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Measuring competition: How are cost differentials mapped into profit differentials?

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Executive summary (in Dutch):

Dit rapport introduceert een nieuwe manier om concurrentie te meten. Het vergelijkt deze methode met andere bekende concurrentie-indicatoren, zoals de concentratiegraad in een bedrijfstak. We illustreren hoe de indicator in de praktijk geschat kan worden met behulp van een microdataset op het CBS.[1] Verder bespreken we hoe de indicator gebruikt kan worden door beleidsmakers bij zowel de NMa als ministeries die maatregelen introduceren ter bevordering van concurrentie, zoals EZ.

Doel van de indicator die wij hier introduceren is het consistent meten van concurrentie over de tijd. Veel gebruikte indicatoren van concurrentie, zoals de concentratiegraad of de prijs-kost-marge, werken goed als concurrentie toeneemt door een afname in toetredingskosten. Maar als concurrentie toeneemt door agressievere interactie tussen bedrijven, wijzen ze de verkeerde kant op. In die zin zijn deze indicatoren niet consistent.

De indicator die hier voorgesteld wordt, is gebaseerd op relatieve winsten van bedrijven. We beargumenteren dat een toename in concurrentie, of het nu komt door lagere toetredingskosten of door agressievere interactie tussen bedrijven, altijd leidt tot een toename in de winst van een efficiënt bedrijf ten opzichte van de winst van een minder efficiënt bedrijf. Dat maakt deze relatieve winst indicator zo aantrekkelijk: de indicator reageert consistent op verschillende manieren waarop concurrentie kan toenemen in een bedrijfstak.

De intuïtie voor de indicator is als volgt. Een toename in concurrentie zorgt ervoor dat efficiënte bedrijven hun kostenvoordeel beter kunnen uitbuiten. Daardoor wordt een efficiëntievoordeel relatief meer beloond in een sterk concurrerende markt dan in een markt waar elk bedrijf veel monopoliemacht heeft. Anders gezegd, een gebrek aan concurrentie beschermt inefficiënte bedrijven tegen de meer efficiënte bedrijven in de markt.

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[1] De resultaten zijn onderzoeksresultaten van het CPB, en reflecteren niet de mening van het CBS.

Als een illustratie schatten we de indicator over de tijd voor een aantal bedrijfstakken. Op deze manier brengen we in beeld hoe de concurrentie evolueert over de tijd in een bedrijfstak. Is de bedrijfstak concurrerender geworden over de tijd? Of laten de data juist zien dat de concurrentie is afgenomen, bijvoorbeeld door prijsafspraken tussen bedrijven?

De indicator kan in de beleidspraktijk voor de volgende doelen gebruikt worden. Ten eerste, de NMa kan de indicator in haar proactieve mededingingsbeleid gebruiken. Door de indicator over de tijd te bekijken voor een aantal (of alle) Nederlandse bedrijfstakken, kan een voorselectie gemaakt worden van bedrijfstakken die nauwkeuriger onder de loep genomen moeten worden. In het bijzonder, als de indicator aangeeft dat de concurrentie in een bepaalde bedrijfstak de afgelopen vijf jaar sterk is teruggelopen, is dat een reden wat nauwkeuriger naar deze bedrijfstak te kijken. Ten tweede, de indicator kan de NMa helpen in haar reactieve rol als concurrentiebewaker. Dat wil zeggen, de indicator kan gebruikt worden als bewijsmateriaal dat er bijvoorbeeld misbruik gemaakt is van een machtspositie. De consequenties van afspraken door bedrijven die de mededinging beperken, kunnen met behulp van de indicator aan het licht gebracht worden. Ten derde, kan de indicator gebruikt worden om beleid ten aanzien van concurrentie te evalueren. Als een ministerie of de NMa een maatregel neemt om concurrentie te bevorderen, is het wenselijk achteraf te toetsen of de maatregel de verwachte effecten gehad heeft. Zo niet, dan kunnen eventueel aanvullende maatregelen genomen worden. De indicator wordt in dit geval gebruikt om te zien of de concurrentie toegenomen is in een bedrijfstak nadat de maatregelen geïntroduceerd zijn.

Hoewel de nieuwe indicator een aantal duidelijke voordelen heeft ten opzichte van andere indicatoren, is ze niet perfect. Een probleem is dat de benodigde variabelen zoals marginale kosten niet altijd perfect meetbaar zijn. In de meeste bedrijfstakken zullen dergelijke meetproblemen min of meer constant zijn over de tijd en dus het verloop van de indicator niet beïnvloeden. Er is echter geen reden om aan te nemen dat twee verschillende bedrijfstakken dezelfde meetproblemen vertonen. Daardoor is het maar zeer beperkt mogelijk de indicator te gebruiken om de mate van concurrentie tussen bedrijfstakken te vergelijken. Dit houdt in dat de indicator niet gebruikt kan worden om te zien in welke bedrijfstak veranderingen in de institutionele omgeving (bijvoorbeeld door aanpassing van wetgeving) het meest wenselijk zijn. Met andere woorden, het is met de indicator niet mogelijk om de minst concurrerende bedrijfstak te selecteren uit een groep van bedrijfstakken.

Samenvattend, dit rapport introduceert een nieuwe indicator gebaseerd op relatieve winsten. Met deze indicator kan het verloop van concurrentie over de tijd in een bedrijfstak geanalyseerd worden. Dit levert een zeer bruikbaar instrument op voor de proactieve en reactieve taken van de NMa en voor ministeries die willen toetsen of bepaalde genomen maatregelen inderdaad de concurrentie bevorderd hebben.

Preface

How should competition be measured? This paper argues that measures like concentration and price-cost margins have the undesirable property that ‘more competition’, as it is usually perceived, can be consistent with both increases and decreases of these measures. Instead the authors propose to use a competition indicator based on relative profits. This indicator is applied to Dutch manufacturing data. The results are quite promising: the indicator does not have the undesirable properties mentioned above and can be used on a broader basis.

The study was conducted by Jan Boone and Jürgen Weigand. The empirical part of this research has been executed at Statistics Netherlands' Center for Research of Economic Microdata (Cerem). We would like to thank Bert Balk, Marcel Canoy and colleagues at the CPB for their help and suggestions. We are grateful to Krijn Schep and Martin Godfried for their enthusiastic support and cooperation. Finally, we acknowledge the contributions made by the 'advisory committee'.

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1 Introduction

This research makes two contributions to the debate on competition. Most importantly, it introduces an intuitively appealing way to measure competition in an industry over time. Second, it introduces a framework to think about competition without equating it with welfare or concentration.

A vast literature in empirical industrial organization has been devoted to measuring the intensity of competition. Many empirical approaches use measures like concentration, profits and price-cost margins. The problem with these measures is that they do not capture the notion of increased competition through more aggressive interaction between firms. To illustrate, when firms start to interact more aggressively, the likely result is that an industry's more efficient firms gain market share at the expense of the least efficient firms. In fact, the least efficient firms may be forced to exit, thereby concentration may increase. Hence a rise in competition through more aggressive interaction between firms can raise concentration. This insight is at odds with the interpretation of low-concentration industries being very competitive.

It is quite problematic that a widely used indicator such as concentration cannot capture the idea of increased competition through more aggressive interaction. First, policies may exactly be aimed at raising competition by heating up competition between incumbents. Hence, concentration cannot be used to measure the success of such policies. Second, from a competition authority’s or regulator's point of view it is puzzling if more aggressive interaction between firms leads to a rise in concentration. So if the competition authority observes a rise in concentration in an industry, is this caused by a rise or by a fall in competition?

Considering this shortcoming, a competition indicator is called for which always moves in the same direction as competition itself. In this study we claim that an indicator based on relative profits complies with this requirement: it is monotone in competition. The intuition is the following. If firms differ in their efficiency levels, one would expect the more efficient firms to make higher profits. In a sense, less efficient firms are punished by having lower profits. In a very competitive market the relative reward for being (relative) efficient is big. By contrast, in a market with soft competition, a deterioration in efficiency hardly causes a fall in profits. In other words, for given efficiency differences between firms, a rise in competition causes bigger differences in profits.

The idea that competition affects how efficiency differences are mapped into profit differences also partly solves the problem of what competition is, without equating it to welfare. Thus a change in policy enhances competition if it allows efficient firms to gain at the expense of inefficient firms. This is the reallocation effect of competition. Further, due to the rise in competition, inefficient firms may lose profits to such an extent that they will leave the industry. That is the selection effect of competition. Competition selects 'good' from 'bad' firms by inducing bad firms to exit. However, we do not attribute any normative considerations to these observations. Selection and reallocation are not necessarily good (or bad) for welfare. We come back to this issue below.

A competition indicator based on relative profts is useful for policymakers who want to enhance competition. First, the competition authority can use the indicator as a screening device to identify industries which may require closer examination to ascertain whether competition has deteriorated over time. Further, the indicator can be used as a component of evidence that anti-competitive behavior is present in a certain industry. Finally, if policymakers introduce new measures to enhance competition, the indicator can be used to see whether competition indeed rises over time after the measures have been implemented.

Based on Statistics Netherlands CEREM firm-level data set we select a couple of industries for which we show how to implement the indicator in practice and interpret the empirical results. However, the purpose of this report is not to evaluate the state of competition in the respective industries. A more comprehensive analysis and more disaggregated data would be needed to achieve such a goal.

The report is structured as follows. In Section 2 we argue that competition indicators like concentration and profits can be misleading about what happens to competition. Section 3 introduces our relative-profits indicator. We argue that it is an intuitive and robust way to measure competition. Section 4 highlights the advantages of the relative-profits indicator for competition authorities or policymakers aiming to enhance competition. Section 5 summarizes the empirical results. Section 6 discusses some extensions of the framework, Section 7 concludes. All details with respect to theoretical and empirical modelling are confined to technical appendices. Sections 3 and 5 have separate appendices containing the figures and tables referred to in the text.

2 What is wrong with the "old" indicators?

This section argues that competition is not the same as concentration. In particular, we argue that a rise in concentration, profits, price-cost margins and import penetration can be caused by either a rise or a fall in competition. As an aside, we discuss the relation between competition on the one hand and innovation and welfare on the other.

In this section we argue that frequently used competition indicators such as concentration indices, price-cost margins and firm or industry profits can convey the wrong impression about the nature of competition.[2] Our claim is that an indicator based on relative profits captures the ideas economists have about competition better than the “old” indicators. We do not claim however that these old indicators are useless. We just want to point out that an additional indicator is called for and advocate to use different indicators for

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[2] It should be noted here that here are more sophisticated ways of measuring competition empirically than using simply concentration or price cost margins. Some of these approaches are discussed in the appendix. Although these sophisticated measures have a better foundation in economic theory than the "old" indicators, their main disadvantage is that they are not easily understood nor interpreted. Our claim is that the relative profits indicator is equally robust on the theory side but easier to understand and work with than the sophisticated indicators.

Box 1: Entry costs reduced
Consider a market where deregulation reduces entry costs. We will see more firms enter the market. These firms gain market share at the expense of the incumbents. Further, the entering firms force the incumbents to lower prices to defend market share by reducing customers' incentive to switch to a new supplier.

different purposes. As an aside, we discuss the relation between competition on the one hand and innovation and welfare on the other. Although this is not directly related to the problem of measuring competition, we believe this discussion is instructive in clarifying our approach to competition.

As competition is not a clearly defined concept, we want to be precise about what we mean by competition. Therefore, we give examples in boxes 1, 2 and 3 of ways in which competition can be intensified. This approach allows us to distinguish competition from concentration. There appears to be consensus that these instances indeed characterize changes in competition. When discussing the limitations of the "old" indicators, we will use the perspective provided by these examples. In the appendix (to Section 3) we provide a simple model to demonstrate how competition can be parameterized.

In thinking about competition, it is important to distinguish two different ways in which competition can be increased. On the one hand, as illustrated in box 1, competition can be raised through a reduction in entry costs, thereby inviting more firms into the industry. On the other hand, as illustrated in boxes 2 and 3, competition can be intensified through more aggressive interaction between firms. The latter will often force less efficient firms to exit.

We now illustrate the limitations of "old" indicators like concentration, profits, price-cost margins and import penetration. Again, this is meant to show that there is room for an additional indicator, not that these indicators are useless.

Concentration and competition

Perhaps the most famous measure of competition is concentration. However, we argue that observing a rise in concentration in an industry, does not give any information about what really happened to competition in that industry. This ambiguity can be made clear as follows. First, consider a rise in competition due to a reduction in entry barriers as discussed in box 1. Then the entrants will gain market share at the expense of the

Box 2: Minimum price

Consider a market where the government has imposed a minimum price. Therefore, the most efficient firms in the market cannot undercut less efficient rivals by setting a price lower than the minimum price. In other words, the less efficient firms in the market are protected from their more efficient opponents by the minimum price. For instance, in the case of a minimum price for bread, very efficient supermarkets want the minimum price to be abolished, whereas small shops and bakeries favors the minimum price because it helps to avoid default.

We interpret a lowering or complete abolishment of the minimum price as a rise in competition.* The idea is that without the minimum price competitive forces can work more freely and competition is more aggressive.

What are the effects of intensifying competition by abolishing a minimum price? First, the most efficient firms will reduce their price (if they did not do so, the minimum price would in fact be irrelevant). Second, the least efficient firms will lose profits (if not, everyone would have preferred abolishing the minimum price in the first place) because they are not able to follow this price reduction. Hence they lose customers and market share, while the most efficient firms gain customers and market share.

* Note that there may be good reasons why the minimum price should not be abolished. If consumers value variety and the minimum price ensures that more products are available welfare will be higher with the minimum price. However, this does not contradict the idea that competition is lower with a minimum price.

incumbents and concentration falls as competition rises. Now consider the case where competition intensifies because the interaction between firms becomes more aggressive.

Think for instance of the case where a minimum price in the market is abolished (see box 2) or where shop opening hours are liberalised (see box 3). We would expect the most efficient firms in the market to attract new customers and gain market share at the expense of the least efficient firms in the market. Therefore, concentration can rise after competition has heated up. When we observe deconcentration in an industry, we do not know whether competition has increased because of lower entry costs or whether it has decreased through less aggressive interaction, say due to a rise in the minimum price. Similarly, the number of firms in the market does not tell us much about what happened to competition. If the number of firms in the market falls, two things may have happened. On the one hand, the drop in the number of firms may result from reduced competition as entry barriers have been raised. On the other hand, it may be caused by increased competition through more aggressive interaction which forced inefficient firms to exit.

It is this difference between intensifying competition through reducing entry costs and through more aggressive interaction that causes problems for the “old” indicators. Interpreting concentration in the usual way (think of ‘a fall in concentration signals a rise in competition’) can often give the wrong impression about what really happened to competition.

Industry profits and competition

Another way in which competition has been measured is the sum of firms’ profits or industry rents. As mentioned above, a reduction in competition can be seen as a protection of inefficient firms from efficient rivals. In other words, a rise in competition always reduces the profits of the least efficient firms in the market. However, it is not necessarily the case that a rise in competition reduces each firm’s profits. If all firms are symmetric (have the same costs), a rise in competition reduces each firm's profits and hence industry profits. But if firms differ in efficiency, a rise in competition can increase

Box 3: Shop opening hours
Consider deregulation in the food retail market. The liberalization of shop opening hours can be interpreted as a rise in competition for the following reason. Before opening hours were extended, people coming from work had to buy groceries at the shop they could reach most quickly. By going to another shop they risked arriving there too late and not being able to buy anything. In other words, people did not buy from the shop which they preferred in terms of selling good quality at a low price, they bought from a shop which just happened to be close to their place of work. Thus limiting shop opening hours protected inefficient retailers from their more efficient rivals. Liberalising shop opening hours made consumers more sensitive to the price/quality performance of shops and less sensitive to their location. In this sense competition intensified after the liberalisation.

Another way to interpret this liberalisation as a rise in competition is as follows. Firms now have an additional dimension on which they can compete: the hours on which their shops are open. Efficient and well managed firms can now capture consumers also using this instrument, besides the quality of products they sell, their price and their marketing effort. In other words, competition heats up because more weapons are allowed.

