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Market structure and cartel duration
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Evidence from detected EU cartel cases

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Vorwort

Die Aufdeckung von Kartellen geschieht manchmal überraschend, manchmal war sie für die Marktteilnehmer zu erwarten. Auch welche Akteure letztlich dafür ausschlaggebend sind, kann sich unterscheiden. Zunehmend häufiger erfolgt die Aufdeckung durch Kronzeugen, doch nach wie vor sind die Wettbewerbsbehörden mit ihren Ermittlungen erfolgreich. Mit der Aufdeckung, deren Modalitäten und der Stabilität von Kartellen eng verbunden ist die Frage nach der Dauer von Kartellen.

IfG-Mitarbeiterin Sandra Swoboda stellt in diesem Arbeitspapier die Dauer von Kartellen in den Mittelpunkt. Sie prüft, ob sie mit der Marktstruktur im Zusammenhang steht. Dafür analysiert sie mit adäquaten ökonometrischen Modellen bereits aufgedeckte EU-Kartellfälle im Zeitraum von 2001 bis 2017 und kann interessante und neue Ergebnisse vorlegen. So kann sie zeigen, dass Probleme in einer Branche oder ein hoher kumulativer Marktanteil dazu geführt haben, dass Kartelle tendenziell später durch die Kronzeugenregelung aufgedeckt wurden. Die Existenz von Käufermacht war häufig Hintergrund dafür, dass Unternehmen ihr Kartell selbst angezeigt haben. Waren die Unternehmen auf mehreren Märkten tätig, hatten die Kartelle tendenziell eine längere Dauer. Interessant ist ebenfalls das Ergebnis, dass die Wahrscheinlichkeit einer Kartellaufdeckung gestiegen ist, wenn die Unternehmen an Verbandstreffen teilnahmen oder ein Kartellführer im Kartell existierte..

Dies sind nur einige Ergebnisse des Promotionsprojekts von Sandra Swoboda, das unmittelbar vor dem erfolgreichen Abschluss steht. Es stammt aus dem „IfG-Forschungscluster II: Kooperationen“. Kommentare und Anregungen sind herzlich willkommen.

Univ.-Prof. Dr. Theresia Theurl

Zusammenfassung

Die Kartelldauer kann je nach Ursache des Kartellzusammenbruchs variieren. Dieses Arbeitspapier unterscheidet zwischen den Ursachen der Inanspruchnahme der Kronzeugenregelung und der selbstständigen Ermittlungen von Wettbewerbsbehörden. Es werden Proportional Hazard Modelle für bereits aufgedeckte EU-Kartellfälle im Zeitraum von 2001 bis 2017 geschätzt. Die Analyse zeigt, dass die Existenz von Problemen in einer Branche oder ein hoher kumulativer Marktanteil dazu führen, dass Kartelle später durch die Kronzeugenregelung aufgedeckt werden. Im Gegensatz dazu führen Vorteile in einer Branche oder Käufermacht dazu, dass Unternehmen ihr eigenes Kartell eher bei den Wettbewerbsbehörden anzeigen. Unabhängig von der Ursache des Kartellzusammenbruchs ist ein Kartell von längerer Dauer, wenn die Unternehmen auf mehreren Märkten tätig sind. Die Wahrscheinlichkeit einer Kartellaufdeckung durch Wettbewerbsbehörden sinkt, wenn heterogene Produkte Gegenstand der Absprachen sind. Im Gegensatz dazu steigt diese Wahrscheinlichkeit, wenn die Unternehmen an Verbandstreffen teilnehmen oder ein Kartellführer existiert.

Abstract

Cartel duration is influenced by market structure but it also varies depending on the cause of cartel death. This paper distinguishes between determinants which increase the probability of death by leniency application and those that increase the probability of death through intervention by competition authorities. Proportional hazard models with competing risks are applied to detected EU cartel cases for the period 2001 to 2017. The analysis indicates that the existence of industry specific problems or high cumulative market share do not give cartel members an incentive to apply for leniency, whereas companies which benefit from advantages or the existence of buyer power on the demand side are more likely to denounce the cartel. Regardless of the cause of their death, cartels lasted longer if they operated across different markets. Likewise, the probability of cartel detection by competition authorities decreases if cartel agreements affect heterogeneous products. In contrast, detection probability increases if companies are organised around an industry association with regular meetings or in case the cartel has a leader.

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1 Introduction

In the last two decades, antitrust prosecution in the EU has become increasingly important. In particular, the introduction of the leniency policy in 1996 and its fundamental revisions in 2002 and 2006 have led to an increased effectiveness of antitrust proceedings in the EU. This is also reflected in the number of cartel proceedings that have been completed. In the 90's, only 20 antitrust cases were closed, in the period from 2000 to 2004, when the first revision of the Leniency Notice took place, these were already 30 and in the period from 2005 to 2009, when the second revision took place, there were 33 closed antitrust cases (EU COMMISSION (2017)). The fines imposed also show that antitrust prosecution gains in significance: The total amount of fines imposed in the period from 1990 to 1999 amounted to more than EUR 615 million, compared with over EUR 11 billion in the period from 2000 to 2009 (EU COMMISSION (2017)).

As STIGLER (1964) noted, the aim of firms is the maximization of their profits which depends on their own and on their rivals' demand- and supply-function. This aim can be achieved by cartel formation. In this context longer cartel duration means higher individual firm's profits which in turn means higher damage to welfare, because there are several negative side effects of a cartel, such as higher prices or no incentive to innovate. Based on this potential negative impact to economic welfare, it is crucial to investigate which determinants affect on cartel duration.

In 2011 the EU-Commission had already introduced Guidelines on horizontal cooperation agreements, which state that collusion is more likely to occur in markets which are sufficiently transparent, concentrated, non-complex, stable and symmetric. This statement is based on various studies, which analysed the relationship between different determinants, referring to one of the above characteristics and the formation and sustainability of cartels. Past researchers have focused on a broad array of specific determinants and their relationship to cartel stability and cartel formation. STIGLER (1964) and KÜHN/VIVES (1994) state that the publication of firm-specific information makes it easier to identify and punish a deviating firm. According to KÜHN/VIVES (1994) a concentrated market also leads to an increase in monitoring possibilities. Furthermore, access to several markets can facilitate the formation of cartels and their

sustainability (BERNHEIM/WHINSTON (1990), IVALDI et al. (2003)). By contrast, product differentiation (IVALDI et al. (2003), DENECKERE (1983)) and buyer power (STIGLER (1964), SNYDER (1996), MOTTA (2004)) have destabilizing effects on a cartel. There are contradictory arguments in theoretical literature regarding the effect of demand. GREEN/PORTER (1984), HALTIWANGER/HARRINGTON (1991) and STAIGER/WOLAK (1992) state that it is more difficult to sustain cartels in recession, while ROTEMBERG/SALONER (1986), ESWARAN (1997) and VASCONCELOS (2008) identify demand growth as a destabilizing factor for cartels. As far as the existence of market entry barriers is concerned, the majority of the studies conclude that they facilitate the formation and sustainability of cartels (e.g. IVALDI et al. (2003), SCHMITT/WEDER (1998)). In addition, most studies agree that symmetry between companies facilitates cartel formation and its sustainability. For this purpose, studies consider different determinants, such as market share (e.g. IVALDI et al. (2003), HARRINGTON et al. (2015)), capacity constraints (e.g. COMPTE/JENNY/REY (2002), BOS/HARRINGTON (2010)) or the cost structure (e.g MASON/PHILLIPS/NOWELL (1992)).

