrium probability is lower than 1, and that the stability conditions are met.

[87] As usual in all Bertrand games with cost asymmetries, there are two ways to present equilibrium outcomes. One is to say that both firms set the price that equals the highest marginal cost, and consumers are assumed to choose the low cost firm. The other is to say that the low cost firm sets a price that is a shade (that is, an $\varepsilon$, with $\varepsilon$ arbitrarily small) lower than the highest cost.

has been successful, it will not be able to market its product, since the other complementary product is sold by the incumbent as a bundle (tying trivially excludes a rival active in one market only when two products must be combined in fixed proportions).

**Investment sub-game** Under *no tying*, the profits obtained by an entrant are:

$$\pi_{i2} = p(I_{i2})[1 - p(I_{k2})](1-\lambda)(c_h - c_l) + p(I_{i2})p(I_{k2})(c_h - c_l) - C(I_{i2}), \text{ with } i,k = A,B,\ i \neq k \tag{80}$$

where the first term indicates firm $i2$'s profits when it innovates whereas the other entrant does not, and the second term profits when both entrants innovate. By substituting the specific functions chosen for $p(I_{i2})$ and $C(I_{i2})$, one obtains FOCs as:

$$\frac{d\pi_{i2}}{dI_{i2}} = [1 - (\varepsilon + I_{k2})](1-\lambda)(c_h - c_l) + (\varepsilon + I_{k2})(c_h - c_l) - \gamma I_{i2} = 0, \text{ with } i,k = A,B,\ i \neq k. \tag{81}$$

At the symmetric equilibrium $I_{A2}^* = I_{B2}^* = I_2^*$ the optimal investment is therefore given by:

$$I_2^*(\lambda) = \frac{(1 - \lambda(1-\varepsilon))(c_h - c_l))}{\gamma - \lambda(c_h - c_l)}. \tag{82}$$

Note that, not surprisingly, equilibrium investments fall with the degree of price squeeze, (if the incumbent appropriates most of the surplus created by the innovation, the returns from innovating decrease): $dI_2^*/d\lambda < 0$.

Under *tying*, entrant $i2$'s profits are:

$$\widetilde{\pi}_{i2} = p(I_{i2})p(I_{k2})(c_h - c_l) - C(I_{i2}), \text{ with } i,k = A,B,\ i \neq k, \tag{83}$$

since only when both entrants innovate will they be able to sell their product. FOCs are:

$$\frac{d\widetilde{\pi}_{i2}}{dI_{i2}} = (\varepsilon + I_{k2})(c_h - c_l) - \gamma I_{i2} = 0, \text{ with } i,k = A,B,\ i \neq k. \tag{84}$$

At the symmetric equilibrium the optimal investment is:

$$\widetilde{I}_2^* = \frac{\varepsilon(c_h - c_l)}{\gamma - (c_h - c_l)}. \tag{85}$$

A simple inspection of (82) and (85) reveals that tying lowers the investments made by the potential entrants, and thus reduce the probability that there will be entry at equilibrium. (Only if $\lambda = 1$, the two investment levels coincide: $\widetilde{I}_2^* = I_2^*(1)$: when entrants anticipate a perfect price squeeze, the returns from being the only innovator are nil, like in the case of tying.) In this sense, tying has exclusionary effects. However, we still have to check if this practice is profitable. For this, consider the first stage of the game.

**Tying decisions** If there is *no tying*, firm 1's expected profits are:

$$\pi_1^*(\lambda) = [1 - (\varepsilon + I_2^*(\lambda))^2](\theta - 2c_h) + 2\,(\varepsilon + I_2^*(\lambda))\,[1 - (\varepsilon + I_2^*(\lambda))]\lambda(c_h - c_l), \tag{86}$$

Note that for $\lambda = 0$, the second term is zero, as the incumbent does not extract any rent from the innovation.

If there is *tying*, firm 1's expected profits are:

$$\widetilde{\pi}_1^*(\lambda) = [1 - \left(\varepsilon + \widetilde{I}_2^*\right)^2](\theta - 2c_h), \tag{87}$$

since when only one entrant is successful, there will be no entry, and the incumbent cannot extract any rent from the innovation.

It can be showed that there exists a value $\widetilde{\lambda} \in (0,1)$ such that $\widetilde{\pi}_1^*(\lambda) \geq \pi_1^*(\lambda)$ for $\lambda \leq \widetilde{\lambda}$. Rather than doing tedious calculations to find the precise expression for $\widetilde{\lambda}$, note that there is a trade-off for the incumbent in tying the goods. On the one hand, by tying it decreases the risk of entry, which increases its profits (exclusion effect); on the other hand, tying decreases the profit that the incumbent makes when only one entrant makes it (price squeeze effect). But the latter effect on profits is absent when $\lambda = 0$, since the incumbent is not able to extract profits (hence, tying is more profitable in this case), whereas it is very strong when $\lambda = 1$, as the incumbent appropriates all the surplus created by the innovation.

Indeed, when $\lambda = 0$, bundling is preferred as:

$$\pi_1^*(\lambda) = [1 - (\varepsilon + I_2^*(0))^2](\theta - 2c_h) < \widetilde{\pi}_1^*(0) = [1 - \left(\varepsilon + \widetilde{I}_2^*\right)^2](\theta - 2c_h), \tag{88}$$

which always holds since $I_2^*(0) > \widetilde{I}_2^*$.

When $\lambda = 1$, bundling is unprofitable, since $I_2^*(1) = \widetilde{I}_2^*$, which implies

$$\begin{aligned} \pi_1^*(1) &= [1 - \left(\varepsilon + \widetilde{I}_2^*\right)^2](\theta - 2c_h) + 2\left(\varepsilon + \widetilde{I}_2^*\right)[1 - \left(\varepsilon + \widetilde{I}_2^*\right)]\lambda(c_h - c_l) > \\ \widetilde{\pi}_1^*(1) &= [1 - \left(\varepsilon + \widetilde{I}_2^*\right)^2](\theta - 2c_h). \end{aligned} \tag{89}$$

To sum up, tying can indeed lead to exclusion, but it might still be more profitable for the incumbent not to resort to such strategy.

## 3.3 Incompatibility, and other strategic behaviour in network industries

This section first deals with *compatibility* (or *inter-operability*) issues when an incumbent sells two complementary products and faces competition in one of them. Then with compatibility issues when it sells a product that is characterised by network effects and faces a rival that offers a substitutable product (i.e., a competing network, if the products are not compatible). Finally, it makes some remarks on strategic behaviour - other than incompatibility choices - that could be used by incumbents in network industries.

**Complementary products** Suppose that an incumbent monopolist sells both a product A and a complementary product B, the latter sold also by competing firms, to final consumers. By denying compatibility between A and competing versions of B, the incumbent could leverage its monopoly position into market B, in very much the same way as we have seen in tying models (see section 3.2):[88] to tie the sales of A and the own version of B amounts to make rivals' B products incompatible with A. However, we have seen when discussing tying that A's producer would generally have little interest in excluding rivals from the complementary product market. Therefore, despite the easy way available to foreclose rivals, it is far from obvious a priori that a monopolist will want to use incompatibility as a way to leverage power into another market, although in some particular circumstances exclusion might indeed be profitable,[89] leaving us with no clear policy towards compatibility.

The same sort of arguments also applies to the case where A is not sold directly to consumers, but is instead just used as an input in the production of product B. We know, from the discussion of vertical mergers (chapter 6.4), that it is possible but not very likely that the upstream monopolist will want to foreclose rival versions of the final product B.

**Competing networks** The issue of whether competition policy should promote (or impose) compatibility is particularly crucial in network industries,[90] where entry by a new firm is made very difficult when it has no access to the customer base of an incumbent network (note that here I refer to competing versions of substitute networks, think for instance of two cellular phone networks). Indeed, in network markets, a firm endowed with a large installed base often has no incentive to offer interoperability to a smaller rival. This topic is analysed in technical section 3.3.1, which shows that granting compatibility (or interoperability, or connectivity) to a smaller network is optimal for a large

[88] A difference between incompatibility and tying decisions is that the former is more likely to be built in product design and is therefore unlikely to have the commitment problems.

[89] Again, this conclusion comes from a straightforward application of the results of the literature on tying. See the discussions of Whinston (1990), as well as the short descriptions of the models of Choi and Stefanadis (2001) and Carlton and Waldmann (2000) in section 3.2.

[90] See also the discussions in chapter 2 (on the main features of network effects) and in chapter 4 (on co-operative standard setting, a very close issue to the one touched upon here).

firm only if it expects that access to two fully compatible networks will exhibit so strong network externalities that it will attract a large number of new consumers. The large firm then prefers to share a larger market with the small rival over dominating a smaller market.

It would be very tempting to argue that in a network industry dominated by an incumbent one should force compatibility to allow for otherwise very difficult entry. However, this ex-post intervention would not take into account what has happened in the industry beforehand. Very often, when products are incompatible, network industries are characterised by a very intense period of early competition until one firm establishes itself as the market leader, and strong market power is the reward for a tough battle between competing networks (a process often described as "competition *in* the market being replaced by competition *for* the market"). If this is the case, forcing compatibility onto the incumbent would imply depriving it of the returns it expected and that motivated the initial strong competition.[91] This would also send the wrong signals to firms in other industries, leading them to revise their expectations of profits if they are successful in a network war, and therefore reducing their incentives to compete.

Nevertheless, there might exist situations where a more interventionist public policy in this sphere might make some sense. Consider for instance an industry where the incumbent derives its strong customer base from a legal monopoly (think of the national telecommunications operators in pre-deregulation Europe): in such a case, obliging the incumbent to open up its network to rivals looks like an appealing policy.[92]

In general, one is left with the impression that network markets under incompatibility are prone to problems, especially because the role of entry in moderating the market power of the incumbent is strongly reduced, but it is hard to come up with solid and clear policy implications that have general validity.[93]

[91] Another way to put the same concept is that the apparently high price set by the incumbent are the other side of the coin of the low prices set by the rivals at the early periods of the market. Concluding that the industry is not competitive just looking at the ex-post situation overlooks what has happened beforehand.

[92] Further, Farrell and Katz (1998: 649) find that in some cases incumbent networks enjoy a monopoly for reasons that little have to do with R&D or investment strategies, and an exceptional relaxation of intellectual property rights might be justified. Think for instance of number portability. An incumbent telephone operator might argue that the phone number it has assigned to a customer is protected by copyright laws. However, it would be difficult to argue that this is an innovation which deserves protection, and allowing the customer to keep its number if it moves to a new provider would strongly increase competition.

[93] Under network effects, policy assessments become more complex because a number of externalities come into play. For instance, persistence of a monopolist might even have some positive effects in that it allows network effects to be larger and avoids consumers being *stranded* when a new incompatible product becomes the new standard. Fudenberg and Tirole (2000) analyse an overlapping generation model where an incumbent engages in limit-pricing to increase its customer base and deter entry in a network industry. But the welfare effects of entry-deterrence are ambiguous, due to the presence of stranded users and other externalities that might lead to excess entry.

**Product pre-announcements in network industries** The importance of consumers' expectations in network markets (prophecies tend to be self-fulfilling: if consumers expect an entrant not to win much custom, this prediction will turn out to be correct, and the entrant will fail even if it has a superior product) opens the way for further manipulation by the incumbent. *Product pre-announcement*, for instance, is a strategy whereby the incumbent declares it will release a new version of its product soon, so as to possibly persuade consumers to wait rather than buying the currently superior product made by a rival company that enjoys a smaller network base.[94] How to deal with such a strategy is not straightforward. Probably, the only feasible way is to judge it anti-competitive only to the extent that such announcements are not truthful and are made in bad faith.

### 3.3.1 Interoperability choices in asymmetric networks*

This section, which is based on Crémer, Rey and Tirole (2000), analyses the different incentives of providing inter-operability of two firms that have asymmetric networks.[95]

There exists a market for a network product and two firms. Firm 1 is the incumbent, and has already an installed base of $\beta_1$ consumers, and firm 2 is a new firm, with an installed base of $\beta_2 = 0$ consumers. There is now a set of new consumers who are not attached to either network yet, and who are considering joining a network.

Consumers have the following net benefit from network product $i$:

$$S_i = T + s_i - p_i, \tag{90}$$

where $T$ is the intrinsic value of the network, with $T \in [0,1]$, $p_i$ is network $i$'s price, and $s_i$ represents the network externality, given by:

$$s_i = v\left[\beta_i + q_i + \theta\left(\beta_j + q_j\right)\right], \tag{91}$$

where $q_i$ and $q_j$ represent the number of new consumers buying respectively from firm $i$ and $j$, $v < 1/2$ is a parameter (common to all consumers) that indicates the importance of the network externalities,[96] and $\theta \in [0,1]$ is a parameter that indicates the quality of the inter-operability between the two networks: if $\theta = 0$, there is no compatibility between the networks, whereas if $\theta = 1$, they are perfectly compatible. (Intermediate cases of imperfect interoperability can describe cases where a consumer who has joined a network might use the other network, but in an imperfect way, for instance because there is a lower

[94] See Dranove and Gandal (2000) and the discussion in chapter 2.

[95] Crémer et al. (2000) is based itself on Katz and Shapiro (1985). See also Malueg and Schwartz (2001) for an extension and a discussion of Crémer et al. (2000).

[96] I show below that $v < 1/2$ guarantees stability of the interior equilibrium of the Cournot game. See chapter 8 for an explanation of the stability concept.

performance, or because it takes more time to get the same service, or because some services are unavailable.)

If each firm is to attract some of the new consumers, it must be that the net benefit is the same: $S_1 = S_2$, which van be re-written as:

$$p_1 - s_1 = p_2 - s_2 = \widehat{p}. \tag{92}$$

The new consumer who is indifferent between joining either network or not buying the network product at all is the one such that $S_i = T + s_i - p_i = T - \widehat{p} = 0$. Therefore, all consumers with $T \in [\widehat{p}, 1]$ will be either product, whereas those with $T \in [0, \widehat{p})$ will not be in the market. It must then be:

$$q_1 + q_2 = 1 - \widehat{p}. \tag{93}$$

From expression (92) it follows that $p_i = \widehat{p} + s_i$, that after using expression (93) becomes $p_i = 1 - q_i - q_j + s_i$, and finally by (91), for $i, j = 1, 2$, $i \neq j$, one can write firm $i$'s demand function as:

$$p_i = 1 + v(\beta_i + \theta\beta_j) - (1 - v)q_i - (1 - v\theta)q_j. \tag{94}$$

**Competition in the product market** Given the inter-operability parameter $\theta$, each firm chooses output so as to maximise its profits $\pi_i = (p_i(q_i, q_j)) - c)q_i$. It turns out that there exist two types of equilibrium in this game. The first is an interior solution, the second a corner solution.