What are the effects of this rise in competition? First, efficient retailers like large supermarket chains gained customers and market share.* Since such chains have always argued in favour of this liberalisation, it may well also have increased profits. Second, small (family run) shops at the street corner have lost customers, market share and profits. These small firms have always opposed the liberalisation and some of them may well exit due to the intensified competition.

* One would also expect small specialised shops selling more expensive and higher quality products to have gained from the liberalisation. The argument is similar: these shops gain because they offer a better price/quality combination than the shops people went to before the liberalisation. Thus, the argument is theoretically sound. However, empirically there are problems if we cannot observe the quality of the goods on offer. We will return to this point below.

the profits of the most efficient firms because they can use their cost advantage more aggressively. This intuition underlies the observations in boxes 2 and 3 that efficient supermarket chains favored increasing competition through abolishing the minimum price on bread and extending shop opening hours.

A positive relation between competition and industry profits can be explained as follows. A rise in competition reallocates sales from inefficient firms, where sales add little to industry profits, to efficient firms, where they add a lot. Hence if this reallocation effect is strong enough, a rise in competition leads to higher industry profits, while it reduces industry profits if all firms were equally efficient. Thus observing increasing industry profits over time does not necessarily imply that competition has deteriorated in that industry.

Price-cost margins and competition

Next we consider the price-cost margin as a measure of competition. As argued in box 1, if competition is intensified through a reduction in entry barriers, the incumbents are forced to lower prices to compete with the entrants. A rise in competition is then associated with a reduction in price-cost margins. Similarly, if a minimum price is abolished one would expect price-cost margins to decrease. To see that a rise in competition may raise some firms' price-cost margins, consider the example in box 3.[3] If shop opening hours are liberalized, consumers will buy from the most efficient firms at the expense of less efficient firms. A possible response of the most efficient firms to this rise in competition is that they raise their price. The rise in competition makes consumers more price sensitive. They now buy from the firm with the best price/quality performance not from the closest firm. Therefore, the inefficient firms become marginalised, creating an opportunity for the most efficient firms to raise price (but making sure it stays below the price of the other firms). In other words, observing that the price-cost margins of some firms go up in an industry does not necessarily signal a reduction in competition.

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[3] See also Stiglitz (1987) and Bulow and Klemperer (1999) for other reasons why a rise in competition can cause a rise in prices.

Aside 1: Competition and innovation

Two notions that are often associated with competition are innovation and welfare. One may conclude that instead of trying to measure competition, it is better to look at innovation behavior or even welfare directly. Here we would like to point out that such a direct approach is not as simple as it may sound, for a number of reasons. First, innovation and welfare are not concepts that are easily measured in practice. To measure welfare we need information on consumer surplus, which requires a survey of customers. Such data is not easily available. Innovation decisions by firms are long-term strategic decisions. If policymakers take measures which change the business environment in some sector, one would not expect firms to change their R&D behavior the very next day. In other words, it may take a long time for changes in economic policy to show up in innovation data. If one uses innovation output data (such as patents granted to firms in the sector), it can easily take more than ten years for the effects of a change in competition to show up. Here lies the advantage of the relative profits indicator. A change in competition will immediately cause a fall in profits for inefficient firms, and profits and cost data are more easily available than consumer survey data.

A second reason why a direct approach to measure innovation and welfare is not the same as measuring competition, is explained in this aside and the next. There is no clear cut relation between innovation and competition nor between welfare and competition. In other words, measuring welfare and innovation is *not the same* as measuring competition.

There is an extensive theoretical and empirical literature on whether competition is good for innovation or not. The underlying ideas can be easily summarized in two lines of thought: the Arrow-von Hayek thinking versus the Schumpeterian reasoning. As innovation is not only risky business but the success of R&D efforts is simply unpredictable, it is hard to find outside investors for R&D projects. Therefore, Schumpeter's (1942) emphasis is on financing innovation. Market power and large firm size are prerequisites to generate sufficient cash flow to finance innovation internally. Moreover, market power or the (partial) exclusion of competition helps to appropriate the returns from innovation and thus increases the incentive to innovate. Consider the case where a rise in competition in a certain product market reduces the profits a firm can earn with a product in that market. Then there is less incentive for the firm to introduce that product, since the return will be low. Going one step back, there is little incentive for the firm to invent a product for that market in the first place. This is the Schumpeterian argument that profits are needed for firms to innovate. From the Schumpeterian perspective, there is an inverse relation between competition and innovation. The Arrow-von Hayek line of thought comes to the opposite conclusion. As argued by Arrow (1962), competition enhances the incentive to innovate because the prospect of monopoly rents is valued more by a firm earning zero profits under (perfect) competition than by a monopolist who has already been reaping the benefits of his monopoly position for some time. Further, as explained by von Hayek (1968, p. 3), competition spurs and keeps the "process of discovery" going, revealing information ("facts") and opportunities which without competition would remain unknown or at least unexploited. Michael Porter (1990) has argued recently that a rise in competition gives incumbent firms in the market a higher incentive to outperform each other. As competition heats up, the gain from being market leader will increase. However, it is also conceivable that, as competition heats up, the laggards in the market basically give up. Because of the rise in competition they have no chance of winning anyway and they will reduce investment in innovative activities. In conclusion, there is no clear-cut theoretical relation between competition and innovation. One aspect of innovation is improvements in machinery such that efficiency goes up. Nickell (1996) focuses on this aspect. Although he finds that competition does increase firms' efficiency, he admits that this link is rather weak empirically. Yet, the Schumpeterian view is not supported by empirical evidence.[4]

Aside 2: Competition and welfare

Although it is sometimes claimed that more competition necessarily raises welfare, the relation between competition and welfare is not a simple one. To see this consider the following example based on Mankiw and Winston (1988) in which competition is measured by the number of firms in the market.[5] Firms first pay a sunk entry fee before entering the market. After they have entered the market they produce output and compete to sell this output to customers. Can we expect to see the welfare maximizing number of firms in the market? No, because there are two externalities which firms do not take into account. First, firms only enter if expected profits at least cover the cost of entry. From a welfare perspective, however, the relevant consideration is whether the rise in consumer surplus justifies paying the entry cost. If firms cannot perfectly price-discriminate they will not be able to appropriate the full surplus. Hence too few firms will enter. On the other hand, an entering firm steals customers from other entering firms, but the firm does not take this business stealing into account. In other words, there is a negative externality associated with entry and too many firms will enter. Depending on which of the two effects dominates, increasing competition through a rise in the number of firms in the market can either increase or decrease welfare.

Import penetration and competition

Sometimes an industry's degree of import penetration is used as a measure of competition. The idea is that the more foreign firms compete in the domestic market, the more intensive competition must be. Here we see again the ambiguity result. If the government lowers import tarrifs foreign firms have to pay to sell goods on the domestic market, both competition and import penetration go up. However, consider the case where competition heats up in the domestic market through more aggressive interaction. Then one would expect domestic firms to gain market share and import penetration to fall if domestic producers are more efficient than foreign firms. Hence a rise in competition, in that case, causes a fall in import penetration.

[5] As argued above, observing an increase in the number of firms in the market does not necessarily signal a rise in competition. It could, for instance, be the case that the aggressiveness of firms' interaction is reduced (say through price fixing) so that less efficient firms are also able to make a living. In that case the reduction in competition allows more firms to enter. However, this does not contradict the statement above that a rise in the number of firms *all other things being equal* (in particular, the aggressiveness of interaction does not change) is a rise in competition. So in this particular case, the number of firms can indeed be used as a measure of competition.

Conclusion

In this section we have argued that there is no simple relation between competition on the one hand and concentration, the number of firms in the market, firms' profits, industry profits, price-cost margins, import penetration, innovation, and welfare on the other. Although these concepts are often thought to be closely related to competition, in important instances one can show that they are not. This insight leads to the question: Is there an indicator which is closely related to competition? In particular, is there an indicator which always and unambigiously increases as competition intensifies?

3 The relative profits indicator

This section argues that an indicator based on relative profits always moves in the same direction when competition increases (either through a reduction in entry costs or through more aggressive interaction). In particular, a rise in competition increases the profits of a firm relative to the profits of a less efficient firm. Further, the relative profits indicator has the useful property that it measures competition even if one does not observe all the firms in the industry.

The way people think about competition captures two important notions. First, people say that competition is raised if there are more players around. Second, competition can be increased because the incumbent firms in the market start to behave more aggressively. As argued in the previous section, the 'old' indicators capture the first notion but not the second.

To measure competition in a consistent way, we need an indicator which captures both interpretations of competition. In other words, the indicator should move in the same direction when either entry costs are reduced (as in box 1) or the interaction between firms becomes more aggressive (as in boxes 2 and 3). In short, we need an indicator which always moves in the same direction as competition. If this is not the case, we do not know how to interpret an observed rise in the indicator because this may then be caused by either a rise or a fall in competition. An indicator such as an index of concentration suffers from exactly this ambiguity problem.

The indicator we would like to suggest does move in the same direction as competition. It is based on the idea of relative profits. In particular, it is always the case that a rise in competition raises the profits of an efficient firm relative to the profits of a less efficient firm. Therefore, we analyse how cost differentials between firms are translated into profit differentials. A change in the way costs are translated into profits is interpreted as a change in competition. We first discuss the underlying intuition and then illustrate the indicator graphically using simple simulations. These simulations reveal that it is not necessary to observe all the firms in an industry for the relative profits indicator to measure competition. We conclude with discussing some problems associated with the relative profits indicator.

Intuition of the relative profits indicator

The indicator builds on the intuition that the market mechanism rewards efficiency advantages of one firm over the other with higher profits. In other words, the inefficient firm is punished for its inefficiency by earning lower profits. As competition intensifies, the reward of the efficient firm relative to an inefficient firm increases. Defining relative profits as the profit of the efficient firm relative to a less efficient firm, a rise in competition raises relative profits.[6] This definition does not necessarily mean that a rise in competition raises the profits of an efficient firm. The point is that if a rise in competition decreases the profits of the efficient firm, the profits of the less efficient firm decrease even more.

In other words, the market can be seen as a mechanism that maps cost differences between firms into profit differences. This mapping is downward sloping in the sense that

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[6] Boone (2000) proves theoretically that for a wide variety of economic models it is the case that a given marginal cost differential between any two firms operating in the same market will be mapped into a bigger profit differential the more intensive competition is.

the market rewards more efficient firms (i.e. lower costs) with higher profits. Further, as competition intensifies, the mapping becomes steeper in the sense that a given gain in efficiency is rewarded more by a greater increase in (relative) profits. So in practice and for a certain market, we estimate to which extent cost differences between firms translate into profit differences between these firms.

How does this work in practice?

When analysing the evolution of competition in an industry over time in practice, we propose to do the following. Determine at each moment in time how the market translates cost differences into profit differences, by analysing firms' profits relative to the profits of the most efficient firm. If this changes over time, say that cost differences are translated into smaller profit differences over time, then competition has changed over time; in particular competition has decreased. This follows from the fact that more efficient firms now earn less for their relative efficiency than before: the same cost difference is translated into a smaller profit difference between firms.[7]

The idea of the empirical approach below is to estimate a linear approximation of the mapping from cost differences into profit differences. In particular, we look at how relative profits of firms *i* are related to the relative costs of firm *i*. Equation (3.1) describes the relationship we have in mind.

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[7] It is important to note that profits here mean variable profits and efficiency is defined in terms of marginal costs. To be precise, variable profits equal total revenue (turnover) minus total variable costs. Marginal cost is the increase in total costs incurred by producing an additional unit of output. In Boone's (2000) theoretical analysis only the case of constant marginal costs is considered. Strictly speaking, we cannot claim that a rise in competition raises relative profits for all types of cost functions. However, so far we have not come across any counter-examples. Two technical points can be noted here. First, it is always possible to approximate a cost function locally by a linear cost function which has constant marginal costs. In this sense the results in Boone (2000) are valid locally for general cost functions. Second, the problems mentioned below with unobservable quality differences between goods etc. seem more important than problems with cost functions that do not feature constant marginal costs.

(3.1) $$\frac{\pi_{it}}{\overline{\pi}_t} = a + b\frac{c_{it}}{\overline{c}_t}, \qquad i = 1,\ldots,n,\ t = 1,\ldots,T$$

In (3.1) $\pi_{it} = (p_{it} - c_{it})x_{it}$ defines profits of firm *i* (excluding possible fixed costs) producing output level x_{it} at marginal cost c_{it} and selling the output at a price p_{it} in period *t* in a certain market or industry; $\overline{\pi}_t$ and $\overline{c}_t$ are used to normalize firm *i*'s profits and marginal cost. In the simulations below we use the profits and marginal cost of the most efficient firm in the market to normalize. When applying the indicator to actual data, however, the use of the costs and profits of the most efficient firm puts a lot of weight on potential outliers. Therefore, in the subsequent empirical analysis (see section 5) we normalize by the industry median of profits and marginal cost.

The coefficient on the marginal cost ratio measures the intensity of competition. All theoretical models relating profits and efficiency imply *b* to be negative: firms with higher relative marginal costs have relatively lower profits. This hypothesis is supported empirically for the industries we have investigated (see Section 5). As competition increases (say entry costs are reduced) the slope *b* becomes larger in absolute value. In words, in a more competitive environment a given gain in efficiency (fall in marginal cost) is better rewarded in the sense that (relative) profits increase more. We will use simulations with a simple example to illustrate this idea.

Graphical illustration of the indicator's properties

In order to explain the indicator, we run some simulations. Figures 3.1 - 3.4 depict the simulation results, which are described in greater detail in the appendix. For each graph we have generated one hundred firms by drawing their constant marginal cost levels from a beta distribution. These firms compete with each other in a certain way (see appendix for details) and earn profits. Firms only enter the market if expected profits exceed the sunk entry cost that they have to pay to enter the market. The figures rank the firms on the horizontal axis by their marginal costs relative to the marginal cost of the most efficient firm. The most efficient firm thus has relative marginal cost equal to one. The vertical axis shows the profits of a firm relative to the profits of the most efficient firm.

Since the most efficient firm has the highest profits, it has relative profits equal to one. The relative profits of the other firms are calculated for two cases. First, for the case where competition is high (denoted RPhigh in the figure) and, second, for the case where competition is low (denoted RPlow in the figure). Note that the relation between relative profits and relative marginal cost is indeed downward sloping in all cases.

What happens to the relation between relative profits and relative costs when competition increases? Figure 3.1 assumes that competition increases because the interaction between firms becomes more aggressive.[8] The top curve depicts the low competition case. Two effects emerge from Figure 3.1. First, some firms which make strictly positive profits under the soft competition regime are forced to exit as competition heats up. The firms with marginal cost exceeding 1.7 times c_1 are not viable in the more competitive environment. Here we observe the selection effect of competition. Raising competition selects 'good' from 'bad' firms by forcing inefficient firms to exit.[9] The second feature brought out by the figure is that the relation between firms' relative costs and relative profits becomes steeper. In the more competitive market, a given increase in marginal costs is punished more severely by a decline in profits (relative to firm 1).

Further, note that we do not need to observe all firms in order to estimate the slope of the relation between relative profits and relative costs. As long as we observe a number of firms we can estimate a linear approximation of the curves in Figure 3.1. This property is helpful because usually data availability is limited to only the larger firms in an industry. In the empirical analysis to be presented in Section 5, we use a data set which only contains firms with more than 20 employees. We know that there are more firms in a market than we observe. In addition, most of the time we work with a balanced data set

[8] In particular, the conjectural variation is reduced. The conjectural variation measures the rise in output a firm expects from its opponents if the firm itself raises its output level by one unit. If the conjectural variation is high, the firm expects a very aggressive response from its opponents to a unit increase in its own output level. Hence the firm restricts its output to a great extent. If the conjectural variation is low, the firm expects a weak response from its opponents. Hence the firm behaves very aggressively.

[9] See Vickers (1995) and Boone et al. (2000) for a theoretical discussion.

for technical reasons, that is, we impose the restriction that all firms included in the analysis have the same number of time series observations. In that case, it is important to know that the indicator is not biased by the omission of firms.