The empirical literature has also dealt with determinants which have an impact on cartel duration, although the majority of these studies are based on legal cartel cases with cartels existing up to 40 years ago. Recent studies refer to illegal cartel cases but in this case the cartels were also detected at least 10 years ago. Furthermore, only LEVENSTEIN/SUSLOW (2011) and GIESEN (2011) distinguish between cartels that break up due to different causes. Even though these causes are defined differently in these studies, they both distinguish between cartels that dissolved and were detected by competition authorities after their dissolution, and those discovered by competition authorities' investigations. Nevertheless, a question arises if cartels had indeed already dissolved at the time when competition authorities detected them. The cartel members may inform the competition authorities that the cartel is not active anymore if the cartel is uncovered. The reason for this is that the competition authority can only record the date of a cartel breakup, as one for which there is evidence. Consequently, it is possible that the cartel would have continued to exist if it had not been detected by the competition authority. In addition, there is no study, which considers the increasing

importance of the Leniency Notice relative to causes of cartel breakup, as the last fundamental change was made in 2006.

This paper aims to make the first step in rectifying this deficiency. While the factor of detection by competition authorities remains similar to previous studies, more recent cases are introduced. In addition particular emphasis is placed on the impact of the major change in regulation which is the aforementioned opportunity to apply for leniency.

The results indicate that the existence of a highly controlled cumulative market share or the existence of problems, such as deterioration in prices or overcapacities, decrease the probability of a cartel breakup by an application for leniency. By contrast, if there are advantages in an industry such as lack of substitutes, the probability of a cartel breakup by leniency application increases. Moreover, buyer power also results in a higher probability of a cartel breakup as a result of leniency. In addition, cartels lasted longer if they operated in different markets. In regard to the detection by competition authorities, it can be stated that the probability of cartel breakup decreases if the agreements affect heterogeneous products. On the contrary, if companies participated in industry association meetings, they were more likely to be discovered by competition authorities. Furthermore, the existence of a leader or a follower increases the probability for a cartel breakup. In particular, cartels with a leader are more likely to be detected by competition authorities.

The outline of the paper is the following. Section 2 gives an overview of the existing empirical literature. Section 3 presents the empirical strategy, while section 4 presents the data basis and summary statistics. Section 5 provides the empirical results and section 6 concludes.

2 Literature review

From an empirical point of view the topic of cartel duration has received relatively little attention by researchers until now. Those who have taken a closer look can be grouped into two categories. One group observed legal cartels. JACQUEMIN/NAMBU/DEWEZ (1981) analyse the stability of Japanese export cartels using a linear regression model. The authors state that export cartels are short-lived and

focus on price and quantity agreements. However, this does not apply to cartels covering both the domestic and foreign markets. Furthermore, they show that homogeneous products prolong the duration of the cartel, while new products shorten its duration. MARQUEZ (1994) uses the model of JACQUEMIN/NAMBU/DEWEZ (1981) and extends the model to include a maximum likelihood estimate for truncated data. The results show that cartels are more durable the higher the concentration and the larger the market share of the cartel members. For development of demand the author finds no significant correlation. DICK (1996) also uses export cartels for his analysis. The author examines the relationship between market structure, cartel-specific characteristics and cartel stability using proportional hazard and Weibull models. His findings on the market structure indicate that export cartels tend to collapse when they sell their goods to relatively large customers. This result enforces the theoretical findings of STIGLER (1964) who assumes that collusion in an oligopoly is more effective when serving smaller customers. In addition, fluctuations in demand also lead to a faster breakup of the cartel. If there is a recession in the export market, cartel duration is also reduced. SUSLOW (2005) examines the relationship between cartel duration and the uncertainty of demand as well as the cartel organisation by means of a proportional hazard model. In respect to the uncertainty of demand, the author shows that a cartel is shorter in duration the more unsafe the environment in which the cartel operates is. Similar to DICK (1996), the author states that both a decline in demand and fluctuations in demand have destabilising effects on cartels. Furthermore, the author supports the result of JACQUEMIN/NAMBU/DEWEZ (1981) that product differentiation shortens the duration of the cartel. A higher controlled market share also leads to a significantly longer cartel duration.

Analysing legal cartel cases may cause a problem because in comparison to illegal cartels the determinants differ. Furthermore legal cartels do not impact economic welfare in a negative way.

The other group of researchers studied illegal cartel cases. ZIMMERMAN/CONNOR (2005) use a proportional hazard model and state that cartel duration is related to market structure, internal cartel organisation, industry-specific conditions, external macroeconomic conditions and competition law. Like MARQUEZ (1994), they conclude that a high degree of concentration prolong the duration of the cartel.

Contrary to SUSLOW (2005) and DICK (1996), however, their results show that cartels live longer when there is a decline in demand. Similar to ZIMMERMAN/CONNOR (2005), LEVENSTEIN/SUSLOW (2011) analyse the impact of cartel organisation, the external macro-economic conditions and the industrial structure on the cartel duration. Their analysis is based on a proportional hazard model with competing risks. They distinguish between cartels which were abandoned and afterwards detected by the competition authority, for example through leniency application, and those which broke up because of the investigations of the competition authority. In this context the first cause is refered to as “natural death”, since the competition authority did not have to intervene for the breakup to occur. The authors show that considerably more cartels have collapsed due to intensive antitrust proceedings since 1995. The participation of an association leads to a faster detection by competition authorities. At the same time, the association's participation slows down natural death. The authors argue that although an association can stabilize the cartel due to communication and coordination possibilities, it is also visible to the competition authorities. However, the authors find no significant link between the concentration of an industry and a cartel breakup. GIESEN (2011) examines the impact of the market structure and cartel organisation on cartel duration. Similar to LEVENSTEIN/SUSLOW (2011), the author estimates the relationship with a proportional hazard model with competing risks and distinguishes between cartels detected by competition authorities and those which dissolve on their own. In contrast to LEVENSTEIN/SUSLOW (2011), applying for immunity is considered part of the investigation by competition authorities. To depict the market structure, however, the author uses only the market share of the cartel and the buyer power. His analysis shows that it is more difficult for competition authorities to detect cartels operating in markets with buyer power.