To find the *interior solution*, compute $d\pi_i/dq_i = 0$ and obtain the best-reply functions in the plane $(q_2, q_1)$ as follows:[97]

$$R_1 : q_1 = \frac{1 - c + v\beta_1 - (1 - v\theta)q_2}{2(1 - v)}; \; R_2 : q_1 = \frac{1 - c + v\theta\beta_1 - 2(1 - v)q_2}{1 - v\theta}. \tag{95}$$

The intersection of the best reply functions gives the interior equilibrium of the game:[98]

$$q_i^* = \frac{1}{2}\left(\frac{2(1 - c) + v(1 + \theta)\left(\beta_i + \beta_j\right)}{2(1 - v) + (1 - v\theta)} + \frac{(1 - \theta)v\left(\beta_i - \beta_j\right)}{2(1 - v) - (1 - v\theta)}\right). \tag{96}$$

Note that, to be precise, in this game we are using a concept that extends the usual concept of Nash equilibrium in quantities, since we have to consider

[97] Stability requires $R_2$ to be steeper than $R_1$, that is: $2(1-v)/(1-v\theta) > (1-v\theta)/(2(1-v))$, or equivalently $v < 1/(2-\theta)$. Assuming that $v < 1/2$ is therefore sufficient to guarantee stability for all values of $\theta \in [0, 1]$.

[98] For the model to hold, the market must be uncovered, i.e., some consumers should not buy. This requires $q_1^* + q_2^* < 1$, which amounts to $v < (1 + 2c)/[2 + \theta + \beta_1(1 + \theta)]$.

consumers' expectations. Katz and Shapiro (1985) call this concept "Fulfilled Expectations Cournot Equilibrium", and it is an equilibrium where not only the firms' output decisions form a Nash equilibrium, but also consumers' expectations are fulfilled: they take their purchase decisions expecting the sizes of the networks to be $(q_1^*, q_2^*)$ and such expectations are fulfilled.

Note also that

$$q_1^* - q_2^* = \frac{(1-\theta)v\beta_1}{2(1-v)-(1-v\theta)} > 0, \tag{97}$$

which implies that more consumers will join the incumbent's network than the rival network's, except for the case $\theta = 1$ (perfect interoperability), where the networks are perceived identical by consumers.

Let us now look for the *corner solutions*, or "tipping equilibria", as Malueg and Schwartz (2001) call them (because the market "tips" in favour of one or the other firm).

We have seen in chapter 2 that models with network externalities can be characterised by multiple equilibria, caused by the fact that each consumer's choice depends on all other consumer's choices. Here, expectations may support tipping equilibria where only one firm gets new consumers.

**Tipping to the firm with the large installed base** Check first that there exists an equilibrium where all consumers expect that no consumer will patronise firm 2, that is, expect $q_2 = 0$. Under these expectations, firm 1 will behave as a monopolist, and maximise $\pi_1^m = (1 + v(\beta_1 + \theta\beta_2) - (1-v)q_1 - c)\, q_1$. From $d\pi_1^m/dq_1 = 0$ one obtains the monopoly output:

$$q_1^m = \frac{1-c+v\beta_1}{2(1-v)}. \tag{98}$$

For $(q_1^m, 0)$ to be an equilibrium, it must be that firm 2 has no incentive to deviate. This will be the case if, given the quantity $q_1^m$ produced by firm 1, firm 2 would make losses if it sold a positive quantity. Or, equivalently, if given the output sold by firm 1 it would not be able to impose a price above cost even when producing an arbitrarily small output: $p_2\,(q_1^m, 0) \leq c$. By recalling the inverse demand function (94), this condition becomes:

$$1 + v\theta\beta_1 - (1-v)\frac{1-c+v\beta_1}{2(1-v)} - c \leq 0. \tag{99}$$

Note that the lower $\theta$ the more likely this condition will be satisfied. For the case where the networks are fully incompatible ($\theta = 0$), tipping to firm 1 will occur if:

$$v \geq \frac{1-c}{2(1-c)+\beta_1}, \tag{100}$$

and this condition is compatible with $v < 1/2$.

**Tipping to the entrant** Let us now check if there exists an equilibrium where all consumers expect that $q_1 = 0$. Under these expectations, firm 2 will behave as a monopolist, and maximise $\pi_2^m = (1 + v\theta\beta_1 - (1-v)q_2 - c)\, q_2$. From $d\pi_1^m/dq_1 = 0$ one obtains the monopoly output:

$$q_2^m = \frac{1 - c + v\theta\beta_1}{2(1-v)}. \tag{101}$$

For $(0, q_2^m)$ to be an equilibrium, firm 2 must have no incentive to deviate. This will be the case if $p_1(0, q_2^m) \leq c$. By recalling the inverse demand function (94), this condition becomes:

$$1 + v\beta_1 - (1 - v\theta)\frac{1 - c + v\theta\beta_1}{2(1-v)} - c \leq 0. \tag{102}$$

The lower $\theta$ the more likely this condition will be satisfied. For $\theta = 0$, tipping to firm 2 would occur if:

$$c \geq 1 + \frac{\beta_1 v^2}{1+v}, \tag{103}$$

but this condition never holds, as it must be $c < 1$ in order for $q_2^m > 0$. Tipping towards the incumbent might occur, but tipping towards the entrant in this example does not.[99]

**The choice of interoperability** So far we have regarded the parameter $\theta$ as exogenous. However, it likely is a strategic variable of the firms, that can decide the degree of interoperability they want among networks. Sometimes, to increase interoperability might be costly, but assume for simplicity that is not. Assume also that $\theta = \min(\theta_1^*, \theta_2^*)$, where $\theta_i^*$ is firm $i$'s optimal degree of interoperability.

We want to study the firms' preferences for interoperability.

To start with, note that we have to separate the analysis according to the type of solutions arising in the Cournot game. For tipping equilibria, the incumbent's preference for a low interoperability was already seen above: if $\theta = 0$, we have seen that the condition for a tipping equilibrium to firm 1 is maximal, whereas teh market cannot tip to firm 2.

For interior solutions, the results are less straightforward. Firstly, note that $\pi_i^* = (1-v)(q_i^*)^2$. This means that the higher the output the higher the profits of the firms. Therefore, firm $i$'s desired degree of interoperability is the one that maximises output $q_i^*$.

Crémer et al. (2000) show that the new firm would always choose the maximum degree of interoperability, whereas the incumbent's preferred choice is

[99] Malueg and Schwartz (2001) show that, within the same model but with more than two firms, tipping away from the incumbent might occur.

either $\theta = 0$ or $\theta = 1$, the latter when the installed base is small relative to the new consumers. To gain some insight while keeping to a simple example, consider the case where $c = 0$ (this excludes tipping equilibria, but it does not matter as I consider interior solutions here) and suppose that firms can only choose between $\theta = 0$ and $\theta = 1$ (given Crémer et al.'s result, this is without loss of generality).

Firm 1 will prefer full interoperability if:

$$q_1^*(\theta = 1) - q_1^*(\theta = 0) = \frac{v\left(1 - 2v - \beta_1\left(3 - 4v + 2v^2\right)\right)}{3(1 - v)(3 - 8v + 4v^2)} > 0, \tag{104}$$

which is true for $\beta_1 < (1 - 2v) / \left(3 - 4v + 2v^2\right) \equiv \overline{\beta}_1$. Hence, if the installed base is small enough relative to the new consumers, the incumbent will want to guarantee full interoperability. If the installed base is large enough, the incumbent will prefer incompatible networks. (Note that $\overline{\beta}_1$ decreases with $v$, so the more important the network externalities the more likely that firm 1 prefers low interoperability.)

Firm 2 always prefers full interoperability because:

$$q_2^*(\theta = 1) - q_2^*(\theta = 0) = \frac{v\left(1 - 2v + \beta_1\left(6 - 11v + 4v^2\right)\right)}{3(1 - v)(3 - 2v)(1 - 2v)} > 0. \tag{105}$$

To sum up, this model, however simple, shows that in network markets an incumbent (more generally, a firm with a large installed base) might have an incentive to degrade the degree of interoperability (or compatibility, or connectivity) with new entrants (more generally, firms with a smaller customer base). However, this is not always the case: the incumbent might actually gain from full interoperability. This is because full interoperability eliminates the incumbent's competitive advantage due to its larger customer base, but it increases the demand of new consumers in the market.[100] If the installed base is small relative to the new demand, the market expansion effect dominates: the incumbent prefers to share equally a bigger cake than to get a larger slice of a small cake.

### 3.4 Refusal to supply and exclusive contracts (reminder)

Some anti-competitive practices have already been analysed elsewhere in the book. Refusal to supply a key input, resulting in foreclosure of rivals, has been analysed in chapter 2 with reference to the *essential facilities* doctrine. I have argued there that obliging a firm to give access of a key asset to a rival might have the effect of discourage investments. Accordingly, such policy should be used only in very specific circumstances (see also chapter 6, where some situations

[100] New demand is given by $q_1^* + q_2^* = [2(1 - c) + v(1 + \theta)\beta_1] / [2(1 - v) + (1 - v\theta]$, which increases with the degree of interoperability $\theta$.

where a firm has an incentive to foreclose, resulting in lower welfare, have also been identified).

Chapter 6 has also showed that exclusive contracts might have exclusionary effects, but that these should be balanced against possible efficiency reasons before concluding that they are anti-competitive.

## 3.5 Raising rivals' costs

Krattenmaker and Salop (1986) claim that among the monopolisation tools available to firms there are also so-called *raising rivals' costs* practices.[101] These are all sort of practices that aim at increasing the costs of one or more rivals, thus leaving room for the firm that engages in these practices to increase prices without losing market share. These practices would be particularly appealing for a firm that has anti-competitive aims because they do not require it to run losses in the short-run, as in predatory pricing. If the impact on rivals' costs is immediate, there will also be an immediate positive impact on profits.

A number of practices have been interpreted as belonging to the category of raising rivals' costs strategies. Some of them are probably of little relevance, such as those that increase rivals' costs directly, either through sabotage (if one destroys the rivals' plants it also increases its costs, but there is no need for anti-trust laws to take care of such bbehaviour); or through lobbying and regulation (think for instance of domestic firms that convince the government to introduce tariffs or other taxes on imported products).[102] More interestingly, a number of practices that we have already analysed might be seen as raising rivals' costs. Exclusive dealing might make it more difficult or more costly for a rival to find distributors that can sell its products. A vertically integrated firm might refuse to supply a key input to a downstream rival (or to engage into a price squeeze, that is sell the input to the rival but at a prohibitively high price), increasing the production costs of the latter. Furthermore, denying interoperability to a rival network might also be seen as a strategy which increases the rival's cost of doing business.

Not all actions that increase rivals' costs are necessarily anti-competitive. For instance, one might argue that a firm that carries out significant R&D activities to increase its product quality is also raising the cost of its rivals: if they want to be competitive and keep their appeal, they also have to sustain higher R&D expenses. Yet, this is not a practice that harms competition: R&D will benefit consumers. Therefore, a crucial step in the theory is to distinguish between practices that harm competitors only from those that also reduce welfare.

To sum up, raising rivals' costs theories provide a concept that encompasses very different practices. Due to the specificities of such practices, I have preferred to deal with them separately.

[101] See also Salop and Scheffman (1987).

[102] An interesting US case is *Pennington*, where a large mine operator and the miners' trade unions lobbied for a minimum wage. The resulting increase in production costs would have hurt smaller competitors more than the large firm.CHECK DETAILS

# 4 Price discrimination

Price discrimination is a pervasive phenomenon, of which examples from our daily life abound.[103] Books are sold at different prices according to whether they are hardback or paperback (but the cost of the hardback binding does not explain alone the price difference); journals charge a higher price for libraries and institutions than for private citizens (and sometimes make further discounts to students); if we buy in a shop pencils and paper for our private use we certainly pay more per item than our university or firm that buy large amounts of them; airlines apply very different tariffs not only for business versus economy trips, but often charge very different prices for the same type of seat and trip according to whether the passenger is a student, a senior citizen, has booked early or in the last minute, and so on. Some of the strategies firms use to discriminate across consumers (and as we shall see, price discrimination increases their profits) are fascinating and extremely sophisticated, but the main purpose of this chapter is not to study firms' discriminating practices but rather to identify the likely effects that price discrimination has.

**The two main ingredients of price discrimination** There are two main ingredients for price discrimination to arise.[104] The first one is that a firm must have a way to sort consumers so as to charge them different prices. Different situations can arise, that broadly correspond to different types of price discrimination identified by economic theory.[105]

Under *first-degree* price discrimination, for instance, a monopolist would know each consumer's precise willingness to pay for its good, charge each of them exactly the maximum they would pay and therefore capture all the consumer surplus. Under *second-degree* discrimination, a firm offers different deals to everybody and lets different consumers "self-select", that is choose one particular deal. Quantity discounts are a natural example: a cinema, for instance, might offer to all customers the option to pay a lower unit price for film if they buy a ten-films card, but some customers will prefer just to pay one film ticket at the time. Third-degree discrimination refers to the possibility that a firm charges different prices to consumers having different (observable) characteris-

[103] I do not give a precise economic definition of price discrimination, which can easily become a thorny issue. Varian (1989: 598) follows Stigler's definition: there exists price discrimination when two or similar goods are sold at prices that are in different ratios to marginal costs. (Note that if a firm charges the same price to two different consumers, but it has to pay a higher cost to ship the good to one than to the other, this will effectively be price discrimination.) Tirole (1988: 134) warns that "[a] general equilibrium theorist might rightly point out that goods delivered at different locations, in different states of nature, or of different quality are distinct economic goods and thus that the scope of 'pure' discrimination is very limited."

[104] Varian (1989) suggests that another ingredient is that firms should have market power. As I have repeatedly said in the book, it is unlikely that real world firms (as opposed to firms in perfect competition models) lack of all market power: therefore, we should expect all firms to have an incentive to discriminate, although I will show below that firms with very little market power have also very limited ability to have an impact on market prices through discriminatory practices.

[105] This, now standard, classification is due to Pigou (1920).

tics. For instance, a student might be able to fly cheaper; a citizen over 65 years old might receive discounts on train tickets; the same good might be sold at a lower price in Portugal than in Germany.

The second crucial feature for price discrimination is that *arbitrage* should be absent. In other words, a firm would not manage to price discriminate if consumers could re-sell the goods among each other. Under first-degree discrimination, a monopolist would not be able to appropriate the consumer surplus if Mr. A - who has a lower valuation for the good than Ms. B - could buy not only the good for himself but could also buy it to re-sell it to Ms. B. Under second-degree discrimination, arbitrage opportunities arise if I can buy a ten-films card at a 5$ unit price and then offer to use it to ten spectators who would be charged 10$ each by the cinema. Under third-degree discrimination, the firm would not be able to segment national markets if a Portuguese could buy the good at the lower Portuguese market price and then ship it to Germany where it commands a higher price. (This practice of arbitraging across countries is called *parallel imports*, and it attracts a lot of attention in the EU law, as we shall see below).

Arbitrage is of course not always feasible, either for natural obstacles or for obstacles created by the firms themselves. For instance, transportation costs, tariffs, transaction costs and red-tape might prevent parallel imports from one country to another; firms might require proof that the purchaser is a student (or a senior citizen); a ten-film card might be nominative and an ID required at the cinema; a firm might require an exclusive distributor not to sell the product beyond a particular territory and to unauthorised dealers; a car manufacturer might want require its dealers in a country not to sell their car to citizens resident in other countries (a practice systematically outlawed and heavily fined in the EU), and so on.

