

Economic Incentives and Policy Frameworks: The Role of Whistleblowing in European Cartel Prosecution

Otto Höjer (25367)

Jim Lind (25260)

Abstract: By using data on cartels from the European Commission, this paper empirically assesses the incentives of cartel firms to cooperate with the investigators under current European antitrust policy. Since the introduction of the European leniency program in 1996 and its consequent adaptations, the European Commission has granted fine reductions and fine immunity for whistleblowing firms exposing cartels. To evaluate the effectiveness of this policy, we observe stock market reactions to firms applying for leniency and receiving fine reductions. Our sample consists of 188 convictions from 44 different cartels between 2007 and 2022. Our results consist of three main findings. Firstly, on average, cartel firms decrease their share price by 1.98% around the final decision using an event window of +/-10 days. Secondly, we find that firms receiving immunity from fines experience more positive stock returns than firms receiving fines around the time of the immune firm being revealed to the public at a 95% significance level. Finally, we find promising but inconclusive support for a percentage reduction in fines being associated with positive stock price reactions around the time of the final decision.

Keywords: Leniency, Cartels, Antitrust Policy, European Union, Whistleblowing

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Supervisor:	Abhijeet Singh
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Discussants:	Abhinav Jain and Oskar Ekblom
Examiner:	Johanna Wallenius

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Table of Contents

1. Introduction.....	3
2 Background and Legal Context.....	4
2.1 Cartels.....	4
2.2 European Antitrust Policy.....	5
2.3 Investigation Procedure of European Antitrust Policy.....	5
2.4 European Leniency Program.....	6
3 Literature Review and Theoretical Background.....	6
3.1 Previous Research on Leniency.....	6
3.2 Previous Research on Stock Performance of Cartel Firms.....	7
3.3 Theoretical Background.....	8
3.3.1 Efficient Market Hypothesis.....	8
3.3.2 Legal Costs.....	9
3.3.3 Lost Monopoly Profits.....	9
3.3.4 Market Signal Effects.....	9
4 Hypotheses.....	9
5 Data and Methodology.....	10
5.1 Data.....	10
5.1.1 The European Commission Competition Policy Website.....	10
5.1.2 Company Information and S&P Capital IQ.....	12
5.1.3 Exclusions from the Data.....	13
5.1.4 Final Sample of Cartels and Firms.....	14
5.1.5 Dataset I and D.....	16
5.1.6 Sample Selection Bias.....	16
5.2 Empirical Strategy.....	17
5.2.1 Event Study Economic Caveats.....	17
5.2.2 Abnormal Returns and the Simple Market Model of Returns.....	18
5.2.3 Welch's T-tests.....	19
5.2.4. Multi-Linear Regression.....	19
5.2.5 Multi-Linear Regression including Clustered Standard Errors.....	21
5.2.6 Difference-in-Difference.....	21
6 Empirical Results.....	22
6.1 CAAR - Time Series - Immunity vs. Non-Immunity.....	22
6.2 Welch's T-test - CAAR of all event windows.....	24
6.3 Welch's T-test - Differences in CAAR between Immunity and Non-Immunity Firms.....	25
6.4 MLR Results.....	27
6.5 Difference-in-Difference - Wealth Effect of All Event Windows.....	29
6.6 Difference-in-Difference - Residuals of All Event Windows.....	31
6.7 Difference-in-Difference - Immunity Status Impact of All Event Windows.....	32
7 Conclusion.....	33
7.1 Discussion.....	33
7.2 Limitations:.....	35
7.3 Future Research.....	37
Bibliography.....	38
Appendix.....	41

1. Introduction

Due to the extensive welfare losses caused by cartels and placed upon consumers, government bodies around the globe put increasing weight and stress on combating their existence. These losses are sometimes difficult to compensate for due to the extent of their negative effects. In July 2016, the European Commission (EC) fined participants of the European truck cartel €2.9 billion (European Commission, 2016), followed by an additional fine of €880 million the following year (European Commission, 2017). This can be contrasted to the €15.5 billion welfare loss estimated by Beyer et al. (2020). The negative consequences go beyond the higher prices placed upon consumers, as put forward by Levenstein and Suslow (2006). These repercussions can be seen in the effects to, among others, innovation and the concentration of producers, but also through detrimental social effects, particularly in developing countries as industry restructures cause job losses which impacts the livelihoods of dependent families.

Regulatory measures to combat cartels include but are not limited to increasing sanctions, deepening the monitoring of markets and, in particular, widening the prospect of *leniency*. The latter aims to incentivize whistleblowing of participating firms with potential fine reductions. Having taken inspiration from the US, the European Union (EU) first introduced a leniency program in 1996, with improvements made in 2002 and 2006 to further increase total fine immunity for the first firms to come forward and incentivize cooperation for subsequent firms as well. This has led to many cartels being broken up, with cooperative firms avoiding billions of euros in fines. By following up on the example of the truck cartel, MAN SE, who notified the EC of the cartel, avoided a fine of €1.2 billion as a result of their cooperation (European Commission, 2016). However, as cartels are dissolved, there are different types of costs other than the actual fines that are put on the participating firms, including additional legal costs, lost monopoly profits, and market signal effects. This makes fines alone a weak measure of incentives to cooperate and policy effectiveness.

To measure the incentives of cartel firms to cooperate under the current European leniency program, this paper will use stock market performance of cooperative firms in relation to uncooperative firms as an estimate of policy effectiveness. The choice of using stock performance as a measure of company performance lies in 1) the effectiveness of stock markets to quickly incorporate information as put forward under the *efficient market hypothesis* and in 2) the incentives for managers to maximize shareholder value. The stock performances will be observed over different event windows with a maximum of 30 days prior and 30 days after two dates. Firstly, around the announcement of which firm has applied for leniency of each cartel case and secondly, around the time of the final decision by the EC being revealed. If investors value cartel firms cooperating with investigators compared to their uncooperative partners, this would imply an effective incentive structure provided by the program. Therefore, this paper aims to answer the following research question:

What is the effect in stock market performance of cartel firms cooperating with investigators under the current European leniency policy program?

The current literature on antitrust policy and leniency programs vary and include both theoretical and empirical papers. Theoretical models have been developed to optimize incentives provided by leniency policy by, for example, Motta and Polo (1999). Using empirical data, Brenner (2009) observed the characteristics of exposed cartels before and after the introduction of the European leniency program. By broadening the scope to general antitrust policy we can see the use of stock data in measuring policy effectiveness. This includes Gunster and Van Dijk (2016) and Bos et al. (2019) who all observed negative stock market reactions around both the surprise inspection and the final decision. From what we have gathered, only one paper, Aguzzoni et al. (2013) has looked at the stock market reaction of cartel firms receiving fine immunity under leniency programs. As this was only one subsection of a larger paper, it involved a smaller sample of cartel cases spanning over older leniency programs and did not include partial fine reductions, consequently not finding any significant results in this part of their study. Through incorporating a newer and larger dataset into a more tailored methodology, we uncover statistically significant and conclusive results.

Having in mind the prior studies on antitrust policy and in particular the analysis of stock market reaction to leniency by Aguzzoni et al. (2013), we believe our paper contributes to this literature in several ways. The first is the use of a greater sample size. In our study, we have a total of 188 convictions, spanning 44 different cartels, 38 of which included a firm receiving total immunity from fines on account

of cooperation under the leniency program. In their paper, Aguzzoni et al. (2013) observe stock market reactions of 17 firms receiving fine immunity around the time of the final decision, and 11 around the time of the surprise inspection. Secondly, we improve the literature by using up-to-date data. This, by exclusively using cartel cases from the most recent policy update in 2006. This can be compared to the data in (Aguzzoni et al., 2013) which ranges from 1969 to 2009, giving a tainted representation of the current leniency program effectiveness. Finally, we conduct multiple tests around the issue of leniency and illustrate the differences in clearer ways. The additional tests include a multi-linear regression analysis and difference-in-difference tests where we observe the wealth effects of receiving leniency and calculate the residual changes in their valuation after accounting for fines. In the MLR analysis, we do not solely include the binary variable of receiving total fine immunity or not, but also include partial reductions and relate these to the size of the individual firm. This leads to an overall greater accuracy of the results and gives additional insights into the incentives to cooperate, not just for the first firms revealing the cartel in order to receive total fine immunity, but also for firms given partial reductions for subsequent cooperation.

Our results consist of significant positive stock market reactions to the cooperation of firms under the leniency program. When observing the differences between cartel firms receiving total immunity from fines as a result of whistleblowing and firms receiving fines, we see positive market reactions to immunity at a 95% significance level in the -3/+5 days event window around both the time of the EC announcing which firm had applied for leniency and around the final decision. These significant results diminished when changing the event window. We also see partial fine reductions resulting from non-whistleblowing firms subsequently cooperating associated with positive stock market performance. This, at a 95% significance level using a +/-5 days event window around the final decision. However, we observe inconsistent signs of this variable dependent on the event window used. Both of these results speak favorably of the current European leniency program and the incentives for cooperation provided by it.

The paper will be outlined as follows: In the following section, we will give a brief background on the effects of cartels and the historical development of European antitrust policy with a focus on leniency. In section three, we will present the relevant literature on antitrust policy and on stock performance of cartel firms and present a theoretical context in which we describe the efficient market hypothesis and the firm-level costs associated with cartel dissolutions. In the fourth section, we put forward our two hypotheses and in section five present the data and methodology used for our study. This is followed with the results being presented in section six and discussing our findings, limitations and suggestions for future research in section seven.

2 Background and Legal Context

2.1 Cartels

The presence of cartels can cause welfare losses for consumers and society at large. As cartels collude to raise prices above the competitive level, the output quantity of production decreases and prices for consumers increase. Using a policy reform in the UK as a natural experiment, Symeonidis (2018) found that the empirical evidence is consistent with this theory. The breakdown of cartels in industries affected by the policy, he found, led to decreased price-cost margins when compared to unaffected industries. The effect was strongest for industries with lower entry costs, larger market sizes, and higher degrees of product differentiation. The economic losses caused by cartels are usually expressed as three inefficiencies, namely allocative, productive and dynamic, as presented by Gunster et al. (2010). The first relates to how cartels misallocate the resources of production to themselves. Productive inefficiency arises in industries characterized by low competition as the monopolists have fewer incentives to operate efficiently. Thirdly, dynamic efficiency relates to the decreased incentives for innovation. When analyzing the European truck cartel from 1997-2011, with a primary focus on the allocative inefficiencies, Beyer et al. (2020) found overcharges amounting to up to 7.6% and a total of €15.5 billion in welfare losses. Said losses can also be seen in non-price variables, as shown by Levenstein and Suslow (2006) where innovation, advertisement, barriers of entry, investment and concentration of producers, factors all impacted by the presence of cartels.

These microeconomic effects on production and prices can have detrimental social consequences, especially for developing countries. Levenstein and Suslow (2006) showed how cartels can lead to harmful industry restructuring, even after dissolution. As industries move to new equilibria, this can lead to cost cuts and plants shutting down. For the local region and country affected, this can have major social consequences as its population experiences job losses and divestments. This negative effect of cartels breaking up will be greater the longer the cartel has been in place. As presented by Bruneckiene et al. (2015), the social effects caused by cartels are particularly damaging for developing countries. Impoverished populations are impacted at a higher degree by price changes due to their weaker purchasing power. Thus, as international cartels raise prices, developing countries are primarily affected. Producers in developing countries can also be hindered from competing in international markets as cartel members may abuse their market power on the international stage. This is particularly destructive for economically weaker countries whose development depends on exports.

Due to the secrecy of undetected cartels, the extent of their presence is difficult to estimate. However, certain common characteristics of detected cartels can help predict which industries are more or less likely to involve such prohibited collusion. According to Dick (1996), cartels are less likely to form in industries consisting of many small producers, with low barriers of entry, selling complex products. These products are primarily sold to a concentrated customer base with infrequent purchases based on individually negotiated prices, and where products and production methods are frequently developing. When summarizing the existing empirical research, Levenstein and Suslow (2006) found cartels to last on average about five years with the main cause of a cartel breakdown being internal conflict or defection. It is with that last point in mind, that government bodies aim to build on antitrust policy with an increased focus on incentivising defection.

2.2 European Antitrust Policy

The purpose of antitrust policy is to maintain competitive markets by preventing companies from entering into anti-competitive agreements, abusing market power and restricting free trade. In this paper, we use data from the EU involving cartels, i.e., anti-competitive agreements. EU antitrust policy is enforced by the EC which is in charge of the entire investigation procedure, requiring no initial court involvement. This is in contrast to the United States, where two separate agencies, the Federal Trade Commission and the Department of Justice, work parallel throughout the procedure and where court involvement may occur from the outset of an investigation. (Gunster and Van Dijk, 2016) European antitrust policy started to take shape with the creation of the European Economic Community in 1957 with the Treaty establishing the European Economic Community. Articles 85 and 86 from the initial treaty, later incorporated into articles 101 and 102 respectively in the Treaty on the Functioning of the European Union, constitute the foundation of EU antitrust policy, with the prior prohibiting anti-competitive agreements between undertakings, i.e., cartels, and the latter focusing on the abuse of market power. (European Union, 2012) As we only cover cartels and not cases of market power abuse, the most relevant article for this paper is article 101 (formerly 85).

2.3 Investigation Procedure of European Antitrust Policy

The rules concerning the procedure of how an investigation is carried out in the EU are primarily set out in Chapter V of Regulation 1/2003. A cartel investigation can be initiated in one of five ways: from a leniency application by one of the cartel members wishing to have their fines reduced, through a complaint presented by a stakeholder, from a report through the EC's whistleblower tool, by the EC's initiative from either an ex officio investigation or, from a more general industry inquiry. (European Commission, n.d.)

The EC is empowered with several investigative capacities to gather information. It can on the one hand conduct an unexpected inspection or "dawn raid" where it is empowered to enter the companies' premises, take copies of records and ask the staff questions related to the investigation. If the EC lacks sufficient compelling evidence that illegal conduct is occurring it may decide not to conduct such an inspection and instead issue a request for information. This can be sent out to undertakings, associations of undertakings or governments of member states and their authorities.

