CHAPTER 4
ENTRY BARRIERS AND TRADEABLE EMISSION PERMITS II

In the former chapter three types of entry barriers have been identified which might occur when a system of tradeable permits is introduced. The consequences of transaction costs on the permit market for entry have been discussed in the context of the limit pricing model. In this chapter the two other types of entry barrier are investigated. In section 1 the consequences of imperfect capital markets and grandfathering for entry barriers are discussed. In section 2 exclusionary manipulation with tradeable permits is examined. The practical consequences for the system of tradeable carbon permits discussed in chapter 2 are determined for both types of entry barriers.

4.1 TRADEABLE PERMITS AND THE LONG PURSE THEORY.

It has been argued in the former chapter that potential entrants are not necessarily put at a disadvantage when they have to buy permits while established firms get them for free. The incumbents have to take into account the opportunity costs of using their grandfathered permits and therefore they do not have a cost advantage over the entrants. However, in reality markets do not always work perfectly. In this section the focus is on the capital market. It will be considered whether the difference between incumbents and potential entrants with regard to grandfathering has consequences for the entry barriers when capital markets do not function perfectly. First the long purse theory, which is based on imperfect capital markets, is discussed (section 1.1). Subsequently the theory is applied to tradeable emission permits (section 1.2). In the last section some empirical evidence on imperfect capital markets is discussed (section 1.3).
4.1.1 **History of the Long Purse Theory.**

The analysis of the relation between imperfect capital markets and entry barriers is part of the literature on predatory pricing. Predatory pricing is a pricing strategy used by a firm (the predator) to force its rival (the prey) out of the market and/or to deter potential entrants. The general definition of predatory pricing is: *predatory pricing behaviour involves a reduction of price in the short run so as to drive competing firms out of the market or to discourage entry of new firms in an effort to gain larger profits via higher prices in the long run than would have been earned if the price reduction had not occurred.* (Tirole 1992, p.373).

There are three types of predatory pricing: signalling predation, predation for reputation and long purse predation (Ordover and Saloner 1989, p. 546). Signalling predation is used by predators when they possess information the potential entrant does not have (asymmetric information), for example on the predators costs or market demand. The price the predator sets provides the prey with information on the market conditions. Presumably, the predator wants to convey bad news to the potential entrant in order to discourage him from entering the industry. Setting a low price might indicate that demand is slack or that the predator has low costs and therefore entering would not be profitable.

Firms predate for reputation when they do not only want to drive out a firm which has just entered but when they also want to show by preying on the first entrant that they will fight all subsequent potential entrants. Fighting the first firm which enters has the added benefit (apart from driving it out) that potential other entrants will be deterred as well. This form of predation is also based on asymmetric information: the potential entrants do not know a priori whether the incumbent will want to fight or whether he prefers to accommodate.

For our analysis in section 1.2 the relevant variant of predatory pricing is the long purse theory. Therefore we shall discuss its development more extensively. According to the long purse theory, predators who have larger financial resources than their prey will start a price war which in the end will financially exhaust their prey. Although the price war will initially diminish profits for the predator as well, it will be attractive for the predator to predate if the monopoly profits he expects to earn after the prey has left
outweigh his price war losses. Because of his larger financial means he can outlast the prey: when the prey goes bankrupt the incumbent is still solvent.

The long purse theory has initially been quite popular. One of the earlier references is from Edwards (1955) who wrote: "An enterprise that is big in this sense obtains from its bigness a special kind of power, based upon the fact that it can spend money in large amounts. If such a concern finds itself matching expenditures or losses, dollar for dollar, with a substantial larger firm, the length of its purse assures it of a victory". Given that the (monopoly) profits the incumbent will enjoy after the prey has left the market outweigh the losses he has to sustain during his fight, predation will be an attractive strategy for the incumbent. It should be noted however that even if predation is profitable, it is not necessarily the most attractive strategy available to the predator (McGee 1958). For example, advertising or exclusionary manipulation are strategies that might have the same effect on the prey but which come at a lesser cost.

Apart from McGee’s observation, two other reservations have been voiced. One criticism that has been made first by Telser (1966) and subsequently by Benoit (1984) is that if long purse predation would be successful the entrant would not enter at all. Assuming complete information, the entrant can foresee that the incumbent will start a price war and that somewhere in the future he will have to leave the market because he has run out of resources. Consequently he would prefer not to suffer the losses of the price war during the time he is in the market because he will not be able to compensate them. He can avoid these losses quite easily by staying out and using his initial resources for a more profitable enterprise. Given that long purse predation is an attractive strategy for the incumbent the entrant will stay out and therefore long purse predation will not occur. The theory of the long purse is in this sense too successful because it predicts that long purse predation will never take place in practice. However, it demonstrates that "having a long purse may provide a credible threat of post-entry predation and thus could deter entry" (Ordover and Saloner 1989, p. 548).

Benoit (1984) has shown that the criticism that long purse predation will never occur follows from the assumption that both firms have perfect information. This however is a strong assumption. Benoit assumed that instead of possessing perfect information, the incumbent does not know whether the entrant is financially constrained or not. He showed that in that case it is possible that a firm will enter and
that subsequently he will be driven out through long purse predation.

Another criticism of the long purse theory is that it is not clear why the potential entrant should be financially constrained. Apparently, if he had enough credit available he would stay in the market because he would in the end be able to make a profit (otherwise he would not enter at all). Therefore it should be in the interest of his creditors to extend more credit facilities so as to make it possible for him to outlive the price war. Presumably, there is no reason why firms should be financially constrained and because the "long purse story lacked theoretical foundations, it slowly fell from grace." (Tirole 1992, p. 377).

However, nowadays there is some justification for the theory. First of all there is evidence that in reality there might exist something like a financial constraint. This evidence stems from the study of the capital structure of enterprises. In order to explain how firms decide on the optimal levels of debt and equity, several theories have been formulated. One of these theories is the pecking order theory. Basically, this theory states that when firms need funds in order to finance new investments, they have a strong hierarchy of preferences for types of finance. They prefer to use internal finance as far as possible. If there are not enough internal funds available and they have to turn to external financing, they will first borrow, subsequently use convertible bonds or likewise hybrid securities and if none of these is possible they will issue equity (Myers 1984, p. 581). The aggregate figures seem to support this theory. Myers notes that in the decade of 1973-1982, capital expenditures of non-financial corporations in the U.S. where covered on average for 62 percent by internally generated cash. Of the external financing the largest part was debt; only 6 percent of the external financing was raised by issuing new stock. While this does not provide an explanation of the financial constraint in the long purse theory, it does indicate that financial constraints might exist.¹

¹ Whether the pecking order supports the financial constraint of the long purse theory or not depends on its rationale. One of the reasons why firms might prefer internal funding is that external financing is more expensive because of administration and underwriting costs. However, these costs seem not to be so large as to warrant the preference for internal funding (Myers 1984, p. 582). Another explanation relies on asymmetric information. Myers and Majluf assume (1) that managers have more information about the benefits of an investment project than potential investors and (2) that it is their objective to increase the intrinsic value of the shares of the "old" shareholders. They conclude that given these assumptions profitable projects which would be undertaken when firms can use internal funding might not be
Other support for the existence of financial constraints is found in recent work on capital markets and asymmetric information. Gale and Hellwig (1985) have studied the question "what is the firm’s budget constraint?" (p. 647). More specifically, they want to find out what the optimal debt contract is and whether credit rationing does appear. The model they study assumes that a firm has a project which yields a revenue which depends on the level of investment and the unknown state of the world. The firm does not have the necessary funds himself so it has to borrow money from an investor. At the time of investment, neither of them knows what the state of the world will be. When the investments matures, the firm will observe his returns but the investor does not know them (this is the asymmetric information). As long as the firm fulfils its contract and pays the debt, the investor has no reason to find out how large the returns are. But if the firm does not pay its debt, the investor will have him declared bankrupt. In that case the worth of the firm is investigated and the scrap value of the firm is distributed among its creditors. The investor will have to bear the costs of bankruptcy. Gale and Hellwig conclude that the optimal contract for the investor for lending money is the standard debt contract. The firm pays a fixed interest on his debt; when it cannot pay the interest, the investor will investigate the state of the world, that is he will have the firm declared bankrupt. Another conclusion which Gale and Hellwig draw is that under asymmetric information credit is constrained compared with the first-best level of investment, that is the amount of money which would be supplied if there was no asymmetric information.

The last, and for our analysis important point is that "the lack of liquidity [...] lies at the root of the credit-rationing problem because, if the firm’s net wealth were large enough to finance the first-best investment, the firm would obviously choose that level of investment" (Gale and Hellwig 1985, p.648). If a firm’s own capital suffices to finance an investment, it does not have to borrow and credit-rationing would not occur.

Tirole and Fudenberg (1985) have used the approach of Gale and Hellwig and they have shown how credit rationing might make it profitable for a predator to embark undertaken when they have to be financed by external funds because of the asymmetric information between the managers and the investors. Also, debt is preferred over new issue of equity. According to this explanation of the pecking order theory, there is not necessarily a financial constraint for the firm. Firms prefer internal funds but they would use external if they had to.
upon a price war against his prey and drive him out of the market. In their two-period model, they assume that at the start of the second period the entrant has to invest a certain amount of capital if he wants to stay in the market. The sum which the entrant can borrow is limited by his own capital, as will be shown below. The own capital resources of the entrant are his retained earnings from the first period. The incumbent can reduce this retained earnings by embarking on a price war which decreases the profits of both firms. The lower the retained earnings of the entrant are, the larger is the additional capital to be borrowed (at higher cost). Consequently, the chance that borrowing additional capital to invest is unattractive increases. Therefore it is more likely that the entrant will find it unprofitable to stay in the market.

