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EMPIRICAL EVALUATION OF THE EFFECTIVENESS OF COMPETITION POLICY

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Empirical evaluation of the effectiveness of competition policy

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Abstract:
This study evaluates the usefulness of different modifications of empirical models estimating the so-called Boone indicator for capturing changes in the intensity of competition. We use as "natural experiments" in this evaluation data from three cartel cases: i) international elevators and escalators cartel in various European countries during the years 1995-2004, ii) Finnish raw wood cartel during the years 1997-2004, and iii) Finnish construction cartel 1994-2002. The findings support our argument that particularly when the primary interest is to evaluate the effectiveness of a certain competition policy action, the empirical model should properly take into account a possible structural break in data due to the policy action. Furthermore, our data hint that the methodological choice of prior empirical studies to use data only from one industry at a time may lead into the false conclusions when the Boone indicator is used for evaluating the effectiveness of sector-specific competition policy actions.

Tiivistelmä:
Tutkimuksessa arvioidaan ns. Boone-indikaattorin erilaisten empiiristen mallinnustapojen käyttökelpoisuutta tarkasteltaessa toimialojen kilpailuintensiteetin muutoksia. Hyödynnämme arvioinnissa aineistoa kolmesta kartellitapauksesta: i) kansainvälinen hissikartelli, joka oli useissa Euroopan maissa vuosina 1995–2004, ii) Suomessa ollut raakapuukartelli vuosina 1997–2004 ja iii) Suomessa ollut rakennusalan kartelli vuosina 1994–2002. Tulokset tukevat hypoteesia siitä, että etenkin silloin kun päämielenkiinnon kohteena on arvioida tietyn kilpailupoliittisen toimenpiteen tehokkuutta, empiirisessä mallissa tulisi huolellisesti huomioida tästä toimenpiteestä mahdollisesti aiheutuva rakenteellinen katkos aineistossa. Lisäksi tulokset viittaavat siihen, että aikaisemmissa tutkimuksissa usein käytetty menetelmä, jossa tarkastellaan vain yksittäistä toimialaa huomioimatta mahdollisia yleisiä kilpailuolosuhteissa tapahtuneita muutoksia, voi johtaa vääriin tulkintoihin, kun Boone-indikaattoria käytetään toimialakohtaisten kilpailupoliittisten toimenpiteiden tehokkuuden arvioinnissa.

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1. Introduction

One major task of the government in private markets is to ensure (fair) competition. *Competition policy* incorporates means aiming at promoting price competition between firms leading to lower prices and further enhancing innovation resulting in both efficiency and a wider consumer choice. In the European Union, competition policy focuses on the four key dimensions: i) *antitrust and cartel policies* aiming at preventing agreements between companies restricting competition (e.g., cartels) and the abuse of dominant market position, ii) *merger control* ensuring that mergers and take-overs between firms are legitimate only if they expand markets and benefits consumers, iii) *liberalization,* i.e. opening up sectors controlled by state-run monopolies to competition and iv) *state aid control* ensuring that public subsidies allocated for companies do not distort fair and effective competition between companies.

For the competition policy authorities, it is of utmost importance to have tools for measuring changes in the intensity of competition. There is also a strong demand for the empirical retrospective analysis of the competition policy actions. Though general competition policy has in many cases replaced sector-specific regulation, policy makers often face situations in which they need to evaluate changes in the intensity of competition in specific industries. Sector-specific regulation plays a notable role still particularly in network industries and, without proper empirical tools, it is impossible to evaluate ex-post the effectiveness of sector-specific policy actions. Furthermore, as the role of merger control has increased and it requires substantial resources, the

retrospective assessment of the impacts of approved mergers on competition is needed (see, e.g., Ashenfelter and Hosker, 2010; Schumacher, 2013).[1]

The state-of-the-art economic literature provides various means to measure the intensity of competition but it still lacks robust empirical techniques to measure changes in the degree of competition. One of the most commonly used measures is Price Cost Margin (PCM), also called the Lerner-Index. It is based on the assumption of the neoclassical economic theory that under perfect competition prices equal to marginal costs. PCM measures the difference between the price of a product and its marginal cost divided by the price. The closer PCM is zero, the fiercer is competition. However, while PCM functions well in certain conditions it fails in others and its use may thus lead to the false conclusions concerning changes in the order of magnitude of competition (see, e.g., Amir, 2003; Stiglizt, 1989).[2]

Boone contributes to the competition analysis by providing an alternative measure for competition (Boone et al., 2007; Boone, 2008). The so-called Boone indicator relies on the notion that in a more competitive industry firms are punished more harshly for being inefficient. Various empirical studies (see, e.g., Creusen et al., 2004) evaluate the intensity of competition using the Boone indicator. For instance, Bikker and von Leuvensteijn (2008) estimate the Boone indictor for the Dutch life insurance market. They use three different marginal cost measures, i.e. average variable costs measured by the share of management costs of the total premium, marginal costs obtained via translog cost function estimations, and marginal costs adjusted for scale economies. Their regression approach uses firm-specific fixed effects, similar to Creusen et al.

