**The competition index,**

**An analysis of the collusive factors**

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Executive summary

The thesis will analyse the Herfindahl-Hirschmann Index and the Number of firms factors of the Competition index designed by the NMA (Dutch antitrust authority) in 2008, in order to provide a stronger theoretical foundation and improvements to the index. In particular it finds that an asymmetric division of the market shares can benefit collusion if firms differentiate in capacity. The views on the effect of increased number of firms on collusion in an empirical setting are analyzed. The thesis ends with a modified competition index and a comparison between our new scoring and the old index.

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## 1.0 Introduction

This year the Autoriteit Consument & markt (ACM), the Dutch antitrust agency, has deployed a new instrument in finding cartels. The competition index is a proactive instrument that uses data from 500 defined markets in the Netherlands, where it checks 9 collusive factors and identifies markets that are prone to cartelization or collusive behavior. 3 Of these inputs are concentration related collusive inputs. In this thesis we investigate whether, and if so, how 2 of these concentration inputs, namely the Herfindahl-Hirschmann index (HHI) and the number of firms, should be incorporated in this index.

One of the fundamental problems of any regulator attempting to monitor is monitoring costs. This relates especially to competition authority's cause there is a big open market. The Centraal Bureau voor de Statistiek (CBS) states that as of 2012 there are 1,247,445 companies in the Netherlands alone. The ACM implements several measures to prevent too much bureaucracy. For example any company that is defined as small is exempt of Cartel regulation. Small companies are defined as having a net revenue smaller than 5,5 million in industrial business, and 1,1 million in service industries. Also any agreement can't exceed 8 companies. Even though this restriction reduces the amount of cases greatly, the ACM depends on reactive monitoring. A rudimentary overview of Cartel detection can be found in Figure 1 [[2]](#footnote-2).

The specified instruments for reactive monitoring are leniency and whistle blowing. There are no direct statistics for the ACM, but the Directorate General for competition of the European commission states that all 5 of the 2012 conviction cases were originated from leniency applications (Directorate General for competition, 2013). To further illustrate the prolificacy of leniency in antitrust agency policy, the OECD had a roundtable in 2012 (OECD, 2012). A complete overview of how leniency affects the cartel equilibrium is given by Motta & Polo (2003).

But in recent years the ACM has concluded that reactive monitoring is a suboptimal method compared to proactive monitoring, although it does underline that the two methods work best in tandem, as more proactive monitoring should increase the incentive for firms to apply for leniency. A direct result of this was the competition index, introduced in an NMA working paper Petit (2012). When an agency such as the ACM is proactively scanning markets for competition problems, there are fundamental issues that must be addressed. It is vitally important that the instrument is both theoretically solid to prevent false accusations, but also to increase the acceptance. Any literature work that improves the fundamental basis of the competition index helps the viability of using the instrument.

This thesis will discuss the competition index and analyze its components, focusing on the concentration variables. The thesis is structured as follows: The index is introduced in section 2. Section 3 discusses specific collusion factors in the competition index. In section 4 the data and methodology will be discussed which are presented in section 5. Finally the findings are concluded in section 6.

## 2.0 Competition Index[[3]](#footnote-3)

The ACM has identified in recent years that relying too much on reactive procedures in its cartel detection methods is a problem that needs addressing. Traditional problems with reactive measures are well established in the literature. For example a cartel that faces leniency incentives can tighten the rules of the cartel and attempt to sustain itself longer. Adding a market screening device to the antitrust agency methods is a logical reinforcement of cartel detection. To accomplish this, the ACM has developed the Competition index.

The competition index consists of 9 factors, grouped in 4 sectors, a short overview follows by sector. Petit (2012):
1. Prices: Prices NL versus EU
2. Degree of organization: Number of trade associations
3. Concentration: HHI, number of firms and import rate
4. Dynamics: Market growth, churn rate, survival rate and R&D rate.

There is some research on how individual collusion factors affect cartel behavior in a market. For example Fraas & Greer (1977) mention that no collusion factor alone is a sufficient condition for noncompetitive behavior, it appears that a combination of factors together facilitates effective non competitive behavior. In a more recent study Dick (2004) estimates that readily available industry characteristics are correlated to cartel activity, but the correlation is so small that any noise in measuring the characteristics is likely to lead towards inaccurate results. Rey (2006) further elaborates on how collusion factors can support cartel detection.

For the purpose of this thesis the focus is on the HHI and the Number of firms, an introduction of these factors follows.

*Herfindahl-Hirschman Index (HHI):*

The HHI is a measurement of the market shares for a given market. For a formal introduction see equation (1), where is the market share of firm i.

 (1)

In traditional literature it is assumed that the HHI is positively correlated to collusion (see Motta ). The antitrust authorities, like the US competition authority, have specific regulations regarding the usage of the HHI index in merger analysis[[4]](#footnote-4). This is an important reason for including the factor in market screening device regarding collusion.

*Number of firms:*

The numbers of firms are defined as any firm with a measurable market share in a given market. This factor is negatively correlated to collusion. As the number of firms increases it becomes increasingly more difficult to collude between firms. The simplest insight is decision making. If firms attempt to collude any decision on setting the collusive price and/or output is increasingly difficult once more firms enter the agreement. The thesis will discuss the conventional wisdom and illustrate some special situations where having more firms might help collusion in section 3.2.

## 2.2 Membership functions

The competition index transforms these 9 inputs into one index number by using membership functions. These functions have no absolute form but are fuzzy sets. An overview of the relevant membership functions is given below (see also, Petit (2012).

A score of 1 is associated with the highest possible chance of collusion, while a score of 0 is the lowest. The construction of these membership functions is not mathematically derived but instead based on general trends and insight. This is no straightforward problem and it is the mechanism that drives the factors into the competition index. In the coming section the analysis will attempt to define the relationship between these factors and collusion as clearly as possible, to possible improve these functions in the competition index.

*Weight:*

There is a secondary input for these variables into the competition index. They are also given a weight that is aggregated into one index, the competition index. The HHI-index and the number of firms are together responsible for 26% of the weight in the index Petit (2012). When analyzing these factors this is an important component that is changeable. Most obvious is when the implied relationship between for example the HHI-index and collusion is so ambiguous that it can't reasonably be used in a screening device like the competition index. Ideally, the weight reflects how informative the membership function, and by extension the collusive factor, is to the existence of cartels.