This long purse theory is based on two assumptions. First, there exists an asymmetry between the incumbent and the entrant because the latter does have to invest if he wants to continue in the market while the former can stay without investing. Second, external financing is limited (the financial constraint). We will look at this assumption and its consequences in more detail (the approach and notation is adopted from Tirole 1992, page 378). In section 1.2 the theory will be applied to investments in tradeable permits.

Suppose a firm wants to invest in a project which it needs to finance partly by borrowing. The gross profit (the total value of the firm after the project has finished) which the project will yield, $\pi$, falls within an interval $[\pi_L, \pi_H]$. The total investment is $K$, the amount of capital to be borrowed is $D$. As long as the profit made is larger than the debt and interest, the firm will not default on the loan and repay the bank who has lend the money. The firm earns a profit of $\pi - (1+r)D$. However, when the firm earns less than $(1+r)D$, it can not repay the loan and it will go bankrupt. The bankruptcy involves costs like the cost of appointing retainers and the probable losses which occur when the firms assets have to be sold. The firms retain nothing, the creditor gets $\pi - B$; $B$ are the bankruptcy costs.

Let the random profit $\pi$ be distributed with a density $f(\pi)$ on the interval $[\pi_L, \pi_H]$.

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2 It should be realised that this assumption makes the model less general: if the incumbent would have to reinvest as well, the price war would not be attractive. Presumably, this asymmetric investment requirement is part of the first mover advantage of the incumbent.
The expected value of the profit in case \( \pi \) is less than \((1+r)D\) is denoted \( \pi^d \) (defaulted). The probability that \( \pi \) is smaller than \((1+r)D\) is denoted \((1-F)\). The expected value of \( \pi \) in case \( \pi \) is above \((1+r)D\) is denoted \( \pi^r \) (repayed), the probability that \( \pi \) is above \((1+r)D\) is \( F \). The expected profit of the bank (the creditor), \( \pi_B \), consists of the repayment of the loan and interest times the probability that the firms profit is above \((1+r)D\) and \( \pi - B \) times the probability that its profit is below \((1+r)D\):

\[
E(\pi_B) = (1+r)D\cdot F + (\pi^d-B)(1-F) \tag{4.1}
\]

If we assume that the capital market is competitive, the net profits of the banks (after deduction of its capital costs which are \( r_0 \)) will be zero:

\[
E(\pi_B) = (1+r_0)D \tag{4.2}
\]

Equation 4.1 and 4.2 define an interest rate \( r \) which is larger than \( r_0 \) because the bank faces the risk that the firm defaults on the debt\(^4\). We will assume that there exists a rate \( r \) at which the bank wants to extend the loan. It is not necessarily the case that it is profitable for the bank to extend a loan. The debt \( D \) might be too high with respect to the expected profits and the level of the bankruptcy costs. While a higher \( r \) might seem to compensate the bank for a higher default risk, it should be realised that a higher \( r \) also increases the probability of bankruptcy. The derivative of the expected profit of the bank would in that case decrease in \( r \).

The expected profit of the firm is equal to the profit he earns minus the repayment of the loan and interest times the probability that the profit is above \((1+r)D\) and the profit he gets when he has to default, which is zero. His net expected profits \( E(\pi_i) \) are equal to his gross profits minus the opportunity costs of the capital he has invested

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3 \( r_0 \) is the capital cost for the bank. Or in other words, it is the interest rate charged in the absence of risk.

4 Combining equations 5.1 and 5.2 yields: \((1+r)D + (\pi^d-B)(1-F) = (1+r_0)D\). Rewriting yields: 
\( r = r_0 + (\pi^d-B)(1-F)/D \). An increase in the chance that the firm will default (represented by decrease in \( F \)) increases the margin between \( r \) and \( r_0 \), between the interest which the firm has to pay and the no-risk market interest.
himself, \((1+r_0)(K-D)\):

\[
E(\pi_i) = (\pi^r - (1+r)D) F - (1+r_0)(K-D)
\]

4.3

The firm’s expected net profit, equation 4.3, can also be written as the total expected retained earnings from the project, denoted \(\pi^r\), minus the opportunity costs of the firm’s own capital, minus the expected bankruptcy costs (the bankruptcy costs times the probability that the firm goes bankrupt):\(^5\)

\[
E(\pi_i) = \pi^r - [B(1-F)] - (1+r_0)(K)
\]

4.4

When the firm has less own capital and therefore has to borrow more, its expected profits will decrease:

\[
dE(\pi_i)/dD = - d[B(1-F)]/dD < 0
\]

4.5

Equation 4.5 is negative because \((1-F)\), the chance that the firm will go bankrupt, increases when the amount borrowed increases: the creditor will charge a higher interest and the debt increases, therefore \((1+r)D\) increases and therefore the chance that the expected profits at least equals \((1+r)D\) declines. An increase in the amount of capital the firm borrows increases the interest \(r\) the bank will charge and the probability that the firm goes bankrupt. Therefore, the chance that the project yields a positive net profit to the firm decreases. In other words, the smaller the amount of own capital of the firm, the smaller is the probability that the project is worthwhile for the firm. Or, as has been noted above, the smaller the amount of own capital the larger the probability that banks do not want to extend a loan. Lack of (internal) funds can therefore restrict firms in the projects they undertake.

The foregoing analysis has consequences for entry barriers when there is a difference between incumbent firms and entrants in that entrants are more depended

\(^5\) This is achieved by including into equation 5.3 the zero-profit condition for the bank:

\[
(1+r)D - (\pi^r - B)(1-F) - (1+r_0)D = 0.\]

The total expected retained earnings from the project are:

\[
\pi^r = \pi^r F + \pi^d (1-F).
\]
on borrowed money than incumbents. Consequently the incumbent can engage the entrant in a price war and drive him out of the market; the entrant has smaller financial resources and therefore he cannot endure a price war as long as the incumbent. Borrowing money does not help because the costs of lending money are higher for the entrant with his smaller resources than they would be for the incumbent.

In the next section this financial constraint theory will be adapted and applied to the problem of tradeable emission permits. It will be shown how the introduction of a system of tradeable emission permits can create differences in access to internal and external (debt) finance, increases the likelihood of predation and thereby raises entry barriers.

4.1.2 Predation and Grandfathering

In the former section, it has been shown that in case firms are constrained in the amount of capital they can borrow their propensity to invest will be smaller. In this section, this theory will be used in a simple game-theoretic model in order to illustrate how introducing tradeable permits with grandfathering might make it more attractive to use predatory pricing in order to drive entrants out (or to deter entry). The model used is an application to tradeable permits of work done by Benoit (1984) and of the financial constraint theory of Fudenberg and Tirole (1985) described in the former section.

Two different situations are discerned. As has been described in chapter 2, a tradeable permit can be defined as a permit which gives a polluter the right to emit 1 ton of a certain pollutant. Each year, authorities can grandfather a number of permits to established firms. The entitlement to such a number of future grandfathered permits can be termed a quota. Firms can sell (and buy) both quota and permits. Buying a permit means that a firm acquires the right to emit one ton, once. Buying a quota means that a firm buys the right to receive a number of free permits each year. Buying permits might therefore be looked at as leasing a quota instead of buying it. In the first variant of the game considered below, the entrant leases quota in each period (he only buys the permits he needs for each period). In the second variant, the entrant buys a
quota which provides him with all the permits he will need in the subsequent periods.

In addition to considering tradeable permits, the potential for impeding entry under a system of TDP’s with grandfathering will be compared with the effect standards and emission charges will have on entry barriers.

*Leasing a quota*

The game considered here is a repeated game. The game consists of two firms, an incumbent (firm i) who initially has a monopoly and a potential entrant (firm e). At the beginning of the first game, the entrant decides whether he enters or not. Subsequently, in each stage game the incumbent first decides whether he will fight the entrant or whether he will accommodate him. After this decision of the incumbent, the entrant decides whether he will stay or whether he will leave the industry. The game is a dynamic game with perfect and complete information.

A central assumption of the model is that at the beginning of each stage game, including the first one, both firms have to invest (for example, in capital goods) in order to be able to produce and stay in the market. It is assumed that the investment can be undertaken after the firm has decided to stay (or leave). In order to be able to make these investments, the firm can either use retained earnings from the former period of the game, or he can lend funds on the capital market. However, the capital market does not work perfectly; a firm is constrained in the amount it can borrow by his own wealth as has been described in the former section. Therefore, the lower the retained earnings of a firm in an earlier period, the higher is the fraction of capital for investment he has to borrow in this period and the larger will be the probability that the investment (entry) will not be undertaken since expected net profits are negative, or because creditors do not want to extend a loan. Consequently, it is forced out of the market. At the end of each stage game, firms who have borrowed money must repay their debt and the interest over that period out of their retained earnings (or go bankrupt).