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[1] See also The Antitrust Modernization Committee's report (2007) to the U.S. President and Congress emphasizing the importance of the allocation of resources to the retrospective analysis of the competitive effects of the mergers.

[2] For instance, fiercer competition may result in an increase in the market shares of more efficient firms and decrease of the markets shares of the less efficient ones. Then, the weighted average PCM for an industry may increase leading to a false conclusion that competition has decreased.

(2004), eliminating the impact of time-invariant firm-specific factors. They conclude that the annual values for the Boone indicator suggest that competition has rather weakened than increased during the last years of the sample time period 1995-2003.

However, the recent literature states that it is still uncertain how accurately the Boone indicator actually measures the intensity of competition and which empirical method most robustly captures (changes in) competition with the Boone indicator. For instance, Maliranta et al. (2007) conclude that the optimal specification and method to estimate the Boone indicator is still an open question. Furthermore, Schiersch and Schmidt-Ehmcke (2010) question the usefulness and robustness of the Boone measure as a measure of competition as the reported empirical tests of the Boone indicator produce mixed results on its capability to properly measure changes in competition. They apply the Boone indicator to explore the development in competition in the three German industries (i.e. power cable, cement and ready-mix concrete industries) before and after the cartel detection in these industries. They use average variable costs, or total variable costs divided by sales, to approximate marginal costs. Based on their log-log regression results following the approach of Boone et al. (2007), Schiersch and Schmidt-Ehmcke conclude that the traditional regression approach of the Boone indicator fails to correctly indicate competition in the case of cartels.

We argue that one major problem in the prior empirical use of the Boone indicator relates to the empirical modifications that do not properly take into account the nature of competition policy actions and their impact on the intensity of competition. Various government actions (e.g., market liberalization, detection of a cartel, approval of a merger) change market conditions abruptly and are likely to cause structural breaks in competition that the empirical approach used for evaluating changes in competition should take into account. Secondly, the methodological choice of prior empirical studies

to use data only from one industry at a time may lead into the false conclusions when the Boone indicator is used for evaluating the effectiveness of sector-specific competition policy actions. This approach ignores the impact of certain macroeconomic factors (such as business cycles) affecting the intensity of competition throughout the economy, and thus do not enable the researcher to distinguish changes in the intensity of competition due to sector-specific competition policy and due to more general competition policy changes or other factors affecting economy-wide.

Similar to Schiersch and Schmidt-Ehmcke (2010), we use cartel cases as "natural experiments" to evaluate the empirical robustness of the Boone indicator. A robust competition measure should capture increase in competition in the markets after the cartel is uncovered. We empirically explore how different modifications of the equation for estimating the Boone indicator capture changes in competition in three different cartel cases (i.e. the international escalators and elevators carter in Europe, the Finnish raw wood cartel, and the Finnish construction cartel). We show that the Boone indicator correctly identifies changes in the intensity of competition if the structural break in data due to the cartel detection is properly taken into account in the empirical estimations. Furthermore, we show that the Boone indicator detects more precisely and robustly changes in competition when the non-cartel industries are used as a reference group in the estimations.

The rest of the paper is organized as follows. Section 2 presents the empirical modeling framework and the variations of the models used for estimating the Boone indicator. Section 3 briefly introduces the three cartel cases and data used in the empirical estimations. Sector 4 discusses the estimation results. Section 5 concludes.

2. Competition: Empirical modeling

Our study focuses on the use of the Boone indicator for empirically measuring changes in competition. We propose, test and assess the usefulness of different modifications of empirical models for capturing changes in the intensity of competition. Our primary aim is to develop an empirical approach that suits for the ex-post evaluation of the effectiveness of competition policy or for the evaluation of whether other changes in market environment (e.g. mergers) have significantly affected the intensity of competition.

We estimate four different modifications of the model for the Boone indicator. The basic model for the Boone indicator can be written as follows:

$$\pi_{ijt} = \alpha_{jt} + \beta_{jt} AVC_{ijt} + \varepsilon_{ijt} \tag{1}$$

where π_{ijt} is the (log) operating profit for a firm i that is active in industry j at time t, and AVC denotes (log) average variable costs. The time varying coefficient β_{jt} is the Boone indicator that measures the relative loss of profits of less efficient firms. The fiercer is competition in a given industry, the lower the value of β_{jt}. The use of log-log model has the advantage that the Boone indicator can be interpreted as a percentage change in a firm's profits as its variable costs change by one percent. In the empirical work, the major disadvantage of this logarithmic specification is that it eliminates all loss-making firms generating potential bias for the estimated Boone indicator. To avoid this bias, we estimate the empirical models for the Boone indicator using no-log modification of the basic model.