## 3. Analysis

## 3.1 Herfindahl-Hirschmann Index

In this section we will first look at the optimal market share division for collusion, after that we introduce some modifications to the standard model with excess capacity constraints. Then we find what happens if the excess capacity is different between firms, and the effect on the market share of the firms.

In the traditional academic literature the HHI index is seen as positively correlated to collusion ( see Motta ). This correlation however is hard to state directly. Conlin & kadiyala find that the HHI index has positive correlation to pricing in the Lodging activities in Texas. Pricing alone is not a strong enough indication of collusion; one can imagine a situation that costs increasing lead to higher prices. Bos et al (2009) Find that the HHI index can measure competition in the banking sector for perfect collusion or perfect competition but not for intermediate levels of competition.

The HHI is linked to the economic literature through the Cournot model by Cowling & Waterson (1976), and its relationship towards market power. The analysis will therefore follow the Cournot model when the HHI index is involved. There is a potential empirical problem with applying these results to a market screening device like the competition index. Because it screens all markets in the Netherlands, not just Cournot models, transferability of the results can be viewed as problematic. This argument however is not strictly a problem for this analysis but more so for the usage of the instrument. It is beyond the scope of this thesis to analyze how applicable the theoretical basis of the competition index is to non-Cournot markets. The HHI index is influenced by both the number of firms and the asymmetry of the market shares, to show why this is ambiguous towards collusion outlining each is necessary.

*Number of firms:*

When the number of firms increases the HHI becomes strictly lower, as long as the assumption that firms are symmetrical is observed. The HHI (equation (1)), becomes , for n symmetric firms (Motta, 2004), which is strictly decreasing as n increases. This result is obtained by seeing that the market share , when all n firms are symmetric. The HHI then becomes , which is equal to . When the traditional view of a higher number of firms being negatively correlated to collusion is applied, this relationship implies a positively correlated HHI with collusion.

*Assymetry:*

The other aspect of the HHI index is the market shares. Given the number of firms in a market that are not symmetrical in market shares this implies a strictly higher HHI index then the symmetrical result. The point here is whether a more symmetrical distribution of market shares is helpful to collusion. If this is true then a lower HHI for a given number of firms is stronger correlated to collusion. And the relationship of the HHI towards collusion is ambiguous, and it is of interest which of the two opposing forces is dominant towards collusion.

To asses this, the first step is to quantify what type of incentive constraint firm’s face when attempting to collude. The market consists of n firms with an infinite horizon game. Equation 2 illustrates the established constraint Motta (2004):

 [[5]](#footnote-5) (2)

For the purpose of this Thesis equation (2) will be rewritten as:

 (3)

The illustrates the discount factor for a firm that is colluding. If a firms individual discount factor exceeds the discount factor of the collusive constraint (3) it will break the cartel (. If it is smaller (), the firm will sustain collusion. The are the profits of a firm when colluding, the are the one time profits a firm can make when leaving the cartel. Finally the are the profits made when the firm has realized the other firm is deviating, and is attempting to punish him for leaving the cartel. In the Cournot model this is equal to the Cournot equilibrium.

In traditional literature the assumption is that a more asymmetric distribution of market shares is harmful for the incentive to collude, the intuition is straightforward Motta (2004) . Often studies deal with market share distribution in Bertrand monopolies; because the quantity effects are more severe (a tiny change in price can capture the entire market), see for example Lambson (1993) ,Prabal (2008) and Schenkmann & Brock (1985). Because our interest is in the HHI the setting for our model is a Cournot market. Firms are undifferentiated in any non-specified way and compete on quantity in a Cournot duopoly. The firms have some share of total quantity , for for 2 firms. The share is defined as , for for 2 firms and distributed between , where is the total quantity . The demand function is decreasing in , and marginal costs are constant and normalized to 0. The model attempts to find the optimal to sustain collusion for the market share . Collusion is optimal when = , as the highest is the constraint for collusion (the firm with the higher will break collusion faster) and both functions are continuous in . In effect we are looking for the min-maximum of the , which is located at =, because of the continuity in . For calculating this, the incentive constraint (equation (3)) needs the cartel profits, deviation profits and punishment profits.

 (4)

, Equation (4), contains 3 different terms, the cartel, deviation and punishment profits. In the cartel equilibrium, illustrated by , firms divide up the market quantity by some share of for each firm. In the deviation stage (), firm i produces capacity , which is higher as its market share is rising. As is shown by the first derivate if the deviation profits with regards to the market share of the other firm () .

 (5)

Equation (5) is smaller than 0 for , which always holds, to illustrate that as the market share of the other firm declines, the deviation profits will increase. Now the only way for the deviation profits to decline is an increase of the , as , are static. Finally the punishment stage is the normal cournot equilibrium. In this equilibrium the market shares are equal, so that both firms have the same profit (), independent of the market shares in the cartel equilibrium.

Now solve for and this becomes equation (6) after some algebra:

 (6)

Equation (6) then illustrates that the optimal market share for collusion , and the firms will share the cartel profits equally. The intuition is somewhat straightforward, as when a firm has higher cartel profits it will have less incentive to deviate compared to a firm with a relatively low market share in the cartel equilibrium. The firm with a low market share and therefore lower cartel profits has comparatively more to gain from deviating, and loses less when the firms enter normal Cournot competition (punishment stage).

Although the argumentation is sound, the assumptions this model is based on are subject to debate. Especially the assumption that says both firms in the standard Cournot model can always optimally deviate and play the output of the Nash equilibrium. It would be a more realistic setting to analyze the collusion constraint from a perspective where a firm can't expand its production so easily. For example Ishii (2011) estimates that in the oil & gas industry the excess capacity was only 30% for the period 1999-2008.