This property does not hold for a concentration index, for instance. Consider the case where turnover data is only available for larger firms in an industry but not for all firms. Then the fact that we do not observe all the other firms implies that the estimated concentration tends to be higher than the actual degree of concentration. In other words, we would overestimate the extent of competition.

Figure 3.2 considers the case where competition is increased by a reduction in entry costs. In contrast with figure 3.1, the more competitive case is the one which features more firms in the industry. In particular, the firms with relative marginal costs of around 1.9 do not enter in the case with high entry barriers but do enter with low barriers. Yet, also in this case the relation between relative marginal costs and relative profits becomes steeper as competition is increased. This result is in contrast with the measures discussed in the previous section which respond differently to a rise in competition through a reduction in entry costs than to a rise in competition through more aggressive interaction between firms. In Figure 3.2, the difference between the relative profits in the low versus the high competition case is rather small. The explanation is that when many firms are already active, entry and exit of some firms does not have much effect.

Figure 3.3 illustrates the case in which a reduction in entry barriers increases the number of firms in the market from 10 to 20. Then the difference between the two curves is indeed bigger.

Finally, Figure 3.4 returns to the case of more aggressive interaction. Now the interaction between firms becomes more aggressive because goods become closer substitutes. That is, firms are no longer protected from each others‘ actions through product differentiation.[10] Again we see that the relation between relative profits and relative costs becomes steeper as competition intensifies. Further, the selection effect shows up again. Firms with relative marginal costs exceeding 1.8 cannot profitably enter after competition is increased.

Limitations of the relative profits indicator

Although the relative profits indicator has a number of intuitively appealing properties, we want to stress that it has some limitations of its own. In a number of important instances it is preferable to measures like concentration and profits, but it also has its weaknesses. Here we discuss problems related to measurement problems with respect to marginal costs and an unlevel playing field. We argue that these problems preclude inter-industry comparisons of competition with the relative profits indicator. However, in most industries it seems reasonable to argue that such measurement problems stay more or less constant over time. Therefore, the indicator can be used to monitor competition over time within an industry.

Measuring efficiency

The indicator measures to which extent the market maps efficiency differences into profit differences. The relevant efficiency concept is marginal costs. Marginal costs are notoriously hard to measure. In the empirical section, we approximate marginal costs with average variable costs. Although this is common practice (see for instance Hall (1988)), strictly speaking, it is only correct if production is characterized by a constant returns to scale technology.

To illustrate what can go wrong if marginal costs are not correctly observed, consider the following example. The example is based on the idea that a firm's marginal cost should be corrected for the quality of the output it produces. Producing higher quality products is

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[10] This can be viewed as a simple formalization of the liberalisation of shop opening hours discussed in box 3. As shop opening hours are liberalised firms are no longer differentiated geographically in a way that affects consumer decisons.

usually more expensive in terms of inputs, but clearly these higher costs (as such) do not indicate a lack of efficiency. To take this into account, a firm's costs should be corrected for the quality of its goods.

Consider a researcher trying to measure competition on the market for watches. To keep things simple, suppose there are only two firms: Casio and Rolex. If the researcher does not observe the quality difference between these two products, he will conclude that there is no competition at all in this market for the following reason. He observes a firm (Casio) which produces watches at very low cost but which makes relatively little profits. Then there is a hugely inefficient firm (Rolex) which produces watches at high cost and which is more profitable than the low cost producer Casio. Hence the mapping from relative costs into relative profits seems to indicate a lack of competition. The problem is, of course, that marginal costs are not correctly observed (because they are not corrected for product quality) and this clouds the relationship between relative costs and relative profits. In other words, the correct conclusion is not a lack of competition in this case.

Relevant market

Another interpretation of this Casio-Rolex example is that the observed firms do not compete on the same (relevant) market. In that case, one would not expect that their relative costs and relative profits are related in any way, because they are not subjected to the same disciplinary force of competition. Put differently, there is no reason to expect an efficient milk producer to make higher profits than an inefficient producer of computers. This is also something that should be kept in mind when reading the empirical section: the 4-digit-industry classification may well contain industries which cover more than one relevant market. This problem can be solved by using better data and by analysing qualitative data to determine the relevant market.

As the extent of measurement problems is likely to vary between industries, the relative profits indicator cannot be used to compare the intensity of competition across industries. If the relationship between relative costs and relative profits is steeper in industry A than in industry B, this may be caused by the fact that marginal costs are better approximated in A than in B. Hence the conclusion should not be that industry A is more competitive than B.

Unlevel playing field

Another problem that precludes inter industry comparisons of competition with the relative profits indicator is an unlevel playing field. The problem is that if the playing field is tilted in favor of the most efficient firms at the expense of less efficient firms, the indicator points to a rise in competition. This can be seen as follows. Consider two firms competing on a domestic market. The more efficient firm is the domestic one and the less efficient firm a foreign firm. Now the (domestic) government decides to levy an import tax per product on the foreign firm while not taxing the domestic firm. This makes the playing field unlevel in favor of the domestic firm. If the researcher does not observe this import tax (or does not include it in his estimate of marginal costs), he sees that the relatively more efficient (domestic) firm is now better rewarded for its relative efficiency. Hence he concludes that competition has increased on the domestic market. Yet, most people would argue that making the playing field unlevel is an example of a reduction in competition.

As the extent to which playing fields are unlevel may differ between industries, we cannot use the relative profits indicator to compare the intensity of competition between industries. The relationship between relative costs and relative profits may be steeper in industry A than in industry B, because the playing field is more unlevel in favor of efficient firms in A. Again, the conclusion should not be that competition is more intense in industry A than in B.

Conclusion: use the indicator to measure competition over time

However, if we can argue, as seems reasonable for most industries, that the extent of measurement problems with respect to marginal costs and unlevelness of the playing field stays constant over time within an industry, then changes in the relative profits indicator over time can be interpreted as changes in competition in this industry. This is exactly the role of the relative profits indicator that we advocate in this report: to monitor how competition changes over time within a certain industry. The next section explains how this application of the relative profits indicator can assist policy makers.

4 How does the relative profits indicator help policymakers?

In this section we argue that the relative profits indicator is a useful instrument for competition authorities or regulators that want to enhance competition. The competition authority can use the indicator to monitor the economy and identify industries which require closer examination. Further, the competition authority can use the indicator to argue that anti-competitive behavior is present in a certain sector. Policymakers or regulators can use the indicator to measure the impact of policy changes aimed at enhancing competition. The indicator provides a coherent framework to think about competition issues which can be fruitful in preparing policy. Unfortunately, the indicator cannot be used to compare the extent of competition between industries. The implication is that it cannot help in selecting the industry (from a group of industries) which is most in need of policy intervention.

By now the reader may be convinced that intuitive notions of competition (as illustrated in boxes 1, 2 and 3) are better captured by an indicator based on relative profits than by any of the “old“ indicators. However, the question remains: what can we do with this knowledge? In this section, we argue that an indicator based on relative profits is indeed very useful for policymakers. In particular, we discuss how the indicator can be used by, say a competition authority.

More precisely, we have developed an indicator which can be estimated for an industry. By analysing the evolution of this indicator over time, we can say whether competition has increased or decreased over time within this industry. How can such an instrument be used by policy makers?

A competition authority, such as the Dutch NMa, has two important tasks: a proactive and a reactive task. Proactively, the NMa monitors the Dutch economy to see whether there are any sectors which require closer scrutiny. The idea is to get some early warning of anti-competitive behavior in a certain sector. Such an early warning can then lead to a closer examination of the industry. If everything looks fine, the case can be dropped, if not, further action is required.

In our opinion the relative profits indicator is well suited for this proactive task. This measure is robust to different forms of anti-competitive behavior; whether it is caused by incumbent firms raising entry costs or by softening competition through tacit collusion. As we show in the next section, the indicator is especially geared to monitor competition over time within the same industry. The idea is that we estimate how the slope coefficient in equation (3.1) of Section 3 varies over time. We ask whether the extent to which firms are rewarded for their efficiency varies over time? If we observe that, say, in 1980 firms are strongly punished for being inefficient while in 1989 this is no longer the case, we have a first indication that competition may have been softening in this industry. This observation may warrant a closer examination of this industry to find out if there are collusive agreements or if, in fact, nothing serious is going on.

The empirical section shows that the relative profits indicator can be implemented rather easily to monitor competition over time in a number of industries. Of course, the more precise the signal has to be, the more time and effort the implementation will take, for two reasons. First, because one may want to use better (in the sense of more disaggregated) data than the 4-digit-level data we have used. Second, because one wants to use more sophisticated econometric techniques. Because of the latter reason, in the appendix to the next section we begin with the simplest way to run the regression and then introduce more sophisticated techniques. At each step, we discuss the benefits and costs of using a more sophisticated model.

The reactive task of a competition authority is to bring a case to court once anti-competitive behavior by a firm (or group of firms) has been observed. Here it is helpful to substantiate a case by empirical evidence. As argued above, the observation that concentration has increased over time in a certain industry is not unambiguous evidence that competition has decreased in that industry. It may well be the case that the interaction between firms has become more aggressive, thereby raising the market share of the leader. In other words, the rise in concentration may have been caused by a rise in competition.

In contrast, if one can show that, in this industry, over time firms get rewarded to a lesser extent for being efficient, this makes a strong case for anti-competitive behavior. Also, once the industry and firms concerned are identified, the competition authority can probably request more comprehensive and detailed data. Because the case is then analyzed in depth, a more appropriate definition of the relevant market can be used (than the 4-digit-classification that we use) and some of the pitfalls (unlevel playing field, unobservable quality differences) mentioned at the end of Section 3 can be circumvented. This will clearly improve the use of the relative profits indicator.

When one observes that in a certain industry over time firms get rewarded less for being efficient, there are a number of possible conclusions. First, firms may have started colluding. Second, the measurement problems, mentioned at the end of section 3 and briefly discussed in box 4, may have become worse over time. Finally, competition may have softened because of changes in the institutional environment firms face, rather than due to anti-competitive behavior by firms. This introduces a role of the indicator for policymakers or regulators.

Box 4: The indicator cannot be used to compare the intensity of competition *between* industries

The indicator is sensitive to certain measurement problems. One reason why in an industry firms are observed to be hardly rewarded for their (relative) efficiency, may be that we do not measure efficiency in the correct way. In other words, the mapping between efficiency and profits is fuzzy due to problems in measuring efficiency but not due to a lack of competition.

We assume that such measurement problems are more or less constant over time within an industry. Hence we can interpret a change in the mapping (from relative efficiency to relative profits) as a change in competition.

However, there is no reason to expect such measurement errors to cancel out when comparing two different industries. In other words, at this stage the indicator cannot be used to support statements like "the leather industry is more competitive than the concrete industry". One reason why the mapping may be steeper in the leather than in the concrete industry is that marginal costs are easier to measure in the leather industry.

In principle, it is not inconceivable that better data may help to make such comparisons possible in the future. If one can argue that a certain proxy of marginal costs works equally well for firms selling meat as for firms selling fish,[*] than one could compare how relative marginal costs are mapped into relative profits in these industries. This would be a first step in comparing the competitiveness of these two industries.

However, for the time being we advise not to use the indicator for inter-industry comparisons. This implies that the indicator cannot be used to find the industry which is least competitive and hence most in need of policy intervention. In this sense, the indicator can be used to evaluate whether a policy change in an industry has raised competition in that industry, but it cannot be used to select (pro-actively) which industry needs a policy change.

* Similarly, if one can argue that the data for a certain industry are collected in an identical manner for the Netherlands and Belgium, and hence that the measurement errors with respect to profits and efficiency are the same in both countries, then the indicator can be used to compare differences in competition intensity between the countries in that industry.

Policymakers or regulators can use the indicator to monitor the effects of changes in policy. For instance, an explicit goal of the MDW-project is to increase competition in certain Dutch sectors. Of course, the ultimate goal is to increase welfare, partly through spurring firms' innovative activities. However, welfare is not easily measured and the effects of policy changes on innovation may be a longer-run phenomenon. Hence it is important to be able to measure whether the policy change has indeed increased competition. As argued above, calculating the concentration index in an industry may not be the way to show what happened to competition. For instance, the examples in boxes 2 and 3 of abolishing a minimum price and extending shop opening hours will (most likely) result in a rise in competition.

If one is able to show that after a policy change, firms are rewarded more (in terms of profits) for being efficient, the claim that the policy change enhanced competition finds support. The empirical implementation of the relative profits indicator, explained in the next section, is suited for this type of analysis. If the measure was taken in, say, 1995, then one can test whether there has been a significant change after 1995 in the way that firms are rewarded for being efficient. If the extent to which firms are rewarded for efficiency is significantly bigger after 1995 than before, one can make the case that competition increased due to the policy change.

In this way, the relative profits indicator can play an important role in evaluating the measures introduced by policymakers. Further, it provides a coherent framework to think about competition, identifying what different policies to enhance competition have in common without simplistically equating competition with concentration or welfare. The distinction between the indicator and welfare is important because the indicator can be measured objectively. The indicator is based on data (profits and costs) and not on normative considerations (like the distribution of money between firms and consumers or between firms and workers). Thus it allows policymakers to agree on whether competition has increased or decreased after a measure was introduced, without necessarily agreeing on whether the measure was desirable.

5 Empirical Results

The suggested indicator of competition has theoretically appealing features but the main challenge is whether it works in practice. In this section we summarize the outcome of an in-depth empirical analysis of two industries, bread and bakeries (Dutch 1974 Industry Classification No. 2081) and periodical publishing (No. 2722). Details of the data set and empirical analysis can be found in the appendix to this section. Here we just note that data on individual firms' costs and profits is needed to estimate the indicator.

We have selected the bread and bakeries industry because, compared with other industries, it can be assumed to produce fairly standardised and thus homogenous products. Further, the number of firms is quite high (about 240). Even if we focus on the industry's incumbents only, that is, on those firms reporting consistent data for each year of the observation period 1978 to 1992, 67 firms remain which is more than sufficient for a sound panel data analysis.

The second industry, periodical publishing, caught our interest, since the CPB has already conducted a case study on the Dutch publishing industry (see Canoy et al., 2000, and therein, Cornet and Vollaard, Hakfoort and Weigand). One conclusion of that study is that the leading Dutch publishers have been enjoying high profits over the period 1988 to 1998, mainly undisturbed by competitors. Given this case study evidence, it would be interesting to know whether our competition indicator indeed signals any deterioration of competition in this industry. In particular, the findings in Hakfoort and Weigand (2000) suggest that the indicator should decrease at the end of the period, that is, around 1988 to 1992.

Due to Statistics Netherlands confidentiality restrictions, we are not allowed to report any results on industries or sub-samples with less than 16 firms. We cannot therefore report results on the incumbent firms in this industry which, of course, are the well-known big publishers. We are only able to report results for the full sample of 57 firms with consistent data over the observation period.[11]

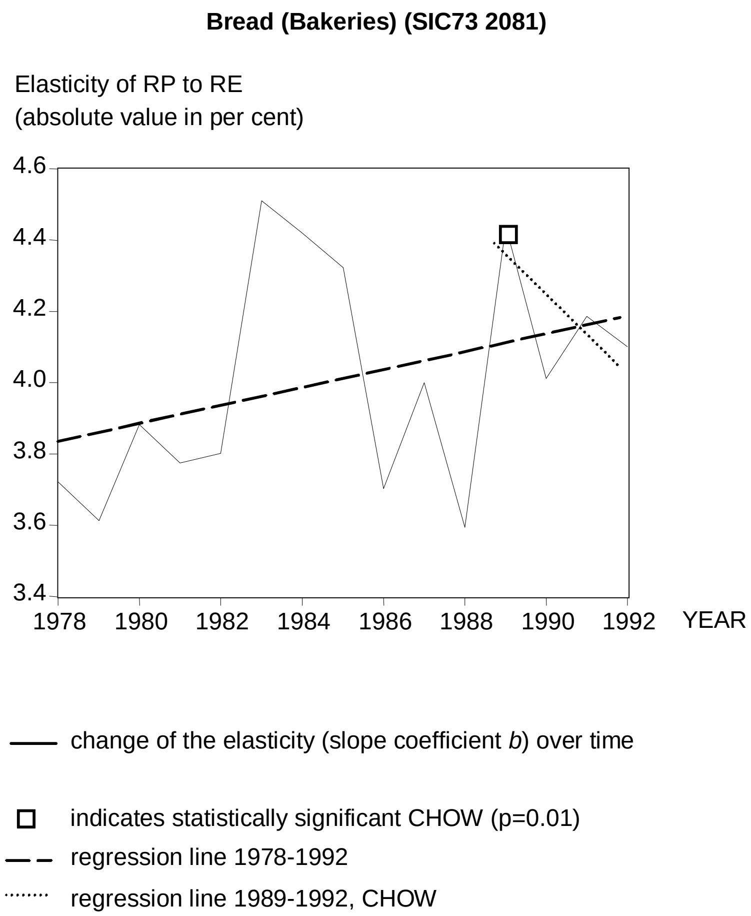

Figure 5.1

[11] See the appendix to this section for the meaning of "consistent data". On average, we observe about 30 firms in each sample year.