Apart from investing in capital, firms also need a given amount of emission
permits in each period in order to be able to produce. We will assume that the amount of permits grandfathered has value G and that it covers exactly the amount of permits needed for one period (this assumption can be made without loss of generality). Let K be the investment which both firms have to make at the beginning of each period excluding the purchase costs of pollution permits. In addition they have to invest in the permits, therefore the total investment for both firms is K + G. It is assumed here that both firms, the incumbent and the entrant, are equal in all respects except with regard to the emission permits. It is assumed that in case no permits were required both firms start with the same amount of own capital, which by assumption is equal to K, the amount of investment needed to start in the market. The incumbent receives permits for free (in all periods) and the entrant has to buy them. The free gift of the permits to the incumbent constitutes an increase in its own capital of G.

As a result of these assumptions the entrant will have to borrow G at the start of the first period because it has to acquire permits worth G. The incumbent does not need to borrow any capital because it has been grandfathered the permits it needs. This means that the entrant will face higher costs than the incumbent because of the costs of borrowing money on the imperfectly working capital market. His expenditure on permits plus interest costs exceeds the opportunity costs which the permits have for the incumbent.

The actions both players take determine the level of profits they will earn. Furthermore, it is assumed that the profits are also influenced by some random variable. One might for example think of this random variable as representing the level of economic growth, inflation or other macro-economic variables which have an effect on demand in individual product markets. Consequently, the profits which firms can

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6 In reality, firms will normally have the choice between either buying permits or reducing their emissions. It is assumed that the amount of permits needed represents the least cost solution for both firms, given the (exogenously determined) price of the permits. The entrant does not need to buy permits but as this is the least cost solution, this is the most attractive option.

7 It should be noted that it does not necessarily matter how large the initial amount of money is. The crucial element is that both firms start equally, the only difference between the firms is the difference in treatment under the tradeable permit scheme. Assuming that both firms start with K own capital is attractive from the point of view of comparing it with a situation in which no permits are needed.
make, given the actions they take, are assumed to be random in an interval $[\pi_l, \pi_H]$ with density $f$. The different profits given in table 4.1 below should therefore be thought of as being the expected profits of the specific actions chosen, given the probability distribution $f$. For example, let the actions be fight and stay. The expected profit in the case of fight is $\pi^F$ which is the expected profit based on a random profit in interval $[\pi^F_L, \pi^F_H]$ which has density $f$. The same reasoning applies to the other expected profits, $\pi^A$, $\pi^{F'}$ and $\pi^M$. It is assumed that all the different profits have the same density function $f$ in their different intervals. In other words, the random variable which influences profits apart from the actions the players take is independent of the strategies chosen by the players.

Table 4.1 shows the pay-offs (in gross retained earnings) of the different actions both firms can take each period (the so-called extensive form of the game). The first profit between brackets is the profit which the incumbent will make, given the actions chosen by both firms, the second is the profit of the entrant.

### Table 4.1: pay-off matrix

<table>
<thead>
<tr>
<th>entrant</th>
<th>incumbent</th>
<th>Fight</th>
<th>Accommodate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay</td>
<td>$(\pi^F, \pi^F)$</td>
<td>$(\pi^A, \pi^A)$</td>
<td></td>
</tr>
<tr>
<td>Leave</td>
<td>$(\pi^F, 0)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When the incumbent chooses to fight and the entrant stays in the market, there will be a price war and both firms will earn $\pi^F$. We will assume that these (expected) earnings cover the investment in production capital (exclusive of the permits) both firms have to make in order to stay in the market in the next period: $\pi^F = K$. While these gross expected retained earnings are positive, the net expected profit in this price war is negative, both for the incumbent and for the entrant.\(^8\)

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\(^8\) This is not necessarily the only way in which the effects of a price war can be modelled. For example, one could imagine that a price war reduces profits even further such that both firms would have to borrow. This does not basically alter the game; the crucial point is that the entrant has less resources because he has not received permits for free. Consequently his
When the entrant leaves, the expected profit of the incumbent is $\pi^F$. In the subsequent periods, when the entrant stays out of the market, the incumbent makes monopoly profits $\pi^M$. It is assumed that (for both firms):

$$\pi^M > \pi^A > \pi^{F'} > \pi^F$$ \hspace{1cm} 4.6

We will assume that when the incumbent has the choice between fighting and driving out the entrant in the first period and accommodating the entrant for ever, he will choose to fight. That is, the incumbent can make larger profits by fighting one period and subsequently enjoying monopoly profits than by cooperating in this period and all following periods. Formally:

$$\pi^{F'} + \sum_{t=1}^{\infty} \frac{\pi^M}{(1+r_0)^t} > \sum_{t=0}^{\infty} \frac{\pi^A}{(1+r_0)^t}$$ \hspace{1cm} 4.7

The last assumption made is that initially, at the start of the first period, the entrant prefers to enter if he would be accommodated by the incumbent. The expected gross profits $\pi^A$ are such that, given the amount of capital $K$ and the amount of money he has to borrow in order to buy permits with value $G$, his expected net profits are positive:

$$\pi^A - (1+r)G - (1+r_0)K > 0$$ \hspace{1cm} 4.8

If this would not be the case, the entrant would not find it attractive to enter and he would stay out. Condition 4.8 states that the expected net benefits of entering are positive when the incumbent chooses to accommodate the entrant. The entrant’s gross profits minus the repayment of his debt, which is equal to the value of the permits he has to buy, $G$, plus interest, are equal to or larger than the opportunity costs of his capital $K$.

Having described the game, we can proceed with the analysis of the equilibrium.

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capital costs are higher.
Suppose the incumbent chooses to fight. The expected gross earnings are $\pi^F$ for both firms. The expected net profit of the incumbent is:

$$\pi^F_i = \pi^F - (1+r_0)(K+G)$$  \hspace{1cm} 4.9$$

It was assumed that $\pi^F = K$, therefore the net expected profits of the incumbent are negative when both firms fight each other in the first period. They are negative because the firm does not earn enough to cover the opportunity costs of his investment $K + G$ (his total own capital: initial wealth plus the permits he received for free). The expected net profit of the entrant after the first period is (the reader is referred to the former section for the derivation of the net profit of a firm which has to borrow on imperfect capital markets (equation 4.4)):

$$\pi^F_e = \pi^F - (1+r_0)(K+G) - B(1-F)$$  \hspace{1cm} 4.10$$

$(1-F)$ is the chance that the gross expected profit $\pi^F$ is smaller than $(1+r)G$, in which case the firm cannot repay his debt and goes bankrupt. B are the bankruptcy costs. The net expected profit of the entrant is lower than the net profit of the incumbent by $B(1-F)$. The entrant has to lend money on the (imperfect) capital market to buy permits and therefore he incurs extra costs compared with the incumbent.

More important than the net profits are the cash flows of the firms because these have consequences for the next stage game. As has been described above, in order to be able to produce each firm has to invest before the start of each period (to be able to produce in that period). This investment consists of the capital investment $K$ and the permits needed for production $G$. The incumbent receives his permits by grandfathering. His retained earnings, which (in the case of fight) are equal to his gross profit $\pi^F$, are $K$. Therefore he can invest in production capital $K$ without having to borrow money. He receives the permits which he needs in the next period for free.

The entrant, however, is in a different situation. From his retained earnings, $\pi^F$, he has at first to pay off his debt to the bank. This debt is $(1+r)G$, therefore he has only left $K - (1+r)G$. The capital he needs for his investment in order to have production capacity for the next period consists of the investment capital $K$ and the permits he
needs in the next period which have value G. Consequently, he has to borrow again. The amount he has to borrow is:

\[ K + G - [K-(1+r)G] = (1+1+r)G \]  

4.11

The amount the entrant has to borrow rises with \((1+r)G\) as compared with the amount he borrowed at the start of the first period.

As the game continues, the entrant will have to borrow more and more as long as the incumbent plays 'Fight'\(^9\). Eventually, a point is reached at which either the project is not attractive any more to the entrant, because his net expected profits when accommodated fall below zero, or because the bank does not want to provide a loan any more (see page 37). At this point (which we will call period N), the entrant will therefore play 'Leave’ and exit the market. The strategy of fighting is therefore an attractive strategy for the incumbent in period N because he will drive out the entrant and he can subsequently enjoy monopoly profits.

In period N-1, fighting will also be attractive for the incumbent. If the entrant would choose to stay in the market, the next period game would be a stage game in which he would have to leave. However, choosing strategy 'Leave’ in period N-1 would save him the costs of fighting the price war in this period and therefore it would be optimal to leave already in N-1. Proceeding by backward induction, as Benoit (1984) has shown, in each foregoing period it would be optimal for the entrant to leave, and therefore it would not be optimal to enter in the first period at all. In the sub-game perfect Nash equilibrium of this entry-exit game with tradeable emission permits the incumbent would choose 'Fight’ in the first period and the entrant does not enter at all. The incumbent subsequently enjoys monopoly profits (which he preferred over accommodating the entrant, see the assumption in equation 4.7).

In order to be able to draw conclusions about the consequences of introducing a system of grandfathered tradeable emission permits for entry into industries, the situation described above must be compared with the situation in which no

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\(9\) The amount to be borrowed in period t is \(\sum (1+r)^t G\). As t rises, the amount to be borrowed rises as well.
grandfathered tradeable emission permits are introduced. In that case, neither of the firms needs to have emission permits, or both would have to buy all their permits (with auction), therefore the necessary investment is confined to the capital investment $K$, respectively $K+G$ (with auctioning). In the first case (when neither firm has to buy permits) if the incumbent would choose to play 'Fight', both firms would have just enough retained earnings, $\pi^F = K$, to invest again. The entrant would never be restricted by the amount of capital he has to borrow and therefore he would be able to endure the price fight indefinitely in this situation. Because the incumbent can not drive out the entrant, he will prefer to accommodate him: the pay-off of accommodating is higher than the pay-off of fighting indefinitely. The entrant will not be deterred when the incumbent chooses to fight: the threat to fight indefinitely is non-credible because accommodating is more attractive. The perfect equilibrium in this case is to accommodate entry for the incumbent and to enter for the entrant.