## 3.1.1 Excess capacity Cournot

Identifying a relevant excess capacity has to be outlined. If both firms can produce the deviation output for any given market share (equation (5) showed that the deviation quantity is rising as the market share in the cartel rises), there is no relevant relationship with collusion compared to no excess capacity, as firms can always optimally produce. If one of the firms can't expand its excess capacity towards the Cournot quantity, which can be defined as normal market operation, it is unclear why a firm that has no excess capacity problems would ever collude. After all if the other firm can't even reach the normal Cournot equilibrium, the firm that can will have deviation profits and won't be punished as severely.

To illustrate this imagine a firm that has no excess capacity at the cartel equilibrium, which will be defined as a hard capacity constraint. This firm can't deviate at all, and can't punish the other firm for deviating. Therefore the other firm faces no repercussions from leaving the cartel. It can even be argued that this doesn't qualify as colluding because no firm would ever agree to the cartel output if the other firm has this hard capacity constraint. These repercussions become more severe as the firm with the hard capacity constraint can expand its production towards the Cournot equilibrium, at which point maximal punishment is obtainable. A relevant capacity constraint than has to conform to neither firm being able to optimally deviate, and both firms have to posses at least some excess capacity.

The problem firms face when there are capacity problems in the market is how to optimally collude, the intuition is the same as with the market shares, if the (equation (3))is equal to the , collusion is optimized for the firms. Initially the setting is that excess capacity (, for 2 firms) is equal for both firms in the cournot market. Firms share the collusive profit equally, so that the market share , for 2 firms .Now the model can predict the optimal excess capacity to sustain collusion, for this we need to find the , Equation (4) translates this into:

 (7)

 (8)

Equation (7) represents equal capacity below the cournot quantity, where both firms can’t punish optimally, equation (8) shows how the develops if the capacity is over the cournot quantity . It should be noted that because excess capacity is equal and so is the market share, the . This means that we can focus on , and see where it is lowest, as when the is minimized the optimal point to collude is reached. Graph 1 illustrates the optimal excess capacity for collusion.

Graph 1

The optimal is found for , also defined as (the nash equilibrium quantity under normal market operations). The relevant excess capacity is equal to , which if we compare this to Ishii (2011), is above normal empirical levels of excess capacity.

The reason the optimal excess capacity is located at the Nash equilibrium is intuitively straightforward. At this point firms can optimally punish each other, mathematically this means that the punishment equilibrium is no longer decreasing for firms in (as illustrated by equation (8)), where they are set at . And will only influence the deviation profits, that are still increasing in . This means that the bottom of equation (7) is minimized for , in order for this to be a minimum of the only thing that is further needed is that top of equation (7) is strictly decreasing faster than the bottom side, which holds so long that .

This is a strong result for firms attempting to collude, but it is still fairly restrictive, as firms can now have excess capacity, but it has to be equal and the division of market share in the cartel has to be equal. Equation (6) showed that with no restrictions on capacity the division of the market shares is optimal when they are equal, but it is unclear if this still holds when there are capacity restrictions. So in order to completely claim the result that the optimal equal capacity = , there is another situation that has to be discussed, if the division of excess capacity is equal ), will it still hold that as we have assumed so far, or is there some intervening factor like the excess capacity that makes sharing the market equally inherently unfavorable for the firms. The , are shown in equation (9),(10).

 (9)

 (10)

, shows after some algebra that:

 (11)

When , the market share of firm 1 is equal to that of firm 2 in the cartel equilibrium, similarly to the results of equation (6), where there was no capacity problem for the firms. The obtained result is that firms with equal excess capacity will sustain collusion best by dividing the market shares equally. This equal excess capacity is located at =. Now that we have shown that if firms have excess capacity problems the optimal excess capacity is equal, the analysis will continue with firms that have an unequal excess capacity.

## 3.1.2 Unequal excess capacity

If firms have different excess capacity’s there is important assumption, namely that firms can’t control their capacity perfectly, as they would simply choose an equal capacity to optimize collusion if they did have perfect control. Intuitively it makes sense that firms don’t always have perfect control. An obvious example is the long term nature of capacity investments and the timeframe for divesting. Another is input for production that can take a long time to plan. Furthermore it is risky for firms to divest their capacity, although it optimizes collusion, the firms in the collusive agreement have an incentive to maintain capacity as it helps their strategic position. In either case the analysis will assume that firms have some excess capacity and don’t have perfect control.

Without loss of generality, let , and see what the effect is on the firms ,The cartel profits are divided by the market share , for 2 firms . The , from equation (9,10) is now different, as illustrated below:

 (12)

 (13)

Now the last situation that has to be illustrated is when , the deviation profits are still the same as before, firms produce up to their capacity, but the punishment stage is different in this scenario. Firm -i will still simply produce up to its capacity to punish, but firm i either produces its best response () to firm –i and capacity , or it is limited by it owns capacity and produces .

 (14)

 v

 (15)

When , there is a optimal point to collude. There are multiple scenarios to analyze as illustrated above. However not all capacity divisions are as realistic. When the cournot quantity output (, is defined as the normal market operation, or in other words without collusion in place, this would be the standard capacity found in the market. But holding excess capacity has a cost, and if collusion is in place it would be a normal response for firms to decrease their excess capacity. Certainly holding capacity over the normal cournot quantity, as is the scenario in equation (14,15), seems unprofitable for firms. Therefore the analysis will focus on the situation described in equation (12), and the capacity constraint of . This is the section to the left of , in graph 1.

When the excess capacity , and the market share , the optimal excess capacity was equal to , now assume that the excess capacity is no longer equal, and . The presumed effect is that the firm with a higher excess capacity has a higher and will therefore break the collusion earlier then the firm with the lower excess capacity, furthermore as this asymmetry of excess capacity increases the difference in the will increase. Graph 2 illustrates how the reacts to range of excess capacity’s that are smaller than .

Graph 2

 Graph 2 is a little bit counterintuitive to interpret, the easiest point to understand is where the excess capacity is equal, . To the left of this point the excess capacity , and the excess capacity is decreasing from . Thus confirming that is decreasing as is increasing. Now to the right of the equal excess capacity, the reverse is happening, , and decreases from . The result is that if we set the firms excess capacity at some point ( in this case), and decrease the other firms excess capacity this is a non-optimal result compared to both firms having equal excess capacity.