Our benchmark model for the Boone indicator is the Fixed Effects (FE) model[3] following the state-of-the-art empirical literature (see, e.g., Creusen et al., 2004; Bikker and Leuvensteijn, 2008):

$$\pi_{ijt} = \alpha_{ij} + \beta_{1jt} AVC_{ijt} * D_{Year} + \varepsilon_{ijt} \tag{2}$$

where D_{Year} is a vector of dummy variables for the sample years. This model produces a separate (i.e. time-varying) estimate for the Boone indicator for each year.[4] However, the changes in the intensity of competition are often more interesting than the levels captured by this measure. Therefore, a re-specification of the model that captures the change in competition is appealing. We first estimate a modified model that captures a linear trend in competition (see Maliranta et al., 2007, for the derivation of the re-specified equation):

$$\pi_{ijt} = \alpha_{0j} + \alpha_{1j} AVC_{ijt} + \alpha_{2j} T + \beta_{2j} AVC_{ijt} T + \varepsilon_{ijt} \tag{3}$$

where T is a time trend. Now, the estimated Boone-indicator is not time-varying; it captures a linear trend change in the intensity of competition in a given industry. As changes in competition policy or other government actions may result in sudden changes in markets and also abruptly affect the intensity of competition (such as uncovering a cartel[5]), the linear trend approach may not fit into empirically analyzing changes in competition. When there is such a structural break, the linear model may still capture changes in the intensity of competition if the data are divided into two time periods (i.e. before the policy action vs. after the policy action) and the estimations are

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[3] The fixed effects model has the advantage that the estimated coefficient α_i captures the impact of firm-specific characteristics on profits.
[4] However, as Maliranta et al. (2007) show, this specification does not lead into the estimation of the coefficients of the original Boone model.
[5] The empirical study of Levenstein and Syslow (2011) finds that the major underlying reason for cartel death is active antitrust enforcement, thus further suggesting that cartels tend to die abruptly rather than face slow death.

undertaken separately for each time period. However, it is possible that the intensity of competition is relatively stable before the policy action and then shifts to a totally new level, but again remains relatively stable after the policy action. In this case, we may not find any significant changes in competition either during the time period before or after the policy action.

When the major interest is to learn from data whether a certain policy action has affected the intensity of competition within a certain industry, another possibility is to re-specify the model as follows:

$$\pi_{ijt} = \alpha_{0j} + \alpha_{1j}AVC_{ijt} + \alpha_{2j}P + \beta_{3j}AVC_{ijt} * P + \varepsilon_{ijt} \tag{4}$$

, where P gets value 1 during the years after the policy action, and 0 otherwise. Again, we'll get a time-invariant estimate for the Boone indicator. Now, the Boone indicator tells us the difference in the intensity of competition within the industry, on average, after a change in competition policy vs. before the policy change took place.

The prior reported empirical studies on the Boone indicator typically estimate the model separately for each industry to avoid bias in the estimations due to some unobserved industry-specific factors. We, instead, argue that when other industries are included as a reference group in the estimations of the Boone indicator, we can capture the changes in the intensity of competition of one industrial sector due to a certain policy action even more precisely. This happens as the comparison of the change of intensity of competition in an industry to the average change in the intensity of competition in all other (relevant) industries eliminates the bias in the Boone indicator arising from the changes in macroeconomic conditions that further affect the intensity of competition in

the economy (e.g., business cycle fluctuations[6]). Unobserved industry-specific variation can be captured by the inclusion of industry dummies, and the re-specified model can then be written as follows:

$$\pi_{ijt} = \alpha_0 + \alpha_1 AVC_{ijt} + \alpha_2 T + \beta_4 \, AVC_{ijt} * T_K * K + J_{it} + \varepsilon_{ijt} \qquad (5)$$

, where J is the vector of industry dummies capturing industry-specific variation in operating profits, T_K is a dummy variable that gets value 1 for years after cartel was uncovered and 0 otherwise, and K gets value 1 if a firm belongs to the industry in which a certain government action targeting to affect competition has been implemented, and 0 otherwise. The Boone indicator is again time-invariant but, rather than comparing within industry changes in competition, it measures a change in the intensity of competition in the industry of interest after certain policy action compared to the development of competition before policy action (in all industries, including the industry of interest) and after policy action in other industries. This approach eliminates the impacts of macroeconomic factors such as business cycles affecting industries throughout the economy. Therefore, we believe that this variation of the empirical model for the estimation of the Boone indicator produces more accurate tool for the evaluation of the effectiveness of practiced competition policy.