Following the initiation of an investigation, the EC sends out a statement of objections to the parties under investigation where the EC's concerns are detailed. The accused firms are entitled to see the

EC's investigative file. Shortly after, an independent hearing officer, whose post was first established in 1982, conducts oral hearings and acts as an impartial arbiter throughout the investigation.

If an infringement is established, the EC may offer the parties the possibility to settle the case through the settlement notice, thereby withdrawing the parties' ability to appeal the decision. This is a procedure where the EC benefits from a quicker administrative process as the parties admit to their full participation in the cartel in return for a 10% settlement reduction of the final fine. While both can potentially lead to fine reductions, the settlement instrument differs from the leniency instrument in that the prior concerns procedural efficiency while the latter is aimed at gathering evidence. In case a settlement is not reached, the EC sends out a prohibition decision where the EC requires the parties to stop the infringement and potential fines are imposed.

The final fines imposed on the firms in case an infringement is established are based on the 2006 Guidelines on Fines and are individual for each firm. The fines are aimed at encompassing the gravity and duration of the infringement. The gravity is given by a "gravity percentage" which is a percentage of the company's sales of the product under infringement during the last full business year, at a maximum of 30%. Based on the number of days the firm was involved in the cartel, the amount is multiplied by a duration multiplier. The amount can be increased if it concerns e.g., a repeat offender. Reductions can be imposed following settlement, leniency, or in exceptional cases, inability to pay. Finally, the fine is limited to 10% of the company's overall annual turnover during the last business year before the decision.

2.4 European Leniency Program

The possibility for a cartel member to come forward and potentially have their fine reduced partially or completely was first offered in 1996 with the introduction of the leniency program. Since then, the regulations of this program have been updated twice to make it more attractive for companies to come forward. First in 2002 and secondly in 2006, from when the current version was established. During the first version of the program, the EC granted full immunity only on three occasions until 2002, when changes and clarifications were made to when full immunity from fines was possible. Initially, companies who had played an instigative or decisive role in the cartel were excluded from possible immunity and only when the leniency applicant provided "decisive" evidence immunity could be given. Both of these considerations left room for interpretation.

Following 2002, complete immunity would be given to the first company to present sufficient information for the EC to either launch an investigation or when an investigation had been initiated, sufficient evidence to establish an infringement of the cartel members. It also enhanced the leniency for subsequent applicants so they could receive partial reductions in fines even though they are not the first ones to come forward.

The current version from 2006 has been further amended to increase the incentives of cooperation. Firstly, it consists of a marker system where an applicant can submit a limited amount of evidence to reserve its position in the leniency "queue" during a period while it gathers further evidence. It also states the different thresholds for later applicants who are not first to apply but still cooperative with the EC. Later cooperators can receive up to 50% reductions in their fines if they provide "significant added value" to the investigation.

The leniency program can be explained to contribute to antitrust policy in three ways. Firstly, it helps the EC to discover cartels through evidence presented by leniency applicants. Secondly, it destabilizes current cartels as it changes the incentive structure of the cartel members and can thus lead to decreased trust among the members. Finally, it has the potential to have a deterrent effect on the formation of future cartels due to the increased distrust and suspicion among members.

3 Literature Review and Theoretical Background

3.1 Previous Research on Leniency

Whenever research is being conducted on antitrust policy in general and on leniency programs specifically, some problems are difficult to overcome. These include the sample selection bias resulting

from the secrecy of undetected firms and the endogenous nature of introducing such a program.¹ Ways of attempting to circumvent these problems include Borrell et al. (2013). They used bilateral trade agreements being conditional on the introduction of stricter antitrust policy as an exogenous driver of leniency program adoption. To measure the program's effectiveness they observed an increased perception of antitrust policy prevalence among business executives following the implementation of leniency incentives. Studies on the European leniency program include (Brenner, 2009), in which he compared characteristics of cartels between those detected before and after the introduction of the leniency program. Notable changes include how more information is revealed and how costs for the EC related to the investigations are decreased.

There is also relevant literature that does not evaluate leniency programs through empirics but gives important insights nonetheless. Aubert et al. (2006) discuss the potential benefits and possible adverse effects of leniency programs. Benefits can come from sufficiently large rewards for firms cooperating which can have deterring effects and make collusion unsustainable. Possible adverse effects include decreased incentives of firms to exchange information which can be crucial for efficient markets and innovation to flourish. Additionally, they also discuss the prospect of giving rewards to individuals instead of on a firm level. This can bring additional deterrence for collusion but can create agency problems for owners with managers. Motta and Polo (1999) analyze the optimal policy regarding leniency and discuss the risk of decreasing the overall expected costs of cartel participation with leniency programs. This is due to the risk of fine reductions making cartel prosecution on aggregate cheaper for all members. This is offset, however, by the incentives of breaking up the cartel. Finally, Spagnolo (2004) discusses the differentiation of “courageous” and “moderate” leniency programs. Courageous programs reward the first party to come forward with the reward being completely financed by the fines placed upon the other firms, resulting in a zero-sum game. Moderate leniency programs cancel or partially reduce the sanctions placed upon the whistleblowing firm, which is the category that best describes the current European leniency program.

With the methodology of this paper, we can examine the incentives for cartel members to come forward and admit to their infringement under the current leniency program. The reasons for using stock returns to measure the effectiveness of the EC's leniency program are primarily based on stock prices' ability to incorporate complete information and price changes in the perceived trust for firm performance. One could simply look at the amounts of fines avoided by the cooperating firms and judge the leniency program accordingly. However, the many instances of repeat offenders among cartel participants suggest a weak deterring effect of simply the amount of fines received. There are also other costs than the fines associated with cartel participation, later discussed in part 3.3, where we also present the efficient market hypothesis. Stock returns are quick and precise in reflecting the performance of firms and are the primary motivation for shareholders to invest. It is therefore the ultimate key performance indicator when evaluating the decisions made by managers, and the foundation for the choice of the methodology of this paper.

3.2 Previous Research on Stock Performance of Cartel Firms

Research on stock market evaluation of firms involved in antitrust investigations has been done in many settings, including both the US and EU. The first paper published on this topic that we are aware of is Burns (1958) which analyzed the impact of the Sherman Act from 1911. The law led to the dissolution of three companies: American Tobacco, Standard Oil and American Snuff that could all be described to have similar characteristics as cartels in today's standard. The study showed no significant effect on the stock market evaluation of these firms, indicating a belief by investors that the performance of the companies would not be impacted by their respective dissolutions. A study conducted with data from the second half of the twentieth century, also on American companies, is Bosch and Eckard (1991) which analyzed 127 firms from 57 different federal indictments. They had hypothesized three different aspects of which the market reaction is composed, namely lost monopoly profits, expected legal costs and negative “market signal effects”. They found significant price drops in their valuation around the time when the indictments were announced in the Wall Street Journal, highlighting the importance of the role of the media in the evaluation of cartel firms.

¹ Sample selection bias is discussed more thoroughly in part 5.1.6.

Because European antitrust policy has been inspired by and implemented at a later date than American policy, studies conducted with European cases have generally used more recent data. Gunster and Van Dijk (2016) used a relatively large sample of 253 companies involved in 118 cases of both cartels and antitrust breaches between 1974 and 2004. They found a significant negative stock price response of nearly -4.74% around dawn raids and -1.85% around final decisions, with a positive response of up to 4% around successful appeals. 75% of the total losses are shown not to be attributable to legal costs, suggesting the importance of reputational damage and anticipated profitability decreases. In their dataset, they also include fine size, infringement duration, firm size, and media attention which are all shown to have an impact on the changes on stock valuation. Additionally, Bos et al. (2019) used cartel cases from 1990 to 2016 and estimated the changes in stock prices in both cartel firms and non-cartel competitors around the time of both the raid and the decision. Around both dates, they find significantly negative price changes for cartel firms and statistically insignificant changes to the evaluation of non-cartel firms.

The only paper we find that looks at the difference between immune firms and non-immunity firms is (Aguzzoni et al., 2013) which used 180 listed firms related to procedures between 1979 and 2009. They found that a surprise inspection leads on average to a decrease in the firm valuation of 2.89% and a 3.57% decrease from the final decision. The paper also discusses the evolution of the EU's fining policy, indicating a shift towards harsher penalties over time. In the one part of the paper that specifically looks at differences between immune firms compared to non-immune firms, they find no significant difference in market reactions between the two groups of companies. However, due to the evolution of the leniency program, if one were to evaluate it through stock prices, we believe it's important to use up-to-date cases. Aguzzoni et al. (2013) use only 11 firms with immunity around the date of the raid and only 17 immune firms around the decision date and these cases are primarily covered by the old leniency program before 2006.² We believe our paper adds to the current literature in that we exclusively use cases after 2006 that explicitly refer to the newest regulations and have a significantly larger sample size of immune firms. In addition to this, we conduct a multilinear regression analysis where we include the running variable of fines avoided as a percentage of market capitalization. This gives greater accuracy of the results and gives insights into the valuation of firms that cooperate but that do not receive total immunity from fines. Moreover, we include a difference-in-difference approach to incorporate the compounding effects to test for robustness and provide an insight from an investors perspective.

3.3 Theoretical Background

In this section we, as carried out by Bosch and Eckard (1991), present and distinguish the costs to the cartel firms into three different types: legal costs, lost monopoly profits and market signal effects, but will specifically connect these to the matter of cooperation with investigators and consequent leniency reductions. However, we begin by presenting the Efficient Market Hypothesis (EMH) and how it relates to the evaluation of firms.

3.3.1 Efficient Market Hypothesis

The EMH, originating in the late 1960's, primarily by the work of Eugene Fama, is central to the methodology of this paper. The theory states that share prices reflect all available information that is relevant to their valuation. Company news that could affect their valuation, for example, a fine imposed by the EC is therefore incorporated into the price of the stock upon publication. This central concept makes up the primary rationale for why we have decided to use stock prices as a dependent variable. Important to consider regarding our dataset is that we only observe the price changes around the date of the first public announcement about which firm is the leniency applicant (t_i) and the date of the decision (t_d). Depending on the case, the EC sometimes presents which firm had applied for leniency before revealing the final decision when the fines imposed are announced. In other cases, these are presented simultaneously. Unlike many previous studies, among others, Gunster and Van Dijk (2016), Bos et al. (2019) and Aguzzoni et al. (2013), we do not include the date of when the investigation was first announced through either a dawn raid or a request for information. This implies that for the cases in our study, at t_i and t_d , the market already knows that an investigation is underway, and the possibility of a fine being imposed on the firm should be incorporated into its valuation based on the market's estimated

²Cartel data from Aguzzoni et al. (2013) ranges from 1969 to 2009. This is similar to Gunster and Van Dijk (2016) and Bos et al. (2019) with data from 1974–2004 and 1990–2016 respectively.

probability of conviction multiplied by the estimated fine and additional costs associated with the decision. If a firm is shown to be immune from fines or have their fines significantly decreased, this could therefore hypothetically lead to a positive change in stock valuation.

3.3.2 Legal Costs

As presented by Bosch and Eckard (1991), the first part of the costs placed upon cartel firms when their cartel is dissolved are the legal costs, which are made up of different types. The first and most central part of the legal costs is the fine placed upon the firms. The size of the fines are given for each case and therefore easily measured. As described in 1.1, the size of the fines depend on the gravity and duration of the infringement and potential leniency and settlement reductions. The exact size of the fine should be unknown to the market up until t_d . Secondly, there is the possibility of private damage claims. This has been prominent in the US for a long time but has gradually been increasing in Europe since EU Directive 2014/104/EU was adopted. (Wurmnest, 2023) Thirdly, convicted firms may be forced to adopt measures to counter future breaches of antitrust policy. This can, for example, be in the form of introducing a supervisory committee. Finally, firms are liable for the direct costs of the lawyers' fees.

3.3.3 Lost Monopoly Profits

The second part of the costs borne by cartel firms, as presented by Bosch and Eckard (1991), are related to losing the beneficial position of having participating in the cartel. As a cartel is dismantled by the investigators, its members will have to sell at competitive prices. Hüscherlath and Veith (2015) showed that the break up of a German cement cartel caused prices to fall far below the manufacturer's suggested retail price, known as the list price. This decrease in selling prices will impact profit margins and increase competition among actors. This affects all cartel firms, regardless of their cooperation or fine reductions. This will most likely lead to a negative stock price effect at the time of the investigation first being announced, depending on the market's perceived probability of conviction, and will therefore already be partially priced prior to the event window for our study. These costs are, however, still relevant for our study as they could also affect the stock prices at t_d due to the possibility of the case being dropped. If the case were to be dropped, there would be no changes to selling prices and the possibility of this to happen would therefore be incorporated into the valuation of the stock prior to t_d .

3.3.4 Market Signal Effects

The final category of costs caused by having participated in a cartel, as given by Bosch and Eckard (1991), concerns reputational damages. Being part of a cartel may signal dishonesty and might therefore deter potential customers, suppliers or lenders from conducting business with them or deterring employees from working there. This could either be due to the risk of being misled as the party enters an agreement or due to the reputational damage of being associated with a dishonest firm. Cartel conviction could also imply involvement in other undetected cartels. Gunster and Van Dijk (2016) included reputational damage as a variable by using media coverage in the form of how many newspapers covered the cartel. They found that the severity of the market reaction to a cartel conviction was dependent on media coverage. The reputational effect of firms cooperating with investigators to receive fine reductions could work in two opposite ways. On the one hand, cooperation and whistleblowing might signal legal compliance and a willingness to uphold fair markets and transparency. On the other hand, it might signal dishonesty and unreliability toward other firms when entering agreements and collaborations.

4 Hypotheses

As described in the introduction, this paper aims at estimating the effectiveness of the current European leniency program in providing incentives for cartel firms to cooperate using the stock performances as a measure. The policy effectiveness can be evaluated using two different lenses, as a firm's cooperation with the EC can occur at two different stages of the prosecution, the first being when the cartel is undetected. To estimate this first stage of cooperation, we will observe the differences in stock market performance of firms receiving full immunity from fines compared to those receiving fines. This will be measured around t_i when it is revealed which firm is the leniency applicant. The first hypothesis is therefore the following:

Hypothesis 1: The stock returns of cartel firms cooperating with the investigators sufficiently to receive total immunity from fines around the time of the immune firm being revealed to the public are more positive compared to the returns of firms receiving fines.