Figure 5.1 contains the results for the bread and bakeries industry. The horizontal axis shows the years of the observation period. The vertical axis gives the absolute value of the slope coefficient *b* which denotes the average percentage change of relative profits when relative efficiency changes by 1 per cent. The average value of *b* over the observation period is 4.00, implying that a 1 per cent increase in a firm's efficiency (relative to the industry's median efficiency) raises its profits (relative to the industry's median profit) by 4 per cent on average.[12]

The solid line depicts the estimated slope coefficient *b* over time.[13] The dashed line running from 1978 to 1992 depicts the regression of this estimated *b* on time. The slope of this line is positive and statistically significant. This enables us to conclude, within an error margin of 10 per cent, that competition has increased between 1978 and 1992 in this industry.

The square marks the year for which the Chow test indicates a structural break in the development of competition.[14] We illustrate the implication of the Chow test graphically by drawing a second, dotted regression line running from 1989 to 1992. This line has a negative slope, implying that in 1989 a structural break occurred, leading to a statistically significant reduction in *b*. To conclude more from this observation, we require detailed qualitative information on the bread and bakeries industry to find out why this implied new trend (i.e., a fall in competition) took place.

Figure 5.2 summarizes the results for the publishers industry. The axes are defined as before. The average value of *b* over the observation period is 4.18, thus a 1 per cent increase in a firm's efficiency (relative to the industry's median efficiency) raises its profits (relative to the industry's median profit) by about 4.2 per cent on average. The

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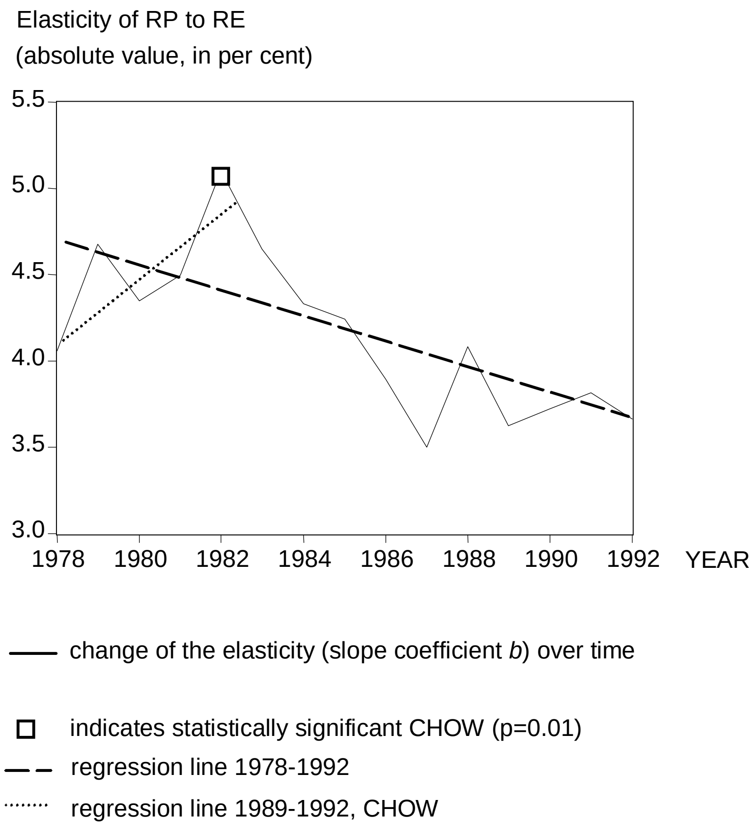
[12] The formulation is equivalent to saying that a 1 per cent *decrease* in a firm's marginal cost (relative to the industry's median marginal cost) raises its profits (relative to the industry's median profit) by about 4 per cent.

[13] These coefficients have been estimated from a panel regression model shown in the appendix.

[14] The Chow test is a statistical test which compares two sub-period regressions with the full-period regression to detect a structural break in the assumed relationship over time.

solid line shows the estimated slope coefficient *b* over time. The dashed line again depicts the regression of the estimated *b* on time. This slope is significantly negative.

Magazine Publishing (SIC73 2722)



For the publishers industry between 1978 and 1992, the graph shows that competition has softened, given an error margin of 1 per cent. The Chow test shows a significant structural break (at the 1 per cent error level) in 1982, highlighted by the square on the solid line. Based on the Chow test, we may argue that competition increased between 1978 and 1982, as depicted by the positively sloped dotted regression line, but deteriorated steadily thereafter.

Again, to substantiate these findings, we would have to gather detailed qualitative information to find out more about what happened in this industry at these particular points in time. However, drawing on the case study results and some anecdotal evidence on anti-competitive strategies employed by the leading publishers (cited in the case study), we are quite confident in claiming that the trend picked up by our indicator is clearly not inconsistent with what Hakfoort and Weigand (2000) concluded for the 1990s: publishers enjoyed a quiet life.

For a more elaborate discussion of our empirical analysis the interested reader is referred to the appendix.

6 Possible extensions

As this report is intended as a pilot study into the use of the relative profits indicator to measure of competition, there are a number of issues that we have not been able to analyze. Here we want to discuss three of these issues: using a structural approach to estimate marginal costs, comparing the relative profits indicator for a number of industries with the 'old' measures of competition discussed in Section 2 and, finally, using different data sources which may provide data better geared for measuring competition.

We have used average variable costs as a proxy for marginal costs. The advantage of this approach is that it is simple. An alternative approach is a structural one. In that case, one tries to model how a firm's total cost function varies with output and over time. One obtains a cost function for each firm in the sample and for each time period. Differentiating such a cost function with respect to output then yields an estimate of marginal costs. Since more information is used to estimate marginal costs in this way (as compared to using average variable costs), this may yield a better estimate of marginal costs and hence improve upon the analysis we have done.

Another issue which is left open is how does the relative profits indicator empirically relate to the other measures of competition. Above we have argued that the 'old' indicators work fine if competition is intensified through a reduction in entry costs, but give the wrong impression if competition is intensified through more aggressive interaction between incumbents. By analysing the relationship between relative profits and the other indicators over time and in the cross-section, we could potentially find out how important this distinction is empirically. What is the major determinant of changes in competition in Dutch industries: reduction in entry costs or more aggressive interaction between existing firms?

One disadvantage of the data set applied is that the industry classification at the four-digit level does not necessarily coincide with the relevant market. In general, one would expect a four-digit industry to include more than one relevant market. Thus, the empirical relationship between relative profits and relative costs is clearly blurred. If, however, a competition authority analyzes a market, it can probably get more accurate data on which firms are active in a particular market. Further, it will have better knowledge about the nature of the market. In that way, it can better identify than we are currently able to do, issues related to quality differences between firms or unlevelness of the playing field. With such detailed knowledge, one can avoid some of the pitfalls associated with the relative profits indicator as discussed at the end of Section 3.

7 Conclusion

This report suggests a new approach to measure the intensity of competition. We claim that in a more competitive environment firms are rewarded better (in terms of profits) for being efficient. We have argued that there is a need for such a new measure of competition, because the 'old' measures of competition have a number of drawbacks. Most importantly, such measures are not able to register a rise in competition through more aggressive interaction between existing firms, while this is an important form of competition for policy makers.

We have used a Statistics Netherlands micro data set to illustrate how the relative profits indicator can be used to monitor the evolution of competition over time in a certain industry. Although the indicator is not free of problems (measurement problems with respect to marginal costs etc.), it seems a promising way to measure competition and in the future can be a useful instrument for policy makers.

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Abstract

We suggest a competition indicator based on the idea that the market mechanism translates efficiency differences between any two firms into profit differentials. Using a simple oligopoly model and simulations we show that a given efficiency differential will be mapped into a bigger profit differential the more competitive the market is. This relation between relative profits and relative efficiency can be approximated by a linear regression equation in which the coefficient on relative efficiency measures the intensity of competition. With intensifying competition, this regression coefficient can be expected to increase in absolute value. We present firm-level panel data evidence in support of the empirical usefulness of the proposed indicator for a selection of Dutch four-digit industries over the period 1978-1992.

Appendices Sections 2, 3 and 5

Appendix to Section 2

In this section we summarize some of the more sophisticated ways in which economists have proposed to measure competition.

As surveyed by Bresnahan (1989), there are the structural and non-parametric approaches to measuring competition. Both approaches usually model the industry as a representative firm and try to identify a conjectural variation parameter. Bresnahan (1982) and Lau (1982) were the first to show that different hypotheses about conduct have different implications for the comparative statics of industry price and quantity with respect to demand and supply shocks. The structural approach estimates the demand curve a (representative) firm faces, its cost curve and a supply curve. Examples are Bresnahan (1987), Porter (1983) and Wolfram (1999). The main problem with this method is misspecification. The estimate of the conjectural variation parameter is sensitive to how, say, the cost curve is specified.

The non-parametric approaches of, for instance, Panzar and Rosse (1987) and Ashenfelter and Sullivan (1987), are more general in the sense that they use revealed preference arguments which hold for any demand and cost function. In particular, Panzar and Rosse (1987) estimate a reduced form revenue equation where among the independent variables are factor prices of the industry's inputs. Then they calculate a statistic ψ which equals the sum of elasticities of revenue with respect to factor prices. They show that monopoly implies $\psi \leq 0$, (long run) monopolistic competition implies $\psi \leq 1$ and perfect competition implies $\psi = 1$. This is a general approach, but cannot be used to see how competition changes. To illustrate, if in a certain industry ψ increases from -0.75 to 0.5 either competition increased from monopoly to monopolistic competition or it has stayed under monopolistic competition, in which case competition has not necessarily increased. In this approach there is the following misspecification problem. How should the relation between revenues and factor prices be specified; linear, log-linear or otherwise? The indicator proposed here has the same problem. For instance, equation (3.1) in section 3 specifies a linear relation between relative profits and relative efficiency. But there is no reason to expect this relation to be linear in practice.

Also in this vein is Hall's (1988) instrument test of the joint hypothesis of perfect competition and constant returns to scale production technology. Hall shows that under this hypothesis, the Solow residual in an industry is uncorrelated with instrumental variables like military spending and the oil price. The problem is that in an industry where this hypothesis is rejected, nothing can be said about whether competition increases or decreases. To say more about competition in this case, Hall estimates the mark up ratio (price over marginal costs) for an industry and uses this as a measure of market power. One problem with this approach is that the mark up ratio is not monotone in competition. Second, as argued by Shapiro (1987), the mark up ratio should be corrected for the market elasticity of demand to derive a measure of competition. Third, as shown by Domowitz et al. (1988) the estimated mark ups are sensitive to the way marginal costs are measured. Similarly, the relative profits measure, proposed here, is sensitive to measurement problems with respect to marginal costs.

Summarizing, one can say that when using measures of competition in practice, one faces the following trade off. On the one hand, there are measures like concentration and industry profits which are relatively easy to calculate, but not monotone in competition. On the other hand, there are the structural and non-parametric approaches which are better grounded in theory but harder to calculate in practice. The relative profits measure clearly belongs to the latter category. However, it remains an empirical question to which extent these measures of competition yield different conclusions in practice.

Appendix to Section 3

Consider the following two-stage oligopoly game with linear demand and constant marginal cost under perfect information. In the first stage, firms decide simultaneously and independently whether to enter a market or not. If firm i enters, it is common knowledge that it will produce in the second stage with constant marginal costs c_i. Entrants have to incur a sunk entry fee f. In the second stage, it is common knowledge which firms have entered and these firms choose individual output simultaneously and independently. This two stage game is solved by backward induction.

Suppose that the *n* firms which have entered face a demand curve of the form

(A3.1) $p(x_i, x_{-i}) = a - bx_i - dx_{-i} \qquad x_{-i} := \sum_{j=1,\, j\neq i}^{n} x_j$

where $0 < c_i < a$ and $0 < d \le b$. Then firm *i* chooses output x_i which solves

(A3.2) $\max_{x_i \ge 0} \quad \pi_i = (a - bx_i - dx_{-i} - c_i)x_i$

From the *n* first-order conditions, assuming $x_i > 0 \quad \forall\, i = 1,...,n$, we obtain individual output

(A3.3) $$x_i = \frac{\left(\frac{2b}{d} + \lambda - 1\right)a - \left(\frac{2b}{d} + \lambda + n - 1\right)c + \sum_{j=1,\, j\neq i}^{n} c_j}{[2b + d(\lambda + n - 1)]\left(\frac{2b}{d} + \lambda - 1\right)}$$

where the conjectural variation is defined as $\lambda \equiv dx_{-i}/dx_i$. Further, by substituting (A3.3) into (A3.2), profits can be written as

(A3.4) $\pi_i = (b + \lambda d)x_i^2$

By invoking the entry condition that the last firm *n* to enter the industry reaps a non-negative profit, $\pi_n \ge f$, but firm *n*+1 cannot profitably enter, $\pi_{n+1} < f$, we can determine *n* in the first stage.

The conjectural variation parameter λ is one parameterization of competition. The lower λ, the more lenient a firm expects rivals to react to an increase in its output. Hence the more aggressively (in the sense of producing more output) the firm will behave. Also, a lower entry fee *f* increases the number of active firms in the industry and hence intensifies competition. Finally, we say that competition intensifies as goods become closer substitutes, that is *d/b* approaches 1.

To illustrate the relative profits indicator we focus on changes in λ, *f* and *d/b* in a simple simulation exercise. We choose the following values for the parameters: $a = 10$, $b = 1$, $d = 0.7$ and $f = 0$. Then we generate *i* = 1, …, 100 firms by drawing their marginal cost levels from a beta distribution.[15] These firms are sorted such that $c_1 \leq c_2 \leq \ldots \leq c_{100}$. In figure 3.1, we compare Cournot competition, $\lambda = 0$ (the low-competition case), with $\lambda = -1$ (the high-competition case). For both cases we calculate the number of firms that enter, each firm's profits π_i and normalize by the profits of firm 1, π_i / π_1. Firm 1's marginal cost is used to normalize each firm's marginal cost ($Rcost_i$ in figure 3.1). The relative profits of firm *i*, π_i / π_1, are denoted $RPlow_i$ in the low-competition case and $RPhigh_i$ in the high-competition case.

Figure 3.2[16] is generated with the same parameter values and Cournot competition. The high competition case features zero entry costs and 100 active firms. The entry barriers are increased such that only 20 firms can profitable enter. This is the low competition case.

In Figure 3.3 the high competition case is the one with 20 active firms. Then entry barriers are raised further, such that only 10 firms can profitably enter. This equilibirum with 10 firms is the low competition case.

In figure 3.4, we use the same parameter values as in figure 3.1 (with the exception of *d*) and Cournot competition. The case with low competition has $d = 0.5 < 1 = b$. The case with high competition features perfect substitutes ($d = b = 1$).

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[15] In particular, firm i’s marginal costs equal 1 plus a random draw from a beta distribution with parameters 0.5 and 0.05.

[16] For each of the four figures (1-4) a separate cost distribution is sampled from the beta distribution. Comparing high and low competition within a figure happens, of course, with the same cost distribution.