Therefore, *if* competition authorities think that price discrimination should be forbidden, they will try to intervene on the practices on which firms rely to prevent arbitrage. For instance, they could require a firm not to include any clause limiting the ability of dealers to re-sell the product in other territories; or they could prevent an airline clerk or a train conductor from asking the ID cards to passengers and so on. (I am just following a hypothetical reasoning, and not suggesting what should be done: this will have to wait until an analysis of welfare effects is done.)

## 4.1 Welfare effects of price discrimination

### 4.1.1 First-degree (perfect) price discrimination

To understand that it is not to be taken for granted that price discrimination hurts welfare, it is enough to look at first-degree price discrimination. Suppose a monopolist (whose marginal cost is equal to $c$) faces a demand function as in Figure 7.7: this demand can be interpreted as the aggregation of unit demands of very many consumers, each with a different willingness to pay. If it were able to set a different price to each different consumer (and of course knew their valuations), the monopolist would be able to extract all the consumer surplus: it would make each consumer pay exactly their maximum willingness to pay, and get a profit equal to the whole area of the triangle $Op_cS$. Since welfare is the sum of profits and consumer surplus, welfare will also be equal to the area of $Op_cS$.

INSERT Figure 7.7. Welfare under perfect price discrimination

Perfect price discrimination would lead to the highest possible welfare, then. To see this, just note that allocative efficiency under uniform pricing would require the monopolist to sell to all consumers at a price equal to marginal cost, leading to welfare being equal again to the area of the same triangle $Op_cS$. By contrast, if the monopolist were forced not to discriminate, it would sell at a price $p^m$ and welfare would equal the area of the trapezoid $ORTC$, which is lower.[106]

This example should not be over-emphasised because perfect price discrimination is unrealistic, as it would require firms to have perfect knowledge of consumers and their preferences. However, it serves my purpose, which is to start and make the reader aware that price discrimination should not necessarily be thought of as a practice detrimental to welfare.[107]

### 4.1.2 Quantity discounts

Another form of price discrimination (second-degree) occurs when a firm offers consumers different price-quantity packages - that give discounts to those buying a larger number of units of the product - or it imposes a two-part tariff, which requires the consumer to pay a flat fee $T$ independent of the quantity bought plus a variable component $pq$ which does depend on the quantity bought.[108] For instance, in many countries the price of gas, electricity, phone services is composed of a fixed fee plus a variable one. Note that two-part tariffs and quantity discounts are equivalent: for a consumer buying $q$ units of a good or service, and subject to a two-part tariff, the average price is given by $p + T/q$, and therefore decreases with the number of units bought.

[106] More generally, any (uniform) price above marginal cost would create a deadweight loss. For the price $p^m$ the deadweight loss equals the area of the triangle $RST$. See also chapter 2.

[107] Of course, a reader who thinks that the appropriate objective of competition policy is maximisation of consumer surplus and not of total welfare, would not accept the case of perfect price discrimination as an example showing that price discrimination is not necessarily "bad". I have explained in chapter 1 why most economists prefer a total welfare standard.

[108] Quantity discounts are not the only instance of second-degree price discrimination, which refers to all situations in which firms provide different packages to consumers, who then self-select among the available packages. For instance, airline companies offer business and (much cheaper) economy fares, the latter requiring a Saturday night stay, and therefore less interesting for those travelling for business purposes (whose willingness to pay is higher since the ticket is on a company's budget). Note also that the airline's cost of providing a seat does not vary (or varies only marginally) with the type of fare offered, whose rationale lies only in separating consumers with different willingness to pay. See Tirole (1988, ch.3) for modeling issues.

This type of price discrimination also tends to be welfare improving. The firm will use the flat fee to extract surplus from consumers with a lower intensity of demand (those who buy fewer units of the good at any given price) but will use a lower marginal price than the price it would set if it was obliged to use only a variable component. The result is similar (although less extreme) as under perfect price discrimination: the lower marginal price reduces the allocative inefficiency, and therefore increases welfare (the firm compensates the lower marginal price by using the flat fee). To better see the similarity with the case of perfect price discrimination, note that in that case a monopolist might appropriate all the consumer surplus by using a marginal price equal to $c$ (its marginal cost) and then charge each consumer a fixed fee that equals her surplus. A two-part tariff (where only one fixed fee is used) therefore aims at (imperfectly) replicating this outcome.

In most jurisdictions, such as for instance the EU and the US, quantity discounts are not prohibited by competition law. Economic analysis, as we have just seen, suggests that this is a sensible approach.[109]

### 4.1.3 Price discrimination across countries

As seen in chapter 1, EU law, while not objecting to price discrimination within a member country, takes a negative view of price discrimination among member countries: any practice used by firms to prevent parallel imports (that is, arbitrage) is basically under a status of *per se* prohibition and is considered, along with cartels, the gravest competition offence under EU law.

It is therefore very important to see what economic analysis has to say on this issue, and not only with respect to the usual standard of total welfare, but also to the objective of "economic integration" that the Commission seems to have when dealing with inter-country price discrimination.

Suppose that a monopolist (but the same arguments can be made to any firm enjoying some market power) sells the same product in two different markets, say Germany and Portugal; assume also that transportation costs are nil, for simplicity. In Germany there exists a higher intensity of demand for the good than in Portugal, that can be thought of as reflecting the higher German incomes.[110] If the monopolist is allowed to price discriminate, it will set a higher price in Germany, say $p^D$, than in Portugal, say $p^P$. (Of course, it will be able to enforce this price difference only if it can prevent consumers and intermediaries to exploit arbitrage opportunities. For instance, if it forbids Portuguese buyers to re-sell outside their home country.)

Suppose instead that price discrimination is prohibited by law. One would then expect the new uniform price, $p^u$, to be located somehow in between $p^D$ and $p^P$, if the firm wants to serve both markets. What is the effect on welfare of imposing the same price across countries? A priori, it is ambiguous: profits decrease (as the firm is not able to exploit the different intensities in

[109] See section 4.2.2 for a technical treatment.
[110] See Tirole (1988: 143-144) for why different incomes generate different tastes.

demand), Germans would gain (since they buy at a price $p^u$ lower than $p^D$), and Portuguese would lose (the new price $p^u$ is higher than $p^P$).[111]

Nevertheless, technical section 4.2.1 shows that aggregating losses and gains, overall welfare increase when banning price discrimination *if* both markets are served under both regimes.

This result would seem to support the claims of critics of price discrimination. However, there is a strong assumption behind the result above, which is that the firm has always an interest in serving both markets. This is not necessarily the case: if the Portuguese market is very small compared with the German one, and/or if Portuguese demand is much smaller than German one, the firm that cannot price discriminate will prefer to set the price $p^D$ in both markets even if it implies losing all sales in Portugal. In this case, banning price discrimination is clearly welfare detrimental: it reduces the profits of the firm, reduces Portuguese consumer surplus, and leaves unchanged German consumer surplus.

More generally, price discrimination would allow firms to reduce prices to categories of consumers who would not buy otherwise, thus increasing the total quantity sold, and economic theory shows that price discrimination unambiguously reduces welfare only when it does not raise total output, whereas the sign of welfare change is ambiguous in all other cases.

If a clear assessment of price discrimination cannot be reached when using the welfare criterion that economists prefer, note that banning price discrimination need not fare better under the criterion of "achieving market integration": the effect of it might well be that a product will completely disappear from one market (in the example above, no unit of the good will be sold in Portugal).[112]

### 4.1.4 Dynamic effects of price discrimination: incentives to invest

Price discrimination might affect welfare in a long-run perspective too, by modifying firms' incentives to innovate. A simple argument that does not require any technical treatment is as follows. Suppose that a firm has to decide whether to introduce a new product in the EU or not, and that the cost of developing and launching the product is independent of output, as is reasonable to assume. Since price discrimination allows the firm to have higher profits, if the fixed cost falls between the price discrimination and the uniform pricing profits, then the product will be introduced if the firm expects to be able to prevent parallel imports, but will not be introduced if price discrimination practices were outlawed. More generally, price discrimination can affect the marginal profits from investing or innovating, creating more incentives to engage in such activities (See technical section 4.2.3).

This is an important issue in some recent EU cases, where pharmaceutical companies have been fined by the European Commission for having forbidden

[111] For those who think that equity is an issue, note that higher income consumers are better off and lower income consumers are worse off from the prohibition of price discrimination.

[112] This seems to have been the final effect in the *UK Distillers* case, where following the judgment of the ECJ, a whisky brand (previously sold in Continental Europe at a lower price than in the UK) was not sold outside the UK. [I NEED A REFERENCE ON THIS]

intermediaries in some country to sell the product in countries where the sales price was higher. In 1996, Bayer was fined by the EC because it reduced supplies of the cardio-vascular drug Adalat to French and Spanish wholesalers that have been re-exporting to the UK, where the price for the drug was higher.[113] In *Glaxo-Wellcome* (2001), the EC prohibited the dual pricing system introduced by Glaxo-Wellcome for all its pharmaceutical products in Spain. According to this system, Spanish wholesalers were charged a higher price for supplies which were to be re-sold abroad than those aimed at the local market, a practice that effectively impeded parallel exports.

The pharmaceutical market is unusual since prices are regulated by national governments (or set after negotiations between the government and the companies), and because patent protection might differ across countries. Therefore, it does not surprise that firms want to avoid that low prices in a country (due to regulations and/or less intellectual property rights protection that raises competition) might prevent them from commanding higher prices in other countries. Although the effect is probably not easily quantifiable, reduced profits are likely to reduce the R&D investments that pharmaceutical companies can make, thus harming both consumer surplus and total welfare.

### 4.1.5 Does market power matter?

As I have hinted at above, any firm that has some degree of market power will have an incentive to price discriminate. Indeed, small and large firms, operating in very different sectors of activity, try to discriminate prices to increase their profits. In the EU, all firms are currently prevented from prohibiting parallel imports. For instance, in 2000, the European Commission has - after investigations and even surprise inspections - prohibited a small manufacturer of motorcycles of large engine capacity (750cc and over), Triumph, from banning exports of motorcycles from Belgium and the Netherlands to the UK (where its products commanded a higher price). Triumph's market share for this kind of motorcycles in any individual EU country is below 5% and only in the UK it oscillates around 10%.[114] The question is: does it make sense to extend the prohibition of preventing parallel imports to any firm, independently of their market power, as is currently the case in the EU?

First of all, it should be noted that - whatever its sign on welfare - one should expect price discrimination by firms with little market power to have a small effect in magnitude on welfare. Second, we have seen above that price discrimination might also - by increasing profits - boost investments. As such, price discrimination by firms having small market power should be welcome rather than prohibited, as it may give a small firm a way to become more

[113] The *Adalat* decision by the EC was later annulled by the Court of First Instance (mostly for formal reasons, although the Advocate General's opinion seemed for the first time to accept that forbidding parallel trade should not necessarily be a per se anti-competitive practice). The case is under appeal at the European Court of Justice at the moment I am writing.

[114] See Press Release IP/00/1014 of 15 September 2000, and Competition Policy Newsletter, no. 1, February 2001, 34-35.

competitive.[115] It is therefore difficult to justify, *on competition grounds*, why the EC does not introduce a safe harbour according to which firms with a market share below a certain threshold will not be investigated for practices hampering parallel trade. The objective of such a tough stance against price discrimination seems to be dictated by political reasons only (giving citizens of different countries access to the same deal), but the Commission should be aware that this comes at a cost in terms of efficiency, and might also backfire in some cases (when a firm sets a price that effectively implies ceasing supplying a country altogether).

### 4.1.6 Price discrimination as a monopolisation device

So far, I have dealt only with the effects of price discrimination on consumer surplus and welfare *given the structure of the market* in which the discriminating firm operates. A different question is whether price discrimination can be used to change such market structure, for instance by preempting entry, or forcing exit, of competitors.

To discuss whether discrimination might be used in an anti-competitive way, imagine that an incumbent-monopolist that produces a good with relevant transportation costs is located in the centre of a country whose population is concentrated around two cities, one in the North and the other in the South. Suppose also that a new competitor sets up a plant in a neighbouring country which lies North. It is then clear that the monopolist has an incentive to price discriminate, charging a higher price in the Southern city than in the Northern one. Is this anti-competitive behaviour or not?

As seen in section 2.4, there is little doubt that this behaviour should be seen as predatory if the price is below average variable cost. But one might wonder if price discrimination is sufficient to evaluate this as monopolisation or abuse of dominance independently of whether prices are above or below any cost benchmark.

Banning price discrimination in such a circumstance has similar ambiguous effects as the ones seen for price discrimination in general. If uniform pricing leads the incumbent to serve both cities at an intermediate price, one would expect a positive welfare impact. But it might also happen, if the Northern city is less important in income or population, that the incumbent prefers to comply with the uniform pricing requirement by keeping the same high price as in the South. If this happens, welfare will likely decrease (See also technical section 4.2.5). Note also that in this case some productive inefficiency might also arise *if* the incumbent is more efficient than the entrant, as a more efficient producer is replaced by a less efficient one. Further, there is the risk that a rule preventing a monopolist from discriminating gives an incentive to inefficient producers to enter the market: knowing that the incumbent cannot cut prices unless it cuts them in all its markets, they will expect a weak reaction to their entry and get higher profits than otherwise.

[115] Both effects can be seen formally in technical section 4.2.4.

**Selective discounts and fidelity rebates** Apart from setting different prices to final consumers, a firm might also discriminate among its retailers and distributors. Examples of such practices are not only quantity discounts (that are usually considered lawful) but also discounts and rebates that firms give to push their buyers to purchase more from them. *Fidelity rebates*, for instance, are discounts that a producer gives to a customer to reward the latter for purchasing most or all of its requirements of a given product from the former.[116] *Aggregate rebates* are discounts given to a customer that buys most or all of its products from that same producer.

In the EU, the European Commission and the European Court of Justice have always taken a tough stance on discriminatory prices adopted by dominant firms and that are not justified by cost savings.[117] [118]

First of all, it should be recalled that not only cost, but also demand and market conditions might explain why firms would want to engage in discriminatory pricing (and that price discrimination is not always a welfare reducing business practice). Therefore, automatically outlawing selective discounts, even when used by a dominant firm, does not appear a robust policy recommendation: as seen above, it is part of a normal competitive process that a firm charges lower prices when its rivals are stronger (but of course, prices below average variable costs should be deemed predatory).

Once said so, some types of rebates made by dominant firms should be carefully monitored because of their exclusionary potential. The effect of fidelity rebates, for instance, is to try and induce the retailer not to buy from rivals, and it is therefore similar to exclusive dealing; and aggregate rebates are similar in their effects to tying or full-line forcing (when the supplier imposes a purchaser to buy all of its range of products). Accordingly, these types of discounts achieve a similar purpose to exclusive dealing and tying, whose possible anti-competitive effects have been discussed at length above.

**Price transparency** In chapter 6, we have seen that a monopolist might be unable to fully exploit its market power due to a commitment problem. This is because given the input price contract signed with a buyer, it might have an incentive to offer a better deal to another buyer. Anticipating this, a buyer will be unwilling to accept a high price contract in the first place.

The EC has repeatedly stated that a dominant firm should give the maximum transparency to its buyers, that it should be guaranteed that they will all receive an equal deal from the monopolist when they buy similar quantities.[119]

---

[116] For example, a firm A might give a fidelity rebate that consists of a 10% discount if the customer buys more than 50% of its requirements from A, a 15% discount if it buys more than 70%, and a 20% discount if it buys more than 90% of its requirements from A.