As the majority of empirical studies on this subject, the analysis in this paper is based on the proportional hazard model distinguishing between different causes of cartel breakup. The focus of this paper is on the determinants of market structure that affect the probability of cartel breakup. Determinants affecting internal cartel organisation that have been identified as significant in previous empirical studies

are also included as control variables in this analysis in order to reduce the problem of omitted variable bias.

3 Econometric implementation

The relationship between cartel duration and market structure is analysed by using a semiparametric Cox Proportional Hazard model (COX (1972)). Cartel duration is measured by the time that elapsed from the beginning to the end of the cartel. The survival function indicates the probability that a cartel will remain in existence after the predetermined time t:

$$S(t) = \Pr(T > t) = 1 - F(t), \tag{1}$$

where F (t) represents the distribution function of event time T. While the survival function concentrates on the existence of a cartel, the hazard function indicates the level of probability that an object will die at a certain point in time. In this analysis, the hazard function therefore expresses the probability that a cartel will collapse at time t, provided that it has survived until then. To this end, the cartels that collapsed at time t are compared to cartels that might have collapsed at that time. The cartels, which could have collapsed at a certain point in time, represent the so-called risk set. Therefore, the hazard function is also called failure rate. It indicates the risk of experiencing the event, in this case the cartel collapse, at time t. Mathematically, this can be expressed as follows:

$$h(t) = \lim_{\Delta t \to 0} \frac{Pr(t \leq T < t + \Delta t \,|T \geq t)}{\Delta t} \tag{2}$$

However, this analysis does not only consider the end of the cartel, but also the cause for a cartel breakup. This requires the introduction of competing risks. In literature, there are two approaches that can be used in order to look at competing risks. Either the cause-specific hazard rate or the sub-distribution hazard rate can be modelled for the analysis (PINTILIE (2006)).

The cause-specific Cox Proportional Hazard model is used to model the cause-specific hazard rate. The cause-specific hazard rate can be defined mathematically as follows:

$$h_c(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T_c < t + \Delta t | T_c \geq t)}{\Delta t} \tag{3}$$

where c represents the individual competing events. In this case, a separate Cox regression is performed for each competing event, while the other event is considered as censored in the analysis. Thus, the cause-specific hazard represents the risk that a cartel breakup occurs due to a specific event without the cartel having already collapsed due to another event (CLEVES et al. (2010)). This means that the continuous, instantaneous risk for a certain event is indicated at any time. The cause-specific Cox Proportional Hazard model for event c can therefore be represented as follows:

$$h_c(t, X) = h_{0c}(t) exp \sum_{i=1}^{p} \beta_{iC} X_i \quad (4)$$

The c in the notation of the regression coefficients β means that different events can have different effects on the estimators. If another event than c occurs, this results in a censored event. For example, if the event is the cartel's collapse due to leniency application, a cartel can no longer experience this event if it has already been uncovered in advance by the competition authority.

In contrast, the model of FINE/GRAY (1999) takes competing risks into account by modelling the sub-distribution hazard rate which is derived from the cumulative incidence function (CIF), also known as subdistribution (PINTILIE (2006), CLEVES et al. (2010)). It corresponds to the distribution function F (t) in the Cox Proportional Hazard Model and, taking into account competing risks, represents the probability that an event j will occur before time t (HOSMER/LEMESHOW/MAY (2008)). This relationship can be expressed mathematically as follows:

$$CIF_j(t) = Pr(T \leq t, C = j) \quad (5)$$

where T represents the event time and C the competing risks. The subdistribution hazard rate can be represented mathematically as follows:

$$\overline{h_c}(t) = \lim_{\Delta t \to 0} \frac{P\{t \leq T < t + \Delta t, c = 1 | T > t \cup (T \leq t \cap c \neq 1\}}{\Delta t} \quad (6)$$

The subhazard for the cause c represents the likelihood of a cartel collapse by c in time t under the premise that the cartel did not collapse before t or due to another risk before t. The estimators are interpreted as absolute probabilities. In this context it has to be taken into account that the greater the probability of the competing event, the lower the chance that the event will occur.

The difference between the cause-specific Cox Proportional Hazard model and the model of FINE/GRAY (1999) is that the cause-specific Cox Proportional Hazard model does not take into account the effect of the covariates on the competing event. Thus, in the cause-specific Cox Proportional Hazard model, the number of cartels in the risk set decreases any time a cartel collapses due to another risk (FINE/GRAY (1999), CLEVES et al. (2010)). Consequently, the influence of the covariates on the cause-specific hazard cannot be readily transferred to the CIF. For the analysis presented here, this means that a higher level of cause-specific hazard for cartels collapsing through applying for leniency compared to cartels discovered by competition authorities does not necessarily increase the incidence of cartel collapses by applying for leniency (HALLER/SCHMIDT/ULM (2013)). In contrast, the regression coefficients in the model of FINE/GRAY (1999) are connected to the cumulative incidence function, since the sub-distribution hazard rate is used (HALLER/SCHMIDT/ULM (2013)). Therefore all cartels remain in the risk set, even if they have collapsed due to a competing risk (FINE/GRAY (1999), CLEVES et al. (2010)). In terms of interpretation, the cause-specific Cox Proportional Hazard model takes on the perspective of the cartel members who are interested in the probability of their cartel breaking up, for example through a leniency application. In contrast, the model of FINE/GRAY (1999) assumes the perspective of the competition authority, for whom the absolute figures are relevant, since the competing event is taken into account.

4 Data and Descriptive Analysis

Data set. The analysis of the relationship between the probability of cartel breakup and market structure is based on 127 cartel cases, which were fined by the EU Commission between January 2001 and August 2017. The information was taken from the EU Commission's decision reports on the individual cartel cases. Cartel cases in which there was a suspicion of a competition infringement or in which the suspicion was not confirmed after an investigation were not taken into account. In addition, the EU Commission combined a number of cartels into one cartel, because they were detected during one investigation. This analysis considers these cartels separately as they may differ in terms of their market characteristics. The data is taken from the detailed decision reports of the EU Commission, which have a similar structure for all cartel cases. In most of the

decision reports, the affected industry is presented by describing the product concerned, the firms involved and the situation of supply and demand. The cartel proceedings are then described chronologically. Afterwards the amount of the fine is determined on this basis. However, it should be noted that important information has been censored to the public in the EU Commission's decision reports. This mainly affects the market shares of the companies. That is why the number of observations in this analysis decreases when this variable is taken into account. The 127 cartels operated in 142 sectors. 77.4% of these sectors are part of the manufacturing industry. The chemical and pharmaceutical industries account for 26.7% of the affected sectors, followed by the automotive industry with 10.6%.