We apply the above defined empirical models for the three cartel cases. The estimated coefficients β_{1jt} for equation (2) provide the measure for the intensity of competition in cartel industries for each sample year. The estimated coefficients β_{2j} of equation (3) capture the linear trend in competition (i.e. change in competition over time) in each cartel industry. We further estimate equation (3) in two parts - before and after uncovering the cartel - to investigate the change in the intensity of competition during

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[6] The previous economic literature suggests that firm profits are closely related to the changes in business cycles (see, e.g., Macallan et al., 2008).

the two periods. Equation (4) is also estimated only for the cartel industries but it uses, instead of the time trend variable, the dummy variable P that gets value 1 after the detection of the cartel, and 0 otherwise. The estimated coefficient β_{3j} thus describes a change in competition over time in the cartel industry after the detection of cartel vs. during the years when cartel was functioning. Equation (5) is estimated for all (relevant) industrial sectors, and in addition to the cartel time control P, we add a separate dummy to control for firms in the cartel industries, K, that takes value 1 if a firm is active in uncovered cartel industry, and 0 otherwise. The estimated coefficient β_4 thus captures the change in the intensity of competition in the cartel industry after cartel was uncovered compared to the development of competition in all industries before cartel detection and in other industries after cartel detection.

3. Data

3.1 Cartel cases

We use data from three different cartel cases: 1) Elevators and escalators cartels in several European countries, 2) Finnish raw wood purchasing cartel and 3) Finnish construction cartel. In the first cartel case, the cartel was international taking place nationwide in four different countries, while in the second and third cases, the cartel was nationwide in a single country, Finland. The selected three cartel cases are all notable. The international elevators and escalators cartel case is one of the biggest cartel cases, measured by the order of magnitude of fines imposed, in the European Union, while the raw wood purchasing cartel and asphalt cartels are among the biggest national cartel cases in Finland[7]. Consequently, it is credible that uncovering the sample cartels has

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[7] Relatedly, see Hyytinen et al. (2013) for an interesting study on Finnish manufacturing cartels.

resulted in a notable change towards fiercer competition in the industrial sectors in which cartels have been effective. Therefore, data from these industrial sectors before and after the detection of a cartel provides an excellent opportunity to test the power of different modifications of empirical models for the Boone indicator to detect the changes in the order of magnitude of competition.

The cartels for the installation and maintenance of elevators and escalators in Belgium, Germany, Luxembourg and the Netherlands were maintained by four company groups (i.e. Otis, KONE, Schindler and ThyssenKrupp, including their subsidiaries).[8] Cartel firms agreed on sharing elevator and escalator sales and installation sectors. They shared commercially important and confidential information, used price fixing and allocated projects to each other. The European Commission concluded that elevators and escalators cartel was effectively functioning between at least 1995 and 2004. The total fine imposed by the European Commission to the cartel firms exceeded 992 million Euros, making it one of the biggest cartel penalties in the history of the European Union.

In Finland, the Market Court found that the three major forestry companies (i.e. Metsäliitto Osuuskunta, Stora Enso Oyj and UPM-Kymmene Oyj) had participated a price-fixing cartel for purchasing raw food in the Finnish markets[9]. The participants of the cartel were found guilty of national forbidden price cooperation and sharing of procurement sources in the purchase of raw wood during 1997-2004. Directors of the companies regularly discussed of the development of the procurement prices of timber as well as the availability of timber, and they further compared company prices to the prices of other companies. Also regional heads shared their procurement prices with

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[8] Commission decision of 21 February 2007 relating to a proceeding under Article 81 of the EC Treaty Case COMP/E-1/38.823 – PO/Elevators and Escalators. Brussels, 21/02/2007. C(2007) 512 final.
[9] Decision of the Market Court of 3 December 2009, diary no 407/06/KR, no 614/2009.

each other, and made comparisons to the average prices. There were no decisions or agreements on exact prices made in the meetings but the aim of the meetings was clearly to affect future pricing of timber and to further stabilize the price development of raw wood. Furthermore, the cartel members shared information concerning theirs costs and other factors enabling them to coordinate their competitive actions in their downstream markets (i.e. markets for wood, pulp, and paper) in which they were the major players. Two of the cartel members were ordered by the Market Court to pay 51 million euros fine, in total, while the third participant (i.e. UPM) was granted immunity as it was the first company voluntarily submitting evidence concerning the existence of the cartel.

In Finland, particularly the construction sector has often been the subject of cartel speculations, and also the biggest Finnish cartel case in terms of fines imposed involves this sector. The Supreme Administrative Court detected a national asphalt cartel taking place from 1994 to 2002 comprising all main Finnish companies active in asphalt business (i.e. Asfaltti Oy, Lemminkäinen Oyj, VLT Trading Oy (former Valtatie Oy), NCC Roads oy, Skanska Asfaltti Oy, SA-Capital Oy, Rudus and Super Asfaltti Oy).[10] The combined market share of the companies was about 70 percent. They used price collaboration (i.e. they agreed in advance on the bid prices to be offered in tenders) for regionally and quantitatively sharing the asphalt works. These actions were effectively used for the elimination of competition from the asphalt market. Companies involved in illegal activities suffered the maximum penalty permitted by the Finnish law, i.e. in total 82.55 million euros.

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[10] Decision of the Supreme Administrative Court of 29 September 2009, KHO:2009:83.