[117] Examples of discounts justified by cost savings might be discounts based on the quantity bought (that leads to economies of scale), for immediate payments, or that reflect lower transportation costs, or that reward retailers that engage in promotional activities.

[118] ADD:? The classic cases are United Brands, Hoffman-La Roche and Michelin, with recent decisions involving British Airways' discounts to travel agents.[RECALL BRIEFLY, Furse, 151, Ritter et al 395 ff., NERA brief]

[119] See for instance the *Michelin* case.

This effectively removes any temptation from the monopolist to offer a price discount to a buyer after having signed with another (since a discount should be offered to all buyers), and therefore provides it with a commitment mechanism that allows it to command high prices. Perhaps paradoxically, therefore, the effect of requiring transparency is to restore all the market power of the monopolist.

### 4.1.7 Anti-dumping

Anti-dumping laws have been adopted by many countries (USA, Australia, Canada and the EU are the main users of such laws, whereas less developed countries are usually defendants) and are often enforced vigorously.[120] They are generally seen as an instrument of trade policy rather than one of competition law (for instance, in the EU its is not DG Competition that deals with anti-dumping). My objective here is to underline the competition implications of anti-dumping.

The World Trade Organisation (the organisation that presides over multilateral trade agreements) recognises the right of its members to take unilateral actions to protect themselves when their domestic industry is injured by unfair trade practices, such as foreign firms "dumping" (i.e. selling at an exceedingly low price) their products. More precisely, anti-dumping actions are legitimate when two conditions are verified. First, export prices are *below their normal value*; second, exports cause or threaten *material injury* to the domestic industry of the importing country.

The ambiguity of the WTO provisions leaves space to quite different notions of dumping. For instance, there exists a substantial margin of discretion and arbitrariness in the calculation of the "normal price".[121] As for the determination of the injury created by dumping (however one would measure the latter), some commentators have suggested that it is too open to political influences (Tharakan and Waelbroeck, 1994).

For the way in which anti-dumping regulations are implemented in both the EU and in other countries, more than an instrument to avoid unfair practices, they appear as an instrument of trade protection in disguise. As such, it should not come as a surprise that its relevance has increased over the years, seemingly

[120] See Trebilcock and Howse (1995) for a discussion of law and practice of anti-dumping.

[121] One way to compute the normal price is to look at the price in the exporters' home market. By using this method, however, the EC Commission excludes from such a calculation all the sales which occur at "less than fully allocated cost", as well as those which do no not occur "under the ordinary course of business". In most cases, however, the normal value is found by using the "constructed cost method", which consists of adding up all the average costs of production, average fixed costs, general expenses, and a "reasonable" profit margin (which can vary across industries and which is not specified once-and-for-all). The exclusion of transactions in which price is lower than costs because "not in the ordinary course of trade" clearly inflates the normal value, by rendering the finding of dumping more likely. In the same way, the inclusion of all sorts of fixed costs and of a profit margin in the calculation of the normal price lacks of economic rationale, and also tends to find dumping more frequently than it should be. The EC Commission has been in particular criticised for the procedure used which biases the results of the investigation towards the outcome of dumping.

caused by the lower availability of more traditional instruments of protection (such as tariffs, reduced over time by successive multi-lateral negotiations).

Independently of the specific ways in which anti-dumping is calculated by the different national laws and regulations, it should be emphasised that there is little economic rationale for considering the difference between the home price and the export price as an "unfair practice". As we have seen in this chapter, price discrimination between different markets is compatible with the simple objective of profit maximisation and neither necessarily entails the intention of forcing rivals out of the market, nor is it necessarily welfare detrimental.

In international trade, price discrimination takes naturally the form of different prices in different markets. Normally, since firms tend to have a larger market share and a more faithful demand on their domestic market, this implies that domestic price is higher at home than abroad.[122]

The welfare effect of anti-dumping measures so loosely defined as to comprehend most situations where foreign producers are more competitive than domestic ones, is clearly negative, as not only consumers but also firms which use the good as an input might be penalised by the antidumping actions. This implies that a measure which is supposed to help the national industry might actually be detrimental to it. Furthermore, anti-dumping laws might remove threats to domestic firms which are not competitive enough. This has productive efficiency implications (as domestic firms put their energy more in lobbying for state intervention than in improving their processes and products) and might allow them to preserve market power positions.[123]

One case which illustrates the conflict that anti-dumping laws have with economic efficiency, is that of the soda-ash industry, whose two main European producers (Solvay had 70% of the market share in Continental Europe in 1990, while ICI had a quasi-monopoly in the UK market) received heavy fines for collusive agreements and for abuse of dominant position. It is then surprising to discover that the industry has been repeatedly protected from foreign competition by anti-dumping actions.[124]

Of course, the European anti-dumping laws are not the only ones which can be criticised. The US anti-dumping measures, for instance, have also attracted a number of criticisms. Empirical analyses have showed the anti-competitive effect of anti-dumping. Further, they have confirmed the theoretical suspicion that anti-dumping laws have a negative effect even when they do not result in final duties. The mere threat of anti-dumping sanctions can enough to induce foreign competitors to be less aggressive, and very often investigations end up with a suspension decision, in exchange for the promise of the foreign firms to

[122] A well known model where each firm sets a lower (f.o.b.) price abroad than in the domestic market is given by Brander (1981) where reciprocal dumping occurs in a Cournot setting.

[123] Messerlin (1990), for instance, finds that anti-dumping actions have been crucial for the survival of collusive agreements among European firms in two sectors.

[124] Less surprisingly, the Commission found that "one of the major preoccupations of Solvay's commercial policy in the soda sector is to ensure the continuation of the anti-dumping measures established both against US producers of dense soda and Eastern European producers of light soda" (Official Journal, 15 June 1991: 23, my translation).

stop "dumping" their goods.[125]

Anti-dumping duties should be justified only when predatory pricing is involved. Accordingly, dumping should not be considered as belonging to the domain of trade policy, but rather to that of competition policy. And to justify anti-dumping actions, the standards set up in section 2 should be used.

## 4.2 Price discrimination*

I offer here a technical presentation of the arguments made in the previous section. Section 4.2.1 deals with the case of price discrimination across national markets, section 4.2.2 with quantity discounts,[126] section 4.2.3 with price discrimination and incentives to invest, section 4.2.4 with the role of market power, and section 4.2.5 with the effects of discrimination when a monopolist faces an entrant.

### 4.2.1 Third-degree price discrimination)*

A monopolist serves two markets, $l$ and $h$, that one can think of as two regions that are part of the same country (or two countries that are part of a union). The weight of the two regions in the country is respectively $\lambda$ and $1-\lambda$, with $0<\lambda<1$. Market $i=l,h$ demand is given by $q=v_i-p$, with $v_h>v_l$. This can be rationalised by assuming that a type-$i$ consumer has a utility function $U_i=v_iq-q^2/2$.[127]

The monopolist serves both countries from the same plant, and has a unit cost $c<v_l$ (we disregard transport costs for simplicity). We want to compare the case where the monopolist can discriminate with the one where it cannot.

**Price discrimination** The monopolist can choose two different prices and its profits in each market are given by $\pi_i=(p_i-c)(v_i-p_i)$. From $d\pi_i/dp_i=0$ the equilibrium solutions are easily found (total profits should be weighted by population shares):

$$p_i^d=\frac{v_i+c}{2};\ \pi^d=\lambda\frac{(v_l-c)^2}{4}+(1-\lambda)\frac{(v_h-c)^2}{4}. \tag{106}$$

The consumer surplus in each market can easily be found as the area of triangle between the demand function and the market price; aggregate consumer surplus and welfare are obtained by weighting each market:

$$CS^d=\frac{\lambda(v_l-c)^2}{8}+\frac{(1-\lambda)(v_h-c)^2}{8};\ W^d=\frac{3}{8}\left(\frac{\lambda(v_l-c)^2}{4}+\frac{(1-\lambda)(v_h-c)^2}{4}\right). \tag{107}$$

[125] See Staiger and Wolak (1994).

[126] For presentation reasons, it is more convenient to invert the order followed in the previous section, and deal with second-degree price discrimination after third-degree discrimination.

[127] From the maximisation of its utility subject to the budget constraint, it follows that $v_i-q=p$.

**Uniform pricing (both markets served)** Suppose now that there is a ban on price discrimination. The monopolist is then obliged to set the same uniform price $p$ for both markets and its programme is $\max_p (p-c)\left[\lambda(v_l - p) + (1-\lambda)(v_h - p)\right]$. Suppose for the moment that both markets are served. From $d\pi/dp = 0$ the equilibrium solutions are:

$$p^u = \frac{\lambda v_l + (1-\lambda)v_h + c}{2}; \ \pi^u = \frac{(\lambda v_l + (1-\lambda)v_h - c)^2}{4}. \tag{108}$$

One can easily check that the uniform price is in between the prices the monopolist would charge if it were allowed to price discriminate: $p_h^d > p^u > p_l^d$. Consumer surplus and welfare under uniform pricing are:

$$CS^u = \frac{(\lambda v_l + (1-\lambda)v_h - c)^2}{8} + \frac{\lambda(1-\lambda)(v_h - v_l)^2}{2}; \ W^u = \frac{3(\lambda v_l + (1-\lambda)v_h - c)^2}{8} + \frac{\lambda(1-\lambda)(v_h - v_l)^2}{2}. \tag{109}$$

We can now compare the two equilibria. It is easily checked that the firm prefers to be free to discriminate ($\pi^u < \pi^d$), which should not come as a surprise since under discrimination it has two instruments to maximise its objective function, whereas under uniform pricing it has only one. Few steps of algebra also show that:

$$W^u - W^d = \frac{\lambda(1-\lambda)(v_h - v_l)^2}{8} > 0, \tag{110}$$

which implies that welfare is higher under uniform pricing. Indeed, it is a general result that price discrimination decreases welfare if it does not increase total output,[128] and one can check that here total output sold is the same under the two regimes, making it an application of the general result:

$$Q^d = \lambda q_l^d + (1-\lambda)q_l^d = \frac{\lambda v_l + (1-\lambda)v_h - c}{2} = Q^u = \lambda q_l^u + (1-\lambda)q_l^u. \tag{111}$$

**Uniform prices (one market not served)** There is a strong assumption behind the analysis just carried out: that the monopolist serves both markets. However, uniform pricing to serve both markets entails reducing prices (and profits) in the high demand market. The monopolist might prefer instead just to set the price $p_h = (v_h + c)/2$ that maximises its profits in the high demand market, even if this implies to lose all sales in the low-demand market. For instance, assume that $v_h + c > 2v_l$. In this case, demand in the low demand market is zero, and the monopolist will earn:

$$\pi_h^u = (1-\lambda)\frac{(v_h - c)^2}{4}. \tag{112}$$

[128] For a proof, see Varian (1989), or Tirole (1988: 137-138).

Standard calculations show that:

$$\pi_h^u > \pi^u \text{ if } \lambda < \frac{(v_h - c)(v_h - 2v_l + c)}{(v_h - v_l)^2}, \tag{113}$$

that is, the lower the share of the low-demand market in total demand the more likely it will not be served if price discrimination was banned. It can also be checked that the RHS of expression (113) increases with $v_h$ and decreases with $v_l$: the higher the gap between the demands the more likely one market only will be served.

Finally, it is straightforward to check that if one market only is served (that is, if (113) holds) welfare is higher under price discrimination, since the high-demand market has the same consumption and profits under both regimes, but low-demand market contributes zero to both under uniform pricing.

#### 4.2.2 Quantity discounts: Two-part tariffs as price discrimination*

I consider here the case where the monopolist uses a two-part tariff $T + pq$: a consumer buying $q$ units of the good will have to pay a fixed fee $T$ plus a variable component $p$. Note that this amounts to a quantity discount, as the average cost of the purchase, $p + T/q$, decreases with the number of units bought.

Let me continue with the example of the previous section 4.2.1: there are two different types of consumers, low-types having demand $q = v_l - p$ (they are a share $\lambda$ of the population) and high-types having demand $q = v_h - p$ (a share $1 - \lambda$ of the population).

Assume that $v_l > (c + v_h)/2$, that ensures that everybody buys under both uniform pricing and two-part tariffs.[129]

**Non-discrimination** This case has been already analysed in the previous section.

**Quantity discounts (two-part tariff)** Since low-types have lower intensity of demand, the fixed fee will be chosen so as to make them willing to pay. Given that their consumer surplus is given by $CS_l = (v_l - p)^2/2 - T$, it follows that the monopolist will set $T = (v_l - p)^2/2$. As for the variable component of the tariff, it is found as the one which solves the problem:

$$\max_p \pi = (p - c)\left[\lambda (v_l - p) + (1 - \lambda)(v_h - p)\right] + (v_l - p)^2/2. \tag{114}$$

From $d\pi/dp = 0$ it follows that:

$$p^{qd} = c + (1 - \lambda)(v_h - v_l). \tag{115}$$

[129] For future reference, note that $(c + v_h)/2 > (c + (1 - \lambda) v_h)/(2 - \lambda)$.

Note that the quantity bought by the low-types is $q = v_l - p^{qd}$, so that $q > 0$ amounts to $v_l > [c + (1-\lambda) v_h] / (2-\lambda)$, which is satisfied by the assumption $v_l > (c + v_h)/2$. At this price, the surplus of high types is:

$$CS_h^{qd} = (v_h - v_l)[v_l(2-\lambda) - c - (1-\lambda) v_h] > 0 = CS_l^{qd}, \tag{116}$$

and the monopolist's profits are:

$$\pi^{qd} = \frac{1}{2}\left[(v_l - c)^2 + (1-\lambda)^2 (v_h - v_l)^2\right], \tag{117}$$

and welfare can be found by substitution as $W^{qd} = \pi^{qd} + (1-\lambda) CS_h^{qd}$.

**Quantity discounts and uniform pricing: a comparison** The reader can check that the monopolist will be better off by using this form of price discrimination: $\pi^{qd} > \pi^u$. But even without doing any calculations, this is straightforward, since two-part tariffs provide the monopolist with two instruments, $T$ and $p$, rather than only one as under uniform pricing (the monopolist could always replicate the result under uniform pricing simply by setting $T = 0$ and choosing the same unit price).

As for marginal prices, it is easy to check that $p^{qd} < p^u$ for $v_l > [c + (1-\lambda) v_h] / (2-\lambda)$, which is true: when two-part tariffs are used, the variable component consumers will pay is lower (but the monopolist will gain from the marginal price decrease because it can use the fixed fee).

Therefore, welfare will also be higher under quantity discounts than under uniform pricing, as the lower marginal price entails a smaller distortion.[130]

### 4.2.3 Price discrimination and investments*

In this section, I analyse a simple model of a monopolist that invests in the quality of its good. I show that under price discrimination the equilibrium quality offered will be higher.

Consider a monopolist that sells a good of quality $u$ to two different markets, each of size one. Consumers in both markets have preferences $CS = \theta u - p$ if they buy one unit of the good, and 0 otherwise. In market $h$, consumers' taste for quality, $\theta$, is uniformly distributed on $0 \leq \theta \leq \theta_h$. In market $l$, the taste parameter is uniformly distributed on $0 \leq \theta \leq \theta_l$.