Appendix to Section 5

In this section, we present a step-by-step guide of how to implement the indicator and assess its empirical performance. After discussing data requirements and definition of variables (subsection 5.1), we use the bread industry (SIC 2081) as an example and go through the empirical routine of simple descriptive analysis (5.2), cross-section regression analysis (5.3), and standard and advanced panel regression analysis (5.4). In parts 5.5 and 5.6 we show how to analyze the statistical relevance of the time development of the slope coefficient *b* which expresses the mapping of cost differentials into profit differentials. The section ends with a short summary (5.7).

5.1 Data and variables

Any empirical test of theoretical insights has to cope with two major problems. First, can the variables implied by the theoretical model be translated into empirically observable variables? Second, is the data to construct these variables indeed available or accessible?

Our theoretical indicator requires economic profits and marginal cost, both variables are not directly observable. The theoretical notion of "economic" profits correctly accounts for the opportunity cost of all factors of production, especially capital, in a forward-looking way, that is, based on market valuation. In reality however, a firm's economic profit has to be inferred from balance sheet information which comes from historical accounting data and is based on book values. Therefore, as the input factors' opportunity costs (e.g. the user cost of capital) are not known, accounting profits measure economic profits with (substantial) error. Marginal cost is even more of a problem, since it is not observable at all. It can only be approximated either by estimating the first derivative of a conveniently specified total cost function or by assuming constant returns to scale in which case observable average variable cost can be used.

If one accepts accounting profits and average variable cost as fairly good proxies for economic profit and marginal cost respectively the researcher's problem boils down to gathering the following data on the firms which are assumed to operate in the same market: turnover, expenses for direct labor (payroll) and materials.[17] To approximate marginal cost more precisely other costs such as expenses for debt service, taxes, depreciation, advertising, and administration may also be needed.

For our exploratory analysis we define the following empirically observable firm variables

Profit = Turnover – payroll – expenses for materials

Average variable cost = (Payroll + expenses for materials) ⁄ turnover

For purposes of comparison, we also use the so-called price-cost margin (pcm)

PCM = Profit ⁄ turnover

which is frequently used in the empirical industrial organization literature as an empirical approximation to the theoretical Lerner index.[18]

We apply Statistics Netherlands (CBS) CEREM firm data set which contains internal accounting data on sales revenues (turnover) and costs for about 4,000 Dutch firms with at least 20 employees over the period 1978 to 1992. These firms are assigned to about 70 different four-digit level industries. The data set has been used by Statistics Netherlands as input for preparing the National Production Statistics. However, many firms are only represented for a subset of the whole period because of late entry or early exit. Entry means that at a certain point in time a firm started reporting because it had grown to having 20 employees, requiring it to submit information to Statistics Netherlands. Firms

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[17] We cannot discuss the problems of market delineation and multi-product firms here.

[18] The Lerner index derives from the monopolist's profit maximisation condition as price minus marginal cost divided by price. The monopolist maximises her profit when the Lerner index is equal to the inverse price elasticity of market demand. Under perfect competition, the Lerner index is zero (market demand is infinitely elastic), in monopoly it approaches 1 for positive non-zero marginal cost. The Lerner index can be derived for intermediary cases as well. See for a discussion e.g. Church and Ware (2000).

usually stopped reporting if the number of employees fell below the threshold but not in all cases. For that reason, the data set also contains some observations for firms with less than 20 employees. Before embarking on a sophisticated econometric analysis one has to carefully check the consistency of the data. It has to be checked whether absolute values and year-to-year changes of the variables of interest really make sense or rather are statistical artifacts generated by incomplete or wrong reporting. A complete consistency check of the enormous set of raw data which includes more than 120,000 observations would be extremely time-consuming. We therefore decided to start off with an exploratory analysis of a few industries for which the industry delineation could be expected to be close to the economic concept of the "market". From these industries, we selected only firms which reported turnover, payroll, expenses for materials and the number of employees consistently and continually over time. We then deleted all firms for which turnover was insufficient to cover the sum of payroll and expenses for materials, that is, we did not allow for negative gross "profits".

Take the following fictitious but representative example of data consistency problems.[19] Both firms in the table only reported for a subset of the observation period. Although having less than 20 employees, firm 1 is included but the data on employees and turnover is identical in each year. Firm 2 experienced a sharp drop in the number of employees in 1981 and a substantial increase in employees in 1983 while turnover did not change much in these years but declined dramatically in 1984. Including this data as it is, may generate severe outliers. How did we handle such or similar inconsistencies?

[19] Confidentiality restrictions do not allow us to present original raw data or identify excluded firms.

Year	Employees	Turnover (in 1,000 Guilders)
Firm 1		
1984	18	3,144
1985	18	3,144
1986	18	3,144
Firm 2		
1978	294	25,306
1979	282	26,750
1980	287	28,502
1981	50	27,222
1982	90	29,411
1983	181	28,999
1984	149	8,011

1. As a starting point, we created balanced samples of firms for the selected set of industries, that is, we only included firms which reported consistent information for *all* years of the observation period. We may call this balanced sample the long-time incumbents.

2. Firms with dramatic and unexplainable changes in any of the key variables (turnover, average variable cost, employment) were not included in the balanced sample.

3. For an unbalanced sample (that is, firms may have differing numbers of observations), we require *consistent* data for at least three *consecutive* years. We thus exclude firms such as firm 1 and use for firm 2 only the observations for 1978 to 1980. We excluded some observations for firms with reporting gaps. For example, if a firm reported in 1978 to 1981 and then again from 1985 to 1992, we only included the longer consistent and consecutive data series, here 1985 to 1992.

In each year, we use the sample median of accounting profit and average variable cost to normalize the respective firm-specific variables. In other words, firm *i*'s relative profit (cost) in year *t* equals *i*'s profit (cost) in year *t* divided by the median profit (cost) in that industry in year *t*. The reason for using the median instead of the minimum as in the simulations above is that the median is less sensitive to outlier problems. We will call the ratio of firm-specific average variable costs to the industry's median average variable costs "relative efficiency". A firm with a *higher* ratio is thus said to have *lower* relative efficiency.

In the following sections, we will present a step-by-step empirical analysis of the Dutch bread industry (SIC 2081).

5.2 Descriptive analysis

Table 5.1 provides summary statistics for the variables of interest. Figure 5.1 depicts the time development of the mean (A), the minimum (MIN) and the maximum (MAX) of the respective variables. Table 5.2 reports the results from a simple OLS regression of these summary statistics on a time trend.

Mean firm profitability as measured by the price-cost margin improved slightly over time while there was no statistically significant trend in its upper and lower bounds. Relative profits remained more or less stable with respect to the mean and minimum but the upper bound was significantly lowered. The gap between the highest-profit and median-profit firm narrowed. Put differently, the incumbents moved closer together.

Table 5.1 also shows that firms differ substantially with respect to their absolute size, as measured by turnover, or alternatively, by the number of employees (not reported here). The standard deviation of turnover is very large. Figure 5.2 reveals a highly skewed distribution of firm size, with 28 firms (41.8%) having a mean turnover of less than 5,000,000 FLG and 53 firms (79.1%) having a mean turnover of less than 12,500,000 FLG. Figure 5.3 depicts the density functions for turnover, relative profits, and relative efficiency and for their natural logarithms. Taking the natural logarithm of turnover and relative profits helps reduce the skewness in the respective distribution. It does not make much of a difference for relative efficiency. Is this transformation required?

Figure 5.4 plots the relation between firm size, relative profits and relative efficiency. There is a clear positive log-linear relation between relative profits and firm size (Graph a). The more turnover a firm has the higher is its profit relative to the incumbents' median profit. The relation between relative efficiency and firm size is much less clear-cut (Graph b). The regression line is almost horizontal. The same holds for the relation between relative profits and relative efficiency (Graph c). This scatter plot seems to be in contradiction with our theoretical analysis because the regression line is upward sloping. However, the next graph (d) shows how important it is to control for firm size. To generate the graph we excluded the three largest firms (turnover > 40,000) which also have the highest relative profits (RP > 5). Now the regression line clearly slopes downward as it does in the simulations in Section 3. The final graph (e) shows that the same result can be achieved without excluding the largest firms if we take the logs of the variables. Therefore, given the skewness of the raw data the log-transformation is clearly necessary to approximate the theoretically implied relation between relative profits and relative efficiency.

5.3 Simple regression analysis

Table 5.3 makes the point explicit. It presents the OLS estimates from the "Between" regression of relative profits (*RP*) on relative efficiency (*RC*) (firm-specific time means of variables). The estimates in the second column of Table 5.3 reflect the regression line shown in Graph (c) of Figure 5.4 in which potential size effects are ignored. The third column gives the estimates of

$$\overline{\log RP_i} = a + b\overline{\log RC_i} + c\overline{\log S_i} + u_i \tag{5.1}$$

which controls for firm size *S* as measured by turnover. Now there is a significantly negative coefficient on relative efficiency. As we have the variables in logs, the estimate of *b* yields the elasticity of relative profits with respect to a 1 percentage change in relative efficiency. A 1 per cent increase in relative efficiency, that is, a 1 per cent decrease in relative variable costs, leads to an increase of relative profits by about 4 per cent. Relative profits increase with increasing firm size on almost a one-to-one basis. The size variable indeed explains a substantial part of the variation in relative profits. The interpretation is that there are unobservable variables like quality differences between goods, firm reputation, brand loyalty etc. which explain a firm’s relative profit level but are not captured by relative costs.

Over the whole period, the estimate of the average mapping of cost differences into profit differences is -4.0876 (Table 5.3). In other words, an increase in relative efficiency, that is, a decrease of *RC*, by 1 per cent gives rise to an increase in relative profits by about 4 per cent. Firms with relatively high costs in this industry are punished in terms of profits. Less efficient firms earn lower profits.

Table 5.4 contains the results of estimating (5.1) separately for each year of the observation period. The coefficient on *LRC* is highly significantly negative in each year. The elasticity varies from –3.5158 to –4.6518. The size effect is present throughout. The coefficient of determination (adjusted R squared) is above 0.90 in each year, that is, more than 90 per cent of LRP's variance is explained by the model specification. The annual estimates of *b* do not differ very much from to 1978 to 1982. There are changes in *b* in 1983, 1986, and 1989 which may require further investigation. From the annual regression estimates alone we cannot tell whether the year-to-year is statistically significant, since regression model (5.1) does not consider the time dimension. Each estimated *b* is no more than an isolated snapshot, ignoring any effects that may develop over time. Between and annual cross-section estimates can be severely biased due to mismeasured or omitted variables. However, taking advantage of our data set's panel structure, that is, pooling of cross section and time series data, allows us to directly take changes over time into account and, more importantly, helps correct for such estimation bias.

5.4 Panel regression analysis

We estimate the following panel regression

$$LRP_{it} = a_i + \lambda_t + b_t LRC + \sum_{t'=t+1}^{T} b_{t'} D_{t'T} \times LRC_{it'} + cSIZE_{it} + u_{it} \qquad (5.2)$$

in which the subscript $i = 1, \ldots, N$ defines individual firms; $t = 1978, \ldots, 1992$ and $t' = t + 1, \ldots, 1992$ denote time periods. The parameters *a*, λ, *b*, and *c* are the regression coefficients to be estimated from the data; *u* represents a white noise regression error. The white noise assumptions will be relaxed however in some approaches to allow for heteroskedasticity and first-order serial correlation.

To control for differences across firms which are not captured by the included right-hand side variables we include firm-specific effects, a_i. These individual effects help cope with measurement error and omitted variable bias resulting e.g. from not perfectly observing marginal cost or the firm-specific user cost of capital. There are two approaches in modelling these individual effects. First, one can assume them to be constant over time. In this so-called fixed effects model variant, each firm is represented by its own "indicator (dummy)" variable:

$$a_i = 1 \quad \text{for firm } i$$
$$a_i = 0 \quad \text{for firm } j, j = 1, \ldots, N, j \neq i$$

By including fixed firm-specific effects, the variation of relative profits across firms ("between variation") is removed. The estimated effect of relative efficiency on relative profits then comes only from the firm-specific time series variation of relative profits ("within variation").[20] Second, the individual effects can be taken as firm-specific random deviations z_i from a common regression intercept *a*.

$$a_i = a - z_i \qquad \text{with } E(z_i) = 0 \text{ and } E\left(z_i^2\right) = \sigma_z^2$$

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[20] The estimates reported in tables 5.3 and 5.4 are only based on the "between variation".

To consider time-specific effects which are meant to proxy for unobserved effects common to all firms (e.g. changes in the macro environment, business cycle) we include year-specific indicator variables, or in other words, time-specific intercepts, λ_t.

$$\lambda_t = 1 \quad \text{for year } t = 1978,\ldots,1992$$
$$\lambda_t = 0 \quad \text{for year } t' = 1978,\ldots,1992, t' \neq t$$

As our theoretical discussion suggests that a change in the intensity of competition is reflected in a change of the coefficient *b*, we allow for a different slope coefficient in each year by interacting the variable *RC* with a time dummy $D_{t'T}$. There are a number of ways to define $D_{t'T}$. One possibility is to let $D_{t'T}$ take on unit value only in *t'* = *t* and be 0 otherwise. Under this definition $D_{t'T}$ is constructed like λ_t. The regression coefficient $b_{t'}$ then gives the slope parameter for year *t'*. The estimated coefficient's t-statistic tells us whether *b* changed significantly from the base year 1978 to year *t'*. In the following tables, we present regressions with $D_{t'T}$ defined as a step dummy which takes on unit value in *t'* and thereafter, and equals 0 in all years prior to *t'*.

$$D_{t'T} = 1 \quad \text{for } t',\ldots,1992 \qquad\qquad t = 1978,\ldots,1992,\ t' = t+1,\ldots,1992$$
$$D_{t'T} = 0 \quad \text{for } t < t'$$

The regression coefficient $b_{t'}$ then gives the change in the slope from year *t'* − 1 to *t'*. With this definition we can test whether the slope parameter changes significantly from one year to the next. In other words, we can test whether competition changes significantly over time.

Table 5.5 summarizes the estimation results from the panel regressions. The upper part of the table reports the coefficient estimates, the lower part gives definitions as well as the test statistics of several model specification tests which are explained in the technical appendix. The model we call "Total" does not allow for firm-specific effects but for time-specific effects and a change in the slope coefficient *b*.[21] It is our benchmark for testing the importance and the nature of firm-specific effects. The Within model uses fixed firm-specific intercepts, while the RE model assumes random disturbances to be either common to all firms (to be absorbed by the regression error) or firm-specific (to be captured by the distribution of z_i).

As in the simple cross-section regressions, the coefficient on relative costs is indeed negative and highly significant in all panel regression models. The change of the slope coefficient over time is captured by the coefficients on the interaction of *LRC* with the step dummy D_{tT}. For instance, the coefficient on LRC×D1979-1992 implies that the slope parameter *b* became less negative from 1979 to 1981. Our interpretation is that competition decreased in the industry from 1978 to 1979. However, as indicated by the coefficient's t-statistics, this change is not statistically significant.[22] In fact, only the coefficients on the interaction terms in 1983, 1986 and 1989 (in the RE-regression) is significant on its own at the 0.10 error level. However, testing for the joint significance of these coefficients reveals a highly significant F-statistic in all three models. This test implies that there were statistically significant changes in *b* over time despite the fact that the point estimates have large standard errors. The imprecise point estimates may simply be caused by multicollinearity among the interaction terms.

The firm size effect is important in all models. Firm size captures some of the heterogeneity among firms but not all of it.

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[21] For sake of giving this benchmark model a name, we deviate in our terminology from the standard literature in which the "total" model denotes a panel regression model with the intercept and all slope coefficients restricted to be fixed across firms and over time.

[22] The interpretation of the p-value 0.724 (corresponding to the t-statistic 0.35) with respect to the coefficient on LRC×D1979-1992 in the Within-regression is the following. If in reality this coefficient is zero, than we can expect to observe a value of 0.1284 with a probability of 72%. In other words, we cannot reject the hypothesis that the coefficient is zero.