Outcome Variable. The dependent variable is the cartel duration, measured in months. The information is taken from the decision reports of the EU Commission. The EU Commission indicates the month and the respective year as the start or end date. However, it should be noted that the EU Commission can only identify the date as the beginning of the cartel based on the earliest evidence available. Consequently, it cannot be ruled out that a cartel had already been active before the defined starting. The average duration in the considered cartel cases is about 83.06 months (6.92 years). Cartels applying for leniency last 84.41 months (7.03 years) and hence longer than those discovered by the EU Commission (80.24 months and 6.68 years respectively). In total, 67.72% of the relevant antitrust cases were detected because of a leniency application. A comparison with other studies shows that illegal cartel cases existed longer than legal cartels. The average duration of legal cartels is 5.3 years in the research of DICK (1996) and 2.8 years in the research of SUSLOW (2005). The average duration of illegal cartels examined in other studies, however, is similar to that of this sample (ZIMMERMAN/CONNOR (2005): 6.3 years, LEVENSTEIN/SUSLOW (2011): 8.1 years, GIESEN (2011): 5.95 years)

Covariates and Hypotheses. A detailed overview and description of the dependent variables considered in this analysis can be found in Table 1.

This analysis focuses on the influence of market structure on cartel duration, whereby the determinants of market structure are assigned to the five market characteristics that are taken up from the EU guidelines. However, due to a lack of data availability, no determinants could be assigned to concentration. There are variables taken into account whose influence has either been already investigated empirically or whose relationship with cartel formation has not yet been investigated. In addition, this analysis controls for determinants which refer to the internal cartel organisation such as the internationality of the cartel, the experience of the firms, the number of cartel members and the information exchanged, as these variables have been identified as significant in other empirical studies (e.g. DICK (1996), ZIMMERMAN/CONNOR (2005), LEVENSTEIN/SUSLOW (2011), GIESEN (2011)).

Table 1: Summary statistics

Variable Name	Definition	Mean	N	LA	CA
Association	Punishment of an association with a fine or meeting of companies during association meetings = 1	0.24 (0.43)	127	0.22 (0.42)	0.29 (0.46)
Market share	Cumulative market share of the participating companies in percent	78.35 (16.9)	70	75.12 (18.0)	83.48 (13.9)
Individual	Individual customer requirements, e. g. through different or individual product designs = 1	0.40 (0.49)	113	0.44 (0.50)	0.32 (0.47)
Multimarket	Access to several markets or multiple application areas of a product = 1	0.29 (0.46)	114	0.26 (0.44)	0.34 (0.48)
Buyer power	High concentration on the demand side or merger of buyers into groups = 1	0.12 (0.32)	112	0.14 (0.34)	0.08 (0.27)
Problems	Price deterioration of a product, overcapacities in the industry = 1	0.24 (0.43)	115	0.26 (0.44)	0.21 (0.41)
Saisonal	Regular demand fluctuations or regular price negotiations with customers = 1	0.28 (0.45)	112	0.34 (0.48)	0.16 (0.37)
Advantages	Products or technologies without existence of substitutes = 1	0.18 (0.38)	112	0.20 (0.40)	0.13 (0.34)
Competition	Entry of new companies into the market, high imports of foreign companies = 1	0.18 (0.38)	112	0.16 (0.37)	0.21 (0.41)
Leader	Existence of a company which incites or forces other companies to take part in the cartel or threatens retaliation in the event of non-participation = 1	0.17 (0.38)	127	0.09 (0.29)	0.34 (0.48)
Follower	Low cartel participation or actions contrary to the agreements = 1	0.17 (0.37)	127	0.17 (0.38)	0.15 (0.36)
Origin	Number of countries	3.39 (1.86)	126	3.73 (2.01)	2.68 (1.27)
Experience	Repeated cartel formation for at least one company in the cartel = 1	0.28 (0.45)	127	0.29 (0.46)	0.27 (0.45)
Members	Number of companies involved in the cartel	5.37 (3.13)	127	5.70 (3.28)	4.68 (2.70)
Allocation	Allocation of customers or territories = 1	0.61 (0.49)	127	0.59 (0.49)	0.63 (0.49)
Submission	Allocation of submission = 1	0.13 (0.33)	127	0.10 (0.31)	0.17 (0.38)

LA= Leniency Application, CA=Competition Authorities

Transparency

One variable which is referred to transparency is the participation of association in cartels. Associations can provide a platform for communication. According to further theoretical studies, communication between companies can facilitate collusion. LEVENSTEIN/SUSLOW (2011) state that the participation of an association leads to a decreasing likelihood that the cartel will collapse on its own. Therefore the estimated coefficient for this variable is expected to be negative.[1] The other variable is the cumulative cartel market share. MARQUEZ (1994) and DICK (1996), for instance, conclude that the higher the cartel's market share, the longer the duration of the cartel. Hence the estimated coefficient for the cartel market share variable is expected to be negative.

Non-complexity

In regard to product differentiation, some theoretical studies conclude that product differentiation makes it difficult to maintain a cartel when there is high product substitutability (DENECKERE (1983), ROSS (1992)). This result is empirically supported by JACQUEMIN/SLADE (1989) and SUSLOW (2005). As a result the estimated coefficient is expected to be positive. Another variable is the access to several markets. To the best of my knowledge only GIESEN (2011) analyses the correlation between cartel duration and the access to several markets. However, the author does not find any significant correlation. Nevertheless, this determinant is considered in this analysis since theoretical studies such as those of BERNHEIM/WHINSTON (1990) or IVALDI et al. (2003) state that the access to several markets can facilitate the sustainability of cartels. Therefore the estimated coefficient for this variable is expected to be negative. Another variable which constitutes part of the non-complexity is the buyer power. Theoretical studies imply that buyer power is a risk for cartel stability (STIGLER (1964), SNYDER (1996), MOTTA (2004)). Empirical studies such as those of DICK (1996) or ZIMMERMAN/CONNOR (2005) support this result. Therefore the estimated coefficient for the variable that refers to the buyer power on the demand side is expected to be positive.

[1] Probability of a cartel collapse sinks (-), increases (+).

Stability

There are several determinants which affect the stability of a market. One of them is the demand situation whose relationship with cartel stability has already been theoretically examined. Although there is a significant correlation, the direction of that correlation cannot be clearly identified. Empirical studies do not provide any definitive results either. DICK (1996) and SUSLOW (2005), for instance, state that demand growth prolongs cartel's life, whereas ZIMMERMAN/CONNOR (2005) state the opposite. An indicator of the state of the demand can be the existence of problems in an industry, such as overcapacities or deterioration in price, which imply a decline in demand. Since this analysis is based on illegal cartel cases, as the analysis of ZIMMERMAN/CONNOR (2005), it is expected that the estimated coefficient of the variable that refers to the problems in an industry is negative.