Furthermore, Finnish Competition Authority found the construction industry federation Rakennustuoteteollisuus RTT and the three largest firms in the roofing-felt sector (i.e. Icopal Oy, Katepal Oy and Lemminkäinen Oyj) guilty of forbidden market information exchange during 1996-2001.[11] The industry federation collected detailed monthly sales information from companies and used it for developing monthly statistics, e.g., on sales and market shares of competitors for the use of cartel participants. The companies involved in illegal information exchange covered about 90 percent market share of the retail sales in hardware stores and about 70 percent market share of the contracting sector.

3.2 Data and variables

Data for the empirical part of the paper have been collected from multiple sources. The data concerning the escalators and elevators cartel in Belgium, Germany, and the Netherlands have been extracted from the Bureau van Dijk's Orbis database, and comprises of firm-level financial data from sample countries for the years 2002-2006.[12] We have in total 183 firms (or 557 observations) from the cartel sector (i.e. NACE Rev. 1 class 2922) of the three countries, and in total 19155 firms (or 60447 observations) from the other manufacturing and construction sectors (NACE Rev. 1 classes 15-45) in the sample countries.

The data concerning the Finnish cartel cases have been obtained from the Statistics Finland's firm-level financial database. The database includes all firms in Finland which employ at least 5 employees. The raw wood cartel industries comprise of the manufacture of wood and of products of wood (NACE Rev. 1 class 20), and

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[11] FCA's decision of 16 February 2007, diary no 1011/61/2002.
[12] Comprehensive data on earlier cartel years as well as data on more recent post-cartel years were not available at the time of the analysis.

manufacture of pulp, paper and paper products (NACE Rev. 1 class 21). The construction cartel industry consists of NACE Rev. 1 industry class 45. In both cartel cases we have data from the beginning of the cartel suspicions to the last available year in the data source. Comparison firms in the estimations of equation (5) are all other firms from manufacturing industries (NACE Rev. 1 classes 15-41). However, as the wood and construction cartels were partly coextensive and were uncovered about two years apart, the sectors affected were all likely to face abrupt change in competition at the same time. Therefore, industries affected by these two cartel cases are not likely to provide a good reference point for each other capturing average changes in the intensity of competition due to macroeconomic factors or non-sector specific changes in policy affecting competition. We thus removed the construction sector from the estimations for the industries affected by the raw wood cartel, and vice versa. In the estimations concerning the raw wood cartel case, we have in total 1206 firms (7457 observations) from the industries affected by the cartel and 11052 firms (71469 observations) from other industries from the years 1997-2011. In the construction cartel case, we have 11716 firms (60684 observations) from the construction sector and 12095 manufacturing firms (84063 observations) from 1994-2011, respectively.

The dependent variable in all of the estimated models is the operating profit of a firm, and the major explanatory variable is the average variable cost that is obtained by dividing intermediate and labor costs by turnover.[13] Table 1 reports summary statistics of these two variables separately for each estimation sample in the three cartel cases. It further reports separately average values for the variables during each cartel and after the detection of the cartel. The average operating profits have increased over time in all

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[13] In all estimations we have also controls for industry and year effects if applicable, and in those concerning international escalators and elevator cartel industries in three different countries, we also control for the country-specific effects.

non-cartel industry cases and also for the construction sector after the detection of the cartel, while the average operating profits of firms in the raw wood purchasing cartel industries have clearly declined after the detection of the cartel. Generally the data indicate that there has been a slight increase in the average variable costs over time. This observation probably reflects the general increase in the prices of raw material after the year 2005, i.e. during "after-cartel years".

- TABLE 1 HERE –

4. Empirical findings

The estimation of equation (2), the benchmark case, follows the methodology used by various aforementioned previous empirical studies. We use the Fixed Effects model to estimate the separate Boone indicators for each year. For the estimations of equations (3)-(5), instead, we estimate the change in the intensity of competition over time. We use the Random Effects model as equations (3)-(5) involve time-invariant dummy variables (e.g., control variables for policy action) that cannot be estimated with the Fixed Effects model.[14]

We first estimated the fixed effects model with separate beta coefficients for each year (see Table 2). The sample sizes of the industries covered vary a lot: we have 557 observations from the elevators and escalators sector, 7457 observations concerning sectors involved in raw wood purchasing cartel and 60684 observations from the

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[14] Our here unreported results (that are available from the authors), however, show that the estimation of the Random Effects models produce qualitatively similar results to those of the Fixed Effects models.

construction sector. Generally, the levels of the coefficients are rather difficult to interpret. Similar to Bikker and Leuvensteijn (2008), we find that the order of magnitude of beta coefficient fluctuates over time in all three models. The estimated annual Boone indicators for the construction sector succeed probably best among the three cartel cases in identifying increased competition after the detection of cartel. The Boone indicators for the elevators and escalators sector also capture increase in competition after the cartel years, 2005-2006, but the estimated beta coefficients for the cartel years 2002 and 2004 also suggest, unexpectedly, statistically significant increase in competition.