In the second case (when both firms have to buy permits), playing 'Fight' is not attractive for the incumbent either. Both firms would retain earnings $\pi^F = K$ minus their debt $(1+r)G$. Consequently, both firms would have to borrow more in order to invest for the next period. The incumbent does not have an advantage over the entrant, therefore he cannot outlive a price war with the entrant. Playing 'Accommodate' is therefore more attractive.

Consequently, it follows that the implementation of the TDP-scheme with grandfathering and more in particular the different treatment of existing firms and newcomers raises entry barriers. Because of the imperfect capital market, the incumbent can force the entrant out through conducting a price war. This price war makes it progressively less easy for the entrant to raise the money he needs to make the necessary investments for staying in the market. Finally, it is not attractive any more for him to stay and therefore he will leave. Looking forward, both firms can predict this outcome and therefore the entrant will decide not to enter at all.

**Buying a quota**

In the game discussed above, the entrant buys permits every period ("leases a
quota”). Another possibility is that outright at the start of the first period he buys a quota. Subsequently, he does not have to buy permits any more in the following periods. How would this affect the entry exit game discussed above? First, the price of a quota must be determined. The price of a quota can be deduced from the price for which the rights are sold (or for which quota are leased). Because a quota is a right to receive a permit for free every period, its current value is the sum of the discounted value it will have in the future:

$$value \text{ quota} = \sum_{t=0}^{\infty} \frac{1}{(1+r_0)^t} G = \frac{1}{r_0} G$$

where \(r_0\) is the discount rate (the minimum lending rate) and \(G\) remains the value of the permits needed each period. If the entrant wants to buy a quota and enter the market at the beginning of the first period, he will have to invest the total sum of \(K + 1/r_0 G\). Assuming that the initial capital of the entrant is \(K\) (as was done in the first variant of the game), this means that the firm will have to borrow more than in the variant presented above: \(1/r_0 G\) instead of \(G\). This will have consequences for his expected profits. As is stated in equation 4.8, it is a necessary condition that the expected profits of the entrant when he is accommodated (profits are \(\pi^A\)) are positive because otherwise he would not enter at all. This condition also holds when the entrant has bought a quota instead of the amount of permits he needs for one period. He will make the necessary investments as long as his net profit in the first and each subsequent period is positive. In this variant he has to repay a larger loan at the end of the first period: not \(G\) but \(1/r_0 G\).10

10 The requirement that the whole loan is repaid at the end of the first period is a strict condition. Another possibility is that the incumbent and the bank sign a debt contract which allows the incumbent firm to spread out his repayment. This would be more in line with the fact that the expected profits he makes on his investment in the quota of emission permits are also spread out over a long time. Other forms of debt contracts will be discussed below.

11 The entrant could sell his quota in order to pay of his debt (assuming there is a well functioning market for emission permits and quota). However, this would mean that in the next period he would have to buy another quota if he wants to stay in the market. Selling and buying a quota at the same time however does not make much sense.
In addition, the interest on the loan will also be higher compared with the interest paid when a quota was leased. The amount borrowed is higher, therefore the risk of default is higher. Consequently, the bank will ask a higher interest rate (see former section, page 8 for proof of this proposition).

Because of the higher debt and next to that the higher interest rate, the expected profit of the entrant will be lower. The chance that entering is not profitable at all is therefore larger when the entrant buys a quota with borrowed money than when he leases a quota every period.

Assume for the moment that the net expected profit of the entrant is positive, therefore he prefers to enter the market if he is accommodated by the incumbent. What are the pay-offs if the incumbent would choose to fight? Again, both firms would make a gross expected profit of \( \pi^F \) if the incumbent would choose to stay in the industry. As has been described above, this leaves the incumbent with exactly enough capital to reinvest \( K \) and to continue in the industry.

The situation which the entrant faces is different from the variant in which he only leased a quota. Because he has acquired a quota, he does not need to buy permits any more: just like the incumbent, he ‘receives’ them for free each period. Consequently, he only needs to invest \( K \) instead of \( K + G \) in all periods starting at period 2. His gross profits from the first period are \( \pi^F = K \), his net retained earnings are \( K - (1+r'/r_0)G \): the gross profits minus the amount borrowed plus interest on his debt (the interest is denoted \( r' \) to distinguish it from the interest which the entrant has to pay when he leases a quota). Therefore, he has to borrow \((1+r')/r_0 \cdot G\) in order to be able to stay in the market. If the incumbent continues to play fight in all subsequent periods, the amount which the entrant needs to borrow will rise: in the beginning of period \( t \), he has to borrow \((1+r')^t \cdot G/r_0 \). Eventually he will be unable to borrow the capital he needs or reinvesting is not attractive anymore because his net expected profit becomes negative.

Following the same argument as in the lease-variant discussed before, the perfect equilibrium of the game is for the incumbent to play fight if the entrant enters and for the entrant not to enter at all. In both variants, the fact that the entrant needs to borrow on an imperfect capital market makes it possible for the incumbent to drive him out if he would enter the market at all. It should be noted that under buying the entry
barrier is not higher than under leasing, even though the expected profit of the entrant is lower. In both cases, the entrant decides not to enter at all and the incumbent enjoys monopoly profits.

Three remarks can be made with regard to this analysis. First, the debt contract which has been specified above might not be the optimal debt contract. Second, the assumption about the amount of capital both firms own at the start of the first period might be changed. Third, according to this game, entry does not occur and therefore long purse predation does not arise either.

1] The debt contract specified above assumed that the entrant had to repay his debt at the end of the first period. However this is a strict condition. It might be more plausible to assume that the entrant will repay his loan over a longer period. An extreme form of such a debt contract is a credit facility, which allows a borrower to have an overdraft up to a certain limit. With such a debt contract, there is no need to repay the debt as long as the interest is paid in each period. If such a debt contract would be available for the entrant, what would the consequences be for the outcome of the entry exit game? At the start of the first period, he would borrow the amount needed to buy a quota: $1/r_0 \cdot G$. Assuming that the incumbent plays 'Fight' and that the entrant stays in the market, both firms will earn $\pi^E = K$. The entrant does not need to pay back his loan, nor does he have to buy permits in the second and subsequent periods. However, he does have to pay the interest, $r'/r_0 \cdot G$. Therefore, he has to borrow $r'/r_0 \cdot G$ if he wants to continue in the market. Assume that the extra borrowing falls within the entrants credit facility limit and that he only has to pay the interest on this lending. After the second period, the interest which has to be paid is: $r(1+r)/r_0 \cdot G$. If the incumbent continues to pay fight, the interest which has to be paid by the entrant will continue to rise and in the end he will have to exit the market. A lenient debt contract which takes the form of a credit facility where the sum borrowed need not to be paid back does not change the outcome of the game. Fighting remains attractive for the incumbent and therefore the entrant will stay out.
Another point which concerns the form of the debt contract has been raised by Fudenberg and Tirole (1985, 1986). Suppose that the bank and the entrant sign a long-term contract under which the bank guarantees the entrant that it will always be able to borrow money. In that case, there would be no incentive for the incumbent to prey upon the entrant because he can not drive him out. However, the problem with such a debt-contract is that the promise of guaranteed finance is a non-credible promise. If the incumbent would choose to play "Fight" in the first and all subsequent periods, the entrant would need to borrow more and more as has been described above. When the point is reached where the expected net profit of the entrant is negative, it would be more profitable for the entrant and the bank to change the debt contract and to leave the market. As there is nothing to stop them from renegotiating the contract, the "threat" of the long-term debt contract to stay in the market indefinitely is non-credible and therefore it still pays for the incumbent to play "Fight".

2] One of the assumptions made in the game described here is that both firms start with an initial capital of \( K \), which exactly covers their capital investment. If there was no emission reduction policy and therefore no grandfathered tradeable emission permit scheme was introduced, both firms would start equal and entry deterrence would not be possible (see page 11). When a TDP scheme with grandfathering is implemented, the entrant has to borrow in order to buy emission permits and therefore the incumbent can drive him out of the market.

However, the case would be different if the entrant would have enough capital himself to make the necessary investment in both capital and a quota of emission permits: \( K + \frac{1}{r_0} G \) instead of \( K \). In that case, he would not have to pay interest and therefore he could endure a price war in which gross profits are \( K \) indefinitely. Essentially, his position in all subsequent games would be the same as the position of the incumbent. Playing 'Fight' would then be ineffective for the incumbent because the entrant would not have to take recourse to borrowing money.