In addition to the development of demand, the relationship between fluctuations in demand and cartel duration is also important. DICK (1996) examines the effects of fluctuations in demand, but does not consider the fact that cyclical fluctuations can have a stabilising effect. In contrast, the results of SUSLOW (2005) show that increased fluctuations in demand have destabilizing effects on the cartel, whereas this is not the case with cyclical fluctuations. Since this analysis takes cyclical fluctuations in demand into account, the estimated coefficient is expected to be negative.

It is also possible that companies benefit from certain advantages in an industry, although there has not been a strong growth in demand. One example for this are new products or new technologies that may exist in a market in which there are currently no product substitutes. A lack of substitutes may also occur for existing products, so that the demand for this product remains relatively constant. This can be a proxy for the R&D activity in an industry. The results of theoretical studies show that it is more difficult to sustain cartels in innovation-intensive markets. As far as my research revealed, this determinant has not been empirically examined yet. For this reason, the estimated coefficient is expected to be positive.

Another determinant which can be assigned to stability is the competition situation of a market. The risk of new companies entering a market is examined in theoretical studies with the help of market

entry barriers. According to these studies high market entry barriers facilitate the sustainability of collusion. In contrast, empirical studies only implicitly investigate this relationship by considering certain industries. ZIMMERMAN/CONNOR (2005) state that cartels last longer if they exist in the chemical industry, since this industry is characterised by high market entry barriers. SUSLOW (2005) examines the cartel duration in the chemical industry, but cannot prove any significant correlation. For this reason the competitive situation is explicitly considered in this analysis and the estimated coefficient is expected to be positive.

Symmetry

Referring to symmetry two variables are considered. Theoretical studies state that symmetric market shares lead to cartel stability (IVALDI et al. (2003), HARRINGTON et al. (2015)). If there is a cartel leader it can be assumed that this company has a higher market share than the other cartel members because only then retaliatory measures appear credible. This in turn implies that market share within the cartel is asymmetrically distributed. ZIMMERMAN/CONNOR (2005) investigate the correlation between a dominant company and the cartel duration, but they do not find a significant correlation. Nevertheless this determinant is taken into account and on the basis of theoretical findings the estimated coefficient of this variable is expected to be positive. In addition to the existence of a cartel leader, the existence of a follower in a cartel can also indicate asymmetry between companies. The relationship between the cartel duration and the existence of a follower in the cartel has not yet been empirically analysed. It is assumed that a follower has a small market share compared to the other cartel members which indicate asymmetrically distributed market shares. Therefore the estimated coefficient is expected to be positive.

Summary statistics. Table 1 shows the summary statistics of the covariates. On the one hand the entire sample is considered and on the other hand there is a distinction between the two different causes of cartel breakup. With respect to the internal cartel organisation, it can be stated that on average one more firm is involved in cartels which break up due to leniency applications (5.7 firms). Regarding the market structure, cartels detected by leniency applications controlled on average 75.12% of the market share, which is

lower than that of cartels detected by competition authorities (83.48%). In addition, cartels revealed by a leniency application more often served individual customer needs than those revealed by the EU Commission (44% compared to 31.6%). Furthermore cartels that applied for leniency only had access to several markets in 26.3% of the cases, compared to 34.2% of the cartels detected by the European Commission. Apart from that, cartels were more likely to be detected through leniency applications if there were specific advantages in an industry (20.3% compared to 13.2%). In only 9.3% of the cases, the existence of a leader in a cartel led to cartel breakup due to immunity application. In contrast, 34.1% of the cartel cases in which a leader existed were detected by the EU Commission.

5 Empirical results

5.1 Cox Proportional Hazard model independent of risks

Table 2 shows the results of the Cox Proportional Hazard model without taking into account competing risks.

Table 2. Cox Proportional Hazard model regardless of the risks

Duration	(1) Hazard Ratio	(2) Hazard Ratio	(3) Hazard Ratio	(4) Hazard Ratio	(5) Hazard Ratio	(6) Hazard Ratio	(7) Hazard Ratio
Association				0.7715	0.7777	1.2418	1.2975
				(-1.07)	(-0.97)	(0.56)	(0.5020)
Market share							0.9877
							(0.0099)
Individual		1.0397	1.0285	1.0848	1.0599	0.6342	0.6516
		(0.19)	(0.14)	(0.38)	(0.26)	(-1.39)	(0.2163)
Multi-market		0.6496**	0.6632*	0.6793*	0.6301*	0.4304**	0.4374**
		(-1.98)	(-1.86)	(-1.74)	(-1.95)	(-2.48)	(0.1481)
Buyer power		1.5357	1.5076	1.5806	1.4728	1.3685	1.6413
		(1.40)	(1.32)	(1.46)	(1.21)	(0.70)	(0.7665)
Problems	0.7768	0.6975	0.6554*	0.6908	1.0204	0.9204	0.8521
	(-1.15)	(-1.49)	(-1.69)	(-1.45)	(0.07)	(-0.19)	(0.3771)
Saisonal	0.9977	0.9937	0.9961	0.9949	0.8674	1.2223	1.1976
	(-0.01)	(-0.03)	(-0.02)	(-0.02)	(-0.57)	(0.61)	(0.3925)
Advan-tages	1.0250	0.9565	1.0102	1.0064	1.0817	1.3253	1.4045
	(0.10)	(-0.17)	(0.04)	(0.02)	(0.27)	(0.78)	(0.5096)
Com-petition	0.6793	0.7309	0.7485	0.7170	0.7818	1.0882	1.0769
	(-1.52)	(-1.20)	(-1.10)	(-1.25)	(-0.94)	(0.21)	(0.4427)
Leader			0.7951	0.7502	1.2751	2.3594*	2.4990*
			(-0.87)	(-1.07)	(0.78)	(1.86)	(1.1724)
Follower			1.2042	1.2077	1.2141	1.8728	1.9383*
			(0.70)	(0.71)	(0.69)	(1.62)	(0.7531)
Origin					0.9617	0.8623	0.8611
					-0.51	(-1.52)	(0.0815)
Experience					1.0931	1.7977	1.8945
					(0.31)	(1.47)	(0.7648)
Members					0.9426	0.8904**	0.8831**
					(-1.21)	(-1.99)	(0.0517)
Allocation					0.3294***	0.1479***	0.1762***
					(-4.10)	(-4.57)	(0.0768)
Sub-mission					0.5380*	0.3916*	0.4068*
					(-1.95)	(-1.90)	(0.1999)
No of cartels	111	110	110	110	110	65	65
Log likelihood	-414.75	-407.14	-406.54	-405.95	-396.05	-191.13	-190.37
LR-χ^2	4.41 (df=4)	10.16 (df=7)	11.36 (df=9)	12.54 (df=10)	32.35 (df=15)	38.72 (df=15)	40.23 (df=16)