- TABLE 2 HERE -

The estimation of equation (3) incorporates a linear time trend and is undertaken for the all sample years (i.e. it covers both years when cartel was active and the post-cartel years). The estimated beta coefficients are negative for all three industries suggesting increase in competition over time (see Table 3). However, the estimated coefficient is statistically significant only in one case out of three (i.e. for the Finnish construction industry). Furthermore, the separate estimates of the Boone indicator for the two time periods, "during cartel" and "after-cartel", find statistically significant changes in competition only in the case of the Finnish construction industry. For the construction sector, data hints expectedly that competition has decreased during the cartel years, while it has intensified after the cartel was uncovered. The estimation of competition using a linear trend assumption does not thus always identify changes in the intensity of competition in the cartel cases.

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- TABLE 3 HERE -

The estimation of equation (4) by cartel cases only for the industries affected by the cartel comprises the dummy variable controlling the structural change in competition. When the Boone indicator captures the difference in beta coefficient after and before the detection of the cartel, we get a negative and statistically significant beta coefficient in two cases out of three (i.e. elevators and escalators industry and construction sector). In other words, in two cases the data indicate that there has been a notable increase in the intensity of competition when we compare after-cartel period to the during-cartel period within the industry. The beta coefficient is negative also for the Finnish raw wood cartel but it is not statistically significant.

Finally, we estimated equation (5) in which the Boone indicator of the cartel industries *after* the detection of the cartel is compared to the Boone indicator of companies in relevant non-cartel industries after cartel was uncovered and of all industries during the cartel. The estimated beta coefficient is negative and statistically significant in all of the three cartel cases. In the three cartel cases, equation (4) thus proves to be the most robust model for identifying increase in competition after the detection of a cartel. Our estimations thus suggest that though the comparison of the intensity of competition before and after the policy action within one sector detects in many cases correctly changes in competition, we obtain even more accurate results when the changes in competition in the industry of interest is compared also to the changes in competition in other sectors.

We further calculated changes in the estimated beta coefficients to shed light on the overtime changes in the intensity of competition in the Finnish cartel industries and average changes in competition in other industries that were not reportedly influenced by cartels[15]. Figure 1 shows the percentage changes in the estimated annual beta coefficients of equation (2) for the sectors affected by the raw wood cartel, construction cartel and other industrial sectors compared to the estimated value of beta for the base year 1997. It illustrates particularly why the linear trend approach succeeds well in revealing changes in competition for the construction sector. In the construction sector, the change in the intensity of competition has been gradual, and generally followed a negative linear pattern. Also, the visual examination of data indicate that there has been less competition during the cartel years than in the beginning of the cartel period, while competition has intensified after cartel was uncovered.

- FIGURE 1 HERE -

In the case of sectors that had a raw wood purchasing cartel in 1997-2004, the intensity of competition fluctuates more over time and does not follow a linear pattern. It also seems that there has been somewhat more intense competition during the other cartel years, with the exception of the year 2003, than in the beginning of the cartel. This is probably the reason why the estimated coefficient β_{3j} for equation (4) is negative but not statistically significant. The estimation of equation (5), instead, indicates that the intensity of competition has significantly increased in the raw wood purchasing cartel

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[15] We excluded data from the international cartel case here as a relatively small number of sample years did not allow such a long-term inspection of changes in beta coefficients in this case (i.e. we had data from changes only for 4 years).

industry after cartel was unrevealed. Here, the estimated equation measures whether firms are punished relatively more, on average, in the cartel industry after the detection of cartel than in other industries and in all industries during the cartel. It takes into account and removes the impact of factors affecting the intensity of competition in the economy as a whole (or on average, in all other sectors).

As Figure 1 shows competition in the Finnish industrial sectors has generally intensified after the first sample year 1997, and particularly after the year 2005. Prior empirical work has focused on the estimations of Boone indicator for individual sectors. Our estimations show that if general changes in the intensity of competition in the economy are ignored, we may make false conclusions from the estimated beta coefficient for one sector only concerning the effectiveness of regulatory or competition policy actions. For instance, when there has been a general increase in the intensity of competition in the economy due to some macroeconomic factor, one sector only analysis may lead the researcher to make a false conclusion that a certain sector-specific policy action has been successful. In the evaluation of the effectiveness of competition policy, this may lead into erroneous policy inference.

5. Conclusions

This study evaluates the usefulness of different modifications of empirical models estimating the Boone indicator for capturing changes in the intensity of competition due to government action or change in competition policy. It uses data from three notable cartel cases: i) international elevators and escalators cartel in various European countries during the years 1995-2004, ii) Finnish raw wood cartel during the years 1997-2004, and iii) Finnish construction cartel 1994-2002. Cartel cases are utilized as

"natural experiments" in the analysis as a robust competition measure should capture increase in competition in the markets after the cartel is uncovered. The data indicate that after-cartel increase in the intensity of competition is most robustly captured by the estimation of a model that incorporates not only the industry of interest but also other industrial sectors of the country. A model comparing the change in competition within one sector during cartel and after cartel was uncovered provides also relatively robust results.