Now that we have shown how the reacts to an unequal division of excess capacity, the question is if the optimal excess capacity is still , for all relevant asymmetry divisions, or if asymmetry is a dominant factor in the . Table 1 solves the for a range of different excess capacity's that hold for or . It is shown that when , the collusive constraint is , and when the relevant constraint is , as was true in Graph (2). Table 1 essentially shows a similar pattern but for more relevant excess capacity’s and asymmetry divisions.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  (), () | : |  |  |  |  |  |  |  |  |
|  |  | a/4b | 25a/96b | 26a/96b | 27a/96b | 28a/96b | 29a/96b | 30a/96b | 31a/96b | a/3b |
|  | a/4b |   |   |   |   |   |   |   |   |   |
|  | 25a/96b |   | 0,920 | 1,692 | 2,333 | 2,857 | 3,276 | 3,600 | 3,839 | 4,000 |
|  | 26a/96b |   | 1,692 | 0,846 | 1,167 | 1,429 | 1,638 | 1,800 | 1,919 | 2,000 |
|  | 27a/96b |   | 2,333 | 1,167 | 0,778 | 0,952 | 1,092 | 1,200 | 1,280 | 1,333 |
|  | 28a/96b |   | 2,857 | 1,429 | 0,952 | 0,714 | 0,819 | 0,900 | 0,960 | 1,000 |
|  | 29a/96b |   | 3,276 | 1,638 | 1,092 | 0,819 | 0,655 | 0,720 | 0,768 | 0,800 |
|  | 30a/96b |   | 3,600 | 1,800 | 1,200 | 0,900 | 0,720 | 0,600 | 0,640 | 0,667 |
|  | 31a/96b |   | 3,839 | 1,919 | 1,280 | 0,960 | 0,768 | 0,640 | 0,548 | 0,571 |
|  | a/3b |   | 4,000 | 2,000 | 1,333 | 1,000 | 0,800 | 0,667 | 0,571 | 0,500 |

Table

Table 1 shows that when , the incentive to deviate (), is increasing as the difference between increases, so that when asymmetry is maximized (, so is the .It is interesting that for a given absolute measurement of asymmetry, for example set at , the collusion becomes more sustainable as capacity moves towards . Furthermore this also holds if the asymmetry is measured percentually, equation (16):

 (16)

Equation (17) illustrates combined with table 1 that the optimal capacity for firms to hold is still equal to the cournot quantity, even if there is asymmetry. Even though this still holds, table 1 does show that asymmetry is the dominant factor over the excess capacity, as the max is located at the maximum asymmetry and not at the smallest excess capacity as was true when the capacity was symmetrical. Firms attempting to collude will therefore benefit more by equalizing their excess capacity compared to optimizing it towards the Cournot quantity (=).

## 3.1.3 Cartel market share:

 If firms can’t optimize their excess capacity, one of the variables that they can control when making a collusive agreement is the market share division , earlier results showed that an equal division of the market shares is optimal. Now with unequal excess capacity the stipulation is that an unequal division of the market shares can benefit collusion. The hypothesis is that there exists some different division of cartel profits that allows for , this division is located between for . When the firm i with the higher capacity gets a higher market share , that reduces its , at the same time if the firm -i gets less market share its will increase. This should bring them closer together, and there has to exist some that equalizes these terms.

To solve the optimal for , equation (12) has to be solved for .

After some algebra this can be rewritten as:

 (18)

Equation (18) can be solved for , the table below illustrates how is chosen so that and collusion is optimized, for a range of capacities that hold for . Specifically it shows the distributed between [0 , 1], meaning that these numbers can only be applied to the after multiplying it with the (=). This is done to show more clear how the market share is divided optimally.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | : |  |  |  |  |  |  |  |  |
|  |  | a/4b | 25a/96b | 26a/96b | 27a/96b | 7a/24b | 29a/96b | 30a/96b | 31a/96b | a/3b |
| : | a/4b |   |  |  |  |  |  |  |  |  |
|  | 25a/96b |  | 0,500 | 0,510 | 0,519 | 0,528 | 0,536 | 0,544 | 0,552 | 0,559 |
|  | 26a/96b |  |  | 0,500 | 0,509 | 0,518 | 0,527 | 0,535 | 0,542 | 0,549 |
|  | 27a/96b |  |  |  | 0,500 | 0,509 | 0,517 | 0,525 | 0,533 | 0,539 |
|  | 7a/24b |  |  |  |  | 0,500 | 0,508 | 0,516 | 0,524 | 0,531 |
|  | 29a/96b |  |  |  |  |  | 0,500 | 0,508 | 0,515 | 0,522 |
|  | 30a/96b |  |  |  |  |  |  | 0,500 | 0,507 | 0,514 |
|  | 31a/96b |  |  |  |  |  |  |  | 0,500 | 0,507 |
|  | a/3b |  |  |  |  |  |  |  |  | 0,500 |

Table 2

Table 2 clearly shows that if , then . This means that if the capacity is unequally divided the optimal solution is to give more market share to the firm with a higher excess capacity. It proposes an interesting insight on the effect of asymmetry on collusion, as it is clear that when capacity is unequal between firms an asymmetric market share is optimal. Firms then can optimize collusion thru dividing market shares if they face different capacities that can't be perfectly controlled.