As the test for homoskedastic regression errors is highly significant (LM statistic), the standard errors of the regression coefficients are based on White's (1980) covariance estimator which is robust to heteroscedasticity of unknown form.

Do time-specific effects other than those captured by the set of step dummies matter? The inclusion of year-specific effects is definitely warranted in all models.

Do firm-specific effects matter? Yes, they indeed do, as is indicated by the test statistics which compare the Total model with the Within (significant F statistic) and the RE model (significant chi-square statistics). A further test (Hausman) shows that there is no statistically significant difference between the Within and the RE estimates.[23] In less technical language, the detected firm-specific effects can be assumed random rather than fixed. In statistical respect, this indicates that the Within estimates are inefficient (i.e., have larger standard errors). Using the RE estimators improves efficiency. However, the Durbin-Watson statistic is significant in all models, indicating that the estimates are biased due to (first-order) serial correlation in the regression errors. Table 5.6 therefore presents the results from GLS-regressions which correct for this deficiency by using an appropriate estimation technique.[24] The regression results using the AR1 correction are qualitatively the same and differ quantitatively only marginally from the estimates in Table 5.5 so there is no need for further discussion.

As there are 67 firms in the balanced sample for this industry, we obtain the same number of firm-specific intercepts. The economic interpretation of these intercepts is straightforward. They represent the firm-specific mean *LRP* after having controlled for

[23] Put differently, the Hausman specification test shows that the included firm-specific effects do not seem to be correlated with the right-hand side variables which renders the RE estimates consistent.

[24] The estimation technique is explained in detail in Hsiao (1986, pp. 50). It uses the Within residuals to estimate a common rho and firm-specific rhos alternatively. The rhos are then used to transform the original data by the well-known Cochran-Orcutt procedure (see any textbook on econometrics). Regressions based on the transformed data are then estimated by OLS or, due to necessary iterations to find a stable rho, by Maximum Likelihood (ML) techniques.

the impact of explanatory variables. Due to confidentiality restrictions Table 5.7 shows only the distribution of the estimated fixed firm-specific effects.

5.5 Development of competition over time

A problem we encounter for all industries we have investigated is that the pattern of the development of the slope parameter over time is often hard to interpret in a straightforward way. As shown by the estimates in tables 5.5 and 5.6, *b* changes from plus to minus and back quite often. One conclusion could be that competition changes a lot over time in a sort of random fashion. However, we do not favor this interpretation. Therefore, to get a more intuitively appealing and also somehow summarizing description of what happens to not only the slope parameter *b* but the whole model (i.e., all other variables in the regression) over time we use the so-called Chow test for structural breaks in a dynamic form. The Chow test is described in the technical appendix.

The idea is to split the available time series into two adjacent sub-periods, estimate a separate regression for each sub-period and compare the dependent variable's variation explained by these two separate regressions with the variation explained by the regression based on the full observation period. As we do not have any qualitative information on potential breaks in the assumed relationship, we use the Chow test repeatedly and forward-moving in time, that is, we first pool the years 1978 and 1979 (which yields a sufficient number of observations to estimate the coefficients of regression model 5.2) and the years 1980 to 1992. We then estimate the regressions for these two sub-periods and calculate the Chow statistic (a standard F-statistic). When the difference between the estimated regression coefficients is statistically significant at the chosen level of confidence (we take $p=0.05$) we say that the year 1980 indicates a structural break. We repeat this procedure by extending the first observation period by one year at each repetition of the test (that is, we add 1980, then 1981 etc.) while excluding this respective year from the second observation period (that is, we exclude 1981, then 1982 etc.). In the final round we are left with estimating the regression for 1978 to 1991, taking 1992 as the termination year.

Table 5.9 contains results of this "moving" Chow test for the AR1-Within (common rho) regression.[25] The F-statistics imply that the intensity of competition changed *statistically* significantly from year to year starting in 1989. Of course, as explained in Section 5 of the main text, we would need more information on this particular industry at this particular point in time to tell what caused this change. The evolution of *b*'s absolute value of over time is depicted and interpreted in the main text's Figure 5.1. The results of regressing the estimated *b*s on a time trend are given in Table 5.9.

5.6 A further check on robustness

Table 5.10 summarizes the results from a second approach to cope with individual firm-specific effects. By taking first differences ("FD") of all variables included in regression model (5.2) the individual effects can be eliminated. The regression model is thus formulated in the variables' "period-to-period" changes rather than in their levels. The second column contains the OLS estimates. The coefficient on *LRC* remains significantly negative as before but is somewhat larger. "Diff Size" represents the logarithmic growth rate of turnover. Growing firms thus enjoy higher relative profits. This regression confirms the change of *b* in 1983, 1986 and 1989. Here the changes in 1983 and 1986 are clearly statistically significant, whilst the change in 1989 is not but the coefficient has the highest absolute value. Running a Chow test (not reported separately) again shows that the 1989 to 1992 period is statistically significantly different, confirming the above conclusion.

The third and fourth column of Table 5.10 contain the results of using the Arellano-Bond GMM estimator, a more sophisticated estimation technique now widely used in panel

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[25] The results are qualitatively identical for the alternative regression using AR1-Within with firm-specific rhos.

data analysis.[26] The advantage of the GMM estimator is that we can control for measurement error in the right-hand side variables by instrumenting these variables by their own lagged levels. Irrespective of the marginal cost problem, which may cause measurement error as discussed above, our efficiency indicator may be endogenous rather than exogenous as assumed so far. If simultaneity is indeed the case, the previous panel regression estimates are biased (unreliable) because we ignored simultaneity. The GMM instrumental variable approach also controls for this problem.

The fourth column differs from the third by the inclusion of the lagged dependent variable as an additional regressor. The economic rationale for including the lagged dependent variable is to test for persistency or disequilibrium effects. From a technical perspective, the inclusion is often helpful to reduce serial correlation. However, including the lagged dependent variable in panel regressions complicates estimation, since standard estimators such as the FE-, RE- and FD-OLS techniques applied so far are rendered inconsistent. An instrumental variable estimator such as GMM has to be employed to obtain consistent estimates.[27]

As the GMM procedure is very sensitive to the set of instruments (collinearity), only one step dummy has been included in columns three and four. We tested the years 1983, 1986, and 1989 but only report the regression for 1989. The coefficients for 1983 and 1986 have the same signs and are of the same magnitude as those in the FD-OLS column but are not significant at any conventional level. The 1989 break is significant at the 10 per cent error level in the regression excluding the persistency variable, thus confirming what we have observed earlier. The coefficient on the lagged dependent variable is very small and completely insignificant. There is no persistency at all, or put differently, the

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[26] The pooled data set can be interpreted as reflecting a system of N firm-specific regression equations. The Generalized Method of Moment estimator is a systems estimator which takes account of potential cross-equation correlations of the regression errors.

[27] We cannot discuss any details here. The interested reader is referred to Arellano and Bond (1991) and Baltagi (1995) for a survey and discussion on appropriate estimators for dynamic panel regressions.

changes of the other right-hand variables fully reflect the log change in relative profits. From this perspective, the inclusion of the lagged dependent variable is not warranted.

The GMM results for the LRC and SIZE coefficients are qualitatively identical and in maginitude very similar to the results obtained by the standard panel regression estimators. To sum up, it can be concluded that our estimates are robust with respect to the specification of the regression model and to using different estimation techniques.

5.7 Evidence for other industries

In Tables 5.11 and Table 5.12 as well as Figures 5.2 (main text) and 5.5 (appendix) we summarize the results of applying our approach to two other industries, periodical publishing (SIC 2722) and offset printing (SIC 2713). The results for the publishing industry are shown and discussed in Section 5 of the main text. In the offset printing industry, an industry with a relatively high number of firms (about 250), the mapping of cost differentials into profit differentials as measured by the elasticity (from AR1-Within estimation using the balanced sample of 80 incumbent firms) has become significantly stronger over time (see Figure 5.5 and Table 5.12). Therefore, we argue that competition has increased in this industry.

5.8 Summary

The goal of this section was to demonstrate the usefulness of the indicator suggested in this report using real-world data. Despite all potential shortcomings regarding the translation of theoretically implied variables into the variables observed empirically, the postulated relation between relative profits and relative efficiency and its development could be found empirically for three Dutch industries, bread, refrigerators, and offset printing. Based on these results it seems promising to scan a larger set of industries in a future study. Preliminary results using unbalanced data for 37 industries (see Boone and Weigand, 2000) are also promising. The postulated relation is clearly supported in almost all industries, even if the time development of the slope coefficient shows a rather erractic behaviour in some industries. The latter drawback might be due to severe outliers and other data-related problems as well as to the fact that for estimation purposes a sufficient number of firms should be present in the industry. The construction of balanced samples for the other industries and the the "small sample" and "unbalanced" sample properties of our indicator will be investigated in future work.

Figures Sections 3 and 5

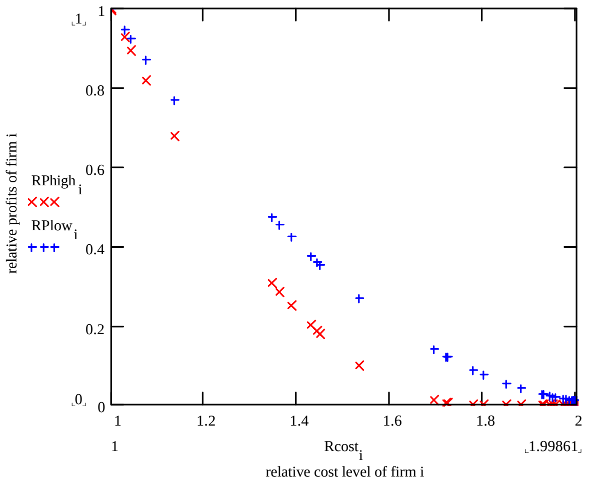
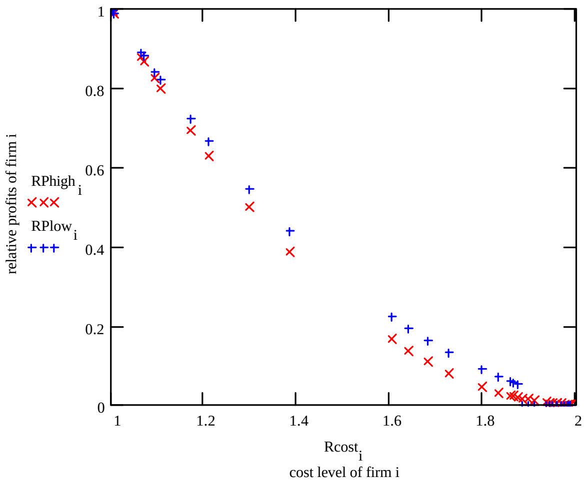


Figure 3.1: a rise in competition through more aggressive interaction



(conjectural variation)

Figure 3.2: A RISE IN COMPETITION THROUGH A REDUCTION IN ENTRY BARRIERS (100 FIRMS IN HIGH COMPETITION CASE AND 20 FIRMS IN LOW COMPETITION CASE)

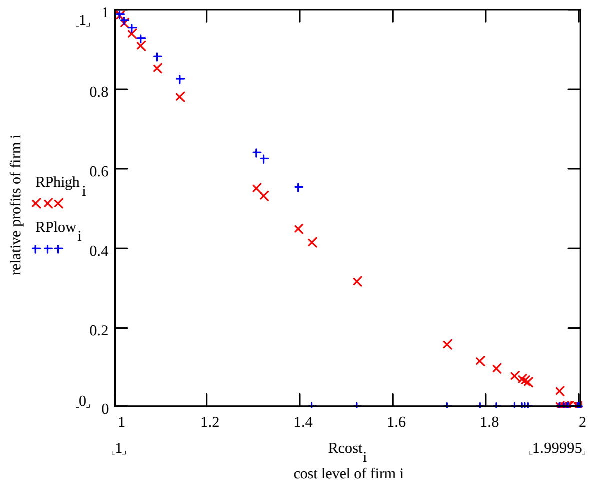


Figure 3.3: a rise in competition through a reduction in entry barriers (20 firms in high competition case and 10 firms in low competition case)

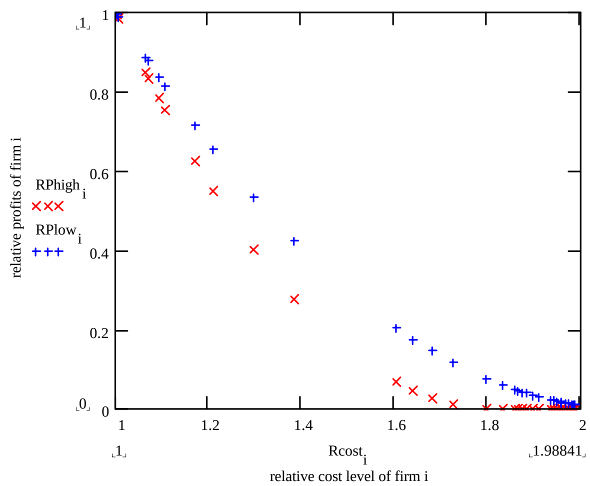


Figure 3.4: a rise in competition through more aggressive interaction (elasticity of substitution)

Figures Section 5

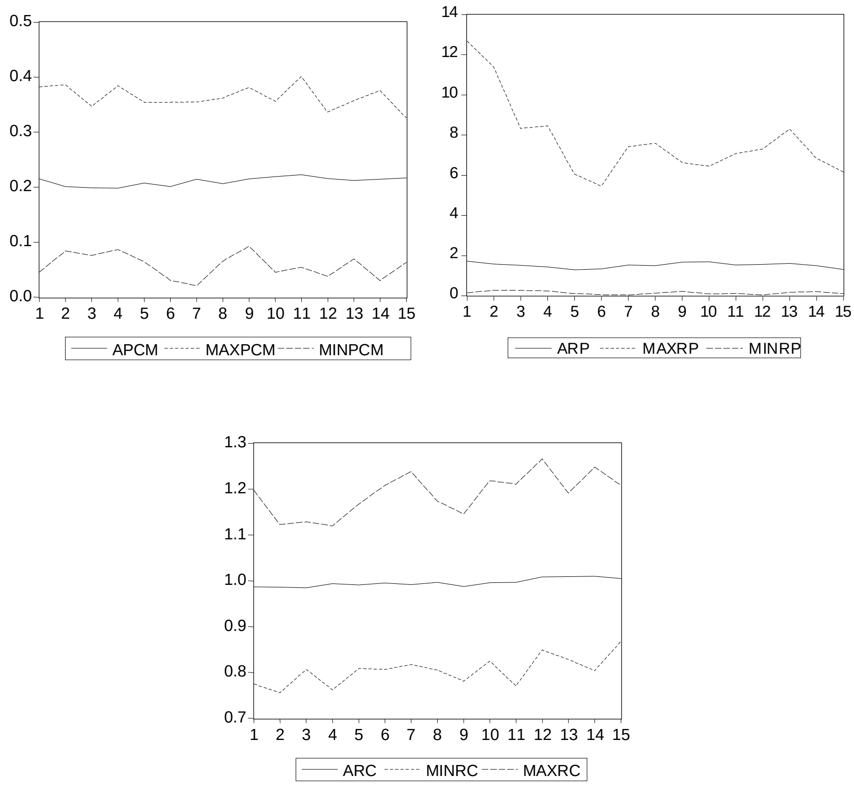


Figure 5.1 Time development of summary statistics

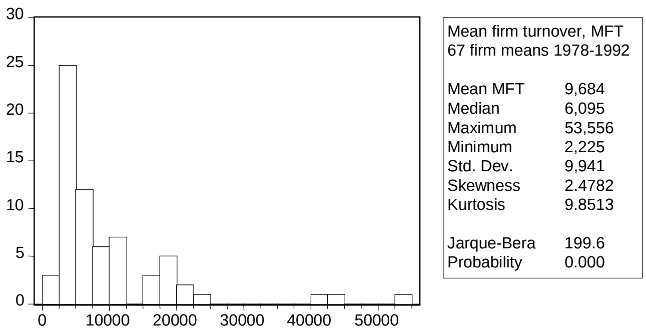


Figure 5.2 Histogram and summary statistics of firm turnover (averaged over 1978-1992)