The monopolist has to decide first on the quality $u$ it wants to supply, and it has a fixed cost of quality improvement $C(u) = ku^2/2$; (assume for simplicity that there is zero variable cost of production); then, it has to decide the price at which it wants to sell the good. Consider two variants of the game: in the first, it has to choose the same price for both markets; in the second, it can price discriminate.[131]

[130] The reader can check that $W^{qd} > W^u$ for $v_l > [c + (1-\lambda) v_h] / (2-\lambda)$.

[131] In international trade theory, the case of price discrimination across markets is called "segmented markets", whereas choosing one price for both markets is called "integrated markets".

**Uniform pricing** First of all, note that the demand faced by the monopolist is determined by finding the consumer who is indifferent between buying or not. Given a price $p$ and a quality $u$, the indifferent consumer $\theta_0$ is given by solution of $CS = \theta u - p = 0$. Therefore, $\theta_0 = p/u$. Therefore, demand is given by all consumers in both markets such that $\theta \geq \theta_0$. Profits in the second stage are:

$$\Pi = p\left[\left(\theta_h - \frac{p}{u}\right) + \left(\theta_l - \frac{p}{u}\right)\right]. \tag{118}$$

From the FOC $d\pi/dp = 0$, it follows that equilibrium prices and profits are:

$$p^u = \frac{u\left(\theta_h + \theta_l\right)}{4}; \quad \Pi^u = \frac{u\left(\theta_h + \theta_l\right)^2}{8}. \tag{119}$$

The total quantity sold by the monopolist is $q^u = \theta_h - (\theta_h + \theta_l)/4 + \theta_l - (\theta_h + \theta_l)/4 = (\theta_h + \theta_l)/2$. The optimal quality choice can be found as the solution of the programme $\max_u \pi = \Pi^u - ku^2/2$; from $d\pi/du = 0$, it follows that

$$u^u = \frac{u\left(\theta_h + \theta_l\right)^2}{8k}. \tag{120}$$

**Price discrimination** Under price discrimination, the monopolist can charge a different price in the two markets. The indifferent consumer $\theta_0^i$ in market $i$ is given by solution of $CS = \theta u - p_i = 0$. Whence, $\theta_0^i = p_i/u$. Profits in the second stage are:

$$\Pi = p_h\left(\theta_h - \frac{p_h}{u}\right) + p_l\left(\theta_l - \frac{p_l}{u}\right). \tag{121}$$

From the FOC $d\Pi/dp_i = 0$, it follows that equilibrium prices and profits are:

$$p_i^d = \frac{u\theta_i}{2}; \quad \Pi^d = \frac{u(\theta_h^2 + \theta_l^2)}{4}. \tag{122}$$

Note also that the total quantity sold by the monopolist is $q^d = \theta_h - \theta_h/2 + \theta_l - \theta_l/2 = (\theta_h + \theta_h)/2$, which is the same as under uniform pricing. The optimal quality choice can be found as the solution of the programme $\max_u \pi = \Pi^d - ku^2/2$; from $d\pi/du = 0$, it follows that

$$u^d = \frac{u(\theta_h^2 + \theta_l^2)}{4k}. \tag{123}$$

It is then straightforward to check that $u^d > u^u$.

#### 4.2.4 Price discrimination and market power*

Consider a vertical product differentiation model where firm 1 sells a product of quality $u_1$ and firm 2 a product of quality $u_2$, with $u_1 > u_2$. Both firms sell in two different markets, each of size one. (A firm does not differentiate quality across markets.) Consumers in both markets have preferences $CS_j = \theta u_j - p_j$ if they buy one unit of the good of quality $j = 1, 2$, and 0 otherwise. In market $h$, consumers' taste for quality, $\theta$, is uniformly distributed on $0 \le \theta \le \theta_h$. In market $l$, it is uniformly distributed on $0 \le \theta \le \theta_l$.

I show here that both firms have an incentive to price discriminate, but that there is little reason to care about price discrimination practices of a firm with little market power.

**Uniform pricing** To find demand functions of the firms, we first need to identify two indifferent consumers: the consumer indifferent between buying from the low quality good and not buying, $\theta_0$, and that indifferent between buying the low or the top quality good, $\theta_{12}$.

From $CS_2 = 0$ it follows that $\theta_0 = p_2/u_2$. From $CS_2 = CS_1$ it follows that $\theta_{12} = (p_1 - p_2)/(u_1 - u_2)$. Therefore, demand functions are: $q_1^i = \theta_i - \theta_{12}$, and $q_2 = \theta_{12} - \theta_0$, with $i = l, h$. Firms' profits are:

$$\Pi_1 = p_1 \left[\theta_h + \theta_l - 2\frac{p_1 - p_2}{u_1 - u_2}\right]; \;\; \Pi_2 = 2p_2 \left(\frac{p_1 - p_2}{u_1 - u_2} - \frac{p_2}{u_2}\right). \tag{124}$$

Equilibrium prices in the price sub-game are found from $d\Pi_j/dp_j = 0$ as:

$$p_1^u = \frac{u_1(u_1 - u_2)(\theta_h + \theta_l)}{(4u_1 - u_2)}; \;\; p_2^u = \frac{u_2(u_1 - u_2)(\theta_h + \theta_l)}{2(4u_1 - u_2)}. \tag{125}$$

Given $u_1$, a low $u_2$ implies that firm 2 can command a low price. For $u_2$ which tends to zero, for instance, firm 2's price would also tend to zero, that is, the low quality firm would have very little market power (which is the ability of raising prices above marginal costs, here zero).[132]

By substitution, one can find equilibrium profits as:

$$\Pi_1^u = \frac{2u_1^2(u_1 - u_2)(\theta_h + \theta_l)^2}{(4u_1 - u_2)^2}; \;\; \Pi_2^u = \frac{u_1 u_2(u_1 - u_2)(\theta_h + \theta_l)^2}{2(4u_1 - u_2)^2}. \tag{126}$$

**Price discrimination** Under price discrimination, both firms can charge a different price in the two markets. Firms' profits are:

[132] Note that there is no monotonic relationship here between $u_2$ and its equilibrium price (market power). This is because when $u_2$ becomes close enough to $u_1$, the products become closer substitutes and equilibrium prices decrease.

$$\Pi_1 = \sum_{i=h,l} p_{1i}\left[\theta_i - \frac{p_{1i}-p_{2i}}{u_1-u_2}\right];\ \ \Pi_2 = \sum_{i=h,l} p_{2i}\left(\frac{p_{1i}-p_{2i}}{u_1-u_2} - \frac{p_{2i}}{u_2}\right). \tag{127}$$

Equilibrium prices in the price sub-game are found from $d\Pi_{ji}/dp_{ji} = 0$ as:

$$p_{1i}^d = \frac{2u_1(u_1-u_2)\theta_i}{(4u_1-u_2)};\ \ p_{2i}^d = \frac{u_2(u_1-u_2)\theta_i}{(4u_1-u_2)}. \tag{128}$$

Therefore, it is clear that both firms discriminate across markets at equilibrium (in other words, not only monopolists want to segment markets!). By substitution, equilibrium profits are:

$$\Pi_1^d = \frac{4u_1^2(u_1-u_2)(\theta_h^2+\theta_l^2)}{(4u_1-u_2)^2};\ \ \Pi_2^d = \frac{u_1u_2(u_1-u_2)(\theta_h^2+\theta_l^2)}{(4u_1-u_2)^2}. \tag{129}$$

**Market power and price discrimination** In this simple model, the distortion created by price discrimination in each market differs across firms:[133]

$$p_{1i}^d - p_1^u = \left|\frac{u_1(u_1-u_2)\left(\theta_h-\theta_l\right)}{(4u_1-u_2)}\right|;\ \ p_{2i}^d - p_2^u = \left|\frac{u_2(u_1-u_2)\left(\theta_h-\theta_l\right)}{2(4u_1-u_2)}\right|. \tag{130}$$

Clearly, the distortion becomes irrelevant when a firm does not have much market power. For small values of $u_2$ (that is, when firm 2 has little market power), the price difference becomes very small. More formally, write $u_2 = u_1 - k$, so that $k$ is the quality gap between the firms. One can write $p_{2i}^d - p_2^u = \left|(u_1-k)ku_1\left(\theta_h-\theta_l\right)/(k+3u_1)\right|/2$, and:

$$\frac{d(p_{2i}^d - p_2^u)}{dk} = \frac{(3u_1^2 - 6ku_1 - k^2)\left(\theta_h-\theta_l\right)}{2(k+3u_1)^2}. \tag{131}$$

From studying the second-order inequality $u_1^2 - 6ku_1 - k^2 > 0$ one obtains that the equilibrium price difference between the two pricing regimes decreases with the quality gap when $k < (2\sqrt{3}-3)u_1$ (roughly, for $k < .46u_1$) and increases for higher values. In other words, when the quality gap is the highest (market power of firm 2 is the lowest), an increase in $u_2$ (an increase in firm 2's market power) raises the price differential until a point where the qualities are similar enough.

This strongly suggests that when a firm has little market power (as is the case with firm 2 here for low enough values of $u_2$), the impact that its pricing policy might have is unlikely to be significant.

[133] Obviously, for both firms the price is higher (respectively lower) under price discrimination in the market with higher (resp. lower) intensity of demand, $v_h$ (resp. $v_l$). Although the sign of the price difference is opposed, the absolute magnitude of the difference is the same for each firm.

**The effect on investments** Suppose now that, for some reasons, firm 1's quality was fixed but firm 2 (the firm in a disadvantaged position) could invest to improve its quality level at a convex cost $C(u_2)$. It is easy to see that price discrimination would allow the firm to have a higher incentive to invest in quality, thereby helping it to fill the gap more than in the case of uniform pricing.

Firm 2's problem is then to choose its quality endogenously so as to maximise its net profits: $\max_{u_2} \Pi_2(u_2) - C(u_2)$. The gross profits, and the first-order condition of this problem are different according to the price regime. Under uniform pricing, it is given by:

$$\frac{d\Pi_2^u(u_2)}{du_2} = \frac{u_1^2(4u_1 - 7u_2)(\theta_h + \theta_l)^2}{2(4u_1 - u_2)^2} = \frac{dC(u_2)}{du_2}, \tag{132}$$

whereas under price discrimination it is given by:

$$\frac{d\Pi_2^d(u_2)}{du_2} = \frac{u_1^2(4u_1 - 7u_2)(\theta_h^2 + \theta_l^2)}{(4u_1 - u_2)^2} = \frac{dC(u_2)}{du_2}. \tag{133}$$

It is easy to check that $d\Pi_2^d(u_2)/du_2 > \Pi_2^u(u_2)/du_2$ as $(\theta_h - \theta_l)^2 > 0$, which entails that the equilibrium quality chosen by firm 2 will be higher under price discrimination (marginal revenue from the investment is higher, whereas the marginal cost is the same). Therefore, by forbidding a firm with a low quality to price discriminate, its chance to reduce the gap that separates it from the high quality firm is reduced.

### 4.2.5 Price discrimination under entry*

Two cities are located along the horizontal line $[0, 2t]$ that delimits a country. The first, city A, is at 0, and the second at $2t$. Firm 1, the incumbent monopolist, is located between the two cities, at $t$. Demand in each city is given by $q = 1-p$; there is no demand elsewhere. Suppose now that firm 1's monopoly is challenged by imports from a foreign firm that is located at $2t+T$. Assume that both firms have zero production costs, but have to incur a unit transportation cost which is equal to distance: for instance, it costs $T$ (resp. $T + 2t$) for firm 2 to bring each unit to city B (resp. A). Assume that $(1 + t)/2 \geq T \geq (1 - 3t)/2$: firm 2 is close enough to challenge firm 1 in city B, but not enough to endanger its monopoly in city A. Firms compete in prices.

I want to compare the regime where firm 1 is allowed to price discriminate between cities with the one where it is not. (Note that the assumption of identical demands ensures that competition is the only reason for price discrimination.)

**Price discrimination** Under the assumptions above, firm 1 is undisturbed in city A, where it will set the monopoly price, $p_A^d = (1 + t)/2$. (This just comes from $\max_p \pi = (p - t)(1 - p)$, and setting $d\pi/dp = 0$.) Bertrand competition in city B implies instead that it will get all demand, but at the price $p^d_B = T$. Its total profits are $\pi^d = (1-t)^2/4 + (T-t)(1-T)$.

**Uniform pricing** If price discrimination was banned, and the incumbent wanted to serve both markets, it would have to set $p^u_A = p^u_B = T$, and would make profits $\pi^u = 2(T-t)(1-T)$.

However, the incumbent might decide instead to serve only its captive market A, and sets prices in both markets equal to $p^m = (1+t)/2$. It would then make monopoly profits $\pi^m = (1-t)^2/4$ in market A but it would not get any demand in market B, where firm 2 would obtain all demand by just slightly undercutting $p^m$.[134]

One can check that serving only market A is more profitable if $T < (1+t)/2 - \sqrt{2}(1-t)/4$.[135] This is because when firm 2 is close enough, serving city B would involve a big drop in prices and profits in city A as well, so it is more convenient not to serve the border city.

Therefore, a ban on price discrimination by the monopolist threatened by entry on one side of its market has ambiguous welfare impact. If the monopolist serves both markets under uniform pricing, prices drop in both markets, the deadweight loss in each market decreases, and total welfare goes up. However, imposing uniform pricing on the incumbent would be detrimental, if it led it not to serve the border city. In this market, a monopoly by the incumbent would simply be replaced by a monopoly of the entrant, and consumer surplus and overall welfare would decrease.[136] More generally, the ban on price discrimination would increase the market power enjoyed by the entrant. Exercise 7 shows that if the monopolist is challenged by firms that cannot have market power, then the ban on price discrimination will not hurt consumers (but may still decrease welfare).

# 5 Exercises

**Exercise 1** ** (The chain-store model with infinite horizon) Consider the model described in section 2.3.1, but with the variant that the stage game of figure 7.1 is repeated for an infinite number of times. (a) Show that predation exists under the following strategies and for a large enough discount factor $\delta$. The incumbent's strategy is: "fight entry, if entry occurs and it has never been accommodated before; accommodate entry, if entry has been accommodated before". The entrant's strategy is: "enter, if entry has ever been accommodated before; stay out,*

[134] Note that the monopoly price of firm 1 is higher than the export monopoly price of firm 2, $(1+T)/2$.

[135] $\pi^m > \pi^u$ if $8T^2 - 8T(1+t) + 1 + t^2 + 6t > 0$. This standard second-order inequality is solved for external roots, but the highest is outside the interval of values assumed for $T$.

[136] This is straightforward if one assumes that profits earned by the foreign firm are not computed in national welfare. But the result is unchanged if one includes any share of the foreign firms' profits earned in the domestic market in the welfare function. It just requires to check one more inequality and few steps of algebra.