But showing that unequal capacity can be ‘solved’ by dividing the market shares unequally, isn’t the final result. As it is still unclear if this division of the market shares is better than the pure symmetric result. Formally:

. (19)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | : |  |  |  |  |  |  |  |  |
|  |  | a/4b | 25a/96b | 26a/96b | 27a/96b | 7a/24b | 29a/96b | 30a/96b | 31a/96b | a/3b |
| : | a/4b |   |  |  |  |  |  |  |  |  |
|  | 25a/96b |  | 0,920 | 0,882 | 0,846 | 0,811 | 0,776 | 0,743 | 0,710 | 0,678 |
|  | 26a/96b |  |  | 0,846 | 0,811 | 0,777 | 0,745 | 0,713 | 0,681 | 0,650 |
|  | 27a/96b |  |  |  | 0,778 | 0,745 | 0,714 | 0,683 | 0,653 | 0,624 |
|  | 7a/24b |  |  |  |  | 0,714 | 0,684 | 0,655 | 0,626 | 0,598 |
|  | 29a/96b |  |  |  |  |  | 0,655 | 0,627 | 0,599 | 0,572 |
|  | 30a/96b |  |  |  |  |  |  | 0,600 | 0,574 | 0,548 |
|  | 31a/96b |  |  |  |  |  |  |  | 0,548 | 0,524 |
|  | a/3b |  |  |  |  |  |  |  |  | 0,500 |

Table 3

As is observable from table 3, the is strictly bigger than the symmetrical capacity solution of , meaning that equality (19) holds. Furthermore the is now much lower than the respective values in table 1. Showing that dividing the market shares differently has a big impact on collusion. In the discussion of table 1 it became clear that asymmetry was the dominant concern for firms attempting to collude, now after the different division of the market shares the excess capacity is again the dominant concern. Meaning that firms are better off optimizing their excess capacity towards the Cournot quantity ( compared to equalizing their excess capacity.

Overall the analysis of the HHI has shown that a symmetrical division of market shares is optimal if the market conditions are perfect. Results have shown that if the firms face excess capacity constraints, they are best off by attempting to equalize it. If they don’t have perfect control over their excess capacity we find that the firm with a bigger excess capacity has a much harder time sustaining the cartel. Firms can solve this problem by optimizing their market shares in the cartel, where the firm with a bigger excess capacity gets a bigger market share in the cartel. Next we have to translate this analysis to the usage of the HHI in the competition index.

## 3.1.4 Competition index

The most relevant result towards the usage of the HHI factor in the competition index is table 2 and 3, that show how some asymmetry of the market share (table 2), may benefit collusion (table 3). Yet translating these results towards the HHI is somewhat problematic. A relevant change might be that a higher HHI (associated with more asymmetry in the market), is not as impactful on collusion. But it is questionable if this is the most accurate portrayal of the result, since the HHI index is also increasing if there are fewer firms in a market. Since the core effect is how asymmetry helps collusion, the HHI index can be transformed into an asymmetry measurement, illustrated by equation (20).

Asymmetry = HHI - (20)

The rationale behind this asymmetry is that the HHI index transforms into in a completely symmetric market, so subtracting the HHI factor by yields a measurement of asymmetry in a market. As this increases the asymmetry in the market becomes bigger. The asymmetry is distributed between , as the maximum score for the HHI=1. This simple adjustment not only portrays the results more accurately then simply saying that a higher HHI has less impact on collusion, it also is easily calculated with the available data used for the competition index. The HHI is already calculated, and the number of firms are available for the 'number of firms' factor of the index. This change then should both yield a more accurate result, and be similarly easy to calculate. The exact form of the asymmetry index regarding collusion will be introduced with the membership functions of the new index. Now the analysis will continue with the number of firms factor in the competition index.

## 3.2 Number of firms

The number of firms factor is defined for the competition index as the number of firms in the specified market. In the economic literature an increase of the number of firms in a market is seen as problematic for colluding. The section will give an overview of relevant literature and conclude with considerations towards the usage in the competition index.

Posner (1970) finds that cartel duration is positively correlated to the amount of firms in a market, Dick (1996) obtains a similar result. But for example Fraas & Greer (1977) finds that the number of firms has a negative effect on the ability to collude. To illustrate this concept, consider the simple scenario where 2 firms that differentiate in costs attempt to reach a collusive agreement, so that they have trouble deciding on the collusive pricing. Now add another firm with another different cost function, this very intuitive argument already illustrates an important point, collusion agreements become harder when more firms join the agreement. To further back this position, consider the following model by Ivaldi et al (2003).

N firms are in a collusive agreement and can earn, or the cartel profits divided by the amount of firms. The assumptions are that firms are identical, goods are homogenous and market shares are equal. Firms compete on price in a Bertrand setting. As n firms increases, the profits of the cartel for an individual firm decreases, however the profits of deviation stay fixed at (for simplification the price decrease that captures the market is so small that deviation profits equal cartel profits). Once firms have deviated they will trigger a price war that yields no further profits (as is the normal equilibrium in a bertrand price competition market, so that:

 (21)

Equality (21) simplifies to,

 (22)

This is strictly increasing as more firms enter the agreement (n increasing), showing that in an idealized setting the result is backing the claim that more firms make collusion harder to sustain.

 In the Cournot model the solution isn’t quite as simple, because the deviation profits are declining as the number of firms increase and the market share in the cartel decreases. Roux & Thoni (2013) do find that with a specific punishment strategy having more firms in the cartel may increase its stability. These types of theoretical models have problems when converting them directly to an empirical device like the competition index. Therefore it is important to analyze these results when some of the firm characteristics differ. Like the effect of the HHI-index on collusion when there are capacity constraints. The number of firms may have a different effect under these differentiating characteristics.

*Hard capacity constraint:*

First set the total capacity in the market K, then if n-firms are symmetric the capacity of each firm is . Following closely the analysis of Kuhn (2006), start with a situation that has a hard-capacity constraint. Meaning that marginal costs are c upto the maximum capacity K, and above the capacity K marginal costs. It is necessary that the total capacity of the market exceeds the monopoly demand, for a strictly decreasing demand function. And now set capacity K so that its lower then , the demand at the nash equilibrium ( in a normal Bertrand model without capacity constraints). Now examine the effect on the discount rate for collusion if more firms enter the market.

If a firm deviates it captures the entire market at capacity , at collusive price , the deviation price should be strictly lower then , but for simplicity assume a minimalistic deviation such that prices are equal. So that . A firm then earns at the collusive equilibrium, and can earn when deviating, where is the competitive nash equilibrium profits that will occur after deviation. Formally:

 (23)

It is straightforward to see that the incentive to deviate from colluding (RHS, (23)) is now proportional to , this result goes directly against the viewpoint that number of firms are harmful to collusion, as long as firms are symmetric and the capacity constraint is hard fixed above the . It is noteworthy that to fully claim that the gains from collusion are higher, it further has to hold that the RHS of (23), , is increasing strictly higher than .