While this argument might seem to weaken the case of entry deterrence as a result of the TDP-scheme, it should be realised that in this situation an asymmetry is introduced between the incumbent and the entrant with regard to their initial
capital resources. The entrant starts with $K + 1/r_0 G$ own capital while the incumbent starts only with $K$ (in addition to which he receives TDP’s worth $1/r_0 G$). Instead, it should be assumed that, if the entrant owns $K + 1/r_0 G$, the incumbent owns the same amount of money. With these assumptions, the entry exit game studied here would still yield the conclusion that the incumbent would not be able to prevent entry. However, the game could be easily modified to allow the incumbent to impede entry effectively. If we assume that the price war results in a profit of $\pi^t$ instead of $\pi^F$, with $\pi^t < \pi^F$, then both firms will have to borrow if they want to stay in the market. However, the entrant has smaller reserves than the incumbent and therefore he will be forced out while the incumbent can still borrow.\(^{12}\)

3] In the introduction to this paragraph, the point was raised that the deep pocket theory was too successful because under complete information the entrant would never enter (see page 2). The same criticism applies to the game of perfect and complete information described above. Analogous to Benoit 1984, the game could be changed to allow for incomplete information. More specifically, it might be assumed that the incumbent is not sure whether the entrant is a firm which already owns a quota (for example, because it had formerly been operating in an industry which also emitted the same type of pollution) or which does not have it yet. It could be shown that in that case a situation might arise in which an entrant without permits would still enter and might or might not be driven out by the incumbent.\(^{13}\)

**Welfare consequences**

The analysis of the welfare consequences of the conclusions of the game presented here is relatively simple. The incumbent will enjoy monopoly profits because the potential newcomer will stay out of the market. If the incumbent would not have been

\(^{12}\) See also Benoit 1984.

\(^{13}\) It would go too far in the context of this study to elaborate on this game with incomplete information. Moreover, the basic analyses of such a game can be found in Benoit 1984.
able to keep the entrant out, profits would have been lower. Their level depends on the form accommodation takes: the two firms might collude, in which case they would together produce the monopoly level\(^{14}\), or they might compete (either in quantities or in prices). As compared with the latter case, welfare will be lower under the TCP-scheme because the incumbent, being a monopolist, will produce the monopoly output. Consequently, there will be a deadweight loss as compared with the fully competitive case. When the two firms compete, they will produce at least the Cournot oligopoly quantity or even the full competitive quantity (Bertrand competition) with a corresponding smaller welfare loss.

**Comparison with standards and taxes**

The analysis presented so far has focused on the difference between on the one hand implementing a TDP reduction policy with grandfathering and on the other hand not having any emission reduction policy at all. The conclusion was that such a type of policy would, under certain conditions, raise entry barriers. An important question is how entry barriers would be affected if other types of policy were implemented. Three other instruments will be analyzed: standards, emission charges and auctioned tradeable emission permits.

When standards are used, both the entrant and the incumbent have to meet this standard (assuming that the same standards apply to both established firms and newcomers, which is not necessarily the case). Therefore there is no difference between the two firms. Fighting a price war does not limit the entrant in its ability to endure the price war and therefore it is not successful. The incumbent will therefore accommodate the entrant.

With emission charges, both firms will have to pay the charge on their remaining emissions. Because both firms are assumed to be equal in all respects, including their abatement cost functions, they have to pay the same amount of tax. If the tax level is equal to the price of the permits (which would be the case if the same emission

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\(^{14}\) Note that in the game described here, collusion is less attractive for the incumbent than fighting a price war because he can drive the entrant out. When he can not forestall the entrant, collusion might be preferable above competing, especially if the discount rate is not too low (Folk-theorem, see Tirole 1992, p.246).
reduction would be achieved as with the permit scheme), the revenue they have to pay is equal to G, the value of the permits. If the incumbent would choose to play "Fight", both firms would earn a gross profit of $\pi_F = K$. However, they would have to pay the tax, so their net retained earnings are $K - G$. Consequently, both firms have to borrow G if they want to continue in the market in the next period. If the incumbent again plays "Fight" and the entrant stays, their net retained earnings are $K - (1+r)G$ and they will need to borrow $(1+r)G$. Eventually playing "Fight" will mean that neither of the firms can profitably reinvest at the start of the next period. In that case, the incumbent will prefer to play "Accommodate". Proceeding by backward induction, it follows that the optimal strategy for the incumbent is to accommodate the entrant right at the start of the first period. The entrant’s optimal strategy is to enter. When emission reductions are pursued by means of emission charges, entry barriers are not raised.

This analysis and its conclusion also applies to the case in which all firms, both established and entrants, have to buy permits under a TDP-scheme. The financial consequences for all firms of such a TDP-scheme with auctioning of all permits are similar to a tax, therefore entry barriers will not be raised either.

**Conclusions**

In this section, it has been shown by means of a repeated game with complete and perfect information that the introduction of a system of TDP’s can make entry unprofitable for new firms when, ceteris paribus, the incumbent firm receives permits for free (through grandfathering) while the entrant has to buy them. The fundamental reason for this is that because of its larger financial resources the incumbent firm can start a price war which will eventually drive out the entrant (the deep purse theory). Because of the free gift of the permits, the incumbent can finance its losses internally at lower costs than the entrant who has to borrow money on the capital market, which is assumed to work imperfectly. A sufficient condition for the incumbent is that he can make higher profits by fighting just one period and enjoying monopoly profits in the other periods than by accommodating the entrant.

Because the incumbent does not have to compete with others, the total output produced will be the monopoly output. As compared with a situation in which the incumbent competes with another firm, the quantity produced will be less (as long as
the incumbent and the entrant would not collude when they are both active on the market) and welfare will be lower.

The conclusion that entry can be impeded when emission are reduced by means of TDP’s is specific for the instrument of grandfathered TDP’s. The incumbent does not have a first mover advantage when standards or taxes are used and therefore these instruments do not raise entry barriers.

What does this conclusion tell us about the practical consequences of introducing tradeable emission permits in an economy? Obviously, the model presented here is quite theoretical in nature. It assumes that initially the incumbent has a monopoly and that both firms are equal in all respects except with regard to the way they are treated under the TCP-scheme. Furthermore, a central assumption is that firms are limited in external financing by their initial capital endowment. These restrictions make it difficult to apply the conclusion straightforward to a more mundane setting. However, if there is a grain of "empirical truth" in the conclusions yielded by this game, grandfathered TDP’s might reduce the competition of newcomers and therefore the dynamics in certain sectors of industry.

The logical next step is to take a closer look at the empirical evidence. Unfortunately, there is no empirical evidence on this model. In general, empirical evidence on game-theoretic models in Industrial Organization is scarce and difficult to get. However, there is a growing body of research which, although it is not based on the game-theoretic models directly, does investigate the empirical data on entry and exit. In the next section, this research is studied and applied to TDP’s.

4.1.3 Empirical Evidence on Capital Requirements as an Entry Barrier

In the former sections, the long-purse theory has been analyzed and applied to tradeable emission permits. In this section the empirical evidence for the theory that capital requirements can be an entry barrier will be discussed. Given the findings of
this analysis, it will be evaluated to what extent a system of tradeable carbon permits with grandfathering might raise entry barriers.

Most recent empirical studies of the determinants of entry have used the model developed by Orr in his study of entry in the Canadian manufacturing industries (1974). In this study, Orr has investigated various entry barriers in a cross section of 71 Canadian three-digit industries\(^{15}\) for 5 consecutive years (1963-1967). In his model, he assumed that there is a certain price-cost margin below which no entry is induced. When the price-cost margin rises above this level, entrants will enter an industry. In the absence of entry barriers, this limiting price-cost margin is assumed to be equal across industries. However, entry barriers will differ between industries and therefore the limiting price-cost margin will differ as well. The model used to estimate the relative importance of the various entry barriers postulates that entry is a positive function of the difference between the actual profit rate which an industry enjoys and the long run profit rate which can be predicted for an industry given the level of entry barriers. Moreover, entry will also be a positive function of the growth rate of the industry because a growing industry will induce additional entry. The model is (Orr 1974, p.59):

\[
E = f_1(\pi_p - \pi^*, z) \quad 4.13
\]

\[
\pi^* = f_2(X) \quad 4.14
\]

**E** entry: number of entrants per year  
**\(\pi_p\)** past industry profit rate  
**\(\pi^*\)** long run profit given the level of entry barriers in the industry  
**X** vector of entry barriers  
**\(z\)** past industry rate of growth output

The vector of entry barriers Orr used consisted of:

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\(^{15}\) Industries are classified according to systems like the International Standard Industry Code. In these classification systems the number of digits stands for the level of disaggregation: the larger the number of digits, the higher the level of disaggregation.
Here, our interest is in the second barrier, capital requirements. As is stated by von der Fehr (1991, p.95), "The hypothesis is that, with imperfect financial markets, average financial costs will increase with the amount needed to enter an industry. [...] If capital costs differ between entrants and incumbents, capital requirements act as a barrier to entry." If the variable used for capital requirements is significant it indicates that CR acts as an entry barrier and that capital markets might work imperfectly and capital costs differ between entrants and incumbents. It might be seen as an empirical validation of the long purse theory. It should be noted that CR differs from the entry barrier which might be created by economies of scale. In the Orr model, the MES plant is used as a proxy for economies of scale type entry barriers.