The reported empirical findings support our argument that when the primary interest is to evaluate the effectiveness of a certain competition policy action or competitive implications of market developments (e.g., ex-post analysis of whether a merger has influenced the intensity of competition), the empirical model should properly take into account a possible structural break in data due to the policy action. Furthermore, the empirical model should also take into account changes in the intensity of competition affecting the whole economy (e.g., due to macroeconomic conditions). Over time comparison of competition within one sector (i.e. before and after policy action) removes only bias arising from certain time-invariant factors affecting the intensity of competition in the industry. Instead, when changes in competition intensity in one sector are compared to that of average in other industries, we may eliminate or at least significantly reduce bias arising from factors affecting the intensity of competition throughout the economy (e.g., business cycles).

Not only the implementation of antitrust and cartel policy calls for empirical tools that can be used for the ex-post evaluation of the effectiveness of the practiced policy. Also, mergers and acquisitions with relatively heavy administrative reviews have recently gained increased importance as part of competition policy, and therefore there is also a proliferated need for the retrospective analysis of the competitive effects of mergers and

acquisitions (Ashenfelter and Hosker, 2010; Hüschelrath and Smuda, 2013; Schumacher, 2013; Winston et al., 2011)[16]. In the United States, The Antitrust Modernization Committee's report (2007) to the U.S. President and Congress made an explicit recommendation to allocate more resources on the ex-post analysis of government merger enforcement and particularly on studies of the effects of market concentration on competition and other market characteristics. The same kind of efforts should be carried out also in Europe and other countries. We believe that the empirical models for the Boone indicator that take into account both a potential structural break due to changed market environment and general changes in the intensity of competition throughout the economy may provide with a valuable tool also for this line of empirical research.

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[16] Also, there is a related, intriguing question on the optimal enforcement of competition law and resource allocation between merger and anti-cartel policies (Cosnita-Langlais and Tropeno, 2013).

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Figure 1. Change in estimated beta coefficients (compared to base year 1997, %)
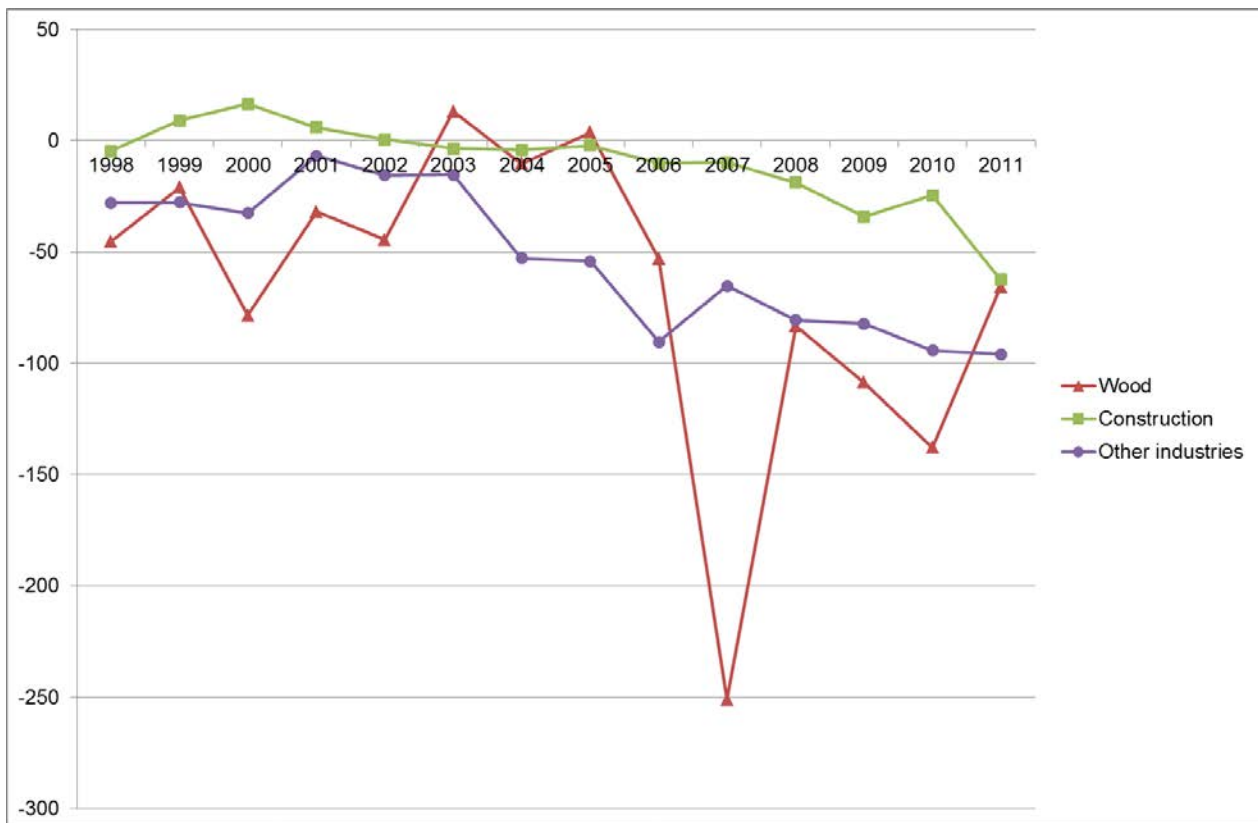
Table 1. Descriptive statistics for operating profits and average variable costs