The formal argumentation is beyond the scope of this thesis, the argument is that the payoffs fall more than proportionally as the number of firms increase. This is because punishment stages are always at least as severe as the normal Nash equilibrium, which in a capacity constraint world is decreasing between as the number of firms increase, meaning that the punishment profits are decreasing as n increases. For further reading see Kuhn (2006).

There is another argument that says more firms may benefit more collusion, to construct this argument I will form a thought experiment.

The world is set in an approximation perfect competition and n-firms, where n is so large that the market price Pc is equal to the marginal cost c. In this world there are 0 profits for all n-firms, now imagine that one individual firm has a huge incentive to try and raise its price, since its base situation is zero profits, any profit is an infinite improvement over this. If two firms find each other in this market and raise their price together, the chance of being found by the antitrust authority is close to non-existent, as there are n-firms in the market. Furthermore both firms have no incentive to deviate, as with an n-firm market deviation will result in zero profits, similar for any potential punishment they may construct outside of contractual measures, leading to collusion being forever sustainable for these 2 firms.

There is a duality problem in this argumentation, because if there are n-firms in a competitive market that competes on price, any raise in price should simply lose all market share to the other firms in the market, so the firms attempting to collude by raising price would not be able to do this. This has to hold in a perfect competition world, but a real screening device like the competition index operates empirically, so relaxing these constraints is more empirically sound. Now if the two firms even sell some infinitely small quantity at the infinitely small higher collusive price this is still preferred over the competitive price that yields no profits at all. Still the concern is that if this is plausible for these two firms that attempt collusion, then it should also be possible for other firms in the market. This makes it unclear why the competitive equilibrium yields zero profits, and the zero profits are mandatory to sustain collusion optimally in this market setting. One of the reasons can be information asymmetry, if the firms don’t know that a small increase in price is plausible for them the competitive equilibrium can remain at zero profits, while the colluding firms gain some profits and keep some market share. Certainly information asymmetry is a very real empirical phenomenon.

The point to take away from this argument is that if there are a lot of firms in the market and competition is fierce, the incentive to raise ones price becomes increasingly large. It doesn't have to be a market that holds for the extreme case of zero profits and an incredible large n amount of firms. As a very small profit can have equal effect, this relates to the opportunity cost, which becomes lower as profits under normal market operations decline. So any relationship between a lot of firms in the market and collusion will not reach a minimum of never as firms increase. This result will be defined as the possibility of ‘hiding between the masses’, and is supported by earlier mentioned studies from Dick (1996) and Posner (1970).

## 3.2.1 Competition index

It is questionable if the few cases where an increasing number of firms actually helps collusion, like Kuhn (2006), are strong enough to change the way this factor is implemented in the competition index. In contrast to the results of the HHI index, where more empirically correct firm characteristics lead to some asymmetry, for the number of firms we have to impose stricter than normal industry characteristics (like a hard capacity in Kuhn (2006)).

A more empirically sound change should focus on findings from studies like Dick (1996), that show that cartels can last longer if there are more firms in the market. This should reduce the negative correlation between number of firms and collusion. The thought experiment attempted to show a similar effect. The negative correlation itself however is indisputable; more firms should reduce attempts to collude in a market. That being said an interesting adjustment would be to keep the relation towards collusion at some minimum level, as it is unlikely that an ever increasing amount of firms will completely remove collusion, since both the incentive to collude increases and the risk of being caught decreases.

This result is not strong enough to directly apply to the index with the asymmetry change, but we can calculate it with the new membership function and the old, and compare the difference. This allows for both effects to be analyzed individually.

## 3.3 Membership functions

The Membership functions above illustrate the technical changes discussed in section 3.1.1 and 3.2.1. The asymmetry factor replaces the HHI, resulting in a more accurate measurement of asymmetry in a market. The membership function shows how this relates to collusion, the shape is convex because as table (3) illustrates, asymmetry has a very big effect on the , that gets bigger as the asymmetry increases. As this factor replaces the HHI-index, it will get the same weight in the index. The basis for this is that the HHI was mainly in the index to measure asymmetry already, so a pure asymmetry index needs to have at least a similar weight.

The number of firms closely resembles the initial membership function of Petit (2012), with the main difference being that the minimum relation to collusion now does not normalize to 0, but to 0,10. There is a technical difficulty with the index, being that the effect on collusion has to be maintained between [0,1]. The reason for this is that the minimum score is otherwise treated as 0. Therefore the end of the membership function for the number of firms, where n=10000 firms, it still has a score of 0. This shouldn’t affect the data, but the results for any market with n=10000 will be checked manually to ensure nothing extraordinary is happing to the results.

## 4. Data & Methodology

All the data from the competition index was retrieved by the NMA from the Dutch Chamber of commerce, the bureau of statistics and the European central bank (see Petit). Together it is divided into 504 markets for the Dutch economy. It is updated as of 2013, the data for the top scoring markets are based on the data of 2012, our own calculations are based on the data of 2013. Coverage of the relevant factors is 75% for the HHI and 100% for the number of firms. Meaning that for 25% of the markets the HHI was unavailable, and any change made to it will be irrelevant to the result.

The competition index will be calculated with just the new asymmetry index, and with both the asymmetry index and the new number of firms membership function. This allows a comparison with both parts of the analysis, first we can isolate the change of the asymmetry, and then we can estimate the relevant difference if the number of firms is modified.

The ranking of the top markets for the competition index is ordinal, meaning that there is no relevant meaning to the score of the competition index, the only important output is the ranking. The best option then for determining the result is a qualitative analysis of the top scoring markets. If the results show that these markets are recently on the forefront of antitrust authorities analysis it reveals at the very least accuracy of these results. Petit (2012) Mentioned a short analysis of worldwide cases that confirmed some of the top results in the index. For example Cement industries were found to be ranked high and are worldwide prevailing in cartel investigations. Al though not definitive, this type of reasoning should validate the results to an extend that is usable for an early market screening device like the competition index.