The measure of CR used by Orr is the costs of fixed capital necessary for establishing a plant of minimally effective size. He calculated this by multiplying total industry fixed assets by the percentage of sales of a MES plant. The size of the smallest plant which still makes a profit was assumed to be an approximation of MES. In the final form of equation 4.15 which Orr has used for his estimations, he used the log value of both E and CR. Consequently, it was estimated whether there was a correlation between the variables in percentage terms, not in absolute values. In the wake of Orr, more empirical studies have been done to determine the significance of various forms of entry barriers. In Geroski and Schwalbach (1991) a number of recent empirical studies are collected, several of which use Orr-type models. Those studies which include CR in their entry barriers cover Portugal, Norway, Belgium and Korea. A study of the V.S. which also includes CR uses a closely related model. Although the studies use the same type of model, their precise formulation, the definitions and measurements of the variables used and the time period covered differ. Table 4.2 presents the different approximations used for CR, the time period covered and the
significance level of CR as a determinant of entry barriers. With the exception of Belgium, in all studies presented above CR, either as capital-to-output ratio or as the capital necessary for a MES plant, came out as a significant determinant of entry. The empirical evidence available therefore appears to confirm that capital requirements can act as an entry barrier.

Table 4.2: The significance of CR as an entry barrier

<table>
<thead>
<tr>
<th>study</th>
<th>time period</th>
<th>CR</th>
<th>significance (percentage level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada (Orr 1974)</td>
<td>1963 - 1967</td>
<td>fixed capital for MES plant</td>
<td>1 percent</td>
</tr>
<tr>
<td>Portugal (Mata 1991)</td>
<td>1979 - 1982</td>
<td>total capital for MES plant</td>
<td>1 percent&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Norway (v/d Fehr 1991)</td>
<td>not indicated</td>
<td>fire insurance value MES plant</td>
<td>1 percent</td>
</tr>
<tr>
<td>Belgium (Sleuwaegen 1991)</td>
<td>1980 - 1984</td>
<td>capital-to-output ratio</td>
<td>not significant&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Korea (Jeong 1991)</td>
<td>1977 - 1981</td>
<td>capital for MES plant</td>
<td>5 percent&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>V.S. (Dunne 1991)</td>
<td>1963 - 1982</td>
<td>capital-to-output ratio</td>
<td>1 percent</td>
</tr>
</tbody>
</table>

<sup>a</sup> In this study, a division was made between small and large entrants. For large-scale entrants, CR was not significant.

<sup>b</sup> The model included also capital outlays on equipment and machinery as a percentage of total sales times MES. This variable was significant at the 1 percent level.

<sup>c</sup> Significant at the 5 percent level when tested for two different periods: 77-78 and 79-81. The first period was a period of economic expansion, the second one of contraction. When tested over the full period, CR was not significant.

What are the consequences for tradeable emission permits? It should be noted that in the studies mentioned above, the capital requirements were determined on the basis of a measure of fixed capital. Variable costs are not included in the capital requirements necessary for entering a market. The idea behind this is that the costs
which an entrant has to make when he wants to enter a market, the entry costs, are his fixed costs for the first period. The division between fixed and variable costs depends on the time period considered; in the long run, there are no fixed costs because in the long run no costs have to be born regardless of whether a firm produces or not. In contrast, in the short run some costs are unavoidable. How should the costs of tradeable emission permits be considered in this respect? When tradeable emission permits (as defined in chapter 2) can be bought at any time at any quantity, their costs are variable costs; firms need only buy their permits when they need them. However, when there is no day-market in permits, they will have to buy them in advance and consequently they need to invest in permits when they enter the market. To what extent firms will want to invest in permits before they enter a market will depend on the organisation of the permit market. The more regularly markets take place, the more regularly firms can acquire permits. Consequently the number of permits firms need when they start production will be less when markets take place more regularly\textsuperscript{16}. Presumably, trade in permits will take place both at regularly organised markets and through brokers. In the U.S. acid rain tradeable permit scheme, there is a yearly auction of permits and there is a secondary market which functions to a large extent through brokers (Klaassen and Nentjes 1995).

Another factor which might influence the number of permits which a firm wants to start with is the life span of its investments. For example, a power generating company which builds a new plant might want to assure itself of a supply of permits needed to cover its CO\textsubscript{2} emissions in the period during which its plant is economically viable. Power generating equipment can last for up to twenty or thirty years, such a firm might therefore want to acquire permits to cover emissions for thirty years.

We will take a permit supply which covers emissions for one year as a lower limit to the number of permits which firms will buy when they enter the market.

The extent to which entry barriers might be raised will depend on the increase in capital requirements when entrants have to buy permits. Presumably, there will be

\textsuperscript{16} Instead of buying permits (leasing a quota), a new firm can also choose to buy a quota, assuring himself of a supply of permits. In that case, it buys permits for an indefinite period. His initial capital requirements will then increase with the quota price. However, when capital markets are not perfect and the costs of a quota would therefore increase the entry barrier, entrants have the option of buying permits for a more limited period instead.
differences between different sectors of industry.

<table>
<thead>
<tr>
<th>Sector</th>
<th>CO2 emissions 1990 [1000 ton]</th>
<th>number of firms 1990</th>
<th>Capital goods stock (CGS) 1-1-91 [mln. f]</th>
<th>average CO2 with permit price 0,20 ECU/ton</th>
<th>1-year expenditure of 20 ECU per ton CO2 [mln f]</th>
<th>% CGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral extraction</td>
<td>1406</td>
<td>-</td>
<td>45631</td>
<td>58</td>
<td>0,13%</td>
<td></td>
</tr>
<tr>
<td>Petroleum industry</td>
<td>9219</td>
<td>24</td>
<td>22641</td>
<td>943</td>
<td>382</td>
<td>1,69%</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>4010</td>
<td>875</td>
<td>58006</td>
<td>66</td>
<td>166</td>
<td>0,29%</td>
</tr>
<tr>
<td>Textiles</td>
<td>273</td>
<td>217</td>
<td>6710</td>
<td>31</td>
<td>11</td>
<td>0,17%</td>
</tr>
<tr>
<td>Paper</td>
<td>1551</td>
<td>146</td>
<td>12382</td>
<td>85</td>
<td>64</td>
<td>0,52%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>13385</td>
<td>263</td>
<td>70066</td>
<td>266</td>
<td>554</td>
<td>0,79%</td>
</tr>
<tr>
<td>Building materials</td>
<td>2006</td>
<td>299</td>
<td>15149</td>
<td>51</td>
<td>83</td>
<td>0,55%</td>
</tr>
<tr>
<td>Base metal</td>
<td>1219</td>
<td>52</td>
<td>24395</td>
<td>469</td>
<td>166</td>
<td>0,68%</td>
</tr>
<tr>
<td>Other metal</td>
<td>513</td>
<td>1776</td>
<td>44661</td>
<td>31</td>
<td>50</td>
<td>0,07%</td>
</tr>
<tr>
<td>Other industry</td>
<td>6154</td>
<td>376175</td>
<td>1556</td>
<td>0,41%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) 20 ECU/ton CO2 is the tax which according to Barrett (1991, p.14) would be needed to stabilize CO2 emissions in the EU in 2010 on the level of 1989 (1 ECU = \(\frac{2,07}{f}\)).

**Sources:**

Table 4.3 provides an overview of different sectors in the Dutch economy. Unfortunately, the data required were only available at the two digit level. Consequently, the data can only very roughly indicate in which sector a tradeable emission permit scheme might increase capital requirements for new firms. A considerable disadvantage of these aggregated data is that they do not allow to focus on specific markets. Moreover, the average capital requirements are only a very rough indication because within a sector plant sizes will differ considerable, depending on the specific market concerned.

Column 2 of table 4.3 gives the CO2 emissions of each sector in 1990, the next column gives the number of firms per sector. The fourth column gives the value of the capital stock per 1-1-91, in prices of 1991. Dividing column 4 by column 3 yields the average capital stock per firm (column 5). The petroleum industry has the highest average CR, followed by base metal and chemicals. In order to assess the impact of a TCP-scheme on the CR one needs a permit price. It is assumed here that the permit price is 20 ECU. This is the price calculated by Barrett (1991) which is needed to stabilise CO2 emissions in the EU in 2010 on the level of 1988. This price is used to calculate the expenditure each sector would have to make on permits for one years’
CO₂ emissions (column 6)\textsuperscript{17}. Dividing this expenditure by the total CR gives percentage increase in capital requirements for each sector. This is the average increase in capital which new firms have to meet when they enter the market. On average, the CR increase is small, only 0.41 percent. The sectors with the highest percentage increase are, in descending order, the petroleum industry (1.69%), chemicals (0.79%) and base metal (0.68%), all three sectors with a high energy use. These are also the sectors with high average capital requirements. The sectors where the CR increase is largest and therefore a system with grandfathered tradeable permits might erect an entry barrier are the sectors where presumably the entry barrier caused by CR are already high.

The overview presented here of the empirical consequences of CR for entry indicate that in practice CR does limit entry, which can be viewed as a confirmation of the long purse theory. Introducing a system of TCP will increase the CR for new firms (as long as the permits are grandfathered to established firms) and therefore it can reduce entry. However, the extent to which entry will be reduced appears to be small. In our calculations it was assumed that firms acquire permits to cover the emissions of one year. Entry will be further impeded if firms start with more permits. The most affected sectors are the energy intensive industries because in these sectors CO₂ emissions are relatively large and therefore the CR of acquiring sufficient permits are large as well. The average CR in these sectors is high to start with, therefore it might be expected that the entry barrier due to the CR already is high before introduction of the permit scheme.