In model (1) only determinants that influence the stability of a market are taken into account. However, there is no significant link to cartel duration. Model (2) also considers determinants that influence the complexity of a market. The results indicate that access to several markets is significantly linked to cartel duration. This correlation also exists in the following specifications. In model (5) the probability of a cartel collapse is almost 37% lower if the companies have access to several markets. This result supports the theoretical findings of BERNHEIM/WHINSTON (1990) and IVALDI et al. (2003). In addition, model (3) reveals that the existence of problems in an industry also has a slightly significant link with cartel duration, although this link does not seem to be robust. Model (5) controls for internal cartel organisation, but this does not result in any significant correlations between the variables of market structure and cartel duration. However, it can be seen that the allocation of customers and territories as well as submission cartels are linked to cartel duration. It can be stated that the probability of a cartel breakup in (5) decreases by 67.1% if the companies allocate customers and territories. This result is in line with the findings of GIESEN (2011) and LEVENSTEIN/SUSLOW (2011). In addition, the probability of a cartel breakup decreases by 46.2% if a cartel is formed with the objective of manipulating the tendering process. This result is also in line with the results of ZIMMERMAN/CONNOR (2005) and GIESEN (2011).

In contrast to model (5), model (7) also takes into account the cumulative market share. This variable was also included in previous empirical studies, even if there is not always a significant correlation. A comparison of these models shows differences in the significance of some variables. To verify whether these differences are due to the consideration of the cumulative market share or the associated loss of observations, the analysis from (5) is repeated with the sample from (7). The results are summarized in model (6). It shows that the results hardly differ between model (6) and (7), which is why the differences between model (5) and (7) can be attributed to the loss of observations and not to the introduction of the cumulative market share. For this reason, the results of models (6) and (7) are not further interpreted here.

In addition, there is a risk of over-identification in the existing models, so that the actual explanatory content of the model could be low.

However, some empirical studies exist, such as DE (2010) or ZIMMERMAN/CONNOR (2005), whose analysis are also based on a relatively small sample and a high number of variables. For this reason, models (5) to (7) are estimated again below without taking into account all the variables mentioned above. The variables are selected using the log rank test for the binary variables and a univariate Cox regression for the continuous variables. If a variable has a p-value<0.25, the variable is considered in the following analysis. The results are listed in Table 3.

Table 3: Simplified Cox Proportional Hazard Model independent of the risks

Duration	(5a) Hazard Ratio	(6a) Hazard Ratio	(7a) Hazard Ratio
Association	0.7447 (-1.16)	0.8006 (-0.66)	0.8145 (-0.61)
Market share			0.9899 (-1.00)
Multimarket	0.6460* (-1.88)	0.3948*** (-2.85)	0.3976*** (-2.82)
Buyer power	1.4482 (1.17)	1.6135 (1.12)	1.9383 (1.45)
Problems	0.9625 (-0.15)	0.6130 (-1.45)	0.5648 (-1.61)
Competition	0.7568 (-1.08)	1.1049 (0.27)	1.1203 (0.30)
Origin	0.9483 (-0.71)	0.9232 (-0.84)	0.9279 (-0.82)
Experience	1.1551 (0.54)	1.1685 (0.48)	1.2088 (0.57)
Members	0.9595 (-0.95)	0.9360 (-1.21)	0.9319 (-1.31)
Allocation	0.3687*** (-4.09)	0.2502*** (-3.86)	0.2979*** (-3.09)
Submission	0.5340** (-2.04)	0.4428** (-2.03)	0.4749* (-1.83)
No of cartels	110	65	65
Log likelihood	-396.89	-195.16	-194.67
LR-χ^2	30.65 (df=10)	30.65 (df=10)	31.64 (df=11)

It can be stated that the same significant variables are observed as in the models in Table 2. The degree of the effects also resembles the original estimates. As there are no significant differences, the following estimates, which take into account the different risks of the cartel collapse, are made exclusively for all variables.

In the following, a distinction is made between the duration of cartels detected by leniency application and those which broke up as a result of investigations by competition authorities. The cause-specific Cox Proportional Hazard model and the model of FINE/GRAY (1999)

are used. GIESEN (2011) and LEVENSTEIN/SUSLOW (2011) also distinguish between two different causes of cartel death, although their definition of the causes differs. For LEVENSTEIN/SUSLOW (2011), for example, the cause "natural death" includes on the one hand the immunity applications and on the other hand the pure dissolution of the cartel. GIESEN (2011) associates the immunity applications with the investigations of the competition authorities. In contrast, this analysis considers only the cartel breakup by applying for leniency as a single cause. For this reason, the results with respect to the different causes of detection are not comparable with those of other empirical studies.

5.2 Cartel death due to the Leniency Programme

Table 4 summarizes the results for cartels which broke up by a leniency application. It can be stated that the coefficients of the two different models differ from each other in a number of cases, which is due to the fact that the competing event was taken into account in the model of FINE/GRAY (1999).

However, the coefficients do not differ significantly in respect to their sign. Both models show a very significant correlation between the market share and the probability of cartel breakup. As a result, cartels detected by leniency application live longer if the cumulative market share of the cartel members is high. Since the correlation is significant in both models, this correlation seems to be very robust. One reason for this relationship could be that cartel members controlling almost the entire market have no incentive to apply for leniency. They cannot achieve a better result without the cartel, since all or almost all market participants are involved in it. Another reason is that there is a high cumulative market share, especially if few large firms form a cartel. As a result, firms have better opportunities to monitor each other due to improved transparency (KÜHN/VIVES (1994)). However, there is no significant link between the participation of an association that is assigned to transparency, and the probability of cartel breakup if the cartel was detected by a leniency application.

In addition, the probability of cartel breakup is reduced by up to 77% if an industry faces problems such as deterioration in price or overcapacity. One reason for this is that the cartel seems to be the best

possible solution to overcome such difficulties. As cartel formation can lead to higher profits, firms will not have any incentive to denounce the cartel. Firms can thus improve their economic situation by creating cartels and increasing their profits (ROTEMBERG/SALONER (1986), ESWARAN (1997)). However, as soon as one of the firms applies for immunity, it will not get punished by competition authorities, but in the long term it will generate lower profit, as the economic situation in the sector would not improve. This result is also shown as significant in both models and thus appears to be robust.