*otherwise". (b) Discuss the model: Do you think it offers a valid formalisation of predatory behaviour?*

**Exercise 2** *** (Pooling equilibria in the predation for merger model, section 2.3.4.) Consider the version of Saloner (1987)'s model presented in section 2.3.4, and check under which conditions there exists a pooling equilibrium where: both the low cost and the high cost firm set the low cost firm 1 monopoly output ($q_{1l}^* = q_{1h}^* = q_{1l}^m$), and offer $Q^* = x\pi_{2l}^d + (1-x)\pi_{2h}^d$ to buy the entrant; if firm 2 observes $q_1^m \geq q_{1l}^m$, it accepts any offer $Q \geq Q^*$ and rejects it otherwise; if firm 2 observes $q_1^m < q_{1l}^m$, it accepts any offer $Q \geq \pi_{2h}^d$ and rejects it otherwise; firm 2 has beliefs $x' = 0$, if $q_1^m < q_{1l}^m$; $x' = x$, if $q_1^m \geq q_{1l}^m$.*

**Exercise 3** ** (Deep pocket predation under perfect information: quantity competition.) Consider a variant of the model analysed in section 2.3.5. Market demand for a homogenous good is $p = \max(0, 1-Q)$, where $Q$ is total output. Firm 1 and firm 2 have respectively costs $c_1 < 1$ and $c_2$, and have to incur a fixed recurrent cost $F$ before production if they are to operate in the industry (if one does not pay this cost once, one has to exit the industry forever). Also assume that it is impossible for a firm to get credit. Firm 2 is more efficient ($c_2 < c_1$) but is cash constrained: its total assets are $A_2 = 2F - \varepsilon$ (whereas firm 1 has deep pockets: $A_1 > 2F + 1$). Consider a two-period game (assume no discounting $\delta = 1$), where in each period (i) each firm decides whether to pay $F$ and stay in the industry or leave forever; (ii) active firms choose outputs. Find: (a) what is the optimal quantity produced by firm 1 if it wants to prey; (b) under what conditions will predation occur as a sub-game-perfect Nash equilibrium.*

**Exercise 4** *** (Deep pocket predation without exit) Consider a variant of the model seen in section 2.3.6, where firm 1 has no cash constraint and firm 2 has zero resources. Firms produce a homogenous good whose demand is $p = 1 - Q$ and compete in quantities. Both firms are in the market when the game starts, and produce at a technology that involves marginal costs $c$. The game is as follows. In the first period, firm 1 decides whether to set the Cournot output, $q(c,c) = (1-c)/3$ (accommodate) or set an aggressive output, $q_1^P(c,c) = 1-c$ (prey). In the former case, both firms earn $\pi(c,c) = (1-c)^2/9$, in the latter case they each get $\pi^P(c,c) = 0$. (Check that firm 2's best response when firm 1 sells $1-c$ units is not to sell anything, and that firm 1 sells at marginal cost.) In the second period, each firm has to decide whether to invest an amount $I$ in a new technology that abates the marginal cost to $c' = 0$, or not. If a firm decides not to invest, it will have marginal cost $c$ in the second period as well, and make profits $\pi(c, \cdot)$.*

*Unlike firm 1 that has enough own assets, firm 2 needs to borrow from banks to pay $I$. If it obtains financing, the manager of each firm has to decide whether it wants to exert high effort or zero effort (a binary decision for simplicity). If the manager implements the innovation properly ("high effort"), the innovation will succeed with probability $p = 1$, allowing the firm to produce at marginal cost $c' = 0$; if the manager shirks ("low effort"), he obtains private benefits $B$ (which he does not get if he makes "high" effort or does not innovate at all), but the* *innovation will fail with probability* 1*, i.e. the firm will produce at marginal cost* $c$ *in the second period as well. Finally, second period profits realise.*

*Assume that with perfect capital markets the innovation would always be financed: (A1)* $\pi(0,0)-I > \pi(c,c)$*, and that a firm which finances the innovation itself would never shirk: (A2)* $B+\pi(c,c) < I$*; If there is accommodation, firm 2's manager will be able to raise funds: (A3)* $\pi(0,0)-B > I-\pi(c,c)$*, but in case of predation in the first period the innovation will not be financed: (A4)* $\pi(0,0)-B < I$*. Will predation occur?*

**Exercise 5** ** (Over-investment in R&D) This is a slightly richer version of the model seen in section 3.1.1, since the entrant firm is also allowed to invest in R&D. The incumbent, firm 1, faces a potential entrant, firm 2, in the market for a homogenous good with demand* $p = 1-q$*. Consider two games. (a) Find the solution of the following simultaneous decisions game. In the first stage, firm 1 and 2 simultaneously decide investment* $x_i$ *in a cost-reducing technology, with total cost of production given by* $C(x_i, q_i) = (c-x_i)q_i$*. Assume a quadratic cost for the investment,* $F(x_i) = x_i^2$*. At this stage, firm 2 also decides on entry, and pays a fixed sunk cost* $F$*. In the last stage, active firms observe each other's investment decision and choose outputs. (b) Find the solution of the sequential investment game, which is like the previous one, with the only variant that firm 1 invests in the first stage; in the second stage, after observing firm 1's investment decision, firm 2 decides on investment and on entry; in the last stage, active firms choose outputs.*

*Show that there is a range of values of the fixed sunk cost* $F$ *where entry deterrence is profitable, in the sense that firm 1 prefers to invest more in the new technology than it would if it took firm 2's entry for granted.*

**Exercise 6** ** (Credibility of product preemption, inspired by Judd (1985) and Tirole(1988)'s comments.) When the game starts, firm 1 is already established in market A, where demand for its product is* $Q = 1-p$*, whereas in market B, no firm is active and there is no demand for the good. At time* $T$*, firm 1 can decide whether it wants to set a plant in market B, at a fixed sunk cost* $F$*. It then sets prices in the market where it is active. At time* $T+1$*, a potential entrant, firm 2, decides whether to set a plant in market B at the fixed sunk cost* $F < 1/4$*. After the entry decision is taken, active firms set prices. Firm 1 and 2 sell the same homogenous good in both markets. However, transporting the good from one market to the other entails a transportation cost* $t < 1/2$*. Assume also that at time* $T$ *demand for the good in market B is zero, whereas at time* $T+1$*, demand is given by* $Q = 1-p$*. Firms serving both markets from the same plant have to choose the same mill price across markets (i.e., prices can differ only by the transportation cost), they have the same discount factor* $\delta = 1$*, and the same marginal costs* $c = 0$*. (i) Assume that firm 1 cannot withdraw from market B if it enters there, and show it will enter at time* $T$ *to preempt entry by firm B. (ii) Assume that, after observing firm 2's entry decision at time* $T+1$*, firm 1 can withdraw from market B at no cost if it wishes so. Show that market preemption will not occur at the (sub-game-perfect) equilibrium.*

**Exercise 7** ** Assume the same setting as in section 4.2.5. City A is located at* $0$*, and city B at* $2t$ *along the horizontal axis. Firm 1 is located at* $t$*. Demand in each city is given by* $q = 1 - p$*. There are two foreign firms located at* $2t + T$*. Assume that all firms have zero production costs, but incur a unit transportation cost equal to distance. Assume that* $(1 + t)/2 \geq T \geq (1 - 3t)/2$*. Firms compete in prices. Find the equilibrium solutions for the cases where (a) price discrimination is allowed; (b) price discrimination is banned. Then show that (c) a ban on price discrimination reduces welfare.*

**Exercise 8** ** (Quantity discounts and incentives to invest) Consider the model described in sections 4.2.1 and 4.2.2. The monopolist faces* $\lambda$ *(resp.* $1 - \lambda$*) consumers with demand* $p = v_l - q$ *(respectively* $p = v_h - q$*). It has an initial marginal cost* $A < v_l$ *of providing the good. Consider the two following games:*

*Game 1: uniform pricing. First, the monopolist decides on the investment* $x$ *to reduce its marginal cost. By investing a given level* $x$*, its new marginal cost will be* $c = A - x$*. The cost of the investment is* $C(x) = \mu x^2/2$ *(assume that* $\mu > 1$ *for the second-order condition to be satisfied in both Game 1 and 2.) Second, it chooses the uniform price* $p$ *at which both markets are served (assume that it is not convenient to supply one market only:* $v_l > [A + (1 - \lambda) v_h] / (2 - \lambda)$*).*

*Game 2: quantity discounts. Same game as game 1, but in the second stage the monopolist can use a two-part tariff* $T + pq$*.*

*Show that the monopolist invests more in Game 2.*

**Exercise 9** *Suppose you hear the CEO of a small firm complaining about the difficulties he faced as he tried to enter a market that has a strong incumbent firm: "As soon as we started to market our product, our rival would basically give away his stuff for free! He did everything to try and drive us out of the market. It was so unfair! We never had a real chance to make it... A firm should not be allowed to do a thing like that. I think the government should pass a law that prohibits to price below cost..." Discuss this proposal. Do you agree?*

**Exercise 10** *(exercise 9 continued) To get a clear picture of the situation, you decide to confront the incumbent's CEO with the smaller firm's allegations and ask for their point of view. Here is what they tell you: "Come on, this is ridiculous! These guys were just not competitive enough... Their product was junk, and their pricing was beyond the beyonds! Do you want to blame us for having the better product and better prices? Let's face it: the marketplace is like the Olympics - it's always the best guy who will win!" Discuss this statement.*

**Exercise 11** *Fernando, who lives in Vienna, recently bought himself a car and went on a long vacation with it. When he arrived in Florence, he happened to stop at a local car dealer's premises, where he discovered that "his" car - the exact same make and model - was sold there for two thirds of the price he had to pay for it in Vienna. Fernando frets and fumes: he somehow feels like he was ripped off mightily, and he thinks that firms should not be allowed to do that - as a matter of fairness, the same car should be sold at the same price everywhere in the world! Discuss.*

**Exercise 12** *In a recent case, the European Commission has fined the pharmaceutical company British Chemicals for abuse of dominant position. The firm has been found guilty of artificially segmenting the markets of member countries because it had forbidden its Spanish subsidiary to export to other EU countries a well known medicine used for heart disease. In Spain the price of this medicine (as well as of many others) is lower than in other EU countries because Spanish law does not protect patents to the same extent as in the other EU countries. As a result, there are many more firms which can produce and sell this product, which brings prices down. Would you agree with the Commission's decision?*

**Exercise 13** *Until the end of 1995, the airline "Golden Wings" was the only one authorised to operate in the passenger air transport business in the country "Eagleland". To operate flights to or from this country, other airlines had to strike cooperative agreements with "Golden Wings", which could impose its conditions without any restriction from the domestic government. Due to the existing situation, "Golden Wings" had 80% of the national market, and basically all the Eaglelandish population had been participating in the frequent flyer programme of the company (out of four trips, one is free), that the company started to run in 1994. Since 1996, the market has been deregulated, and other airlines are now free to sell their services in the country. Immediately after deregulation, the large multinational company "Albion Airways" bought landing slots in the major airports of the country and started to sell aeroplane tickets to and from the country at a rice which is roughly half the prices set by "Golden Wings". The latter firm lost 30% of the market in a few months. It filed a complaint to the national competition authority accusing "Albion" of predatory pricing. According to the complaint, "Albion" was using its strength on the world market (it has 40% of it) to evict "Golden Wings" from the Eaglelandish market. The national authority decided that "Albion Airways" had used a predatory practice, and the company received a fine. In particular, the authority attached much weight to the fact that Albion's prices to and from Eagleland were on average 20% lower than flights operated by Albion on other routes, and 10% lower than "Golden Wings" average costs. Albion has appealed to the Court of Justice, and you have to give your opinion as Advocate General.*

# 6 Solutions of exercises

**Solution of exercise 1.** (a) The incentive constraint for the incumbent is as follows. If it sticks to the strategy when entry occurs, it earns the low payoff $\pi_I^P$ today but entry will not occur forever afterwards. By deviating and accommodating entry, it would get the higher current payoff $\pi_I^A$ but then all potential entrants will enter (and will be accommodated). This trade-off is summarised by the condition $\pi_I^P + \delta\pi^M/(1-\delta) \geq \pi_I^A/(1-\delta)$, which simplifies to $\delta \geq (\pi_I^A - \pi_I^P)/(\pi^M - \pi_I^P)$.

Note that from $\pi^M > \pi_I^A$ it follows that the RHS is smaller than one, so that there always exists a discount factor large enough for this incentive constraint to hold.

As for the entrants, if the incumbent's IC is satisfied, they prefer to follow the candidate equilibrium strategy, and earn 0, rather than entering and get $\pi_E^P < 0$. As a result, entry will never occur at equilibrium.

(b) There are at least two features of the infinite horizon version of the chain store game that make it unsatisfactory. First, as all super-games, this model is characterised by multiplicity of equilibria. In particular, the game has an equilibrium where entry takes place and is accommodated forever. Just consider the following strategies. The entrant enters at the beginning of the game, and always enters as long as entry is accommodated; if entry is ever fought, no entrant will enter. The incumbent accommodates whenever entry takes place. These strategies are nothing else than the equilibrium strategies in the one-shot game, and it is easy to see that they represent an equilibrium. (We have already seen in chapter 4 that the one-shot equilibrium repeated forever is an equilibrium of the supergame.)

Second, in this model even when "predation" is an equilibrium it is never observed along the equilibrium path: entrants simply anticipate that entry would be fought, and abstain from entering the market. According to this story, one should never see any episode of predatory pricing in the real markets. Hence, this does not represent a convincing model of predation.

**Solution of exercise 2.** At the pooling equilibrium, the high cost incumbent imitates the low cost incumbent, and the potential entrant (firm 2) decides on the basis of its ex-ante beliefs, according to which the incumbent (firm 1) is a low cost one with probability $x$. Let us now check if the strategy profile and system of beliefs given above will indeed constitute a Perfect Bayesian Equilibrium.

We start with the entrant's strategy with respect to $Q$, taking firm 1's strategies and firm 2's beliefs as given. At the pooling equilibrium, the entrant will accept the incumbent's offer only if the entrant's expected payoff from entering is lower than the offer $Q$ received. If firm 2 observes a quantity choice $q_1^m \geq q_{1l}^m$ by firm 1, firm 2 will not revise its beliefs about firm 1 being low cost, and will accept the takeover if $x(\pi_{2l}^d) + (1-x)(\pi_{2h}^d) \leq Q$. If, however, firm 2 observes $q_1^m < q_{1l}^m$, it will revise its beliefs and attach probability 1 to facing a high cost incumbent, and will only accept offers $Q \geq \pi_{2h}^d$ (recall that $\pi_{2h}^d > \pi_{2l}^d$).