\textsuperscript{17} Instead of emitting CO₂ and consequently needing permits to cover their emissions, another option for firms is to abate more. This would however also require expenditure, the abatement costs. These costs will consist partly of investment in more energy-efficient equipment, an investment which firms will have to make when they enter the market. Consequently, these costs will also increase their CR. The extent to which firms will prefer to abate more over buying permits will depend on their abatement costs function. For simplicity, it is assumed here that firms will buy permits.
4.2 TDP’S AND EXCLUSION

Absolute cost advantages are one type of entry barriers described by Bain. There are numerous ways in which established firms can raise the costs of (potential) rivals. Indeed, firms have been rather inventive in finding ways to increase their rivals costs. Cost-raising strategies include "exclusive dealing arrangements, inducing input suppliers to discriminate against rivals, lobbying legislatures or regulatory agencies to create regulations that disadvantage rivals, commencing R&D and advertising wars, and adopting incompatible technologies." (Salop and Scheffman 1987). A famous example of the first type is the Alcoa case. Alcoa, the major aluminium producer in the U.S. after WW-II, is reported to have concluded agreements with power companies not to provide electricity to potential rivals of Alcoa (Krattenmaker and Salop 1986, p.227). As electricity is an important input for aluminium production, rivals where put at a considerable disadvantage and therefore competition was reduced. Another example, from the European Community, is the case of the Commission of the European Community against Instituto Chemioterapico Italiano (ICI). ICI is a firm which is owned by the U.S. firm Commercial Solvents Corporation (CSC). CSC is a major world producer of aminobutanol, a semimanufacture for some types of medicines. ICI is both a producer of these medicines itself as a resaler of the semimanufacture to other firms in the Common Market. In 1970, CSC and ICI decided to stop the resale of aminobutanol to other firms. One of those firms was Zoja, also a producer of medicines on the basis of aminobutanol. It discovered that, now that the sale of aminobutanol by ICI was stopped, acquiring the semimanufacture on the world market was impossible as the only producer appeared to be CSC, which refused to sell. In this way, CSC and ICI excluded other producers of the medicines from a necessary input. Consequently, when Zoja brought the case to the court, ICI and CSC were obliged to resume supplying Zoja with aminobutanol (Decision of the Court, March 6, 1974).

In both cases, the established firm in one way or another controlled an important input and used its power on this input market to foreclose the product market. In these cases, competition was completely excluded, which is an extreme case. Instead of effectively deterring entry, incumbents can also use their market power on an input
market to reduce competition from (potential) rivals.

Tradeable emission permits are also an input. Therefore, firms which have market power on the market for emission permits can in theory use this power to reduce competition. If an established firm could reduce supply of the permits sufficiently to drive up its price, rival firm’s costs would be increased. They would either have to abate more or buy the permits at their higher price. This would reduce competition from rival firms or potential entrants. However, driving up the permit price will also increase costs for the incumbent firm.

Cost-raising strategies have been studied extensively by Salop in conjunction with Scheffman and Krattenmaker (Salop and Scheffman 1983 and 1987, Krattenmaker and Salop 1986a and 1986b). Subsequently, Misiolek and Elder (1989) have used the Salop-Scheffman model and applied it to tradeable emission permits. Here, the Salop-Scheffman-Misiolek-Elder (SSME) model is reproduced and it is determined under what conditions TDP lend itself for exclusion. Subsequently, it is analyzed whether the TCP-system described in chapter 2 is susceptible to exclusionary manipulation.

The model

In the standard SSME-model, there is an established firm, which can either be a price-taker or a dominant firm which has control over the price of it’s products. Furthermore, there is a competitive fringe. Here, it will be assumed that there is an incumbent firm which faces potential competition from a rival entrant. Initially, when there is no potential rival, the incumbent maximises:

$$\pi^i = p q^i - C^i(q^i,L) \text{ s.t. } q^i = D(p)$$

where $q^i, p < 0$, $C_{qi} > 0$, $C_L$ is convex

$$4.15$$

$p$ \quad = \text{product price}$

---

18 It should be noted that it is not necessarily the case that the established firm has market power in the product market. The essential fact is that he uses his market power on the input market to influence the product market. See Salop and Scheffman (1984) for an analysis of the model in which the established firm is a price-taker.
q^i \text{ = quantity produced by the incumbent} \\
C^i \text{ = incumbent’s costs (including abatement and permit costs)} \\
D(p) \text{ = market demand for the product} \\
L \text{ = tradeable emission permits acquired by the incumbent}

From the market equilibrium condition the inverse demand function \( p(q^i) \) can be derived. The first-order conditions are:

\[\pi_p^i = q^i + p \cdot q^i_p - C^i \cdot q^i = 0 \quad 4.16\]  
\[\pi_L^i = C^i_L = 0 \quad 4.17\]

Equation 4.16 the usual monopoly profit maximisation condition: marginal revenue equals marginal costs. Equation 4.17 determines the optimal amount of permits: given the amount of \( q^i \) produced, the number of permits \( L \) is chosen such that the sum of the abatement costs plus permit costs are minimised. The monopoly quantity produced in this non-strategic equilibrium is denoted \( q^{i*} \), the number of permits used is denoted \( L \).

When there is a potential entrant, the market conditions for the incumbent change. Instead of total market demand, he now faces a residual demand curve. The maximisation problem becomes:

\[
\max_{\{p, q^i, L\}} \pi^i = pq^i - C^i(q^i, L) \text{ s.t. } q^i = D(p) - q^e(p, p) \quad p > 0 \quad 4.18
\]

\[P^e = P^p(L)\]

\( q^e \) = quantity produced by the entrant  
\( P^p \) = permit price

The permit price \( P^p \) depends on the quantity of the permits acquired by the incumbent, reflecting the market power he is assumed to have on the permit market. The entrant is a price taker on both the market for outputs and the inputs, including permits. The quantity which the entrant produces is determined by maximising his profit function:
\[ \max \pi^e = p q^e - C^e(q^e, P_p) \quad \text{s.t. } \pi^e > 0 \quad C^e_{q^e}, C^e_{P_p} > 0 \quad \text{(4.19)} \]

An increase in the product price will increase the quantity produced by the entrant, an increase in the price of the permits \( P_p \) will increase his marginal costs and therefore he will reduce his production: \( q^e_p > 0, q^e_P < 0 \).

Optimizing (4.19) yields the following first-order conditions (for an interior solution):

\[ \pi^i_p = q^i + p q^i_p - C^i_{q^i} q^i_p = 0 \implies p - C^i_{q^i} = -q^i/q^i_p \quad \text{(4.20)} \]

\[ \pi^i_L = p q^i_p P_{PL} - C^i_{q^i} q^i_L P_{PL} = 0 \implies p - C^i_{q^i} = -C^i_{L}(P_{PL} q^i_{P_p}) \quad \text{(4.21)} \]

Using \( q^i_p = D^i_p - q^e_p \) and \( q^i_L = -q^e_p P_{PL} \), equations (4.20) and (4.21) can be rewritten as:

\[ \frac{q^e_L}{D^i_p - q^e_p} = \frac{C^i_{L}}{q^i_L} \quad \text{(4.22)} \]

The evaluation of equation (4.22) is straightforward (see Salop and Scheffman 1987, p.22 and Misiolek and Elder p.161). The left-hand side of the equation is equal to \( \frac{\partial p}{\partial L} \bigg|_{q^i} \), that is the rise in the product price which results from the reduction in output of the entrant as a result of price-rise of the permits following an increase in \( L \), holding \( q^i \) constant\(^{19}\). Or, as Salop and Scheffman stated (1987 p.22), this derivative represents "the vertical shift in the residual demand curve" of the incumbent. The right-hand side of equation (4.22) equals the change in his average costs, with output \( q^i \) remaining fixed, resulting from an increase in \( L \).

Instead of an interior solution, there is the possibility of a corner solution. A necessary condition for the entrant is that his profit is positive (equation 4.19). At a certain level of \( L \), below the strategic equilibrium level of \( L \) determined by equations 4.20 and 4.21, the costs of the entrant might increase to such a level that profit falls

\[^{19}\frac{\partial p}{\partial L} \bigg|_{q^i} \text{ is determined by totally differentiating } D(p) - q^i(p, P_p(L)) = q^i \text{ with } \partial q^i = 0.\]
below zero. Consequently, the entrant will not enter. The incumbent will buy permits up to the point where the entrant’s profits are nil. Using Bain’s terminology, this could be termed *effectively deterred entry*. Another possibility is that at the non-strategic equilibrium \((q^*, \bar{L})\), the price of the permits \(P_p\) is such that the entrant can not make a positive profit and therefore will not enter at all. In that case, entry is *blockaded*.

From an analytical point of view, the most interesting case is when entry is *accommodated*. It can now be determined whether it will be profitable for the incumbent to raise the entrant’s costs through raising the price of the permits. This is the case when:

\[
\frac{\partial p}{\partial L} > \frac{\partial (C_i/q^i)}{\partial L}
\]

4.23

evaluated at \((q^*, \bar{L})\), with \(q^*\) and \(\bar{L}\) defined as the quantity produced and the number of permits used in the non-strategic equilibrium (where the incumbent is a monopolist and the entrant does not produce). The increase in permit purchases by the incumbent will raise the price of the permits. The change in the product price resulting from the reduction of the entrant’s supply which follows this increase of the permit price must at least equal the increase in the incumbent’s average costs in the non-strategic equilibrium \((q^*, \bar{L})\). If this condition is not fulfilled, increasing the entrant’s costs through manipulation of the permit market is not attractive for the incumbent. The probability that increasing the entrant’s cost is profitable is larger when (see Salop and Scheffman 1987, p.23 and Misiolek and Elder 1989, p.161):

i  the effect on the permit price of increased purchases of permits by the incumbent is larger.

ii  the effect on the entrant’s supply of a rise in the permit price is larger.

iii  market demand for the incumbent’s product is less elastic.

iv  the supply of the entrant is less elastic with respect to changes in the product price.
Given these conditions, systems of tradeable emission permits can be evaluated with respect to their susceptibility to exclusionary manipulation. First of all, it is important that the incumbent firm has sufficient market power and therefore considerable effect on the permit price. If the costs (of extra permits) he will have to make to raise the price are too large, his average costs will rise too much and exclusion will not be profitable.