The second stage at which firms can cooperate is when another firm has already come forward and received immunity. As the subsequent firms are unable to receive total immunity from fines, they can still receive partial reductions if they cooperate and provide evidence to the investigators. To measure the incentives of this form of cooperation, we will observe the percentage reduction of fines for each cartel firm relative to their size in terms of their market value and estimate whether a higher fine reduction leads to better stock returns. This will be measured around the time of the final decision, t_{ds} as it includes the revealing of fines. The second hypothesis is therefore as follows:

Hypothesis 2: An increase in the percentage reduction of fines for cartel firms in relation to their market capitalization resulting from cooperation is associated with positive stock returns around the time of the final decision.

5 Data and Methodology

5.1 Data

Before we were able to conduct our tests and regressions, we had to undergo an extensive process of data gathering from different sources and match these into an aggregated spreadsheet. The first part of this process was obtaining information on the cartel using the EC competition policy website. This website consists of much relevant information for our study, such as the cartels that had been convicted, the members of each cartel, the duration of each firm's participation, the fines imposed on each firm, the firms that had obtained reductions or immunity from fines and, if cases had been settled or not. This information is, however, not displayed in a uniform way which increased the need for manual labor. Each case is described in different documents with different formats depending on the case and with some variables being left out which had to be manually calculated. When this information was obtained and composed into an excel spreadsheet, we downloaded relevant information of each firm from Standard & Poor's Capital IQ and added this information into the spreadsheet. This information was downloaded and matched for the cartel firms that had been observed from the EC website and added into the spreadsheet. This firm-level information included the size of each firm in the form of market capitalization, their stock prices and the prices for each firm's benchmark index. Below, we present all the information we obtained and describe which cases had to be excluded from the data and present some summary statistics for the final sample of cartel firms. Finally, we explain the differences between our two datasets, I and D, and discuss the potential for sample selection bias.

5.1.1 The European Commission Competition Policy Website

As cartels are made public by the EC, they are stored in a website where all decisions regarding the cartels are published. This website includes documents, not just on cartels, but on, among others, other antitrust cases, mergers and public subsidies. However, to only see the relevant material for this study, we filtered the search to exclusively present documents about cartels. At the time of this study, there have been a total of 721 antitrust cases, of which 176 are cartels, with the first cartel case dating back to 1982. On the website, all cases are displayed at the case level, visualized with a photo in the appendix. Each case encompasses several documents, all of specific types. The relevant types of documents for our study include press releases, statements of objections, reports from the hearing officers, and final decisions. The most time-consuming part of the data gathering was to manually add the information from each document into an excel spreadsheet as they were not compiled in a ready-made database but in documents with different formats and with some information being excluded that had to be calculated manually. To do this effectively, we separated the work among the two of us by gathering the same type of information for different cases. This took significant amounts of time and as we had finished with this process we had to double check each other's data in order to avoid any excluded cases that should be included or any human errors which could have occurred by writing the wrong information or through mistakes in calculations. Whenever there was ambiguity in how a piece of information should be treated, for example, when calculating the duration of a firm's infringement of a case that involved many cartels,

we discussed this and amended any differences in order to have a qualitative and consistent database without errors caused by ourselves.

Within each case, the first relevant document was either a press release or a statement of objections. Depending on how the investigation was initiated, the first type of document can differ between these two. For cases where a dawn raid took place, the first is a press release where the EC confirms the unannounced inspection of the suspected firms. If an investigation has been initiated by other means, the EC sends out a statement of objections. Previous research, including Gunster and Van Dijk (2016), Aguzzoni et al. (2013) and Bos et al. (2019) all show that the publication of these documents significantly decreases the share prices of the suspected firms. Since we are not observing the share price developments around the time of these documents being published, we do not include the date of the publication of these documents. However, they are still important to have in mind because investors already know that an investigation is underway before the revealing of which firm has applied for leniency or when the final decision is published.

The second document of interest for our study is the “Final Report of the Hearing Officer”. In 14 cartel cases of our final sample, the publication of this document revealed which firm was first to apply for leniency and which other firms had applied afterwards before the decision being revealed. This is therefore important to include as it reveals to the market which firm has the possibility of receiving immunity from fines before the final decision has been published. For the remaining 30 cases, the leniency applicant was revealed in conjunction with the final decision. The “Final Report of the Hearing Officer” does not present any information regarding the fines, nor does it state whether the leniency applicant has been successful in receiving a reduction in their fines. However, in all 14 cases, the applicants were successful in receiving immunity. The publication of this document is also chronologically close to the final decision as its publication is usually followed by the final decision within a few days, if not released on the same day. However, it is important to include the publication of this document for these 14 cases as it indicates whether a firm will receive a reduction and/or immunity from fines before the final decision is published. We have therefore included both the first date of the EC announcements regarding the leniency application through either the hearing officer’s report or through the final decision, t_b , and the date of the final decision, when the fines imposed on each firm are announced, t_d . The fact that this difference exists essentially doubled the manual work for these cases as we had to note these separate dates and gather stock prices and market capitalization values around both these dates. To be able to conduct tests on stock prices around both these dates separately, we have created two separate datasets, Dataset I and Dataset D. Dataset I is used for tests around t_b and dataset D is used for tests around t_d . The difference between these two datasets are described more thoroughly below in section 5.1.5.

The third and final event of interest is the final decision. This is made public with three different documents: a press release, a summary of the decision and either a settlement decision when cases are settled, or if not, a provisional non-confidential version of the decision. The final decision includes a detailed description of the background of the cartel, including its duration, and how the investigation started. It also presents the final fines imposed on each firm and how these have been calculated. There are several details relevant to this study that are first revealed in the publication of the final decision. The most important details are the fines imposed on each firm and how large the fine reduction was for each firm due to cooperation with the EC through either leniency or settlement of the case. The fines were stated in the press releases or in the more detailed documents and were from there added into the spreadsheet. In most cases, the percentage reductions of each imposed fine were also clearly stated in the press release. However, For cases where the percentage reduction was not included in any of the documents, we calculated them manually. This was done by dividing the fine imposed on the firm with the middle of the firm’s “basic amount”, or if included in the document, the firm’s “adjusted basic amount” range. The basic amount is calculated individually for each firm by the EC to set the minimum and maximum roof of a fine that can be imposed. It is calculated, as previously described in 2.3, by encompassing the duration and gravity of the firm’s infringement. The adjusted basic amounts include all adjustments made prior to possible leniency and settlement reductions. These adjustments can be both increases and decreases and can, for example, include whether the firm is a repeat offender or has cooperated outside the scope of the leniency program.

5.1.2 Company Information and S&P Capital IQ

When gathering data on the individual firms, we used the Standard & Poor's Capital IQ website, a photo of which can be seen in the appendix. The first task was to separate the firms that were private and therefore not traded on any stock market during the infringement and at the time of the final decision from the publicly traded firms. The private firms naturally had to be excluded from our sample. This filtering process was conducted using S&P Capital IQ. If a firm was private, we tried to identify a public parent company. If the parent company had a 100% ownership stake in the cartel firm throughout the infringement period and at the time of decision, that parent company was included instead of its subsidiary. In the case of a parent company being included, the additional company information, for example, repeat offense or market capitalization, was obtained for the parent company, and not for the subsidiary.

Having identified which firms to include in the sample, the second part of the data gathering process was to obtain the dividend-adjusted stock prices along with the market capitalization values of each firm. These prices were downloaded for the firms observed as cartel participants and the prices were specifically downloaded from around t_i and t_d which are unique for each cartel case. The dividend-adjusted stock prices for the event window were obtained around t_i and t_d with windows around both dates of $T_0 = -30$ and $T_1 = 30$ and with a window of $T_0 = -131$ and $T_1 = -31$ for the estimation of a firm's β and α , used in calculating the firms' expected return. As the price data had been downloaded, it was added to the excel spreadsheet and normalized time-wise around each case's immunity reveal, t_i and final decision, t_d . Market capitalization for each firm was also obtained from S&P Capital IQ and was taken from two different dates, namely one day before t_i and one day before t_d . This is to incorporate the benefits of having participated in the cartel while excluding the possible negative effects of the immune firm being revealed to the public or the final decision being published. These values were only available in the local currency of each firm and therefore had to be converted to € value to allow for the comparison of the values to the fines which are in €. The exchange value from the local currency to € was obtained for the same date as the market capitalization value, also taken from S&P Capital IQ.

When the prices and market capitalization values were added to the spreadsheet, we obtained other firm-level variables to include in our dataset. This includes the nationality of each firm, which was determined by the country in which their headquarters were located, as stated by S&P Capital IQ. Gunster and Van Dijk (2016) found that Japanese, French and German firms experienced significantly more negative reactions to stock prices around t_d compared to firms from rest of Asia and Europe using EU cartel data. They suggest these country differences could connect to a history of antitrust policy in those countries. Despite having identified the nationality of each firm, we decided not to control for them in the subsequent regressions as the sample sizes for each nation turned out to be too small and conclusions regarding nationality could therefore be difficult to establish. It is nonetheless of interest to see the distribution of nationality for each conviction, later shown in Figure 1.

We also classified each firm by the industry in which they operate, using the broadest classification available for each firm on S&P Capital IQ. Industry differences in stock price reactions to cartel investigations have been observed by Bos et al. (2019) when separating firms in the chemical industry from those who are not. They found that competitors of cartel firms in the chemical industry experienced a significant positive stock price reaction at t_d while competitors of cartel firms outside the chemical industry experienced a significant negative effect, suggesting that the extent of lost monopoly profits may depend on the industry.

Finally, we observed whether the firm was a repeat offender or not. This was determined by whether or not the firm had been found guilty of being part of a cartel by the EC before. To find this information, we returned to the EC competition website and looked up each firm to see if they had been involved in any other cartel case before the and added this as a binary variable into the excel spreadsheet. We excluded other antitrust offenses and cartel infringements outside of the EU when determining this variable. Repeated offenses can lead to an increase in the fines by the EC in their calculation of the adjusted basic amount so this should be included when the fines have been calculated.

To calculate the abnormal return of each firm, later discussed in part 5.2.2, we obtained values for the Financial Times Stock Exchange (FTSE) Russell national indexes using S&P Capital IQ. The indexes were picked at the national level, so the returns of each firm were benchmarked against the

returns of their national peers.³ In total, we gathered values for 25 different indexes, as our final sample contains firms from 25 different countries. The values for the different indexes were obtained for three periods. The first two were around the time of the immunity reveal and the final decision for each case, using the same time interval of $T_0 = -30$ and $T_1 = 30$ for both. In addition to this, we also had to download benchmark values for the calculation of each firm's β and α . Thus, we obtained index values for each firm with a time interval of $T_0 = -131$ and $T_1 = -31$ as well. More on the use of each firm's β and α in section 5.2.2. In the calculation of abnormal returns, it is important to use an objective and unbiased benchmark which gives a complete view of the market it is designed to measure. According to FTSE Russell themselves, they use no sampling or subjective membership selection when creating indexes. As markets continuously change, for example by listing new companies or by firms being acquired, it is also important that an index has a reliable and balanced governance system. For this, the FTSE Russell indexes use a series of regularly scheduled maintenance controls to ensure the correct firms are included and corporate actions are accounted for. (LSEG, 2023) The use of alternative indexes as benchmarks is discussed in the limitations section in 7.2. Having downloaded the index values from S&P Capital IQ, we added them to the spreadsheet by matching them with every firm based on the firm's nationality. This followed by normalizing the dates of the index values around every firm's t_i and t_d to calculate the abnormal return.

For our wealth and residual effects analysis, later presented in 5.2.6, we need to adjust our approach. To calculate the wealth effects we first calculate the loss or gain in the market cap of each company at the case level during each of the event windows. Following this we need to obtain the relative change by dividing the change in nominal value by the market cap the day before the event window chosen. For example the +/-5 day interval uses the $T_0 = -6$ market cap whilst the +/-10 day uses the $T_0 = -11$. For the residuals analysis, we control for the fine size to obtain the residual value which is lost. This data allows us to incorporate the compounding effect within the event window and better adjust for the investor's perspective. In total, we had to obtain values for market capitalization over 5 dates for all 188 observations, resulting in a total of 940 values. These values were added to the spreadsheet the same way as with previous data, first by matching them with each firm, and then normalizing the correct dates around each observation. After we had included these values into the spreadsheet, we calculated the expected changes in market cap through the use of the formula presented in section 5.2.2 for the expected return analysis.

5.1.3 Exclusions from the Data

Due to the specified purpose of this paper to evaluate the incentives of cooperation under the current EU antitrust policy regime, we have decided to limit the number of cases to the ones that are covered by the current 2006 leniency program. We thus excluded all cases for which a decision came prior to 2006. We have also excluded cases that may have had the final decision presented after 2006 but only refer to old leniency programs or guidelines on fines prior to the 2006 framework in their final decision. This was the case for investigations that were finalized after 2006 but due to the long duration of the investigation had been initiated long before 2006. The first case to openly refer to the current program is named "Professional Videotape" and had the final decision presented on 20th of November 2007. It is also the first case in our dataset.

Individual firms were excluded from the dataset when they were private and therefore not publicly traded. As mentioned above, if a firm was private, we did include their parent company if the parent company was public and had 100% ownership throughout the infringement period and at the time of the final decision. A complete case was also excluded when the number of publicly traded firms involved in it was less than two. This, to be able to cluster the standard errors at a case-level, later explained in section 5.2.5.

Eight of the cases in our final sample included more than one cartel as they involved infringements into multiple product areas by the same firms within the same period. For these cases, although the EC had divided them into different cartels while still including them in the same case, we treat them as one cartel since all public announcements around the cartels occurred on the same day and the market should therefore incorporate the information of all cartels within each case at once. For those cases, we aggregated all the firm-level fines for the different cartels within the same case and the

³ One exception is made for "Les industries Chimiques du Fluor SA (BVMT:ICF)" in the "Aluminum fluoride" case of 2008. The MSCI Tunisia Index is used since FTSE does not have a comparable Tunisian country index

percentage leniency reduction had to be calculated manually. There are two practical implications of this. Firstly, when a firm had received total immunity from fines in one cartel but received a fine in another we counted them as not receiving immunity. Having calculated the aggregate percentage reduction for these firms, they are thenceforth treated as not immune although having received total immunity from one of the cartels. Secondly, when calculating the days of infringement for each firm with multiple cartels within one case, we observed the duration of the longest cartel and used this as the estimator. This, to ensure consistency in the data for results related to the duration variable. All in all, except for the above mentioned exclusions, our sample consists of 100% of cases from 2006 and onwards.