Let us now turn to the incumbent's strategies, taking firm 2's strategies and beliefs as given. Suppose first that firm 1 is high cost. Then, firm 1 has no incentive to make any offer $Q \neq Q^*$. Any offer $Q < Q^*$ would be rejected by firm 2, leading to lower second-period profits for firm 1 ($\pi_{1h}^d$ instead of $\pi_{1h}^m - Q^*$). Moreover, firm 1 will find it optimal to imitate the low-cost type with respect to first-period output ($q_1^m = q_{1l}^m$) if doing so yields higher profits than setting the high-cost monopoly quantity in the first period, thus revealing its true type and having to make a higher takeover offer, $Q = \pi_{2h}^d > Q^*$. We obtain **condition 1**: $\pi_{1h}^m(q_{1l}^m) - \left[x(\pi_{2l}^d) + (1-x)(\pi_{2h}^d)\right] \geq \pi_{1h}^m - \pi_{2h}^d$

If firm 1 is instead low cost, it obviously has no incentive to produce any $q_1^m \neq q_{1l}^m$. Moreover, given firm 2's beliefs, it will be optimal for firm 1 to offer $Q^*$

if taking over the rival at this cost is more profitable than offering zero and accommodating entry, which yields **condition 2**: $\pi_{1l}^{m} - \left[x(\pi_{2l}^{d}) + (1-x)(\pi_{2h}^{d})\right] \geq \pi_{1l}^{d}$

What remains to be checked is if firm 2's beliefs are consistent with the equilibrium strategy profile. Note that if conditions 1 and 2 above hold, the only first-period output observed along the equilibrium path will be $q_{1l}^{m}$, and the only takeover offer made will be $Q^{*}$. Since both high-cost and low-cost incumbents behave the same, first-period actions do not convey any information about the incumbent's type, so following Bayes' Rule the posterior beliefs will indeed coincide with the posterior ones. Off the equilibrium path, any assignment of beliefs is admissible, in particular the one chosen here (i.e. if $q_1^m < q_{1l}^m$, $x' = 0$; if $q_1^m \geq q_{1l}^m$, $x' = x$).

**Solution of exercise 3.** (a) Note that firm 2 has resources just below $2F$. Hence, if firm 1 is to make it exit the market, firm 1 just needs to inflict a loss equal to $F$ upon firm 2. Firm 2 will be left with resources slightly lower than $F$ and will have to exit since it cannot pay up-front the recurrent fixed cost. Firm 2's per-period profits are $\Pi_2 = (1 - q_2 - q_1 - c_2)q_2 - F$, and its best reply function will be given by $q_2 = (1 - q_1 - c_2)/2$. Therefore, by selling $q_1 = 1 - c_2$, firm 1 would induce firm 2 to produce zero output and incur a loss equal to $-F$.

(b) Of course, the issue is whether this is profitable for firm 1 to do. By selling $q_1 = 1 - c_2$ units at a price $p = c_2 < c_1$, firm 1 will suffer a loss $\pi_1^P = -(c_1 - c_2)(1 - c_2) - F$ but it will induce exit of the rival, and operate as a monopolist in the following period (note that firm 1's loss is never higher than $F + 1$). Therefore, it will get a payoff from predation $-(c_1 - c_2)(1 - c_2) - F + (1 - c_1)^2/4 - F$. If it accommodates entry, both firms will get duopoly profits and firm 1's total payoff will be $2[(1 - 2c_1 + c_2)^2/9 - F]$. By comparing these two payoffs and re-arranging one obtains a second-order equation which is solved for $c_1 < (1 + 22c_2)/23$ (the other root is irrelevant since it is lower than $c_2$). This is therefore the condition for predation to prevail.

**Solution of exercise 4.** Note first that $\pi(0, c) > \pi(0, 0) > \pi(c, c) > \pi(c, 0)$. (A1) and (A2) imply that firm 1 will always want to invest and never shirk. By applying the model seen in section 2.3.6 (there is only a slight variation, in that a firm is not forced to exit the market even if it decides not to invest), one can see that firm 2 is unable to raise funding if predation occurs in the first period. However, the question is whether predation is profitable for firm 1 or not. For it to be profitable, it must be that $0 + \pi(0, c) > \pi(c, c) + \pi(0, 0)$ (P1), or $\pi(0, 0) < \pi(0, c) - \pi(c, c)$. (Recall that predation gives zero first-period profit to both the predator and the prey.)

Using (A1) and (A2), we have $(1 - c)^2/9 + B < I < 1/9 - (1 - c)^2/9$. For this interval to be non-empty, we must have $c > 1 - \sqrt{1/2} \simeq 0.29$. Using this lower bound on $c$ in (A3), we can rewrite (A3) and (A4) as: $I + B \in (1/9, 1/9 + 1/18)$. Note that (P1) implies $c > 1/4$ which will always be satisfied if (A1) and (A2) hold. Hence, predation will always occur in this model.

**Solution of exercise 5.** (a) In the last stage, given investment decisions from the previous period, firms will play a Cournot game with (potentially) unequal marginal costs. Output, price and profits are given by: $q_i^C = (1 - 2c_i + c_j)/3$, $p^C = (1 + c_i + c_j)/3$, $\Pi_i^C = (1 - 2c_i + c_j)^2/9$.

In the first stage, each firm chooses its optimal level of investment, taking the other firm's investment as given. The firm's programme, $\max_{x_i} \pi_i^C = (1/9)(1 - 2(c - x_i) + (c - x_j))^2 - x_i^2$gives rise to the following reaction function: $x_i(x_j) = (2/5)(1 - c - x_j)$. The equilibrium level of investment will be $x_i^* = x_j^* = (6/21)(1 - c)$. Firm 2 will enter if net profits cover fixed cost, i.e. $\pi_2^C(x_i^*) = \Pi_2^C(x_i^*) - (x_i^*)^2 > F$, or $(5/49)(1 - c)^2 > F$. Note that under simultaneous investment decisions, there is no room for entry-deterring use of investment by the incumbent.

(b) In the last stage, given investment decisions from previous periods, firms will play the same Cournot game as in (a). Now, however, firm 2 will make its investment decision only after observing firm 1's preceding decision. Firm 2 will invest optimally when $x_2(x_1) = (2/5)(1 - c - x_1)$.

Firm 1 has now two options: it can behave "innocently", i.e. optimise its investment taking firm 2's entry as given, or it can use a "predatory" strategy, i.e. invest so much that firm 2 is discouraged from entry. Under the "innocent strategy", the incumbent's problem is: $\max_{x_1} \pi_1^C = (1/9)(1 - 2(c - x_1) + (c - x_2(x_1)))^2 - x_1^2$ which yields equilibrium solutions $x_{1inn}^* = (4/9)(1 - c)$ and $x_2(x_{1inn}^*) = (2/9)(1 - c)$. Notice the asymmetry in the investment levels, which derives from firm 1's first-mover advantage. Firm 2 will enter if $\pi_2^C(x_{1inn}^*) - F = (5/81)(1 - c)^2 - F > 0$, otherwise, entry will be blockaded, and so there is no need for firm 1 to even consider entry deterrence.

Suppose now that entry is not blockaded. Then, under the "predatory" strategy, firm 1's problem is to set $x_1$ such that firm 2's profits are driven down to zero, i.e. $x_{1pred}^*$ solves $\pi_2^C(x_1) - F = 0$. We obtain $x_{1pred}^* = 1 - c - \sqrt{5F}$. Of course, firm 1 will only want to predate if this yields higher overall profits than accommodating firm 2's entry, i.e. if $\pi_1^m\left(x_{1pred}^*\right) = (1/4)\left(1 - \left(c - x_{1pred}^*\right)\right)^2 - \left(x_{1pred}^*\right)^2 > \pi_1^C(x_{1inn}^*)$. Solving for $F$, we obtain a similar ranking as in section 3.1.1: if $F \leq (1/5)(2/3)^2\left(1 - \sqrt{2/3}\right)^2(1 - c)^2$, entry will be accommodated; if $(1/5)(2/3)^2\left(1 - \sqrt{2/3}\right)^2(1 - c)^2 < F \leq (5/81)(1 - c)^2$, entry will be deterred; if $F > (5/81)(1 - c)^2$, entry will be blockaded. Note that the first-mover advantage is crucial for firm 1: as we saw in (a), no predatory behaviour can emerge if investment decisions are taken simultaneously.

**Solution of exercise 6.** (i) At time $T + 1$, suppose firm 1 has entered market B in the previous period. By entering as well, firm 2 would make losses: price competition with homogenous goods implies zero gross profit, that would not allow it to recoup the fixed cost $F$. Therefore, firm 2 would not enter. Firm 1 will make monopoly profits in each market, $\pi = 1/4$ (the monopoly price is found as the price that maximises the profit in each market, $\pi = p(1-p)$: from $d\pi/dp = 0$, it follows $p = 1/2$ and $\pi = 1/4$). Therefore, total profits will be $\pi = 1/2$.

If firm 1 has not entered market B, and firm 2 entered, it will make monopoly profit $\pi = 1/4 - F$ in that market. This is because firm 1 will set the monopoly price in its own market (since it cannot price discriminate and it has to incur an additional cost to serve market B, it does not have any incentive to set a price lower than the monopoly price in market A). Therefore, firm 1 will have profits $\pi = 1/4$.

At period $T$ , firm 1 will enter since it anticipates that this deters entry, thus giving it higher profits. By entering, it will gain $\pi = 1/2 - F$. By not entering, it will make $\pi = 1/4 < 1/2 - F$ (recall that $F < 1/4$).

(ii) In the previous point (i), firm 1's investment deters entry by firm 2. The issue here is what happens if firm 2 decided to enter the market nevertheless. Price competition would lead to an equilibrium price $p = 0$ in market B. But this implies that firm 1 will not be able to sustain the monopoly price in market A: consumers there can import the good by paying $t < 1/2$. Therefore, firm 1 will set its price in market A so as to be slightly lower than $t$ and make profits $t(1-t)$.

If it closed down its plant in market B, it would relax competition in market B (where firm 2 would become a monopolist) and be able to set the monopoly profits in market A, thus earning 1/4. It is easy to see that $1/4 > t(1-t)$ can be rewritten as $(1-2t)^2 > 0$, which holds true.

Anticipating that by entering market B, firm 1 would prefer to withdraw from it had it invested there, firm 2 will always enter. In turn, firm 1 will anticipate this and not enter market B in period $T$, to save its fixed costs.

**Solution of exercise 7.** (a) As in the text, under price discrimination, firm 1 sets $p_A^d = (1+t)/2$, and $p_B^d = T$. Its total profits are $\pi^d = (1-t)^2/4 + (T-t)(1-T)$.

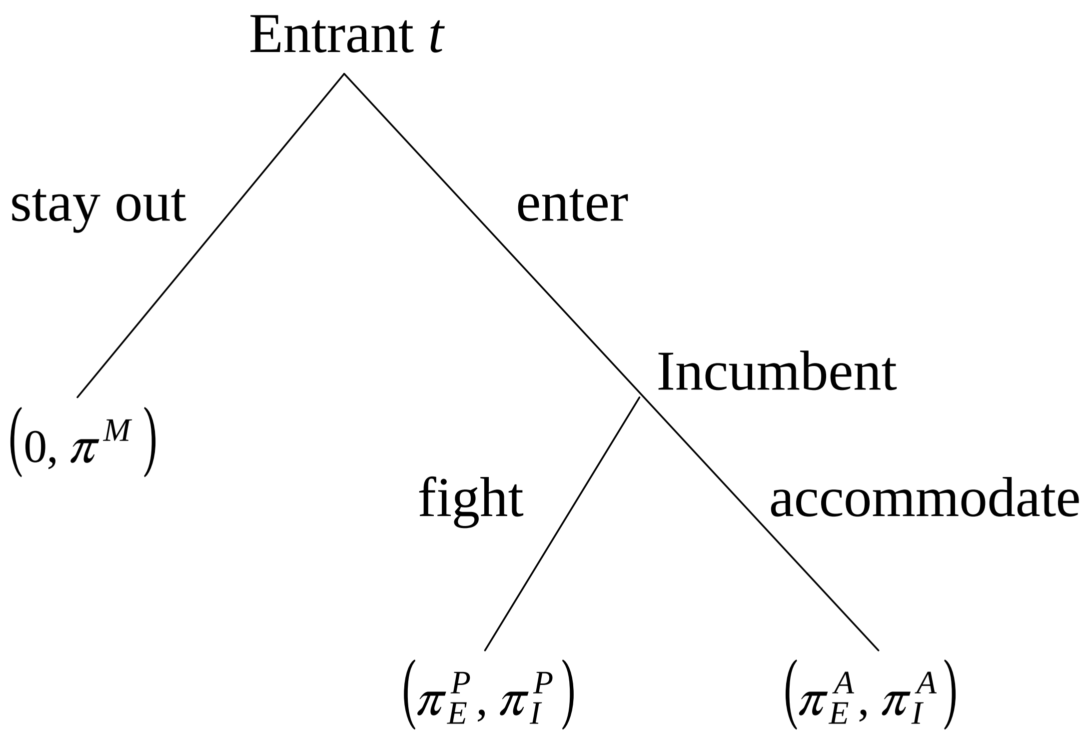
(b) Under uniform pricing, as in the text, if the incumbent serves both markets, $p_A^u = p_B^u = T$, and it makes profits $\pi^u = 2(T-t)(1-T)$. If it serves only market A, it sets prices in both markets equal to $p^m = (1+t)/2$. It would then make total profits $\pi^m = (1-t)^2/4$. The difference with respect to the case treated in section 4.2.5 is that Bertrand competition among foreign firms ensures that the price in market B will not rise above $T$.

(c) We know that if both cities are served, welfare is higher if there is a ban on price discrimination. However, if only one city is served when a ban on discrimination exists, the two regimes are equivalent for consumer surplus, since they lead to the same prices $(1+t)/2$ in market A and $T$ in market B. However, firm 1 makes positive profits in market B under discrimination, and no profits under a ban.

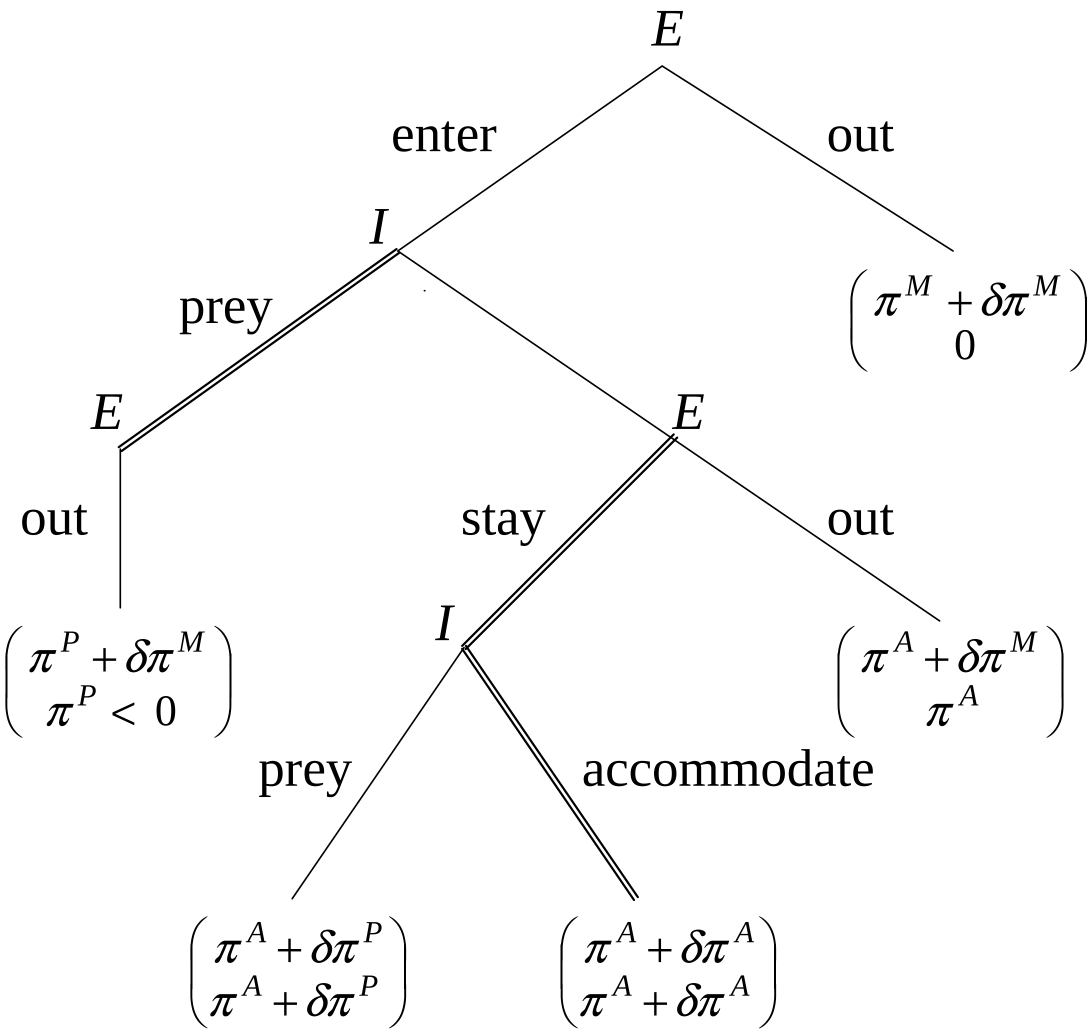
**Solution of exercise 8.** Game 1. As usual, we have to move backwards. The solution of the second stage is given in section 4.2.1. In the first stage, the monopolist chooses $x$ to maximise the net profits under uniform pricing, $\pi^u = (\lambda v_l + (1-\lambda)v_h - c)^2/4 - \mu x^2/2$, with $c = A - x$. Maximisation requires $d\pi^u/dx = (\lambda v_l + (1-\lambda)v_h - A + x)/2 - \mu x = 0$.