Moreover, the increase in the permit price must sufficiently raise the entrant’s costs. If permit outlays per unit of product are relatively small, the increase of the entrant’s marginal costs is relatively small as well and therefore his supply to the product market will only be marginally affected. This implies that EM is more profitable for the incumbent if production of the entrant is pollution intensive.

Last, the demand for the product should be inelastic. The rise in price of the product due to the reduction in the entrant’s supply will then be large, which means that the incumbent will be able to make a large profit.

Given these considerations, how susceptible is the system of TCP’s described in chapter 2 to EM? The foremost requirement is that a firm which wants to reduce competition from potential rivals is able to influence the price of the permits without having to incur costs which are too large. In the case of TCP’s however this requirement is a rather strong one because carbon permits are used in almost any branch of industry and the carbon permit market is not divided up in regional markets. As Misiolek and Elder rightly note (1989, p.160), EM is more likely to occur when permit markets are relatively small and particular to one branch of industry. When the permit market is not divided up into regional markets and all branches of industry require the permits, it will be much more costly for a specific firm to raise the permit price sufficiently to influence its rivals. This is illustrated by table 4.4, which shows emissions per sector, the number of firms and the average market share on the permit market if the TCP system described in chapter 2 were introduced in the Netherlands. The highest average market shares are to be found in the refinery industry and the fertilizer industry. However, the highest average share is only 1.2 %. Given these shares, influencing the permit price will indeed be a costly enterprise, even for firms
from these industries. As regards the other industries, market shares on the permit market are negligible.

The total value of the permits on this market, calculated on basis of a price per ton CO₂ of 20 ECU, is about 6 billion guilders (this is the price which is calculated by Barret (1991, p.14) as being the CO₂ price necessary for stabilising CO₂-emissions in the EU in 2010). Table 6.1 only covers the Netherlands. In effect, it is more realistic to assume that a TCP-system operates EU-wide (see chapter 2). Consequently, the permit market will be still larger and therefore market power on this market is even less likely to occur. With 2676 mln. ton CO₂-emissions in the EU in 1988, the market value of the permits in a EU-wide system would be 111 billion guilders in 2010 if emissions were stabilised at the 1988 level.

Given the size of the market, it will be difficult for any one firm to influence the permit price. However, it might be different when the permit market functions imperfectly. If, like in the early examples of implemented tradeable emission permit schemes (see Hahn 1989), there is little supply of permits, influencing the price of permits is less difficult because the actual market is small. In the TCP system, this problem is less likely to occur because part of the permits are auctioned by the authorities. This means that there is a large primary market. EM would in that case require that firms could control the price on the primary market, the auction. With about half of the permits yearly available put on auction, any effort to influence the price of the permits would still be costly, even though the secondary market might be small.

The foremost requirement for influencing prices, possessing some degree of market power, appears not to be fulfilled in the TCP-scheme. However, if a firm would be able to control prices, its chance that EM would be profitable would also depend on the product market. Sectors in which demand for the product is inelastic are more vulnerable, as has been argued above. Another point is the emission intensity of a sector. If emissions are large per unit of product, permit prices have a large effect on the average and marginal production costs. This however is a two-edged sword, because while it increases the effect on the entrant’s supply and therefore the profitability of EM for the established firm, it also increases average costs of the incumbent.
<table>
<thead>
<tr>
<th>sector</th>
<th>CO2-emissions [mln. ton]</th>
<th>number of firms</th>
<th>TCP market share per firm [percent]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and beverages</td>
<td>3.9</td>
<td>7258</td>
<td>0.0004</td>
</tr>
<tr>
<td>Textiles</td>
<td>0.3</td>
<td>1515</td>
<td>0.0001</td>
</tr>
<tr>
<td>Paper</td>
<td>1.5</td>
<td>362</td>
<td>0.0029</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>6.6</td>
<td>12</td>
<td>0.3881</td>
</tr>
<tr>
<td>Other chemicals</td>
<td>3.8</td>
<td>838</td>
<td>0.0032</td>
</tr>
<tr>
<td>Building materials</td>
<td>2.2</td>
<td>684</td>
<td>0.0023</td>
</tr>
<tr>
<td>Base metal</td>
<td>8.8</td>
<td>119</td>
<td>0.0522</td>
</tr>
<tr>
<td>Other metal</td>
<td>1.8</td>
<td>14563</td>
<td>0.0001</td>
</tr>
<tr>
<td>Other industries</td>
<td>0.5</td>
<td>21358</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Refineries</td>
<td>12.1</td>
<td>7</td>
<td>1.2199</td>
</tr>
<tr>
<td>Power companies</td>
<td>36.8</td>
<td>88</td>
<td>0.2951</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>19.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticulture</td>
<td>6.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>11.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td><strong>141.7</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4 CO2-emissions, Dutch economy, 1989.


conclusions

Exclusionary manipulation is a strategy in which firms try to deny (potential) rivals the use of important inputs to their production processes. This can take the form either of excluding rivals completely or of driving up the price of the strategic inputs. Consequently, these firms either have to use more expensive or less suitable substitutes or use the more expensive input. EM can be an effective way to limit competition,
especially when a firm can exert control over a strategic input at not too high costs. EM does not only exist as a theory, it also occurs in practice. In this section, it has been studied whether it might be possible to use tradeable permits to exclude rivals. Following the analysis of Misiolek and Elder (1989), several conditions have been derived which can be used to establish the susceptibility of systems of tradeable emission permits to EM. Important points are that the increase in the rival’s costs due to EM is large and that the costs of controlling the supply of the permits (the costs of driving up the permit price) is small.

Overlooking the evidence, it can be concluded that the system of TCP’s sketched in this study is not very susceptible to EM. The market for TCP’s, especially for a EU-wide system, appears to be too large for one firm to exercise any market power on this market. Moreover, the auctioning of part of the permits alleviates the danger that the market is too thin, which would make it more easy for a firm to influence the price.

4.3 CONCLUSIONS

In this chapter the analysis of tradeable permits and entry barriers is continued from the former chapter. Two types of entry barrier which might be affected by tradeable permits have been studied in addition to transaction costs which have been studied in the former chapter. First, imperfect capital markets in which case grandfathering puts incumbent firms at an advantage. Second, firms can try to exclude entrants from the permit market, which will raise their costs and reduce entry.

The first type of entry barrier occurs when capital markets do not work perfectly. Given imperfect capital markets, firms with more financial resources can outcompete firms which have less capital. The incumbent firm initiates a price war which the entrant will lose because of his smaller financial resources and consequently higher costs of capital. This form of predatory pricing is known as the long-purse theory. We have applied this theory to the instrument of TDP’s, assuming that the incumbent and the entrant are equal in all respects except as regards the allocation of permits; the incumbent receives them for free while the entrant has to buy permits. Grandfathering
permits is in effect equal to making a capital gift. Therefore, the incumbent will have larger financial resources than the entrant. Consequently, the incumbent can drive potential entrants out of the market in a price war and therefore entrants will not enter the market. Grandfathering effectively reduces entry.

Subsequently, it has been investigated how serious this threat is in practice. There is some evidence from empirical studies that capital requirements do create entry barriers: there is a negative correlation between capital requirements and entry rates across industries.

Introducing the system of tradeable carbon permits described in chapter 2 means that new firms will have to buy carbon permits, which increases their capital requirements. Given the negative correlation between capital requirements and entry rates, this might increase entry barriers. However, the increase in capital requirements appear to be small in the system of tradeable carbon permits. Assuming a permit price of 20 ECU (necessary for stabilisation of the EU emissions in 2010 on the level of 1988), capital requirements increase is small in the Dutch economy. The energy intensive industries are the most affected sectors (the largest increase is in the petroleum industries, 1.7 percent). In these sectors, the entry barrier is already high as far as the capital requirement for the average firm is concerned.

The last, extreme form of entry barriers studied here can occur when a firm or group of firms controls a vital input and exclude other firms from the use of this input. This will force these firms to use less optimal and more expensive substitutes and reduce their competition, or even exclude them from the market. An essential condition for exclusion is that a firm has market power on the input market. Without the power to influence the input’s price, a firm cannot drive up the costs of its rivals.

In the tradeable carbon system described in chapter 2, the market for tradeable carbon permits will be large, especially if the system is introduced in the whole of the European Union. It will be very costly or even practically impossible to influence the permit price on this market. Exclusionary manipulation will not be a problem on this market.

To sum up our results, grandfathering permits to established firms and auctioning them to entrants does not necessarily raise entry barriers because of the opportunity costs of the permits. However, in the case of imperfect capital markets, grandfathering
will raise entry barriers. As far as the system of tradeable carbon permits studied here is concerned, grandfathering and imperfect capital markets will raise entry barriers only to a small extent. The most affected sectors are the energy intensive sectors.