5.1.4 Final Sample of Cartels and Firms

In total, the final sample includes 155 different firms involved in 44 different cartels. Due to some firms being repeat offenders, there are a total of 188 convictions, as seen in Table 1. The first case included a decision taken in 2007, and the last case in 2022. 84 convictions were due to settlements and therefore received a 10% reduction in fines. 100 of the 188 convictions included repeat offenders. 38 of the verdicts included total immunity from fines as a result of cooperation under the leniency program. The median fine imposed, including zero values due to total immunity, was €23 033 500 and the lowest fine imposed, excluding zero values, was €322 000. Regarding the fine imposed relative to the firm's market capitalization, there are a few outliers that received particularly high fines. 8 observations consisted of a fine >10% of the firm's market capitalization and 3 observations with a fine >20%.

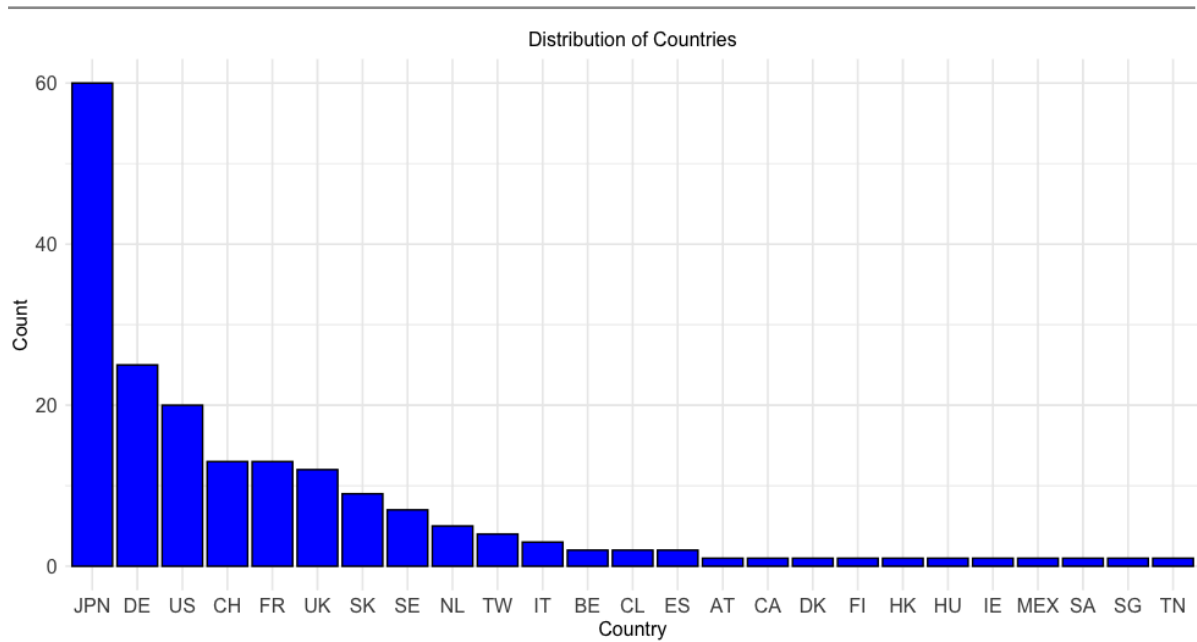
Table 1: Summary statistics

Summary Statistics of Final Sample				
	Nr	Min	Median	Max
Cartel cases	44			
Convictions	188			
Firms	155			
Countries	25			
Settled convictions	84			
First time offenders	88			
Total immunity received	38			
Date of decision	2007-11-20	2013-12-04	2022-07-12	
Days of infringement	19	1446	10 959	
Fine size	0	23 033 500	1 008 766 000	
Leniency reduction (%)	0.00%	20.00%	100.00%	
Market cap (t_{d-1}) (€)	13.34mm	11.01b	3 127.41b	
Fine size (% of Mkt Cap (t_{d-1}))	0.00%	0.17%	39.55%	

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

The distribution of convicted firms by country is seen in Figure 1. This refers to every single observation and not each firm so repeat offenders are included for each conviction. The most common country by far is Japan representing 60 out of 188 convictions. This is followed by Germany with 25 convictions and The United States with 20 convictions. Concerns by Dr. Carugati have been raised in the Breugel website (2023) about antitrust policy being used as a protectionist tool to specifically target foreign firms. However, empirical support for this is weak with e.g., Bradford et al. (2019) observing over 5000 EU merger control cases. They found results suggesting that, if anything, transactions involving non-EU acquirers were less likely to be challenged by the EC than EU acquirers.

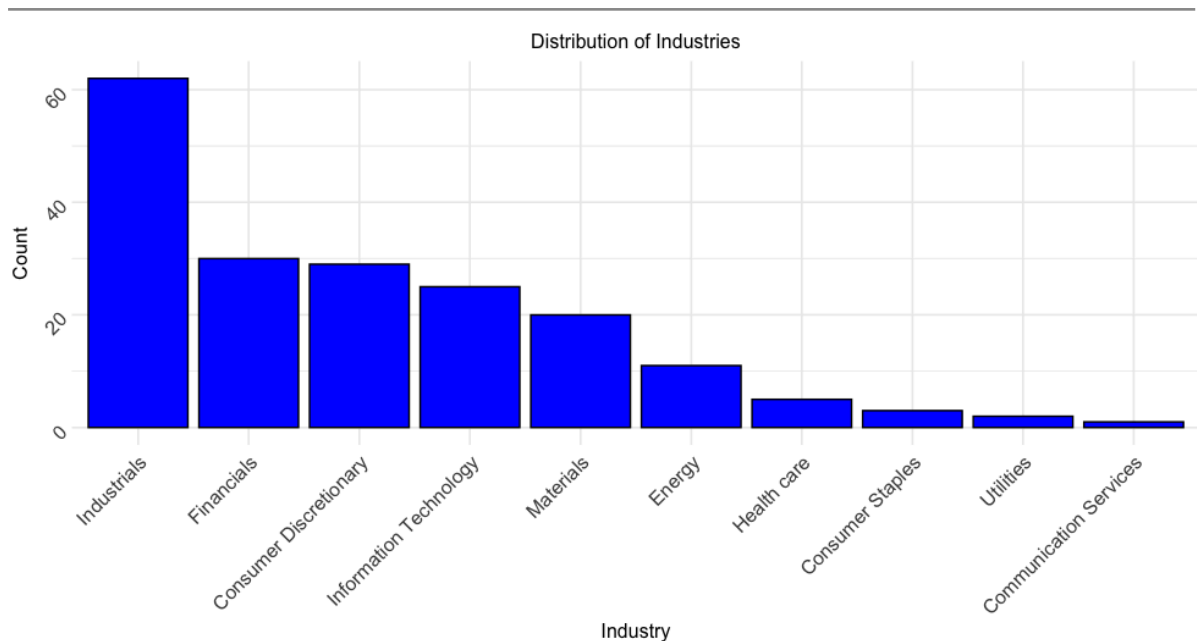
Figure 1: Convictions by Country



(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

In Figure 2, we see the convictions by industry. As with Figure 1, this refers to the total number of convictions and repeat offenders are therefore included for every conviction. The most common industry is industrials followed by financials, consumer discretionary, IT, and materials, in that order. Differences in returns across industries will be discussed following the multilinear regression analysis which will include industry controls.

Figure 2: Convictions by Industry

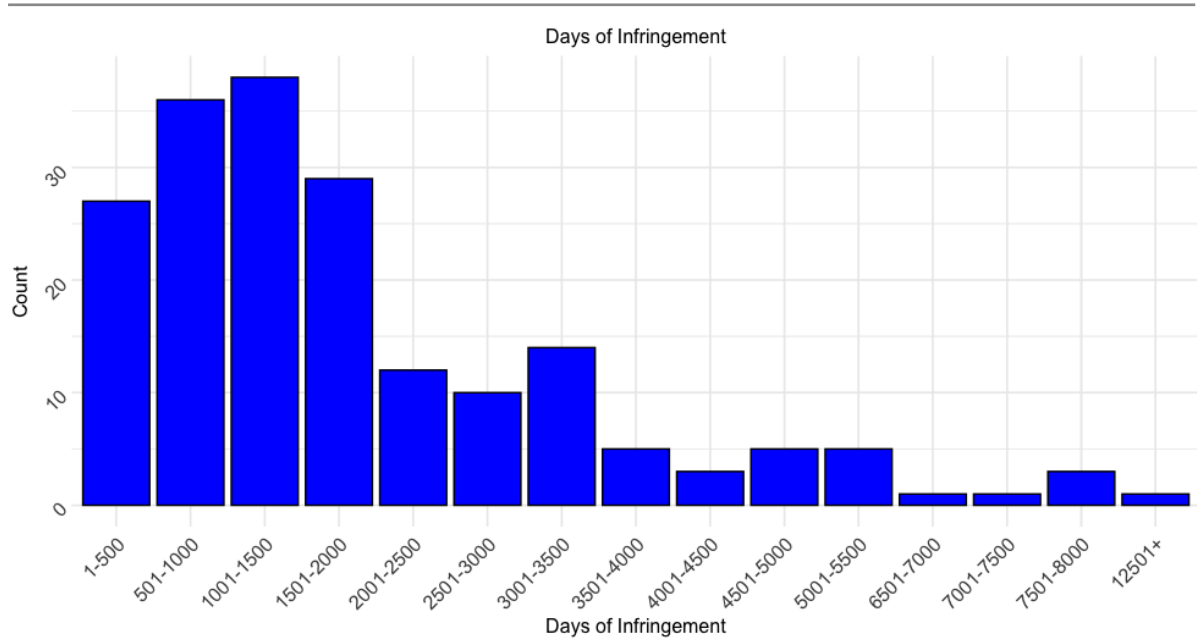


(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

The distribution of infringement length for each conviction, shown in the number of days involved in the cartel is illustrated in Figure 3. These differ significantly across cases, with some lasting for around a year while others remain undetected for decades. The length can also differ within cases, as some firms join or

decide to leave the cartel at different times. The longest duration of infringement for any conviction was the two-firm cartel between E.ON and GDF as they illegally collaborated in the gas industry from 1975 to 2005. The shortest participation of a firm was Panasonic's involvement in the "Capacitors" cartel. While the cartel had been going on for over ten years, Panasonic left the cartel only 19 days after joining. In the end, Panasonic was also the firm who blew the whistle on the cartel and received full immunity from fines.

Figure 3: Days of infringement



Note: the table excludes intervals without observations. European Commission (n.d)

5.1.5 Dataset I and D

When conducting tests and regressions for this study, we have compiled the information into two different datasets, I and D. The reason for having these two datasets regards the 14 out of 44 cases in which the EC revealed which firm was the applicant for fine immunity, which was done through the final report of the hearing officer, prior to revealing the final decision. Both datasets include the same cases and variables, but the distinction is that company information was obtained for different dates. In Dataset I, company information such as market capitalization and stock prices were obtained around the time of the EC announcing which firm had applied for leniency, t_i . In dataset D, the same firm-level information was obtained around the time of the final decision, t_d . In practice, the difference between these two datasets are the 14 cases for which t_i came before t_d . These dates do not differ chronologically to a large extent, with the maximum length between them being seven trading days, for the 'Optical Disc Drivers' case, 2015. However, they can impose significant implications for the results of this study in three major ways. The first implication of this is the use of market capitalization as an estimate of firm size. In dataset D, market capitalization was obtained for t_{d-1} , while for dataset I, it was obtained for t_{i-1} . Had we not made this differentiation, we would not account for how the market already had incorporated the effect of the EC revealing which firm is the immunity applicant in each cartel case when estimating the size of the firm for the 14 cases that differed. This would make market capitalization a skewed estimate of firm size when accounting for each fine in relation to the size of the firm on which it is imposed. A second implication comes when evaluating the results connected to H_1 . When estimating the differences in stock performance between firms receiving immunity from fines compared to firms receiving fines, we will primarily look at the results of using dataset I. The reason for this is self explanatory as it observes the changes in stock prices around t_i . The third implication is based on the same reasoning as the second but relates to H_2 . As the fines are revealed together with the final decision for all cases, the regressions estimating the effect of increased fine reductions on stock performances will use dataset D.

5.1.6 Sample Selection Bias

There is a risk of sample selection bias with regard to the data in the final sample. Marvão, (2016) lists possible dimensions of sample selection bias when gathering cartel data from the EC website. These refer to, among others, the lack of undetected cartels, overestimation of first time offenders, and underestimation of days of infringement. The main problem is the one of undiscovered cartels. The sample only includes cartels that have been discovered and prosecuted by the EC. This problem is difficult to overcome due to the nature of cartels being prohibited and secretive. Observing undetected cartels are also outside the scope of this study since being detected is a prerequisite for cartels to cooperate and receive fine reductions under the leniency program. The repeat offense variable may risk being negatively biased due to the presence of undiscovered cartels. This happens when repeat offenders remain undetected with engagement in other cartels. However, in our case, this variable is specifically designed to explain previous prosecution and not undetected infringement. Days of infringement will be negatively biased as they only include the number of days of infringement that could be proven by the EC. This will naturally be decreased since there is an incentive for the accused firms to understate the infringement period in the investigation process. This may lead to a problem when attempting to quantify the lost monopoly profits since the artificially high cartel prices may have been in force for longer than otherwise thought.

There is also risk of selection bias due to the exclusion of private firms. The firms that are private and therefore excluded are in general smaller than the listed counterparts. (Dinlersoz et al., 2018) Gunster and Van Dijk (2016) showed that the negative effects on stock returns around the decision date are greater for smaller firms among the listed firms in their sample. This may understate the effect of cartel investigations on the valuation of firms if the excluded firms are smaller and more vulnerable to prosecution. This problem is challenging to overcome due to the difficulty of observing frequent changes in the value of private firms.