## 5.0 Results

The membership functions are tested against the dataset, which results in a scoring of the competition index for the collusive factors. In order to state the difference of the new asymmetry index, compare the old average HHI competition index scoring with the new average scoring of the asymmetry index. Table 4 and 5 show the descriptive statistics of the new membership functions score in the index:

Table 4

|  |  |  |  |
| --- | --- | --- | --- |
| HHI old | Asymmetry index | Delta(%) |  |
| 0.2061 | 0.7327 | 2.557 |  |

 Table 5

|  |  |  |  |
| --- | --- | --- | --- |
| Number of firms (old) | Number of firms (new) | Delta(%) |  |
| 0.2630 | 0.4530 | 0.654 |  |

As discussed these average differences don’t mean much, other than showing the scores of the new membership function. We can observe though that the asymmetry index has a much higher score towards collusion then the HHI used to have in the index, the same is true for the new number of firms membership function. Looking at the dataset this is for the most part because of markets with more firms now getting a higher score. The following page shows the new ranking of the markets.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Old | New with Asymmetry | New Asymmetry and Number of firms |
| 1 | Manufacture of lime | Manufacture of plaster | Manufacture of plaster |
| 2 | Manufacture of malt | Manufacture of lime | Manufacture of lime |
| 3 | Manufacture of plaster | Preparation and spinning of flax-type fibers[[6]](#footnote-6) | Preparation and spinning of flax-type fibers |
| 4 | Manufacture of other non‐distilledfermented beverages | Wire Drawing from iron and steel | Manufacture of cement |
| 5 | Processing of nuclear fuel | Manufacture of coffee and tea | Preparation and spinning of other textile fibers |
| 6 | Manufacture of cement | Preparation and spinning of other textile fibers | Processing of fissionable and fertile materials |
| 7 | Production of mineral waters andsoft drinks | Wholesale of tobacco products | Cold drawing of steel and Iron |
| 8 | Transport via pipelines | Processing of fissionable and fertile materials | Manufacture of coffee and tea |
| 9 | Youth hostels | Cold drawing of steel and Iron | Wastewater Collection and Treatment |
| 10 | Manufacture of basic iron and steeland of ferro‐alloys | Residual construction[[7]](#footnote-7) | Remediation of environmental pollution |
| 11 | Retreading and rebuilding ofrubber tyres | Manufacture of vinegar, spices and condiments | Manufacture of other food products  |
| 12 | Camping sites | Manufacture of homogenised preparations and dietetic food | Saltwinning  |
| 13 | Manufacture of steam generators | insulation work | Manufacture of vinegar, spices and condiments |
| 14 | Manufacture of coke ovenproducts | Managed passenger transport by road | Residual construction |
| 15 | Manufacture of rubber tyres andtubes | Manufacture of cement | Managed passenger transport by road |
| 16 | Manufacture of beer | Manufacture of other food products. | Manufacture of homogenised preparations and dietetic food |

In the table the top markets are sorted from high to low, originally the manufacture of lime was the top score in the index. In our new asymmetry index this market has dropped to number 2. Instead the manufacture of plaster is now the top score. A new market defined in 2013 has entered the top 3, namely the Preparation and spinning of flax-type fibers, so the entry of this market is not due to the change in the index. Although the very top scoring markets are still there, a lot of the old markets have dropped out. This shows that the introduction of the asymmetry index has had a big impact. For analyzing the validity of the change we will check the markets against the cartel database of the directorate general for competition of the European commission. Petit (2012) performed a similar qualitative analysis of the top markets for the old score.

A few of the top ranking industries are truly well known for cartelization, the most striking example of this being cement. The European commission has for example opened in 2010 a big investigation in the cement industries across Europe (Commission, 2010), where it further mentions fines in 1994, and other national fines historically. Using the cartel cases database from the European commission this is a small selection of relevant investigations and fines in the industries that score high in our Competition index:

* The fine of a plasterboard cartel in 2008 related to the manufacturing of Plaster
* Fines for a 20 year old cartel in the pre stressing of steel in 2010
* Multiple food examples that all fall under 'other food products', like animal food in 2010, flavour enhancers in 2008 and North Sea shrimp in 2012.
* Italian tobacco cartel found in 2005, but finalized in 2011.

It is clear then that the top scoring markets feature in some way in the investigations of the European commission, proofing some validity to the instrument. Yet Petit (2012) also mentioned multiple markets that were prolific in these databases, so again the change of the instrument is not proven by naming some markets that feature in cartel investigations, or even naming more markets then the original scoring.

The 3rd column of the table shows how the competition index changed with the new number of firms, the change is bigger than expected, as the membership function was not changed as drastically. New entrants are waste collection and treatment, Saltwinning and remediation of environmental pollution. These markets are not found in the database of the directorate general, which is not very promising, but not all conclusive, as some markets like cement now take a higher position, and the very top scores have not changed either. Still based on the weaker theoretical foundation of the membership function change, it appears to be reasonable to reject this scoring over just the adding of the asymmetry index. The decision has to be based on the theoretical foundation of section 3 over these results as it is too difficult make any conclusions on the validity of the changes on just the top markets that appear.

Of our new calculations then the adding of just asymmetry is most valid, yet a true proof of improvement is hard to present. The solution to this lies in time series analysis, to compare the old and the new score over time, which can be done in future research. Currently the data and the index aren’t old enough to perform this type of analysis.

## 6.0 Conclusion

The thesis has analyzed the Herfindahl-Hirschmann index and the Number of firms regarding their relationship to collusion and their role in the competition index, in an attempt to address the ambiguity of the HHI index towards collusion. Furthermore the goal was to benefit the theoretical foundation of the competition index.

The analysis of the HHI has shown that a symmetrical division of market shares is optimal if firms face no capacity restrictions. Results have shown that if the firms face excess capacity constraints, collusion is optimized when they are equal. If firms can't optimize their excess capacity the firm with a bigger excess capacity is much more likely to break the cartel. Firms can solve this problem by adjusting their market shares in the cartel, showing that some asymmetry in the market shares can benefit collusion.