	Mean	S.D.	Obs.
Operating profit, mill. euros			
Elevator cartel industry	2.967 (2.912)	9.641 (9.523)	214 (343)
Other industries	27.011 (22.641)	350.925 (295.617)	24433 (36014)
Wood cartel industries	3.353 (5.133)	42.994 (49.919)	3391 (4066)
Other industries	1.614 (1.386)	14.394 (16.686)	33878 (37591)
Construction cartel industry	0.222 (0.191)	1.592 (0.910)	35332 (25352)
Other industries	1.578 (1.328)	14.197 (15.494)	43621 (40442)
Average variable costs			
Elevator cartel industry	0.920 (0.952)	0.080 (0.352)	214 (343)
Other industries	0.946 (0.938)	1.298 (1.000)	24433 (36014)
Wood cartel industries	0.933 (0.908)	0.102 (0.100)	3391 (4066)
Other industries	0.912 (0.892)	0.126 (0.113)	33878 (37591)
Construction cartel industry	0.910 (0.905)	0.109 (0.104)	35332 (25352)
Other industries	0.910 (0.889)	0.123 (0.113)	43621 (40442)

Notes: Statistics for cartel period years are reported in parentheses and above them are reported after cartel statistics. In the raw wood cartel case construction sector has been removed from the estimation sample, and vice versa.

Table 2. Fixed-effects estimates for annual Boone indicators in cartel industries (β_1)

Year	Elevators Coef.	Elevators S.E.	Wood Coef.	Wood S.E.	Construction Coef.	Construction S.E.
1994					-2.029***	0.280
1995					-1.732***	0.156
1996					-1.653***	0.116
1997			-27.265**	12.904	-1.578***	0.120
1998			-39.594	20.956	-1.651***	0.121
1999			-33.036	17.625	-1.434***	0.099
2000			-48.697**	20.861	-1.320***	0.090
2001			-35.994**	17.024	-1.484***	0.083
2002	-6.687***	0.888	-39.415	20.981	-1.569***	0.112
2003	-1.117	0.700	-23.712**	9.595	**-1.633***	**0.113**
2004	-21.004***	6.343	-30.089**	12.831	**-1.645***	**0.109**
2005	**-35.256***	**11.420**	**-26.247***	**9.735**	**-1.613***	**0.103**
2006	**-54.210***	**18.537**	**-41.734**	**18.196**	**-1.739***	**0.117**
2007			**-95.707**	**68.663**	**-1.734***	**0.153**
2008			**-49.967***	**16.789**	**-1.876***	**0.152**
2009			**-56.869***	**20.759**	**-2.118***	**0.335**
2010			**-64.874**	**31.032**	**-1.967***	**0.133**
2011			**-45.176**	**18.830**	**-2.565***	**0.442**
Observations	557		7457		60684	

Notes: Post-cartel periods have been bolded. Table reports estimation models' β coefficients and their robust firm cluster-specific standard errors. Significance levels are reported on superscripts, where *** denotes significance level of 1%, ** significance level of 5%.

Table 3. Random-effects estimates for changes in competition

	Elevators Coef.	Elevators S.E.	Elevators Obs.	Wood Coef.	Wood S.E.	Wood Obs.	Construction Coef.	Construction S.E.	Construction Obs.
Linear trend (β_2)									
- Whole period	-8.133	5.319	557	-1.589	1.396	7457	-0.031**	0.015	60684
- During cartel	1.461	3.513	343	-0.023	0.708	4066	0.042***	0.016	25352
- After-cartel	-12.425	12.726	214	-3.111	2.461	3391	-0.080***	0.027	35332
Before-after control for policy action (β_3)	-39.199***	14.567	557	-14.338	10.335	7457	-0.258***	0.099	60684
Before-after control for policy action and cartel control. All industries (β_4)	-7.054***	1.799	61004	-3.310**	1.486	78926	-0.175**	0.086	144747

Notes: Table reports estimation models' β coefficients and their robust firm cluster-specific standard errors. Significance levels are reported on superscripts, where *** denotes significance level of 1%, ** significance level of 5%. All estimations include year and industry controls and the elevators case also country controls.