5.2 Empirical Strategy

In this Section, we will discuss the methodology and empirical strategy. The first stage of strategy will be explaining how event studies function and their purpose. From there we present a diagram explaining how we will measure the impact of the immunity and fine information on the stock prices. This measure will act as a proxy for the reaction to the event and thus the policy's effectiveness. Essentially, we calculate the difference between the estimated stock price development had the event not happened, based on the CAPM formula using a benchmark index, and the actual stock price development. This will be followed by t-test statistics, MLR modeling and a difference-in-difference analysis. The t-test statistics are a simple method of identifying the statistical significance and the strength of the difference in the stock prices between immunity and non-immunity firms. The MLR model is used to take other variables into consideration to reduce the omitted variable bias and thereby gain a clearer understanding of the impact that receiving immunity has. These variables include the size of the fine relative to market cap, the size of the fine avoided due to leniency cooperation in relation to market cap, the industry, settlement notices, a dummy variable for being a repeat offender, and the size of the company. Lastly the difference-in-difference strategy will provide an understanding of the impact from an investors point of view, incorporating the compounding effect and also investigating the prevalence of non-fine costs related to cartel punishments, as explained in section 2.2.2-4, in the form of the analysis of the residuals.

5.2.1 Event Study Economic Caveats

The event study is used to estimate the economic impact that an event, in this case, the publication of information on leniency reduction (dataset I) or the size of the fines to be allocated to each firm (dataset D) has on firms being punished for cartel participation. Our study is grounded in the concept of abnormal returns, first introduced by Ball and Brown (1968), in estimating the economic impact of earnings announcements and by Fama et al. (1969) in estimating the effect of announcing stock splits. Since then, the methodology has changed the approach of understanding event pricing through introducing the notion of event time, allowing us to uncover patterns. Our methodology will rely on the semi-strong form of market efficiency, as shown by Fama (1970). This hypothesis dictates that the price of a security, valued by investors in a competitive open market, should reflect all relevant information about the company available to investors. The traditional efficient market hypothesis also stipulates that

this price adjustment shall occur immediately. For further detail on event study, we refer to Campbell et al. (1997).

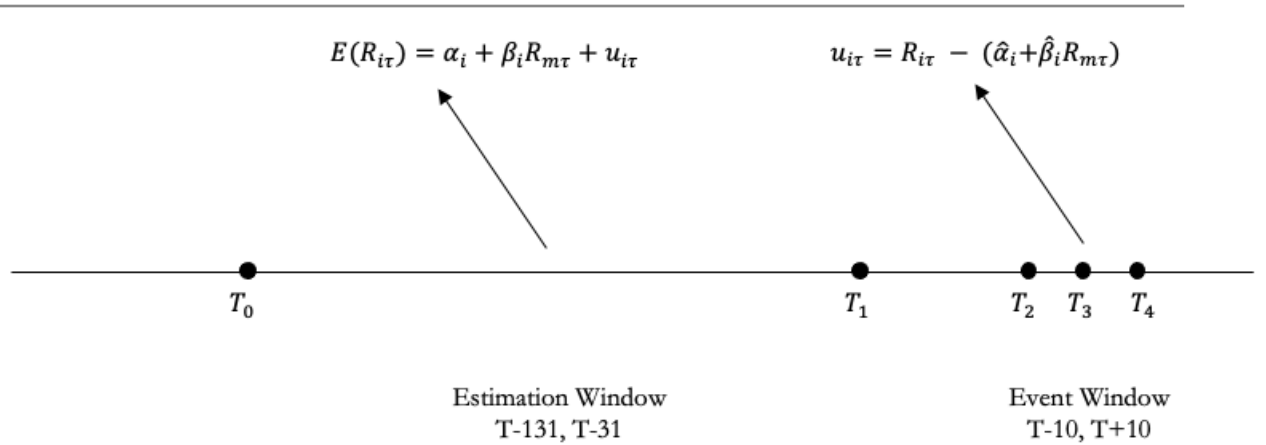
However, we have decided to relax one assumption associated with event studies to incorporate more realistic market conditions, that information is not known prior to formal publishing. The decision is based on the premise that information can be made available to a limited number of traders in the market, causing price movements to reflect the economic impact of an event before the information is made available to the general public. The existence of insider trading is a simple concept, proven by a multitude of academic articles and countless trials and thus will not be explained further.

According to Ahern (2017), increases in the gravity of the event, measured by the potential impact on the firm, leads to increases in the likelihood of insider trading and thus premature pricing of information. The results also show that lawyers and accountants have the highest propensity to give tips to traders in their social networks whilst investment banking analysts have the highest propensity to receive tips. When relating this to our study, the relaxation of the strict assumption of immediate pricing of information becomes apparent. The severity of the fines imposed, the complexity of competition litigation triggering the usage of specialized law firms and all companies being publicly traded, causing analysts/traders to follow the individual companies closely, increases the risk of non-public information being partially priced. Thus we will use a version of event studies in which we take into account the economic impact before the event day as well.

5.2.2 Abnormal Returns and the Simple Market Model of Returns

To understand the economic impact, from now on called the “abnormal return”, of an event we need to estimate the expected return, i.e., the return of the company share price had the event not occurred in the event window. The abnormal return is the difference between the realized (actual) return and the expected return. To calculate the expected return we will use the methodology for generating the market-adjusted model of returns from Aguzzoni et al. (2013). The following figure represents the calculation of the abnormal return.

Figure 4: Timeline and Event Window - a Graphical Summary



Initially, however, we must choose the appropriate benchmark. The benchmarks chosen, as discussed in 5.1.2 are the FTSE country indexes. The indexes are issued by FTSE Russel, a London Stock Exchange subsidiary, and provide a market-cap-based index tracking each country's respective stock exchange's large and mid-cap firms, designed for benchmarking performance. Below we show how the benchmark $R_{m\tau}$ is used.

$$E(R_{it}) = \hat{\alpha}_i + \hat{\beta}_i R_{m\tau} + u_{it}$$

R_{it} and $R_{m\tau}$ are the period- τ returns of security i and the benchmark index of the stock exchange where the security is listed. These are used in the equation above to estimate the α_i and β_i parameters in an OLS for each firm in each case. We used 101 trading days in the period $T_0 = -131$ to $T_1 = -31$. The estimation period ensures that the event windows do not coincide with the estimation window, to decrease the

chances of the event window estimators tainting the relationship. An example of how this would occur is through the increase in volatility arising from the uncertainty of future stock performance from the occurrence of the event, thereby reducing the risk of estimators being biased.

$$u_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$$

Having calculated the α_i and β_i parameters, we then use the benchmark returns in the event window to calculate the expected return at time t . The difference between R_{it} and $E(R_{it})$ represents the abnormal return. These individual daily abnormal returns need to be aggregated to a cumulative abnormal return, representing the sum of the abnormal returns over the event window period (T_2 to T_4). The sum of cumulative abnormal returns of securities is thereafter averaged, resulting in the CAAR, seen below;

$$\overline{CAAR}_{\tau_2, \tau_4} = \sum_{t=\tau_2}^{\tau_4} \left(\frac{1}{N} \sum_{i=1}^N \hat{\varepsilon}_{it} \right)$$

5.2.3 Welch's T-tests

The Welch's T-test for unequal variances is used to test for differences between sample means in single samples. In the scope of our study, this means that we are testing if the CAARs for the different event windows are different from zero and the corresponding significance level at which they differ from zero. A prerequisite for further investigation of the hypothesis is that immunity and fine announcements are incorporated and have a significant impact on the stock valuations of the firms. The calculation for the T-test for one sample is the following, laid out by Snedecor and Cochran (1989), where $\bar{x}$ is the sample mean, S is the sample standard deviation and n is the sample size.

$$t = \frac{\frac{\bar{x}}{S}}{\frac{1}{\sqrt{n}}}$$

As discussed in the literature review, previous papers have shown promising signs that the CAARs are significantly different from zero around final decisions (dataset D). Building on the existing research, the statistical method will then be used to test the level and significance of the difference between the immunity and non-immunity firms. In conjunction with the resulting p-value, this will help in testing H_1 since we can see how investors price the immunity application announcement. Significant positive results would indicate that markets react positively to the news of immunity. Negative or highly insignificant results indicate either too noisy a sample, the value of the fines and immunity already having been priced prior to the event windows used or due to investors valuing the non-fine related costs higher for immunity firms.

The differences in the CAAR between the immunity and non-immunity firms will then be estimated using the T-test for two samples. The methodology of performing the T-test has been laid out in previous works such as (Snedecor and Cochran, 1989), where $\bar{x}$ and $\bar{y}$ are the sample means of the respective samples, s_x^2 and s_y^2 are the sample variances and n_x and n_y represent the respective sample sizes. The T-value will then provide a good measure of the significance that the difference has.

$$t = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}}$$

The reason for including both I and D datasets is that we want to be able to investigate both H_1 and H_2 . Dataset I allows us to see the initial reaction of the immunity status being published. Dataset D will account for the furthering of impact of the immunity status when the fine sizes are published, since there may be differences in what the market was expecting and the actual figures, thereby increasing or decreasing the difference between the two groups. It is more important to look at the shorter event windows for dataset D results as we are interested in the difference between immunity and non-immunity

which is a result of the fine sizes being released. For a reminder of the differences between the datasets, please view 5.1.5.

5.2.4. Multi-Linear Regression

Having observed the impact of the immunity variable as well as its corresponding p-value, we need to control for other factors which can impact the valuation of the company. The control variables include both EC policy-related variables as well as company specific variables. Furthering the study to test H_2 we also introduce variables to measure the impact of the relative size of fines on firms, as well as the relative size of the fines avoided on firms. We choose to use the dataset D results since the fines and the avoided fines are presented at the final decision. In order to be transparent, we must notify that three out of 44 of the cases that we include at the -3/+5 days event window level do not include the publishing of the immunity status of firms. This is since the gap between the immunity decision and the fine size information release are too far apart. Furthermore, for the same reason, one case is not included at the +/-5 days event window. With this in mind we choose not to include the +/-1 day window since it can reduce the readability of the table. The configuration used bears the following form:

$$\begin{aligned} \overline{CAAR}_{it} = & \hat{\beta}_0 + \hat{\delta}_1(Immunity)_{it} + \hat{\delta}_2(Settlement\ notice)_{it} + \hat{\beta}_1(Duration\ of\ participation)_{it} \\ & + \hat{\delta}_3(Repeat\ offender)_{it} + \hat{\delta}_4(Size)_{it} + \hat{\delta}_5(Industry)_{it} + \hat{\beta}_2(relative\ size\ of\ fine)_{it} \\ & + \hat{\beta}_3(Relative\ size\ of\ fine\ avoided)_{it} + u_{it} \end{aligned}$$

Below we look at each of the control variables and why they are chosen.

Settlement notice: The settlement notice, as explained previously, decreases the size of fine which the companies need to pay. However, settlements also represent signals to the market. The choice to settle removes the chance of appealing the decision and thereby forfeiting all chances of future reductions of fines. Gunster and Van Dijk (2016) show that the effect of an appeal decision by the court is more than -2% over the window ($T - 25, T + 3$). They suggest that markets generally assigned a positive probability to a (partial) annulment of the original decision, thereby reacting negatively in cases of the appeal being upheld.

Duration of participation: While being used as a factor for deciding the fine size of participatory firms and thus being a part of the fine variables, the aim of including this variable is to act as a proxy for the dependency of the cartel to the firms. The duration of participation serves as an indicator of both the deep-rootedness of the cartel alignment and thereby the severity that the dissolution of the cartel has on each of the affected firms. What is important to keep in mind, as mentioned in section 5.1.6 under the discussion on sample selection bias, is that this variable is likely to be downward biased due to the duration reported by the EC measuring the length solely for which there was evidence. Reports from the EU mention suspicion of longer durations, but are unable to fine the cartel firms for the entire period due to a lack of evidence. (Marvão, 2015)

Repeat offender: Many previous papers, including Veljanovski (2007) and Stephan (2007) point to a large number of convicted cartel firms repeating their offense, despite having experienced previous prosecution, fines, loss in cartel profits and negative signaling effects. This is also evident in our sample as our dataset contains 100 repeat offense observations, a 53% share. Gunster and Van Dijk (2016) find that repeat offenders experience less negative CAARs than first-time offenders, though not at statistically significant levels. They suggest that the likelihood of further infringements on European antitrust law at the time of the first conviction is priced in the stock value. Additionally, they suggest that the reputational damage is the largest at the first conviction. This will be coded as a binary factor.

Size: It is widely accepted that company size impacts investors' sensitivity to events which the companies face. Important studies by Banz (1981), Fama (1970), and Asness et al. (2013) have shown this to be true. This follows basic economic theory: firms that have less diversified revenue sources, are not as well-known and have a smaller balance sheet to withstand shocks should be more sensitive to events which shape their future. Barely any other topic has been researched as widely within financial economics as factor premia, of which size premia is a part, generating robust results going back to the 1920s. This

will be coded as a binary factor with classification between small, mid and large cap companies. The results in the MLR model will be relative to the large cap classification.

Industry: It follows suit from the previous reasoning that industry classifications of firms should have a large impact on how investors react to the event. The differences stem from distinctions in, for example, customer emphasis on ethical concerns, the importance of relationships between competitors, the supply chain of firms and the harshness of press reaction. Andersen and Dejoy (2011) showed large decreases in the possible endogeneity of results after controlling for industry in testing corporate social responsibility impacts on valuations. This will be coded as a binary factor.

The relative size of fine: Following up on past papers in this area of study, the size of the fine relative to the firm's market cap will be controlled for. The economic reasoning is self-explanatory - an increase in the size of a fine relative to the value of a firm should have a larger impact. Wils (2006) indicate that this is the case, showing that the optimal size of the fine is punitive enough to deter future misbehavior but proportional to market cap to reduce the risk of destabilizing impacted firms too greatly.

The relative size of fine avoided: Taking inspiration from the previous control, the size of the fine which is avoided relative to the firm's market cap is essential to control for. To incorporate the leniency reductions as a result of cooperation, while excluding the 100% reduction as a result of immunity already accounted for, and the resulting size of fine which is avoided, this variable is introduced. The sign and coupled significance level will provide us with the answer to H₂. In case of a significant positive result, the economic significance would be that participating firms in the cartel and those considering cooperation in litigation are provided with incentives to do so.