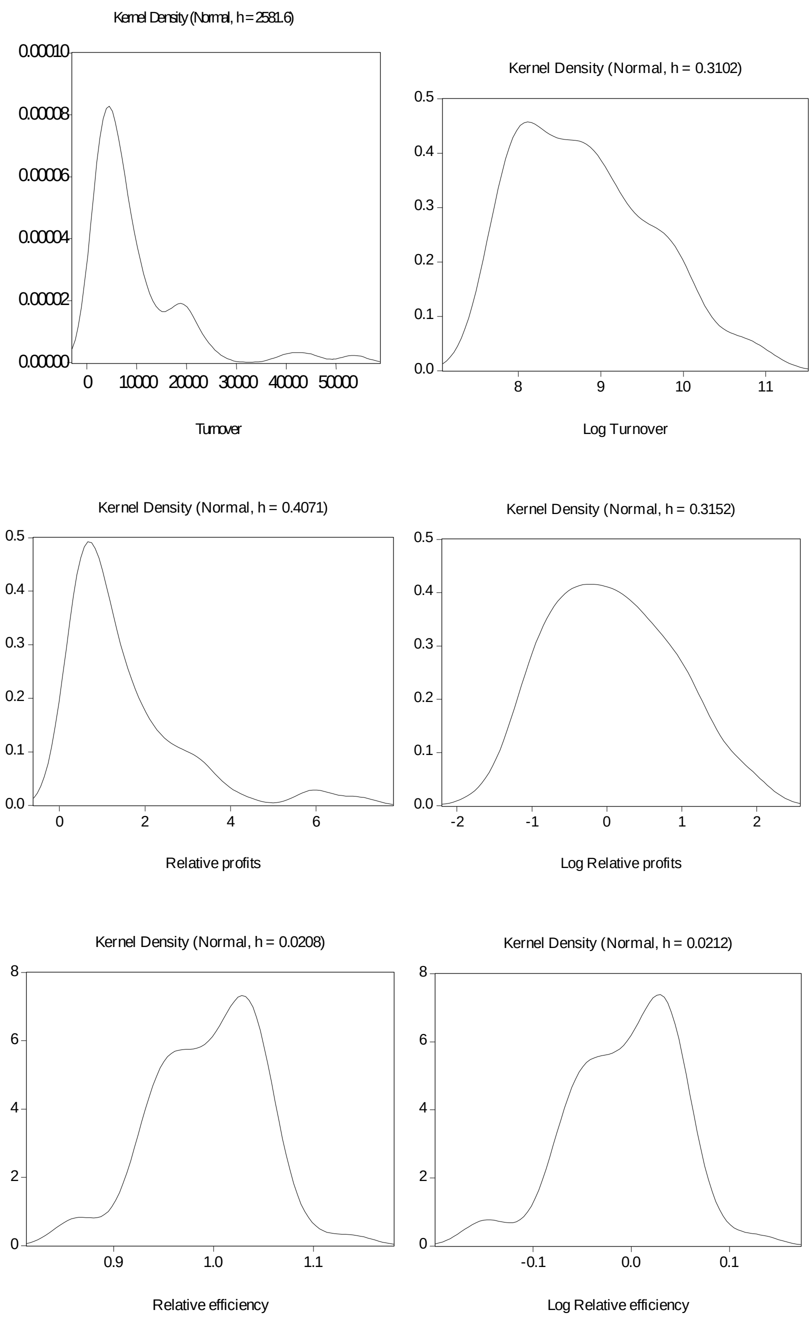
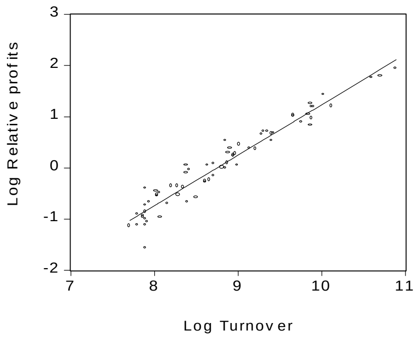
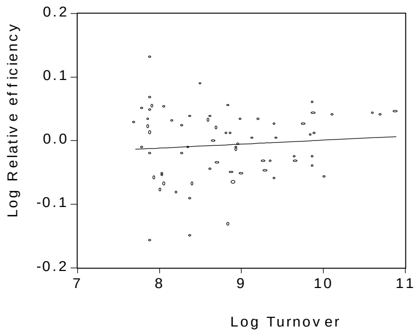
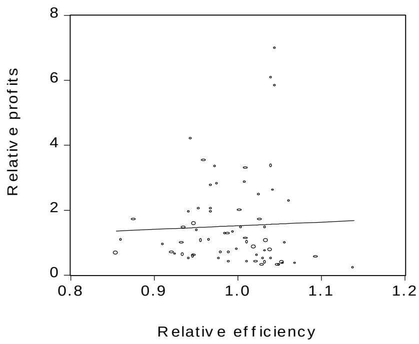


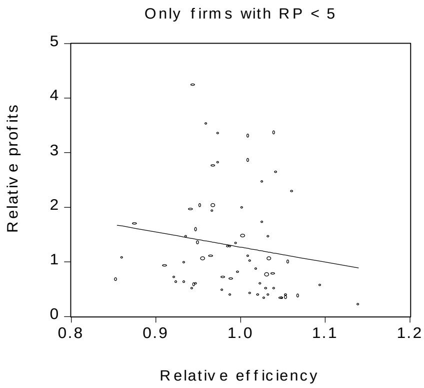
Figure 5.3 Density functions of mean firm turnover



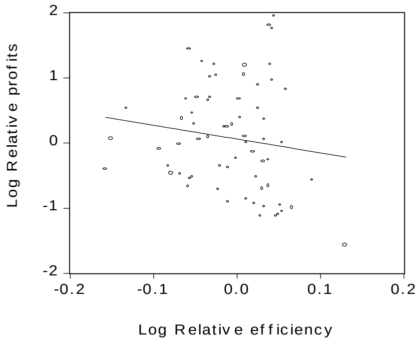


(a) (b)





(c) (d)



(d)

Figure 5.4 Turnover, relative profits, and relative efficiency

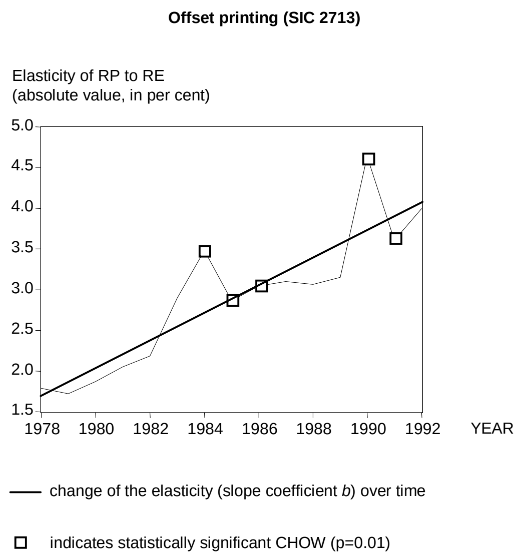


Figure 5.5 Time development of *b* in Industry 2713

Tables Section 5

Table 5.1 Summary statistics for Industry 2081

	Mean (std. dev.) Median Minimum Maximum			
SIC 2081	Price-cost margin	Relative profits	Relative costs	Turnover
Total, 1978 – 1992	0.2106 (0.0585) 0.2080 0.0374 0.4015	1.5155 (1.5284) 1.0000 0.0350 12.6723	0.9958 (0.0741) 1.0000 0.7555 1.2658	9,684 (10,406) 6,107 1,173 73,400
1978	0.2154 (00649) 0.2086 0.0455 0.3822	1.7163 (2.1959) 1.0000 0.1429 12.6723	0.9870 (0.0824) 1.0000 0.7745 1.1974	7,003 (9,147) 4,431 1,173 57,960
1979	0.2012 (0.0652) 0.1819 0.0837 0.3862	1.5835 (1.9619) 1.0000 0.2704 11.3717	0.9864 (0.0817) 1.0000 0.7555 1.1226	7,393 (9,818) 4,444 1,287 64,166
1980	0.1987 (0.0551) 0.1885 0.0755 0.3467	1.5177 (1.5162) 1.0000 0.2681 8.3248	0.9848 (0.0680) 1.0000 0.8036 1.1285	7,659 (9,739) 4,764 1,506 64,137
1981	0.1984 (0.0537) 0.1942 0.0864 0.3844	1.4292 (1.5290) 1.0000 0.2311 8.4604	0.9935 (0.0652) 1.0000 0.7616 1.1197	8,565 (10,941) 5,437 1,773 73,400
1982	0.2073 (0.0592) 0.2029 0.0641 0.3544	1.2792 (1.1578) 1.0000 0.1004 6.0525	0.9908 (0.0732) 1.0000 0.8085 1.1669	8,911 (10,671) 5,832 2,074 71,658
1983	0.2009 (0.0584) 0.1982 0.0307 0.3544	1.3360 (1.1952) 1.0000 0.0509 5.4537	0.9950 (0.0723) 1.0000 0.8065 1.2082	9,003 (10,180) 6,260 2,057 64,801

1984	0.2142 (0.0563) 0.2020 0.0204 0.3549	1.5230 (1.4793) 1.0000 0.0350 7.4141	0.9919 (0.0714) 1.0000 0.8168 1.2381	9,220 (9,385) 6,214 2,174 47,225
1985	0.2063 (0.0533) 0.2028 0.0655 0.3621	1.4982 (1.4880) 1.0000 0.1231 7.5949	0.9966 (0.0669) 1.0000 0.8048 1.1741	9,822 (9,962) 6,293 2,353 78,554
1986	0.2148 (0.0594) 0.2075 0.0924 0.3812	1.6672 (1.5591) 1.0000 0.2149 6.6238	0.9877 (0.0739) 1.0000 0.7808 1.1452	10,050 (9,995) 6,194 1,670 48,072
1987	0.2194 (0.0604) 0.2187 0.0452 0.3560	1.6802 (1.5273) 1.0000 0.0840 6.4421	0.9955 (0.0770) 1.0000 0.8245 1.2183	10,534 (10,390) 6,363 2,302 48,523
1988	0.2228 (0.0558) 0.2195 0.0542 0.4015	1.5312 (1.4274) 1.0000 0.1009 7.0745	0.9964 (0.0713) 1.0000 0.7698 1.2108	10,474 (9,969) 6,917 2,258 53,180
1989	0.2156 (0.0570) 0.2238 0.0374 0.3364	1.5534 (1.4413) 1.0000 0.0374 7.3007	1.0081 (0.0745) 1.0000 0.8485 1.2658	10,599 (9,713) 6,775 2,471 50,079
1990	0.2123 (0.0574) 0.2213 0.0691 0.3572	1.6123 (1.5951) 1.0000 0.1660 8.2993	1.0090 (0.0751) 1.0000 0.8279 1.1913	11,245 (10,985) 6,826 2,434 53,627
1991	0.2143 (0.0592) 0.2199 0.0300 0.3756	1.4954 (1.3957) 1.0000 0.1990 6.8403	1.0093 (0.0797) 1.0000 0.8035 1.2480	12,017 (11,625) 7,398 2,418 59,565
1992	0.2170 (0.0590) 0.2239 0.0631 0.3262	1.3102 (1.1983) 1.0000 0.1000 6.1462	1.0051 (0.0770) 1.0000 0.8668 1.2077	12,764 (12,292) 8,530 2,347 68,068

Table 5.2 Time development of summary statistics

	Estimated coefficient (absolute t-statistic) [p-value]		
Dependent variable	Mean	Minimum	Maximum
Price-cost margin	0.0011 (2.94) [0.012]	-0.0013 (0.95) [0.357]	-0.0015 (1.25) [0.232]
Relative profits	-0.0029 (0.36) [0.728]	-0.0063 (1.36) [0.196]	-0.2621 (2.69) [0.019]
Relative costs	0.0016 (6.25) [0.000]	0.0045 (3.06) [0.009]	0.0064 (2.86) [0.013]

Variable definitions:

Price-cost margin (PCM)	Firm profits / firm turnover
Relative profits (RP)	Firm profits / median profits of the incumbents group
Relative costs (RC)	Firm variable costs / median variable costs of the incumbents group

Notes:
"Estimated coefficient" is the OLS estimate of b in y_z = a + b TIME + u with y = {PCM, RP, RC}, z = {Mean, Minimum, Maximum} and TIME = {1978, …, 1992}.

Table 5.3 Cross-section evidence on the profits-efficiency relation

	Dependent variable	
	Relative profits	Log Relative profits
Independent variable	Estimated coefficient (absolute t-statistic) [p-value]	
Relative costs	1.2839 (0.39) [0.694]	-
Log Relative costs	-	-4.0876 (23.81) [0.000]
Firm size	-	1.0292 (88.05) [0.000]
Constant	0.2371 (0.07) [0.942]	-9.0491 (87.59) [0.000]
Observations	67	
Mean of Relative profits	1.5155	0.0271
Standard deviation of Relative profits	1.4060	0.8314
Standard error of regression	1.4151	0.0755
R-squared	0.0023	0.9920
Adjusted R-squared	-	0.9917
Sum of squared residuals	130.1	0.3651
LM test for heteroskedasticity [p-value]	3.2046 [0.073]	3.9737 [0.046]

Variables are averaged over the period 1978-1992. Heteroskedasticity-robust OLS estimates.

Variable definitions:

Relative profits	Firm profits / median profits of the incumbents group
Log Relative profits	log (firm profits / median profits of the incumbents group)
Relative costs	firm variable costs / median variable costs of the incumbents group
Log Relative costs	log (firm variable costs / median variable costs of the incumbents group)
Firm size	log firm turnover

Table 5.4 Annual cross-section evidence on the profits-efficiency relation

Dependent variable: Log Relative profits				
	Independent variables: estimated coefficient (absolute t-statistic) [p-value]			
Year	Log Relative costs	Firm size	Constant	Adj. R2
1978	-3.7449 (9.54) [0.000]	1.0522 (36.23) [0.000]	-8.8282 (32.98) [0.000]	0.9630
1979	-3.4907 (13.20) [0.000]	1.0020 (59.37) [0.000]	-8.4921 (55.46) [0.000]	0.9838
1980	-3.9586 (15.22) [0.000]	1.0071 (58.03) [0.000]	-8.5863 (56.81) [0.000]	0.9897
1981	-3.9520 (9.42) [0.000]	1.0145 (81.48) [0.000]	-8.8186 (79.66) [0.000]	0.9884
1982	-3.9258 (11.62) [0.000]	1.0258 (46.08) [0.000]	-9.0804 (45.00) [0.000]	0.9847
1983	-4.6518 (7.51) [0.000]	1.0364 (37.52) [0.000]	-9.1774 (35.52) [0.000]	0.9742
1984	-4.3910 (4.81) [0.000]	1.0561 (30.94) [0.000]	-9.2933 (28.21) [0.000]	0.9602
1985	-4.2278 (10.82) [0.000]	1.0339 (80.79) [0.000]	-9.1597 (74.02) [0.000]	0.9893
1986	-3.5158 (15.04) [0.000]	1.0308 (75.30) [0.000]	-9.0589 (73.18) [0.000]	0.9908
1987	-4.0569 (9.15) [0.000]	1.0137 (40.86) [0.899]	-8.9461 (39.03) [0.000]	0.9814
1988	-3.7857 (8.22) [0.000]	1.0384 (53.90) [0.000]	-9.2313 (50.27) [0.000]	0.9848
1989	-4.5916 (4.42) [0.000]	1.0185 (31.62) [0.000]	-9.0156 (29.25) [0.000]	0.9472
1990	-3.9893 (14.18) [0.000]	1.0210 (85.46) [0.000]	-9.0513 (79.55) [0.000]	0.9896
1991	-4.1360 (6.33) [0.000]	0.9905 (41.86) [0.000]	-8.9068 (42.36) [0.000]	0.9585
1992	-4.0143 (14.60) [0.000]	1.0131 (70.94) [0.000]	-9.3424 (76.63) [0.000]	0.9100
Heteroskedasticity-consistent OLS estimates are based on the cross-section of 67 firms				