Table 4: Cartel death due to the Leniency Programme

	Cause-specific Cox Proportional Hazard model		FINE/GRAY (1999)	
	Coefficient	Hazard-Ratio (SD)	Coefficient	Subhazard-Ratio (SD)
Association	-0.3945	.6739954	-0.8798	.4148641
	(0.5404)	(.3642314)	(0.6650)	(.2758965)
Market share	-0.0371**	.9635965**	-0.0460***	.9549944***
	(0.0145)	(.0139517)	(0.0141)	(.0134944)
Individual	0.1943	1.214498	0.4774	1.611878
	(0.4625)	(.5617545)	(0.4221)	(.6804278)
Multimarket	-1.4475***	.2351459***	-0.5650	.5683567
	(0.5277)	(.1240809)	(0.5321)	(.3024128)
Buyer power	1.3523**	3.866348**	1.8396***	6.294118***
	(0.6036)	(2.333624)	(0.6477)	(4.076499)
Problems	-1.3544**	.2580938**	-1.5058**	.2218376**
	(0.6249)	(.1612809)	(0.6825)	(.1513953)
Saisonal	0.5310	1.700568	0.1693	1.184511
	(0.3931)	(.6685632)	(0.4543)	(.5381606)
Advantages	1.1645**	3.20446**	0.6964*	2.006559*
	(0.4904)	(1.571514)	(0.4153)	(.8333292)
Competition	0.0658	1.067962	0.1998	1.221212
	(0.5686)	(.6072729)	(0.4803)	(.5865832)
Leader	-0.9313	.3940348	-2.2882***	.1014479***
	(0.7114)	(.2803294)	(0.7061)	(.0716286)
Follower	0.5695	1.767365	0.0785	1.081635
	(0.5161)	(.9121163)	(0.5442)	(.5886503)
Origin	-0.1662	.8468711	0.0646	1.066779
	(0.1230)	(.1041399)	(0.1014)	(.1081824)
Experience	0.6542	1.923519	-0.4503	.6374138
	(0.5511)	(1.059962)	(0.5092)	(.3245438)
Members	0.0546	1.056083	0.1411*	1.151552*
	(0.0798)	(.0842567)	(0.0757)	(.0872022)
Allocation	-0.9503	.3866376	0.8032*	2.232595*
	(0.6238)	(.2411785)	(0.4776)	(1.066389)
Submission	-2.2201**	.1085975**	-2.2468**	.1057351**
	(0.9079)	(.098596)	(1.0555)	(.1116042)
N	65		65	
AIC	236.5442		279.4532	
Prob>chi2	0.0001		0.0000	

In contrast, the existence of advantages increases the probability of cartel breakup by leniency application. According to the model of FINE/GRAY (1999), this probability doubles and increases by a factor of 3.2 in the cause-specific Cox Proportional Hazard model. In this situation the potential gains for a specific firm of introducing an innovation are higher than if the firm remains in the cartel (IVALDI et al. (2003)). The significant result in both models reinforces its robustness. Furthermore, there is a higher probability of a cartel breakup by leniency application if buyer power exists on the demand sideof the affected market. One reason for applying for leniency could therefore be the firm's fear that the buyers will notice the cartel and file a complaint with the competition authority. In addition, the concentrated orders of the buyers may lead to an incentive for cartel members to deviate from the infringement because of increased short-term profits (MOTTA (2004)).

In addition, the cause-specific Cox Proportional Hazard model reveals a decreasing probability of cartel breakup by leniency application from the point of view of the cartel members if firms have access to several markets. Thus, the probability of cartel breakup by leniency application decreases by 76.49% if firms have access to several markets. This is in line with the results of previous theoretical studies which conclude that companies with access to several markets do not have an incentive to deviate from the agreement, since there are intercompany dependencies in the individual markets. These dependencies in turn bring advantages to the companies (BERNHEIM/WHINSTON (1990)).

In addition, the model of FINE/GRAY (1999) shows significant correlation between the existence of a leader and the probability of a cartel breakup. In this model, for example, the probability of a cartel breakup by a leniency application decreases by almost 90% if there is a leader in the cartel. Other firms may adapt the behaviour of the leader because they fear future retaliation if they uncover the cartel through amnesty policy. Furthermore, the leaders have no incentive to report a cartel to the competition authority, as they won't get full immunity in terms of fines because of their leading role in the cartel, as stipulated in the EU Guidelines (EU COMMISSION (2006)). However, the existence of a follower in a cartel is not significantly linked to the probability of a cartel breakup.

In respect to the cartel organisation, the same variables are significantly related to the probability of a cartel breakup as in the model, which does not take into account the competing risks. However, some of these effects are contrary to each other. According to the model of FINE/GRAY (1999), the probability of a cartel breakup by amnesty policy increases by 15% if one more firm is involved in the cartel. Regardless of the competing risks, however, there was a declining probability of breakup with each additional company. SELTEN (1973) has already stated that with an increasing number of competitors, fewer firms have an incentive to participate in the cartel. This finding can be applied to this situation. Firms are more likely to benefit from the leniency application the more firms are involved in the cartel, since only the firm that first notifies the competition authority of the cartel will receive full immunity. In order to avoid that another firms applies first, the single company applies relatively early for leniency. However, since this correlation is only slightly significant and can only be found in the model of FINE/GRAY (1999), it is not very robust.

Furthermore, there is also a slightly significant correlation between allocation of customers and territories and the probability of cartel breakup by leniency application in the model of FINE/GRAY (1999). In this context, the probability of cartel breakup increases by a factor of 2.2 if the companies allocate customers and territories. GIESEN (2011) notes that there is no need for extensive monitoring mechanisms between the firms when there is market allocation, which reduces the likelihood of competition authorities discovering the cartel. However, if there are no extensive monitoring mechanisms in place, there will probably be a number of meetings for the firms to exchange information. In the absence of this personal contact, firms may find it difficult to evaluate the intentions of the other cartel members, so that they may take advantage of the Leniency Programme rather than agreeing on other information.

The link between the collusion of tender agreements and the probability of cartel breakup by amnesty policy, is consistent with the results of the model in Table 2. This means that the probability of a cartel breakup by a leniency application decreases by almost 90% if it relates to a submission cartel.

5.3 Cartel death due to investigations by competition authorities

In the following, the probability of cartel breakup due to investigations of the competition authority will be examined. This includes the competition authority's own investigations, anonymous notices and notices from other competition authorities or links with other cartels. Table 5 summarizes the results. In this analysis, too, the coefficients sometimes differ considerably between the two models, which is due to the consideration of the competing event in the model of FINE/GRAY (1999).