5.2.5 Multi-Linear Regression including Clustered Standard Errors

As exhibited by many papers in this field of study such as Bos et al. (2019), controlling for clustered observations is crucial in our study. Factors, among others, which can cause unobserved heterogeneity include differing market concentrations, nature of collusive activities, market sentiment, legislative environment, and media coverage. These can lead to heteroskedasticity, violating the assumption that errors are independently and identically distributed. The result is that our MLR would produce biased parameter estimates and incorrect standard errors. Another issue is that the variability of coefficient estimates may be underestimated, should within-cluster correlation be disregarded. This can lead to inflation of statistical significance and increase the likelihood of Type I errors. Crucially this will taint the economic significance of the conclusion reached about our hypothesis. Thereby, we need to make the following alterations to the covariance-variance matrix and the variance of the error term:

$$Var(u_i|C_i) = \sigma_{C_i}^2$$

$$Cov(u_i, u_j|C_i) = 0 \text{ for } i \neq j$$

5.2.6 Difference-in-Difference

Lastly, the difference-in-difference method will be used to understand the wealth effects and the residuals on the firms in the cartels. In combination with past studies which have conducted similar research on the wealth effects resulting from events in the cartel litigation procedure before the leniency and fine announcements, we will see how markets anticipate the fines and leniency. The key difference between the wealth/residuals effect and the CAAR analysis is the inclusion of the compounding effect. Many articles have been written discussing the compounding effect and its importance during times of increased volatility. One example of this is Bouchey et al. (2012) who discusses how the compounding effect becomes pronounced during increased market volatility. Therefore, we will compare the change in the valuation of immunity and non-immunity firms through a buy-and-hold lens. As seen below we take the difference between the market cap at T_4 and T_2 and divide it by $T_2 - 1$. This, to receive the change resulting from the event, relative to the market cap one day before the event window.

$$Wealth\ Effect_{it} = \frac{(Market\ Cap_{it_4} - Market\ Cap_{it_2})}{Market\ Cap_{it_{2-1}}}$$

The wealth effect represents the change in value associated with the market reactions to the immunity and fine decision announcement. Thereafter, we utilize a difference-in-difference approach to quantify the difference in the loss or gain in the market cap between the immunity and non-immunity firms. The following configuration provides an image of how this will be conducted:

$$\hat{\delta}_{it} = WE_{immunity} - WE_{non-immunity}$$

In addition to computing the overall wealth effects, we want to apply a policy-focused approach to build on the wealth effect studies by Bosch and Eckard (1991). Their study presents findings that 13% of the loss in market cap is related to the legal costs resulting from fines. Gunster and Van Dijk (2016) state that when approximating legal costs at 10 million Euros per firm, this still leaves about 75% of the value loss unexplained. Bosch and Eckard (1991) hypothesize that this is due to the termination of profitable anticompetitive conduct combined with reputational losses. It is important to note that these tests were carried out from the start of the investigation process, i.e. the earliest publication of EU cartel investigations. We are interested in seeing if the reputational losses are smaller for immunity firms than for non-immunity firms. Therefore we need to account for the fine size in our calculations to see the residual effects visualized below.

$$Residual_{it} = \frac{((Market\ Cap_{it_4} - Market\ Cap_{it_2}) + fine_{it})}{Market\ Cap_{it_{2-1}}}$$

Having calculated the residual impact in terms of the loss or gain in market cap we once again utilize the difference-in-difference technique to calculate the impact of immunity and to provide an understanding of the associated significance level. Moreover, we will only be using dataset D since we want to make sure that the fine size information effects are included in our results. Using dataset I for the analysis would not take into consideration the pricing of the fine sizes, thereby not producing reliable residuals analysis results. The effects will then be aggregated following the same steps as previously explained and shown.

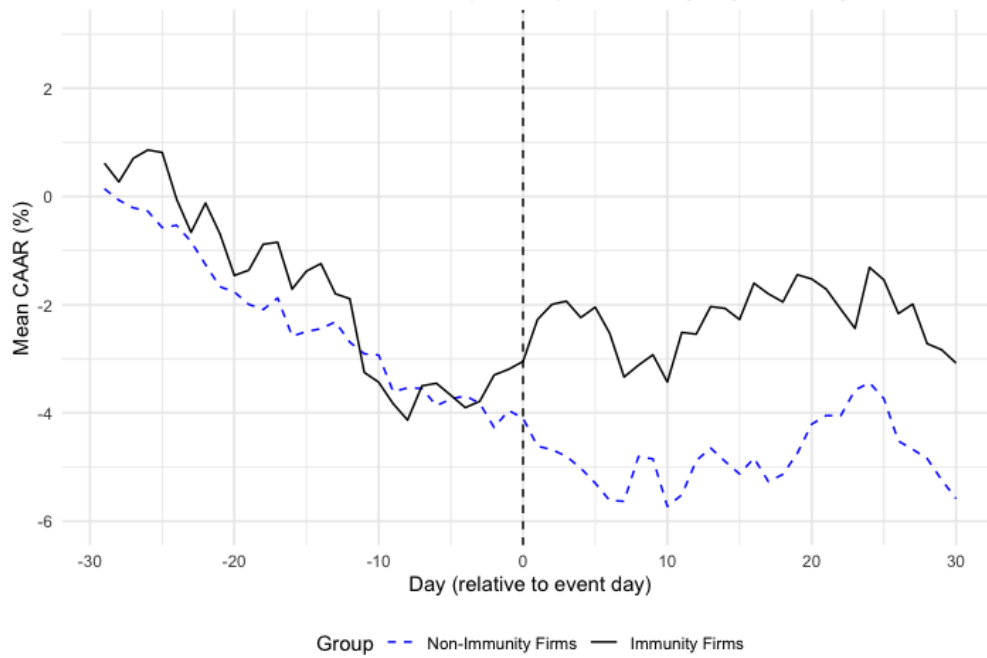
6 Empirical Results

Having motivated the choice of empirical strategy we will present the results and discuss their statistical and economic significance. Firstly the development of the CAAR for the immunity and non-immunity firms will be presented. The time series will provide us with the ability to observe if there is a visible impact of receiving immunity and how the market values this difference. After establishing if there is an impact we need to understand the distribution of the abnormal returns. The reason for this is that the coming analysis will be dependent on the assumption that errors are normally distributed. Following these graphical representations of the CAAR developments we will understand the size of the difference and the associated significance level by using the Welch's T-test. Having interpreted these results we need to further control for omitted variable bias which could taint the true market reaction to the fine sizes and the accompanying leniency reductions. The generated MLR results will be interpreted and the variable coefficients and significance levels discussed. To take into consideration the compounding effect, the wealth effects and residuals will be analyzed using the difference-in-difference methodology. The market cap gain or loss resulting from the event will be analyzed. Furthermore the size of the residuals will be investigated, allowing for possible corrections that are accounted for in compounding.

6.1 CAAR - Time Series - Immunity vs. Non-Immunity

To visually illustrate the effect of receiving immunity we will integrate all data points without controlling for external factors. The time series presents a raw market reaction to the immunity application, oftentimes coinciding with the information release of the fine sizes and partial leniency reductions. In Figure 5, we observe the differences in CAAR developments between the immunity firms, shown in the filled black line, and the non-immunity firms, shown in the dotted blue line. Thereafter, we will determine which event windows should be chosen, combining inspiration from past papers and insights from the graphical analysis.

Figure 5: Mean Cumulative Abnormal Returns (CAAR) around t_i (Dataset I)



(European Commission, n.d.) and (Standard & Poor's Capital IQ, (n.d.)

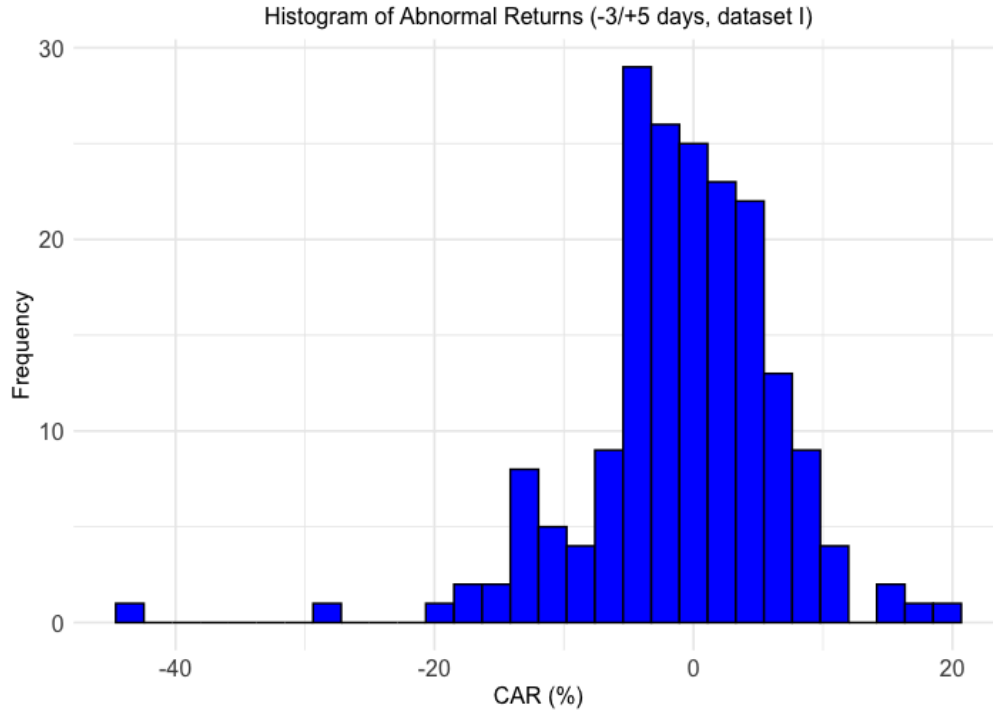
The developments of the CAAR follow the trends we had expected. Prior to the immunity firm being revealed, we see that there are largely no differences in the trends of the immunity and non-immunity firms, both following a negative development. This is in line with our expectations, since, unless the market has already priced the immunity prior to the event, there should not be a difference in the market expectations. However, comparing the developments post T-10 days relative to the event we see that the immunity firms trend ceases and starts to reverse. This is in contrast to the non-immunity firms which see a furthering of the negative development. Moreover, we see that this trend continues, accelerating in the rate of dispersion as the event day nears. This hints towards the market becoming increasingly aware of the immunity being granted, possibly due to information leaks from external or internal partners involved with the investigation. We spot that one specific day where there is a large dispersion prior to the event day between the immune and non-immune firms at T-3. At the event day and shortly after we observe increased volatility for both non-immunity and immunity firms. This is evident in the large changes in CAARs in the shorter event windows relative to the periods further away from the event day. Moreover, we also see the dispersion between the CAARs of the two groups increasing, furthering the distance between the classes of firms as the immunity firms partially regain the losses sustained before the event, whilst the non-immunity firms' trend persists. Both curves seem to return to their normal developments 5 days after the event, signaling that the market is confident in the pricing of the event, with an exception at the +25 day period. The reason for this is likely an increase in idiosyncratic volatility in the non-immunity firms, and due to the smaller sample minimizing the differences between the two groups. Though, the difference is still seemingly large and quite stable after this period as well, further strengthening the theory of the market feeling confident in their pricing of the event. Thus, we will be choosing to integrate a T-3 to T+5 days event window in our analysis, as we believe that the event will be priced in a way that resembles how the market reacts to the event whilst being able to correct any mispricings as well. In combination with this we will choose the event windows; +/-1 day for the immediate impact of the event, +/-5 days for an extended event window in case of further dispersion before the event as well as +/-10 and +/-20 days in line with past research as Aguzzoni et al. (2013).

Whilst the diagram shows very promising signs of an economically and statistically significant difference between the immunity and non-immunity firms, a T-test must be computed in order to verify this speculation. In order to be sure that the t-test results are able to be interpreted correctly we must first

look at the distribution of CAR's to determine if the distribution appears to be normal in line with assumptions that the OLS framework depends on.

In the case of the results being tail driven, meaning highly dependent on few large abnormal returns to increase the average effect size, the credibility of our conclusions is reduced. To investigate this potential issue, a plot of the distribution of the -3/+5 days using dataset I for abnormal returns will be viewed.

Figure 6: Histogram of Cumulative Abnormal Returns (-3/+5 Days, Dataset I)



(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

When looking at the distribution in Figure 6, we can see that it exhibits a clear resemblance to a normal distribution. We see a pronounced concentration around the mean that tapers off on both tails. Thereby, the figure suggests that the abnormal returns are mainly clustered around the mean and limited instances of significant deviation. The only exception is one observation at the negative tail end. However, as it is only one observation, we still draw the conclusion that the distribution is roughly normal. The relatively low frequency of outliers on either side of the mean also suggests that we must not worry too much over the possibility of tail dependencies driving the results. This allows for more inferable results which can be used to reach conclusions on the effectiveness of the leniency program and provide insights to policymakers. What we also observe is the mean of the distribution being in the negative. This observation is expected as we see negative developments of the CAAR during event windows for the non-immunity firms which make up the majority of the dataset (150/188 observations). The distribution of all other event windows and for the dataset D are visible in the appendix. All of the distributions represent a similar form to Figure 5 with the feature of errors becoming increasingly distributed in the fashion of a normal distribution.

6.2 Welch's T-test - CAAR of all event windows

Having decided on the use of event windows through the analysis of past papers as inspiration and through incorporating the time-series development of Figure 5, we need to understand the CAAR's of the whole sample and the associated significance level. This is computed as it is imperative that we understand the CAAR in the event windows specifically, not taking into consideration the duration prior to the event windows. We expect a negative relationship at acceptable significance levels for all of the chosen windows since we have a higher number of non-immunity firms.