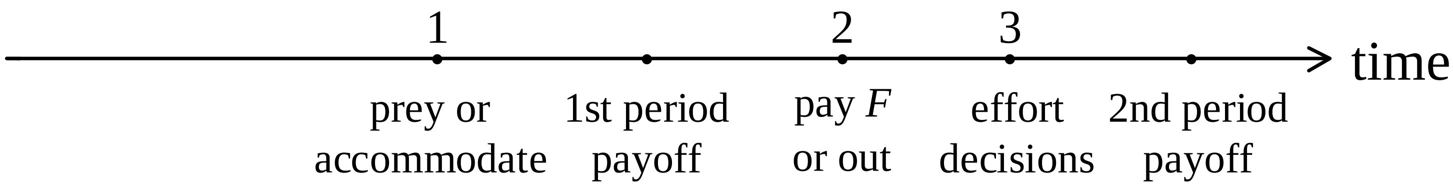
Game 2. The solution of the second-stage is given by section 4.2.2. In the first stage, the monopolist's programme is $\max_x \pi^{qd} = (1/2)\left[(v_l - A + x)^2 + (1-\lambda)^2(v_h - v_l)^2\right]$. The first-order condition is $d\pi^{qd}/dx = (v_l - A + x) - \mu x = 0$.

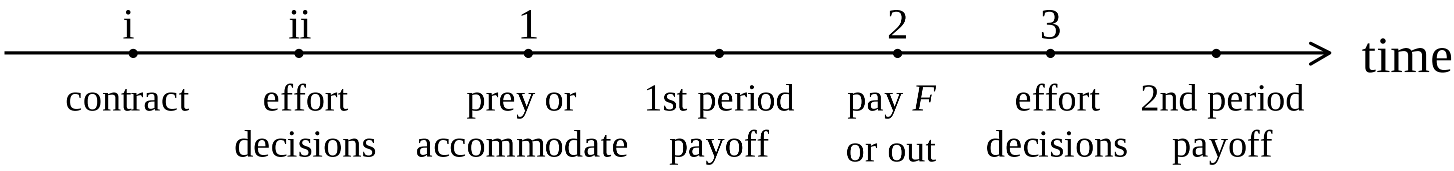
Comparison of the equilibrium investment levels does not require finding the explicit solution. Just note that the marginal cost of the investment, $\mu x$, is the same in both games, but that the marginal revenue is higher under game 2: $(v_l - A + x) > (\lambda v_l + (1-\lambda)v_h - A + x)/2$, since $v_l > [A + (1-\lambda)v_h]/(2-\lambda)$. Therefore, $x$ will be higher under quantity discounts (that is, two-part tariffs).

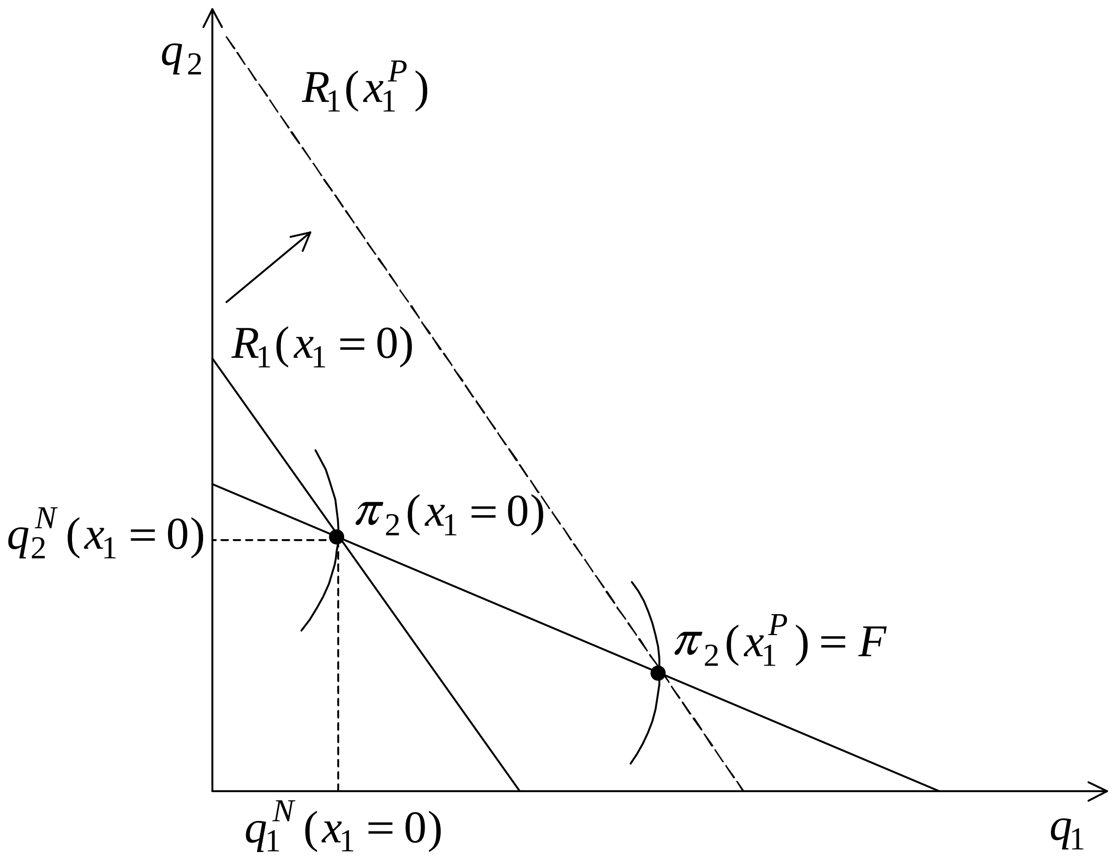


Entrant $t$
stay out
enter
Incumbent
$(0, \pi^M)$
fight
accommodate
$(\pi_E^P, \pi_I^P)$
$(\pi_E^A, \pi_I^A)$

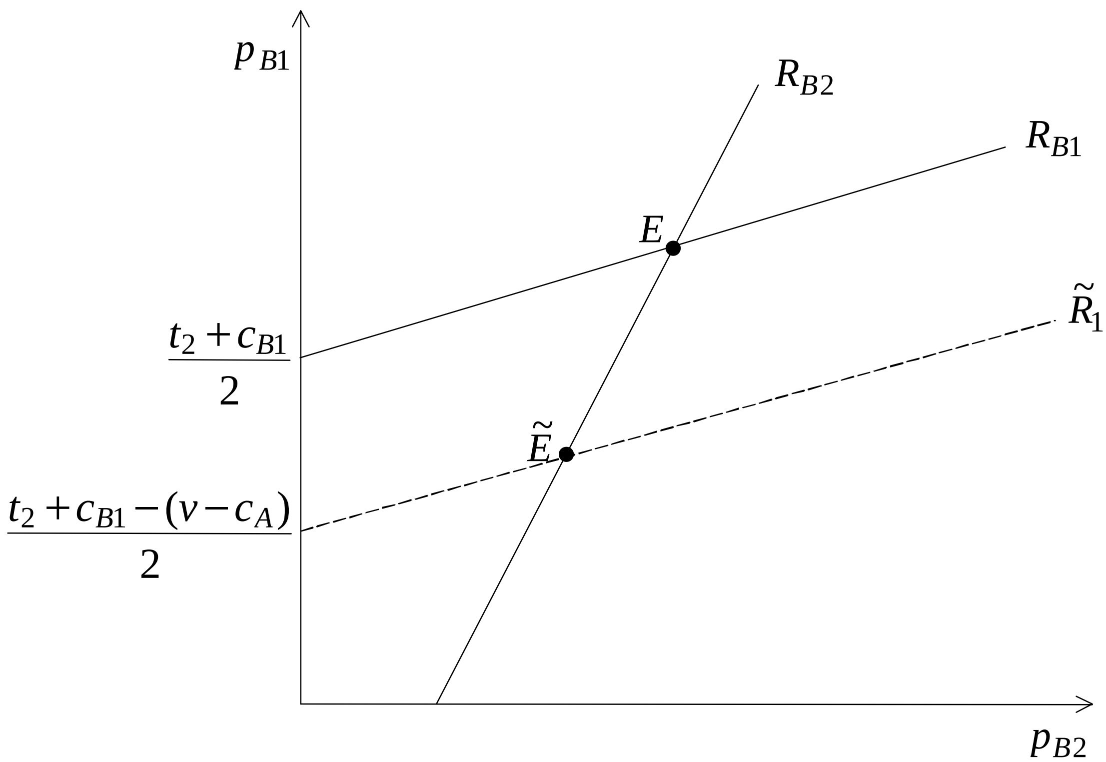

E
enter
out
I
prey
E
E
out
stay
out
I
prey
accommodate
$\pi^M + \delta\pi^M$, $0$
$\pi^P + \delta\pi^M$, $\pi^P < 0$
$\pi^A + \delta\pi^M$, $\pi^A$
$\pi^A + \delta\pi^P$, $\pi^A + \delta\pi^P$
$\pi^A + \delta\pi^A$, $\pi^A + \delta\pi^A$


1
2
3
time
prey or accommodate
1st period payoff
pay $F$ or out
effort decisions
2nd period payoff

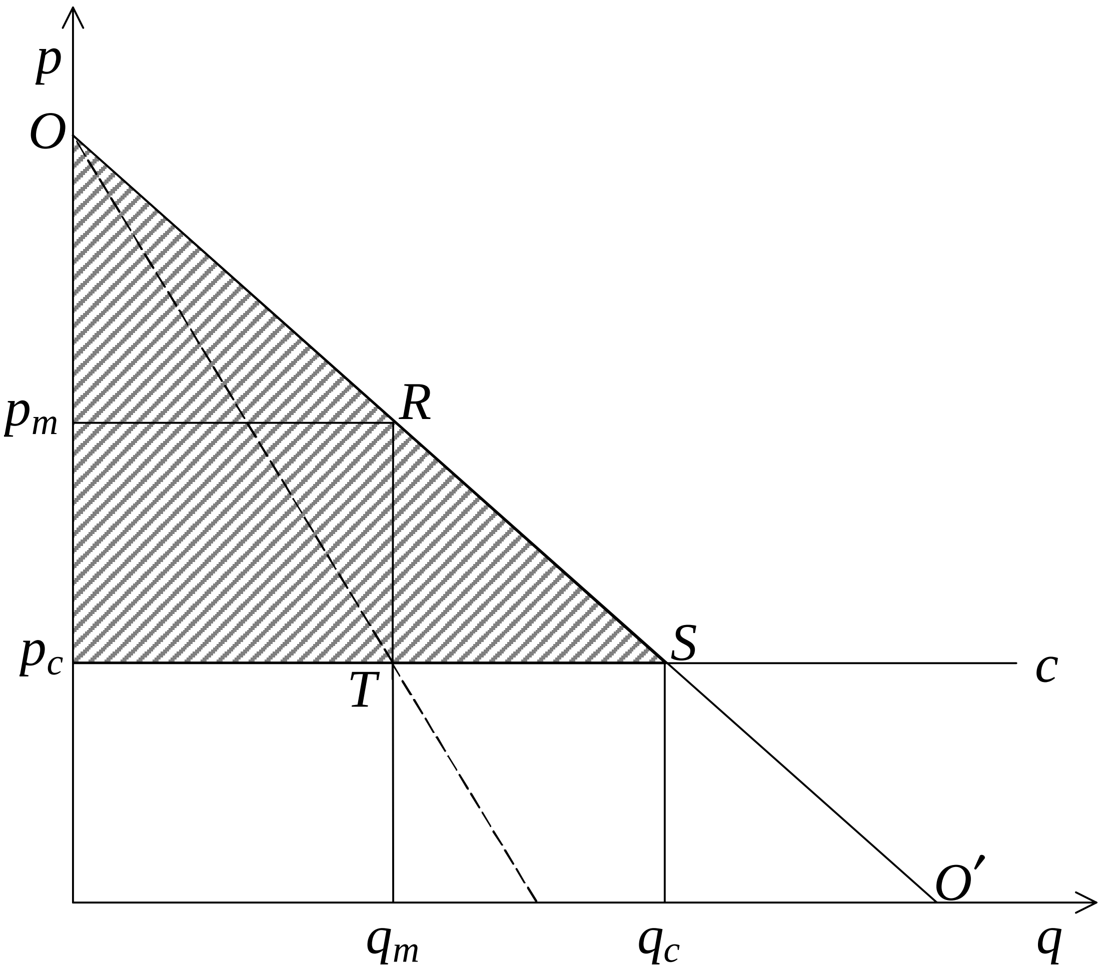

i
ii
1
2
3
time
contract
effort decisions
prey or accommodate
1st period payoff
pay F or out
effort decisions
2nd period payoff



$q_2$
$R_1(x_1^P)$
$R_1(x_1 = 0)$
$\pi_2(x_1 = 0)$
$q_2^N(x_1 = 0)$
$\pi_2(x_1^P) = F$
$q_1^N(x_1 = 0)$
$q_1$



$p_{B1}$
$R_{B2}$
$R_{B1}$
$E$
$\tilde{R}_1$
$\frac{t_2 + c_{B1}}{2}$
$\tilde{E}$
$\frac{t_2 + c_{B1} - (v - c_A)}{2}$
$p_{B2}$



p
O
p
m
R
p
c
S
c
T
O′
q
m
q
c
q