The number of firms do not have this ambiguity towards collusion, the relationship of more firms hurting collusion from the traditional literature holds, only with very severe model restrictions like Kuhn (2006) do we find some evidence of more firms benefiting collusion. We analyzed some intuitive arguments that can show how a market with a very large amount of firms and very competitive behavior may increase the incentive for firms to collude. Furthermore some studies showed that cartels live longer in markets with many firms (Posner (1970) and Dick (1996)). Therefore we formed a new membership function based on many firms not hurting collusion as much, to test this effect against the competition index.

We recalculated the competition index with the new asymmetry index and the old membership function of the number of firms, and with both new membership functions. The results showed that the top markets in the index have changed significantly, after closely analyzing the top markets we found that adding in the new asymmetry index with the old number of firms membership function was the strongest result. This was based on both the theoretical analysis of section 3 and the empirical findings in section 5.

It is extremely difficult to determine some proof of improvement over the old competition index. Section 5 showed that the top markets frequent in the cartel database of the European commission. Qualitative analysis is an important solution to measuring improvement, but before any meaningful results can be found the scoring would have to be compared over a period of multiple years. Further research has to be done in this area to confirm the results.

# Bibliography

ACM. (2013). *ACM Strategic Statement.*

Bos, J., Chan, I., Kolari, J. W., & Yuan, J. (2009). *A Fallacy of Division: The Failure of Market Concentration as a Measure of Competition in U.S. Banking.* Utrecht: Tjalling C. Koopmans Research Institute.

Colombo, S. (2009). Firms symmetry and sustainability of collussion in a Hotelling Duopoly. *Economics Bulletin volume 29, issue 1* .

Commission, E. (2010, December 10). Retrieved from Europe.eu: http://europa.eu/rapid/press-release\_IP-10-1696\_en.htm?locale=en

Conlin, M., & Kadiyala, V. (2007). *Capacity and collusion: An empirical analysis of the Texas lodging industry.* Mimco, Michigan State University.

Cowling, K., & Waterson, M. (1976). Price-Cost margins and Market Structure. *Economica* , 267-274.

Dick, A. (2004). If Cartels Were Legal, When Would Firms Fix Prices? In p. Grossman, *How Cartels Endure and How They Fail* (pp. 144-173). Cheltenham: Edward Elgar Publishing Limited.

Dick, A. (1996). When are cartels stable outcomes. *Journal of Law and Economics* , 241-83.

Directorate General for competition. (2013). *Management plan 2013.* European commission.

European Commission. (2012, December). Retrieved from http://ec.europa.eu/competition/cartels/statistics/statistics.pdf

European Commission. (2008). Consolidated Version of the Treaty on the Functioning of the European Union. *Official Journal of the European Union* .

European commission. (2006). Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation. *Official Journal of the European Union* .

Fraas, A. G., & Greer, D. F. (1977). Market Structure and Price Collusion: An Empirical Analysis. *The Journal of Industrial Economics* .

Fraas, A., & Greer, D. (1977). Market Structure and Price Collusion: An Empirical Analysis. *The Journal of Industrial Economics* , 21-44 .

Hüschelrath, K., & Weigand, J. (2010). *Fighting Hard Core Cartels.* ZEW Discussion Papers 10-084.

Ishii, J. (2011). *Useful Excess Capacity? An Empirical Study of U.S. Oil & Gas Drilling.* Amherst: Amherst College.

Ivaldi, M., Jullien, B., Rey, P., Seabright, P., & Tirole, J. (2003). *The Economics of Horizontal Mergers: Unilateral and Coordinated Effects.* Toulouse: IDEI.

Jong-Hun, P., & Anming, Z. (2000). An Empirical Analysis of Global Airline Alliances:Cases in North Atlantic Markets. *Review of Industrial Organization* , 367-383.

Kuhn, K.-U. (2006). *How Market Fragmentation Can Facilitate Collusion.* University of Michigan and CEPR.

Lambson, E. (1993). Some results on optimal Penal codes in Bertrand Supergames. *Journal of economic theory* , 444-468.

Motta, M. (2004). *Competition policy.* Cambridge University press.

Motta, M., & Polo, M. (2003). Leniency programs and cartel prosecution. *International Journal of Industrial Organization* , 347-379.

OECD. (2012). *Policy roundtables, Leniency for Subsequent Applicants.*

Petit, L. (2012). *The Economic Detection Istrument of the Netherlands Competition Authority, The Competition Index.* Nederlandse mededingingsautoriteit.

Posner, r. (1970). A Statistical Study of Antitrust Enforcement. *Journal of Law and Economics* .

Prabal, R. C. (2008). *Bertrand Competition with Non-rigid.* Munich: Munich personal RePEC archive.

Rey, P. (2006). *On the Use of Economic Analysis in Cartel Detection.* Toulouse: Robert Schuman Centre for Advanced Studies.

Roux, & Thoni. (2013). *Collusion Among Many Firms: The Disciplinary Power of Targeted Punishment.* DEEP working paper 1302.

Samuelson, J., & Roberts, M. (1988). An Empirical Analysis of Dynamic, Nonprice Competition in an Oligopolistic Industry. *RAND Yournal of Economics* , 200-220.

Schenkmann, & Brock. (1985). Price Setting Supergames with Capacity Constraints. *The Review of Economic Studies* , 371-382.

Scherer. (1980). *Industrial Market Structure and Economic Performance.* Rand Mcnally College Publishing Company.

Appendix

Figure 1 (Hüschelrath & Weigand, 2010)



1. Special thanks to Jurjen Kamphorst and Lilian Petit for providing helpfull feedback and directions in the writing process [↑](#footnote-ref-1)
2. All figures are forwarded to Appendix. [↑](#footnote-ref-2)
3. For a full introduction see, [↑](#footnote-ref-3)
4. Any market with an HHI score >0,18 is considered problematic when a merger increases the score by 0,005. Between 0,1 and 0,18 it becomes a problem when a merger increases the HHI score by 0,01. Finally if the HHI score post-merger is below 0,1 there is never a problem. [↑](#footnote-ref-4)
5. Where$ π\_{Dev} >π\_{cart}>π\_{Pun}$ [↑](#footnote-ref-5)
6. New market in 2013 [↑](#footnote-ref-6)
7. Any construction activity that is not specified in other markets [↑](#footnote-ref-7)