Table 5: Cartel death due to investigations by the competition authorities

	Cause-specific Cox Proportional Hazard model		FINE/GRAY (1999)	
	Coefficient (SD)	Hazard-Ratio (SD)	Coefficient (SD)	Subhazard-Ratio (SD)
Association	2.1727**	8.78164**	1.5725	4.818822
	(0.9442)	(8.291466)	(1.3455)	(6.483532)
Market share	0.0232	1.023467	0.0358	1.036455
	(0.0214)	(.0219384)	(0.0224)	(.0231916)
Individual	-1.8792*	.152713*	-0.8344	.4341556
	(1.0159)	(.1551472)	(1.1913)	(.5171917)
Multimarket	-1.0393*	.35371*	-0.8305	.4358366
	(0.6214)	(.2198033)	(0.5053)	(.2202114)
Buyer power	-0.3954	.6733954	-0.3800	.6838691
	(1.0065)	(.6777804)	(1.0705)	(.732082)
Problems	1.6407	5.159031	1.1306	3.097463
	(1.0773)	(5.558016)	(1.2512)	(3.875618)
Saisonal	0.6281	1.874073	-0.9851	.3734022
	(1.0384)	(1.945961)	(1.4791)	(.552307)
Advantages	-0.5274	.5901409	-0.5010	.6059386
	(0.9160)	(.5405564)	(1.3041)	(.7902024)
Competition	-1.2046	.2998155	-0.3565	.7000989
	(1.1463)	(.3436862)	(1.0692)	(.7485168)
Leader	4.6979***	109.721***	4.3459***	77.15762***
	(1.3183)	(144.6505)	(1.2009)	(92.65868)
Follower	0.9015	2.463197	0.8414	2.319633
	(0.9528)	(2.346885)	(0.9595)	(2.225703)
Origin	-0.9696***	.3792505***	-1.1009***	.3325792***
	(0.3400)	(.1289462)	(0.2476)	(.0823557)
Experience	2.5118**	12.32678**	1.1885	3.282162
	(1.0875)	(13.40546)	(1.0837)	3.557012
Members	-0.2424*	.7847719*	-0.0662	.9359751
	(0.1359)	(.1066877)	(0.1140)	(.1067227)
Allocation	-3.7690***	.0230761***	-2.6037***	.0739973***
	(1.0543)	(.0243288)	(0.7487)	(.0553991)
Submission	0.2114	1.235362	1.7475	5.740048
	(1.1201)	(1.383755)	(1.8203)	(10.44833)
N	65		65	
AIC	149.806		170.5294	
Prob>chi2	0.0000		0.0000	

In this context other determinants which have a significant link to cartel duration surface. Cartels are more likely to break up due to the investigations of competition authorities if there is a leader in the cartel. This correlation is highly significant and can be found in both models, making it robust. This result may be linked to the fact that the market share of the leaders tends to be higher and therefore leading companies are subject to special monitoring by the competition authorities. Hence competition authorities can notice changes in the behaviour of these firms as a result of cartel formation, resulting in shorter cartel periods.

Furthermore, there is a slightly significant correlation between product differentiation and the probability of cartel breakup due to investigations of the competition authority. This probability decreases by almost 85% if product differentiation exists or if the products have to be adapted to individual customer needs. A reason for this could be that it is more difficult for competition authorities to observe the changes in parameters for individual product versions compared to those of homogeneous products.

Moreover, the results show that the likelihood of a cartel breakup as a result of investigations of a competition authority decreases by almost 65% in the cause-specific Cox Proportional Hazard model if the firms are active in several markets. This result is slightly significant. It is likely that it is more difficult for competition authorities to monitor the activities of firms and any changes in behaviour if they operate in several markets. Both, product differentiation and activity in several markets lead to higher complexity and hinder competition authorities in detecting cartels. Therefore it helps the cartels to better conceal their collusive behaviour.

The existence of professional association meetings shows a significant result in the cause-specific Cox Proportional Hazard model. It can be stated that the probability of a cartel breakup through intervention by a competition authority is 8.78 times higher if there is an industry association providing a platform for regular meetings. From a theoretical point of view, KANDORI/MATSUSHIMA (1998) have already stated that voluntary communication can support the intention of collusion between firms. For this reason, it can be assumed that competition authorities are also aware of this problem and that industries in which associations play an important role are particularly

observed, since associations serve as a platform for the exchange of information between competitors.

In respect to the control variables the number of cartel members is significantly correlated to the probability of cartel breakup in the cause-specific Cox Proportional Hazard model. This probability decreases by 21.5% if one more firm is involved in the cartel. It can be assumed that it is more difficult for competition authorities to identify cartels in a market where many firms operate. This argument can also be applied to the number of countries the cartel members come from. This allows firms to diversify their activities and make agreements for different products in their countries due to national differences. In this case, it is more difficult for the competition authority to detect anti-competitive practices. This argument is supported by the results. Accordingly, the probability of a cartel breakup by investigations of a competition authority decreases by up to 66.7% if the number of countries from which the cartel members originate is increased by one more country.

Furthermore, there is a highly significant correlation between the allocation of customers and territories and probability of cartel breakup by investigations of the competition authority. According to the model of FINE/GRAY (1999) this probability decreases by 26%, and in the cause-specific Cox Proportional Hazard model by 76.9% if the firms allocate customers and territories. As explained above, this may be related to the limited number of monitoring mechanisms that firms may need, which in turn, results in limited evidence of cartel activity to be detected by the competition authorities.

In addition, firms' previous cartel experience is significantly linked to cartel duration in the cause-specific Cox Proportional Hazard model. This means that the probability of cartel breakup by investigations of competition authorities is increased by a factor of 12 if at least one firm involved in the cartel had already participated in a cartel in the past. One reason for this could be that firms with cartel experience tend to be among the larger firms in the market and are therefore under the supervision of competition authorities.

6 Conclusion

The paper has shown that the probability of cartel breakup depends on both the market structure and the internal cartel organisation.

However, this analysis focuses on the market structure. For this purpose 127 cartel cases which were detected by the EU Commission between 2001 and 2017 were examined. Contrary to previous empirical studies, a distinction has been made between cartels which have collapsed as a result of applying for immunity and those discovered by the competition authorities.Moreover, the access to several markets, the existing competition in a market, the advantages in an industry and the existence of a follower were also considered, since these determinants have not yet been empirically investigated in this context. The reason for taking these determinants into consideration is the existing link to cartel duration which has already been outlined in theory.

Based on the information above, we could see that there is a relationship between the probability of cartel breakup and the different determinants of market structure. What does this mean in terms of practical applications? In summary, this study aims to give competition authorities additional red flags to look for. Given the limited resources of the competition authorities, this study indicates where they should focus their efforts of proprietary investigations and where they can rely on the leniency programme. For example it might be efficient to take a closer look at markets with heterogeneous products than at markets with higher buyer power. The reason for this is that in markets with high buyer power the leniency programme should serve its purpose to break up cartels while the existence of heterogeneous products seems to protract cartel breakup and therefore warrants a focused investigation effort by competition authorities.

While these findings may have an impact on the respective decision makers, similar to other studies, this research has a number of limitations. Firstly, the size of the sample is relatively small. Other empirical studies also worked with small samples but nevertheless the results should be interpreted with caution. It should also be noted that this analysis is based on detected cartel cases. It is therefore possible that there are cartels which acted without the knowledge of the competition authorities and which consequently cannot be considered. Another limitation is that a cartel could have lasted longer than the official information of the EU Commission indicate. By us-

ing a data set that takes into account the intensive antitrust prosecution of the last two decades, these limitations are alleviated but not completely overcome.

Yet, this study can serve as a viable starting point for further research into the determinants of cartel duration.

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