Table 2: Cumulative Average Abnormal Returns (CAAR) T-test Results

Cumulative Average Abnormal Returns (CAAR) Metrics for Dataset I and D					
Average CAR (%)	P-Value	T-Value	Standard Deviation	Time Window	Dataset
-0.0675	0.8087	-0.2424	3.8198	1-1 days	I
-0.9117	0.1006	-1.6499	7.5766	3-5 days	I
-0.8576	0.1091	-1.6099	7.3037	5-5 days	I
-2.2868	0.0045	-2.8734	10.9121	10-10 days	I
-2.1968	0.0603	-1.8904	15.9337	20-20 days	I
0.0488	0.8629	0.1729	3.8698	1-1 days	D
-1.1473	0.0375	-2.0949	7.5091	3-5 days	D
-1.0703	0.0463	-2.0062	7.3154	5-5 days	D
-1.9814	0.0116	-2.5479	10.6626	10-10 days	D
-2.0145	0.0817	-1.7505	15.7793	20-20 days	D

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Table 2 shows Welch's t-test results from measuring the CAAR (%) in the different event windows for both dataset I and D. As espoused, all data points are included, and no factors have been controlled for. The results show a negative CAAR during all time intervals for both datasets, except for +/-1 day (D). Although the -3/+5 of dataset I t-value of -1.6499 is not the largest and the p-value of .1006 scrapes above the required level for the 10% significance level, the negative coefficient of is still a strong indication that markets react negatively to the immunity application. This is due to only one firm being able to receive immunity for each case. Looking more closely at the data we see that p-values are higher and thereby less statistically significant at shorter time intervals for both dataset I and D. This possibly indicates that markets either already have priced in the information of size fines and leniency reports or are slow to price in the changes. This becomes evident when comparing the -2,0145% CAAR of the +/-20 event window, sporting a significance level of 0.0817 to the 0.0488% CAAR of the +/-1 day at 0.8629 of dataset D. One explanation for this is that information about the immunity status is integrated into the CAAR and therefore, we need to be careful when judging these results. The most important time-interval for the D dataset is the +/-1 day since we observe 14/44 cases that only release the data on fines and not immunity related information. The positive coefficient, though very insignificant, could possibly indicate that markets had been fearing harsher fines for the non-immunity firms and thereby react positively. We will discuss this theory in depth during the difference-in-difference discussion related to residuals.

Furthermore, we see significant results starting from the time interval -3/+5 days at the 95% level for dataset D and +/-10 days for the dataset I. This gives allure to the importance of the leniency reductions and fine sizes, outside of the 100% immunity cases. It is interesting that these two datasets produce such different p-values. Although the standard deviation of the two sets are very similar, we observe slightly different coefficient sizes with dataset D showing more significant results. One reason for this difference, portrayed by the difference between the -1.1473 and the -0.9117 coefficients is that dataset D makes sure to include the pricing of the fine sizes for all observations, furthering the negative reactions on non-immunity firms and positive for the immunity firms.

The economic takeaway is that markets show a significant negative reaction to the news of the fine sizes and immunity applications. This shows that markets price the fine sizes, possible losses in cartel profits and reputation, which is in line with theory and previous findings.

6.3 Welch's T-test - Differences in CAAR between Immunity and Non-Immunity Firms

Until now we have established that there is a visible difference between the immunity and non-immunity firms through the usage of the time-series plot, established that the cumulative abnormal returns follow an approximately normal distribution and found significance in the negative development of the CAAR for the whole set of data. However, in order to answer H_1 we need to quantify the difference between the

immunity and non-immunity firms through using a T-test. The following table shows the difference in the mean CAAR in all event windows between the two groups and using the standard deviations calculates the t-value seen below.

Table 3: CAAR Differences between Immunity & Non-Immunity Firms (Dataset I and D)

CAAR Differences with Significance for both D and I Datasets				
Time Window	Average CAAR Difference (%)	P Value	T Value	Dataset
1-1 days	1.3684	0.1037	1.6588	I
3-5 days	3.4700	0.0167	2.4677	I
5-5 days	2.8389	0.0553	1.9607	I
10-10 days	2.6415	0.2402	1.1885	I
20-20 days	1.7049	0.5617	0.5837	I
1-1 days	1.0772	0.1561	1.4387	D
3-5 days	2.9735	0.0302	2.2225	D
5-5 days	2.5820	0.0806	1.7822	D
10-10 days	2.8925	0.1989	1.3021	D
20-20 days	2.5108	0.4073	0.8352	D

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

The table shows the results from conducting a Welch's T-test that quantifies the difference in CAAR values between immunity and non-immunity firms for the different event windows using dataset I and D. No changes to the raw data have been made as it presents the unadulterated view of the market response. This information about partial immunity status and reduced fines are also included in the non-immunity category, thereby theoretically reducing the difference between the two groups.

When relating the results from Table 3 to the descriptive analysis of Figure 5, they tell a similar story. The difference between the CAARs in the immediate event window, +/-1 day of dataset I, is 1.3684% at a relatively significant p-value of 0.1037 and a t-value of 1.6588. Whilst not reaching the conventional requirements set in order for results to be significant, the positive coefficient shows promising signs. As we extend the window to -3/+5 days of dataset I, the size of the differences increases by more than 150% to 3.4700%. The coefficient has a p-value of 0.0167 and a t-value of 2.4677. This is a profound finding as the sign of the effect and the significance level demonstrates that markets react to the news of immunity positively. The EU is thereby able to increase the attractiveness of revealing a cartel to firms who are actively participating in a cartel. Theoretically the EU should thereby be able to increase the number of cartel prosecutions as a result of whistleblowing.

Also worth noting is the seemingly large differences between the I and D results. Although we can expect there to be differences, it is unusual that the differences are so large. This highlights the importance of having separated the data into dataset I and D prior to conducting the tests. Furthermore, we also observe higher t-value for dataset I, demonstrating larger reactions related to the news about the immunity application rather than the fine size.

As the event window widens further, the statistical significance decreases. From the +/-10 days to +/-20 days intervals we see p-values ranging from 0.2402 to 0.5617, and corresponding t-values indicating weaker statistical evidence of a difference. One interpretation of this trend is markets having fully priced in the information, thereby leading to a stabilization of the differences. Another possible explanation is that the event windows start incorporating prices when the market was unaware of the event and thereby integrating non-event related information. As we saw in the diagram, the size of the difference stays relatively stable with deviations not following any particular pattern, indicating non-event related differences in volatility. When looking at the dataset D +/-1 event window we observe the difference of 1.0772% at the t-value of 1.4387. In comparison to dataset I, we notice that the difference is smaller, strengthening our theory that the market prices in harsher expected fines. The choice of observing the difference using a graph and thereby leading to the choice of including the -3/+5 time interval shows its worth as all other t-values are consistently below the deck of +/-2 for results to be

considered significant. The t-value for dataset I reaches 2.4677 and a p-value below the 0.05 suffices as proof that the coefficients are robust against noise.

Although we observe a large spread in the t-values, we can, based on the consistently positive differences, say that there is a strong indication that markets react positively to the news of a firm being granted immunity.

6.4 MLR Results

Following the T-test analysis we will be focusing our coming investigation on our MLR model. The reasoning for choosing to use an MLR has been laid out in section 5.2.4, however, in summary we want to control for other factors which can taint the impact that the immunity status of a firm has on the share value and thereby increases the reliability of using this as a proxy for policy effectiveness. We also want to see what other variables in particular could impact the stock performances.

The MLR is used in our analysis to investigate the potential impact of immunity status on the CAAR of a firm using the OLS framework. The coefficient and accompanying significance levels aim to answer the question of how much investors value the immunity status of firms. In order for the leniency policy to be deemed effective we hope to see positive coefficients, signaling positive market reactions. We will also receive a better understanding of the strength of this positive reaction. Furthermore, due to having 11 different industry factors and to improve the clarity of the table we have chosen to omit the variables from our table, however, they are visible in the full regression results tables in the appendix. For the explanation as to why we have chosen to not show the +/-1 day results and only include the dataset D results, please see section 5.2.4. The tables of the SLR, solely including the immunity variable with clustering of standard errors, non-clustered standard errors and clustered MLR regressions including the industry variables can be observed in the appendix.

Table 4: MLR Results (Dataset D)

Consolidated MLR Results for "D" Type Across Event Windows - Including Clustering of Standard Errors				
	<i>CAAR</i>			
	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity dummy	0.0207 (0.0134)	0.0092 (0.0145)	0.0091 (0.0211)	-0.0009 (0.0305)
Fine avoided % of Mkt. Cap	-0.1003*** (0.0298)	0.1415*** (0.0268)	0.1314** (0.0431)	0.2938*** (0.0676)
Fine % of Mkt. Cap	-0.3045*** (0.0877)	-0.3977*** (0.0968)	-0.4339*** (0.1197)	-0.2278 (0.3079)
Repeat Offence Dummy	-0.0062 (0.0123)	-0.0090 (0.0124)	0.0107 (0.0212)	0.0168 (0.0300)
Settlement Notice dummy	0.0152 (0.0105)	0.0101 (0.0109)	-0.0106 (0.0178)	0.0126 (0.0274)
Days involved	0.000004 (0.000003)	-0.000000 (0.000003)	-0.000002 (0.000005)	-0.000002 (0.00001)
Mid Cap	0.0057 (0.0144)	0.0023 (0.0144)	0.0197 (0.0219)	0.0689* (0.0284)
Small Cap	-0.0052 (0.0165)	-0.0026 (0.0172)	0.0246 (0.0271)	0.0624 (0.0470)
Constant	0.0245 (0.0220)	0.0391 (0.0236)	0.1549*** (0.0440)	0.0460 (0.0666)

Note:

*p<0.05; ** p<0.01; *** p<0.001

Robust standard errors are clustered by case.

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Although sporting consistently positive coefficients, the immunity variable is far from significant. One possible explanation of this is the variation shared between the fine size avoided relative to market cap. However, it is more plausible that high noise in the smaller immunity sub-sample fails to normalize errors and thereby allows for too much idiosyncratic variability. Moreover, we see decreasing effect sizes, exemplified by the decrease from 0.0297 to 0.0207 in effect size of the -3/+5 days event window between the clustered SLR, seen in the appendix, and MLR model specifications.

As previously mentioned, leniency reductions can also be partial. Fine reductions are based on the firm's level of cooperation and effort to break up the cartel. The reward for these actions are a reduced fine, which is taken into consideration by the fine size avoided relative to market cap variable. One element of the analysis which is very vivid is the change in the sign of coefficients from -0.1003 in the -3/+5 days period to 0.1415 in the +/-5 day period. Coming periods produce positive coefficients as well. Theoretically it is difficult to explain this change. However, given the high significance levels it cannot be ignored. Briefly disregarding the first period with the negative coefficient we see large coefficients in relation to the immunity variable and high significance levels above 95% significance. From an economic standpoint, unless we assume investors are expecting higher leniency reductions, this is the reaction we expect. Given our previous results in section 6.2 pointing to a lack of investor optimism in fine sizes, it is more likely that the opposite holds. Smaller fines relative to the market cap decrease the negative impact on cash reserves and disruption of current and future growth operations taking into consideration the resilience of companies, proxied by the market cap. The results speak in favor of the 2006 leniency notice promoting cooperation between firms and the EC to ease the process of prosecution. Thus, the EC can allocate more time towards uncovering potential cartels. In combination with a positive coefficient for the immunity status it creates an additional effect for policy makers. The potential result is a decrease in cartel formation, improvements in the uncovering of cartels and increases in prosecution success rates.

Using similar reasoning but looking at the fine which companies have to pay, we observe expected consistent negative coefficients of the fine size relative to market cap variable. The size of the coefficients are also high compared to the other variables, sporting a -0.4339% effect on the CAAR at a p-value of <0.001 at the +/-10 day level and -0.3045 at the -3/+5 day level. Interestingly there is a large increase in the significance level between the clustered and non-clustered MLR model seen in the appendix. The difference shows the importance of taking into consideration the variation which is present for companies within a case. From an economic perspective the negative coefficient of the fine size relative to market cap and positive coefficients of the fine size avoided serve as proof of policy effectiveness in providing incentives for cooperating. Markets behave as we expect them, rewarding firms who are cooperative and thereby reduce the severity of fines and punishing those who work against the EC.

Repeat offenders make up a large portion of our data and thereby it is probable that markets should react poorly to repeat offender classification. It could signal to markets that the leadership of firms are unfazed by convictions and thereby are more likely to currently be participating in other cartels or are more likely to join other cartels in the future. The negative coefficients of the event windows -3/+5 at -0.0062 to the -0.0090 at +/-5 days suggest that markets may follow the same logic and reasoning, thereby choosing to price in further punishments related to cartel participation in the future. Due to the small effect sizes and the lack of statistical significance, however, we are unsure of this being the case for all of the firms or just a few. Within our dataset, there is a small set of firms overrepresenting this sub sample, an example of this is UBS having been convicted 5 times. A combination of our small and noisy sample and simultaneous market interpretations of repeat offenses cause difficulty when interpreting the coefficients, even when there is more proof of negative reactions than positive since we are more trusting of shorter event windows than longer.

A similar story can be told for the settlement dummy. Our previous discussion in section 5.2.4 underscores the counterarguments for how settling can send market signals. Although the firm is able to lower the fine size by a further 10%, they in turn also forfeit the opportunity of appealing the fine. The lack in consistency is exemplified by the 0.0152 coefficient of the -3/+5 days event window, decreasing to -0.0106 in the +/-10 days window. Generally the coefficients are positive, hinting towards a positive market reaction to the lost chance of appealing the decision that can result in a further decrease in fines

than the 10% decrease. The insignificance of the results point to market reactions being firm and case specific.

When including control variables we receive more information that becomes relevant in understanding how markets react to the event of leniency and fine publications. The duration of cartel participation variable however reveals no information about the market reaction. This is apparent as the coefficients are very small and have very low significance levels. One possible explanation for this is that the duration of participation is a factor used in determining the fine size attributed to each of the firms. Therefore, the variation in CAAR that can be explained by the duration is likely already explained by the variable showing fine size in relation to market cap.

When viewing the coefficients of the size variables we can draw a similar interpretation. Whilst we observe negative coefficients for the small cap dummy in the shorter event windows of -3/+5 and +/-5 days, -0.0052 and -0.0026 respectively, we observe consistently positive coefficients for the mid cap variable. In line with normal economic reasoning, the smaller balance sheets, more sensitive cash flows and less diversified income sources should increase the impact of idiosyncratic risks. However, as time progresses, the coefficients actually reverse and become positive for the small caps. In combination with the reversion we see an increase in the noise, exemplified by the increases in standard deviations of coefficients. Thereby, the lack of consistency of the coefficient signs and a lack in significance makes it difficult to draw the conclusion that investors are more sensitive to event-related information releases for smaller firms in this setting.