Variable definitions:

Log Relative profits	log (firm profits / median profits of the incumbents group)
Log Relative costs	log (firm variable costs / median variable costs of the incumbents group)
Firm size (absolute firm size)	log firm turnover

Table 5.5 Estimates from panel data regressions

Dependent variable: Log Relative profits			
	Method of estimation estimated coefficients (absolute t-statistic) [p-value]		
Independent variables	Total	Within (fixed effects)	RE (random effects)
Log Relative costs (LRC)	-3.6801 (10.43) [0.000]	-3.8661 (12.37) [0.000]	-3.8256 (19.29) [0.000]
Firm size	1.0237 (187.99) [0.000]	0.9564 (15.99) [0.000]	1.0157 (97.01) [0.000]
LRC × D1979-1992	0.1315 (0.31) [0.754]	0.1284 (0.35) [0.724]	0.1350 (0.49) [0.621]
LRC × D1980-1992	-0.4722 (1.42) [0.156]	-0.2046 (0.64) [0.521]	-0.2663 (0.87) [0.385]
LRC × D1981-1992	0.0453 (0.10) [0.920]	0.0666 (0.18) [0.859]	0.0585 (0.17) [0.864]
LRC × D1982-1992	0.0532 (0.11) [0.913]	0.1365 (0.44) [0.659]	0.1278 (0.39) [0.698]
LRC × D1983-1992	-0.7334 (1.10) [0.273]	-0.7791 (1.94) [0.053]	-0.7601 (2.39) [0.017]
LRC × D1984-1992	0.2468 (0.23) [0.816]	0.1905 (0.26) [0.795]	0.2070 (0.64) [0.522]
LRC × D1985-1992	0.1667 (0.17) [0.862]	0.1421 (0.21) [0.835]	0.1411 (0.42) [0.675]
LRC × D1986-1992	0.7265 (1.62) [0.105]	0.6068 (1.75) [0.080]	0.6226 (1.90) [0.058]
LRC × D1987-1992	-0.5368 (1.12) [0.263]	-0.4017 (1.30) [0.194]	-0.4228 (1.39) [0.166]
LRC × D1988-1992	0.2631 (0.43) [0.666]	0.2902 (0.78) [0.436]	0.2881 (0.91) [0.362]
LRC × D1989-1992	-0.7978 (0.74) [0.457]	-0.7239 (0.90) [0.369]	-0.7493 (2.31) [0.021]
LRC × D1990-1992	0.5993 (0.59) [0.555]	0.4484 (0.58) [0.560]	0.5148 (1.62) [0.106]
LRC × D1991-1992	-0.1518 (0.22) [0.825]	-0.2072 (0.32) [0.747]	-0.1641 (0.53) [0.595]
LRC × D1992	0.1308 (0.19) [0.848]	0.0574 (0.08) [0.935]	0.0797 (0.26) [0.793]

to be continued next page

Adj. R2	0.9716	0.9770	0.9715
LM heteroskedasticity	7.2912 [0.007]	5.46 [0.019]	7.64 [0.006]
Durbin-Watson	1.0344 [0.000, 0.000]	1.3733 [0.000, 0.000]	1.0273 [0.000, 0.000]
Time interactions	F(14,974)=13.71 [0.000]	F(14,974)=10.44 [0.000]	F(14,973)=12.52 [0.000]
Firm effects:			
Total vs. Within		F(66,908) = 4.50 [0.000]	
Total vs. RE			Chisq(1)=7.05 [0.000]
Within vs. RE		Chisq(13)=6.59 [0.922]	
Year effects	F(14,974)=882.48 [0.000]	F(14,974)=513.38 [0.000]	F(14,973)=1868.99 [0.000]

Heteroskedasticity-consistent estimates (White) are based on the balanced panel of 67 firms over 15 years.
"Total" denotes OLS estimation of the pooled regression model including a common intercept and 14 year dummies. Constant and year dummy coefficients not reported separately.
"Within" denotes OLS estimation of the pooled regression model including 67 firm-specific intercepts ("fixed effects") and 14 year dummies. Firm-specific intercepts and year dummy coefficients not reported separately.
"RE" denotes GLS estimation of the pooled regression model including firm-specific stochastic effects ("random effects") and 14 year dummies. Common intercept and year dummy coefficients not reported separately.

LM is a Lagrange multiplier test of homoskedastic regression errors.
Durbin-Watson is a test for first-order serial correlation of the regression errors, adjusted for panel data purposes (see Bhargava, Franzini and Narendanathan, 1982).
Firm effects: "Total" vs. "Within" F-test, "Total" vs. "RE" LM test, "Within" vs. "RE" Hausman (1978) specification test.
Year effects: F-test of the unrestricted model including year dummies vs. the restricted model which excludes year dummies.

Variable definitions:

Log Relative profits	log (firm profits / median profits of the incumbents group)
Log Relative costs	log (firm variable costs / median variable costs of the incumbents group)
Firm size	log firm turnover
LRC × D1979-1992 etc.	Relative costs multiplied by a step dummy which is 0 up to 1979 (etc.) and 1 thereafter up to 1992

Table 5.6 Panel data regressions with correction for first-order serial correlation

Dependent variable: Log Relative profits			
	Method of estimation estimated coefficients (absolute t-statistic) [p-value]		
Independent variables	Within	AR1 (common rho)	AR1(firm-specific rho)
Log Relative costs (LRC)	-3.8661 (12.37) [0.000]	-3.8263 (19.15) [0.000]	-3.7212 (18.19) [0.000]
Firm size	0.9564 (15.99) [0.000]	1.0078 (87.78) [0.000]	0.9087 (9.77) [0.000]
LRC × D1979-1992	0.1284 (0.35) [0.724]	0.1787 (0.71) [0.476]	0.1092 (0.45) [0.653]
LRC × D1980-1992	-0.2046 (0.64) [0.521]	-0.3085 (1.09) [0.278]	-0.2702 (1.03) [0.303]
LRC × D1981-1992	0.0666 (0.18) [0.859]	0.1378 (0.44) [0.660]	0.1085 (0.38) [0.707]
LRC × D1982-1992	0.1365 (0.44) [0.659]	0.1302 (0.43) [0.664]	-0.0271 (0.12) [0.904]
LRC × D1983-1992	-0.7791 (1.94) [0.053]	-0.7111 (2.45) [0.014]	-0.7085 (1.75) [0.080]
LRC × D1984-1992	0.1905 (0.26) [0.795]	0.1655 (0.56) [0.575]	0.0910 (0.15) [0.882]
LRC × D1985-1992	0.1421 (0.21) [0.835]	0.1630 (0.53) [0.595]	0.0959 (0.20) [0.843]
LRC × D1986-1992	0.6068 (1.75) [0.080]	0.5762 (1.93) [0.054]	0.6206 (2.02) [0.043]
LRC × D1987-1992	-0.4017 (1.30) [0.194]	-0.3199 (1.15) [0.251]	-0.2969 (0.99) [0.322]
LRC × D1988-1992	0.2902 (0.78) [0.436]	0.3178 (1.10) [0.272]	0.4053 (0.71) [0.477]
LRC × D1989-1992	-0.7239 (0.90) [0.369]	-0.7475 (2.52) [0.012]	-0.8442 (1.09) [0.277]
LRC × D1990-1992	0.4484 (0.58) [0.560]	0.3881 (1.34) [0.180]	0.4259 (0.71) [0.477]
LRC × D1991-1992	-0.2072 (0.32) [0.747]	-0.1859 (0.66) [0.512]	-0.1743 (0.32) [0.753]
LRC × D1992	0.0574 (0.08) [0.935]	0.0847 (0.30) [0.761]	0.0859 (0.18) [0.857]

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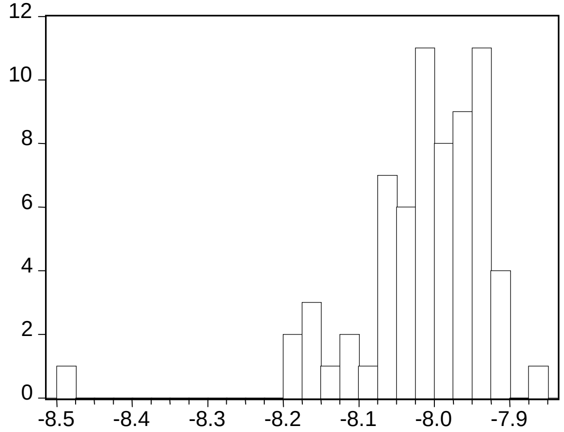
x

Adj. R2 Durbin-Watson rho (t-statistic)	0.9770 1.3337 [0.000, 0.000] -	0.9772 (untransformed data) - 0.2055 (6.33) [0.000]	0.9729 (untransformed data) 1.9793 [0.999] -
Heteroskedasticity-consistent estimates (White) are based on the balanced panel of 67 firms over 15 years. "Within" denotes OLS estimation of the pooled regression model including 67 firm-specific constants ("fixed effects") and 14 year dummies. "AR1 (common rho)" denotes ML estimation of the Within model correcting for first-order serial correlation with rho common to all firms. "AR1 (firm rho)" denotes ML estimation of the Within model correcting for first-order serial correlation with firm-specific rhos.			
Durbin-Watson is a test for first-order serial correlation of the regression errors, adjusted for panel data purposes (see Bhargava, Franzini and Narendanathan, 1982). Year effects: F-test of the unrestricted model including year dummies vs. the restricted model which excludes the year dummies.			
Variable definitions:			
Log Relative profits	log (firm profits / median profits of the incumbents group)		
Log Relative costs	log (firm variable costs / median variable costs of the incumbents group)		
Firm size	log firm turnover		
LRC × D1979-1992 etc.	LRC multiplied by a step dummy which is 0 up to 1979 (etc.) and 1 thereafter up to 1992		

Table 5.7 Fixed firm-specific effects



Series: FIXED EFFECTS	
Observations 67	
Mean	-8.014824
Median	-8.000050
Maximum	-7.870460
Minimum	-8.493750
Std. Dev.	0.093107
Skewness	-2.294382
Kurtosis	11.80043
Jarque-Bera	274.9911
Probability	0.000000

Industry 2081

Table 5.8 CHOW test using the AR1-Within regression (Industry 2081)

Break in 1980: F(98,809) Test Statistic: 0.86 [0.831]
Break in 1981: F(98,809) Test Statistic: 0.94 [0.654]
Break in 1982: F(98,809) Test Statistic: 1.09 [0.275]
Break in 1983: F(98,809) Test Statistic: 0.96 [0.582]
Break in 1984: F(98,809) Test Statistic: 0.69 [0.988]
Break in 1985: F(98,809) Test Statistic: 0.64 [0.997]
Break in 1986: F(98,809) Test Statistic: 0.72 [0.978]
Break in 1987: F(98,809) Test Statistic: 1.01 [0.465]
Break in 1988: F(98,809) Test Statistic: 1.15 [0.159]
Break in 1989: F(98,809) Test Statistic: 1.40 [0.009]
Break in 1990: F(98,809) Test Statistic: 2.84 [0.000]
Break in 1991: F(98,809) Test Statistic: 2.49 [0.000]

p-values are given in brackets. A p-value smaller than 0.050 indicates a statistically significant break in the assumed relationship given an error margin of 5 per cent. Thus the breaks in 1989 to 1991 are significant.

Table 5.9 Time development of *b* in Industry 2081

Dependent variable: Estimated first-period *b* (AR1-Within, common rho)	
Independent variables	Estimated coefficient (absolute t-statistic) [p-value]
Year	0.0252 (2.16) [0.050]
Constant	-45.9332 (1.98) [0.069]
Sample: 15 observations, 1978 to 1992	

Table 5.10 Regressions using first-differenced variables (Industry 2081)

Regressions in first differences			
Dependent variable: Log Relative profits			
Independent variables	Method of estimation estimated coefficients (absolute t-statistic) [p-value]		
	FD-OLS	FD-GMM static	FD-GMM dynamic
Diff Log Relative costs (LRC)	-3.5155 (13.68) [0.000]	-4.2689 (8.26) [0.000]	-4.2188 (7.63) [0.000]
Diff LRC (-1)	-	-	0.0034 (0.06) [0.951]
Diff Firm size	1.0369 (11.06) [0.000]	1.0613 (9.41) [0.000]	1.0025 (8.04) [0.000]
Diff LRC× D1980-1992	-0.5043 (2.20) [0.028]	-	-
Diff LRC × D1981-1992	0.1472 (0.65) [0.519]	-	-
Diff LRC × D1982-1992	0.0804 (0.34) [0.733]	-	-
Diff LRC × D1983-1992	-0.6935 (2.21) [0.027]	-	-
Diff LRC × D1984-1992	0.1374 (0.41) [0.683]	-	-
Diff LRC × D1985-1992	0.2633 (0.49) [0.485]	-	-
Diff LRC × D1986-1992	0.6302 (2.51) [0.012]	-	-
Diff LRC × D1987-1992	-0.1771 (0.58) [0.561]	-	-
Diff LRC × D1988-1992	0.3784 (1.36) [0.173]	-	-
Diff LRC × D1989-1992	-0.8118 (1.46) [0.144]	-0.6866 (1.69) [0.092]	-0.3275 (1.13) [0.257]
Diff LRC × D1990-1992	0.2570 (0.41) [0.682]	-	-
Diff LRC × D1991-1992	-0.1471 (0.32) [0.749]	-	-
Diff LRC × D1992	0.1388 (0.27) [0.782]	-	-

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Adj. R2	0.6981	-	-
Interaction effects	F(13,909)=17.32 [0.000]	-	-
Time effects	F(13,909)=140.60 [0.000]		
Durbin-Watson	2.4774 [0.999]		
m1 serial correlation	-	-3.0020 [0.003]	-2.9414 [0.003]
m2 serial correlation	-	0.1269 [0.899]	0.1083 [0.914]
Sargan	-	CHISQ(120)=1.6055 [1.000]	CHISQ(157)=3.18 [1.000]

Heteroskedasticity-consistent estimates (White) are based on the balanced panel of 67 firms over 15 years.
"FD-OLS" denotes OLS estimation of the first-differenced regression model including fixed firm- and time-specific effects. First-differencing wipes out fixed firm-specific effects but contains (transformed) time-specific constants. Year dummy coefficients not reported separately.
"FD-GMM static" denotes the Arellano-Bond one-step GMM estimation of the first-differenced regression model estimated for the period 1982 to 1992 using instruments T-3 and earlier. Coefficients of the included time constants are not reported.
"FD-GMM dynamic" denotes the Arellano-Bond one-step GMM estimation of the first-differenced regression model as before except for the inclusion of the lagged dependent variable.

m1 and m2 are LM tests for first- and second-order serial correlation. The test statistics are standard normal under the null of no serial correlation of order j=1,2.
Sargan is a test for instrument validity. The test statistic is distributed as chi-square under the null.

Variable definitions:

Log Relative profits	firm profits / median profits of the incumbents group
Log Relative costs	firm variable costs / median variable costs of the incumbents group
Firm size	log firm turnover
LRC $\times$ D1979-1992 etc.	LRC multiplied by a step dummy which is 0 up to 1979 (etc.) and 1 thereafter up to 1992

Table 5.11 Time development of *b* in Industry 2722

Dependent variable: Estimated first-period *b* (AR1-Within, common rho)	
Independent variables	Estimated coefficient (absolute t-statistic) [p-value]
Year	-0.0726 (3.62) [0.003]
Constant	148.26 (3.73) [0.002]
Sample: 15 observations, 1978 to 1992	

Table 5.12 Time development of *b* in Industry 2713

Dependent variable: Estimated first-period *b* (AR1-Within, common rho)	
Independent variables	Estimated coefficient (absolute t-statistic) [p-value]
Year	0.1699 (7.91) [0.000]
Constant	-334.35 (7.85) [0.000]
Sample: 15 observations, 1978 to 1992	