Industry classifications, seen in the appendix, appear to be important for the interpretation of the event, broadly speaking. We observe for example the Energy industry classification sporting a -0.1596 coefficient at the -3/+5 day window, which is very high in relation to other variables, featuring a p-value of <0.001 and thus very significant. For our results analysis, the main takeaway is that they serve their purpose in reducing the omitted variable bias and thereby explaining the variation in the CAAR. This to the benefit of making our estimates used in answering H_1 and H_2 more reliable. For those who are interested in more figures, please view the appendix.

Lastly, we now observe positive constant coefficients. This is in stark contrast to the negative coefficients of the constant in our SLR model, seen in the appendix. Interestingly it follows suit of coming residuals analysis using the DiD methodology. When controlling for the immunity status, the fine size relative to the market cap, leniency reductions in the form of avoiding larger fines, etc. we are left with a positive coefficient. Once again, we find proof that investors respect the EC's ability to pursue convictions of cartel members and punish them financially.

Alluding to a coming point in the discussion section, increases in investor activism within firms has the ability to decrease the probabilities of companies joining cartels. Through significantly positive reactions to fine reductions as a result of increased cooperation and negatively significant reactions to fines actually received, we consistently have found support of the EC's 2006 leniency policy. The policy is shown to increase the cooperation between firms and the EC during investigations, as well as providing clear incentives to avoid participation in future cartels.

6.5 Difference-in-Difference - Wealth Effect of All Event Windows

One fundamental attribute of the cumulative abnormal return calculations is that we disregard the compounding effect of returns. Thereby we may distort the true picture of the effectiveness of the leniency program. To mitigate this risk, we need to account for holding the stock of the associated firm during the event window. As we mentioned in the empirical strategy section, the market cap used to receive a relative impact is the market cap at T-1 before the event windows. In the appendix, we find a table which shows the aggregated wealth effects for dataset D and I. Overall we see the same outcomes as in the previous CAAR studies and we will thus not discuss these in full. The following table shows the results of the difference-in-difference study following the wealth effect strategy previously explained.

Table 5: Wealth Effects - Difference in Mean between Immunity and Non-Immunity (Dataset I and D)

Combined Wealth Effects Study - DiD - Datasets D and I					
Event Window	Mean Difference	P Value	Difference T Value	Std. Deviation	Dataset
+/-1 day	1.6031	0.0477	2.0347	3.5169	I
-3/+5 days	2.4728	0.0160	2.4740	6.0441	I
+/- 5 days	2.5110	0.0148	2.5033	6.1320	I
+/- 10 days	1.8207	0.2191	1.2418	8.4972	I
+/- 20 days	1.8717	0.2667	1.1198	10.4238	I
+/- 1 day	1.3162	0.0662	1.8783	3.4458	D
-3/+5 days	2.3548	0.0241	2.3088	6.2193	D
+/- 5 days	2.3628	0.0243	2.3060	6.3100	D
+/- 10 days	2.1393	0.1584	1.4281	8.5987	D
+/- 20 days	1.8601	0.2847	1.0786	10.5049	D

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

The difference between the immunity and non-immunity firms represents the effectiveness of the 2006 leniency policy, without adjusting for any other internal or external factors. Thereby, the table is representative of the straightforward perspective on market and investor sentiment.

Overall one can observe positive values in the difference between the wealth effects for investors during every event window. Though, we see that the trend of increasing differences does not hold to the same extent as the CAAR developments as time progresses. In the immediate event window, the +/-1 day of dataset I, there is a mean difference of 1.6031% between the immunity and non-immunity firms. Whilst the difference may seem relatively small, it is imperative that we take into account that the median and average market cap of the firms in a sample of total firms is 11.01 and 56.84 billion Euros respectively. Knowing this, the difference represents a 176.5 and 911.2 million Euro change in nominal terms. Thereby, even though it may represent a small change in relative terms for singular investors, it represents huge savings in lost value for investors as a whole. The p-value of 0.0477 tells us that this difference is robust even in our relatively small and noisy immunity sample. The t-value is also above the +/-2 rule of thumb used to establish significance at 2.0347.

Looking at the -3/+5 days and +/-5 days we see that a higher significance level is reached, showing an impressive t-value of 2.4740 and 2.5033 respectively. We also observe an increase of approximately 1 percentage point to 2.5110% in mean difference and even lower p-value in relation to the +/-1 day window. The increase in the mean difference and the significance level indicate that the market either anticipates the leniency and prices the leniency earlier, or that the pricing is corrected following the event. Either way, the results speak in favor of the effectiveness of the 2006 leniency policy in punishing the cartel firms and rewarding those who uncover and thereby initiating the end of the cartel. Judging by our sample containing a large number of repeat offenders, the negative impacts on the valuations of firms and negative economic and social impacts of cartel behavior discussed previously, the difference also needs to be sufficient enough to reduce chances of repeat offenses. The discussion on the optimal size of fines based on studies on the EU antitrust legislation is ongoing. However, the difference and significance shows promising signs. For further discussion on the topic of the optimal size of the fine in antitrust punishments, see Sproul (1993), Geradin and Henry (2005), Bos and Schinkel (2006), Veljanovski (2007), and Combe and Monier (2009).

When comparing this to the same event windows using the CAAR approach, we notice that it is both a larger coefficient and at a higher statistical significance. In combination with observing the original time series development, it is not surprising since we see an initial large dispersion at the event day and then a normalization of the returns differences between the immunity and non-immunity firms. Thereby through integrating the compounding effect, we see that the impact of the immunity status is larger than what we previously had found support for, and at a higher statistical level.

As the event window widens, we see a decline in the statistical significance and a slight decline in the mean differences. From p-values ranging from 0.2191 to 0.2667 and t-values dropping, we find evidence of decreasing robustness of our model. The diminishing significance level indicates that markets

have integrated the leniency information, resulting in a normalization of the differences. Another theory is that investors are reacting to news not related to the event and therefore reduce the readability of the coefficients as isolating the impact of the leniency policy becomes difficult. Given the increasing standard deviations, a combination of these two are likely.

Although the study becomes slightly tampered as the event windows become longer, we still find support for the effectiveness of the leniency program in providing incentives to firms in cartels in uncovering them. Both relative and nominal differences in wealth effects show positive market interpretation of the immunity and nulling of fines. It is also noteworthy that the Gunster and Van Dijk (2016) study finds similar results at the time of the dawn raids, signaling that the total wealth effects differences may be larger than our results show. We believe that, even though the CAAR approach is favored for short-term event study approaches, the integration of the compounding effect allows for a fairer interpretation of the stock price developments.

6.6 Difference-in-Difference - Residuals of All Event Windows

As written in the theoretical background, the fine is not the only negative economic impact that a prosecution has on the involved cartel firms. Other factors can cause residual impacts. Previous literature such as Bosch and Eckard (1991) and Gunster and Van Dijk (2016) have shown the aggregated loss in market value, assuming the legal costs of 10 M Euros per firm in combination with the fine only accounting for 75% of the total loss in market cap. These results also take into account all different events during the cartel investigation. What is interesting for us is therefore, not determining or quantifying the value of the losses in market value associated with the worsening of reputation and loss in cartel profits, but rather if markets anticipate the leniency reduction and the fines which are going to be announced. Significant positive results would indicate markets having more pessimistic estimates of fines given to non-immunity firms than the actual announced fines. The economic significance of this would be that the leniency program is well-respected by investors and company executives, deeming the EU's ability to punish companies effective. Below we present the findings of the DiD methodology seeking to see if this economic conclusion has statistical grounds to be based on.

Table 6: Residuals Analysis (Dataset D)

Residuals Analysis - All Event Windows - Dataset D				
Event Window	Mean Value	T Value	Std. Deviation	P Value
+/- 1 day	1.6565	4.1001	5.5395	0.0001
-3/+5 days	1.1115	2.1617	7.0500	0.0319
+/- 5 days	1.0467	2.0156	7.1204	0.0453
+/- 10 days	0.4834	0.7197	9.2093	0.4726
+/- 20 days	1.7796	2.1444	11.3786	0.0333

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

From the table we observe positive coefficients all across the different event-windows. The positive residuals send a message that investors had anticipated tougher fines on the cartel firms. Although this may not seem overly significant from the perspective of economists understanding the leniency policy effectiveness, it tells us that EC punishments are respected and feared by investors. Investors are increasingly becoming influential on the behavior of senior executives and boards of companies, signaling that the fears of negative market effects can increase the likelihood of investors advocating for companies uncovering their cartels.

One aspect that we observe is the high gain in terms of residuals of 1.6565% at the accompanying t-value of 4.1001 and p-value of 0.0001 in the +/-1 day event window being very statistically significant. However, we must also take into consideration that the wealth effects of 0.0834%

for this event window is very low relative to the other event windows.⁴ Additionally the p-value of the wealth effect related to the residual 0.741, very insignificant and thereby should be interpreted carefully.

Looking at the -3/+5 days event window, the mean residual is quite similar to the +/-1 day window and adequately significant at a p-value of 0.0319. This offers support for the theory that investors are fearful and pessimistic of the fine which is to come at the time of the raid and other previous events related to the cartel prosecution.

Having discussed the CAAR and wealth effects progression over time, we should be wary of looking further than the +/-5 days mark as the information of the fines and the associated leniency reductions seem to be priced by investors. In order to mitigate tainting the validity of the conclusions reached, we will disregard the +/-10 and 20 days event windows in our discussion. These figures are likely not to resemble the investor reactions to the event but idiosyncratic risks and differences which occur after the event window.

6.7 Difference-in-Difference - Immunity Status Impact of All Event Windows

If investors have an overly pessimistic outlook on the severity of EC punishments, it would not be farfetched to assume that investors carry this sentiment when it comes to the immunity status of companies. A way which this could arise is if investors only price parts of the immunity and not the whole immunity. This would result in a positive difference in the residuals of immunity and non-immunity firms as investors price in the remainder of the immunity. The table below presents the findings of the t-test to test this theory.

Table 7: Residuals - Difference-in-Difference - Mean between Immunity and Non-Immunity (Dataset D)

Residuals Analysis - Comparison of Mean Difference Between Immunity and Non-Immunity Groups - Dataset (D)				
Event Window	Mean Difference	P Value	Difference T Value	Std. Deviation
+/- 1 day	-0.8644	0.2867	-1.0723	5.5395
-3/+5 days	0.1896	0.8595	0.1776	7.0500
+/- 5 days	0.2041	0.8494	0.1905	7.1204
+/- 10 days	-0.0416	0.9784	-0.0272	9.2093
+/- 20 days	-0.2594	0.8840	-0.1464	11.3786

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

When looking at the figure, it becomes apparent that the results are noisy. Overall we see a negative difference between the immunity and non-immunity firms for all of all event windows excluding -3/+5 and +/-5 days. These two event windows are those of highest importance as the time series development showed that the market prices in the information in this time interval (see appendix for the time series development for dataset D). In these windows we see that the difference is positive, though small at around 0.2%. The significance drops to levels which are far below those acceptable to base any conclusions on. Consequently it becomes difficult to claim that investors are not fully pricing the immunity status of firms prior to the announcement of fines. Nevertheless, we are able to draw economically important takeaways from this figure. As expressed, cartel firms suffer not only from fines and legal costs but also from market signaling effects. Discussed previously in section 2.2.4, there are counterbalancing market signaling effects associated with receiving immunity.

The insignificance of the results tell us that the immunity status of firms has little or no impact on the non-fine related effects. If the counterargument would hold, it would be reasonable to assume that the difference in the residuals would be significant. In the case of markets reacting positively to the news, for example due to an improved consumer image of a company's social responsibility leading to improved trust, or negatively due to a reduction in trust from distributors or business partners. We observe neither, thereby sending the message that, disregarding the ability to reduce or forgo the fine, it is not important

⁴ See wealth effects analysis for dataset D in appendix for figures

how the participation of the case is handled, but rather, it is more important that firms opt-out of participating in cartels.

7 Conclusion

7.1 Discussion

The results confirm what has been concluded in prior research while giving new knowledge relevant for researchers and policymakers. From section 6.2, not looking at the differences in immunity vs non-immunity firms, we see on average an overall negative stock market reaction to the conviction of all cartel firms. For this test, we used both datasets, but will primarily look at dataset D, as it incorporates the most relevant information for observations over the conviction. While the magnitude of the change in abnormal returns increases with the event window used, we can see the significance being highest for the event window of $-3/+5$, $+/-5$ and $+/-10$ days, all reaching p-values under 0.05. To compare the effect with previous research, depending on the event window, previous papers include overall negative stock market reactions that vary in magnitude. Gunster and Van Dijk (2016) saw a -1.85% decrease around the announcement of the final decision using an event window of $-25/+3$ days. Bos et al. (2019) observed a decrease of approximately -1.16% by using a smaller event window of $+/-5$ days, while Aguzzoni et al. (2013) found reactions of -3.57% around the final decision with an event window of $-20/+10$ days. We can conclude that our results are in line with these findings, spanning the range of -1.15% and -1.98% CAAR with p-values below 0.05 in the most relevant event windows, $-3/+5$ to $+/-10$ days.

Relating to conclusions being drawn surrounding H_1 , we can look at the results in Table 3. As we observe differences in immunity and non-immunity firms, we will primarily look at results from dataset I, the reasons for which have been explained repeatedly before. By looking at the event window of $-3/+5$ days, we can see that receiving immunity from fines is associated with a positive stock market reaction with an average of 3.47 percentage point difference in CAAR compared to firms receiving fines around the time of the EC revealing which firm has applied for immunity. This, at a 95% significance level with a p-value of 0.0167. As we have previously explained, there are two types of cooperation this paper aims to discuss. The first being at the point when no member of the cartel has yet come forward and the incentives for whistleblowing needs to be strongest. This test specifically shows support for this kind of cooperation being incentivized by the leniency program.

In order to integrate the compounding effect and consequently adapting an investors perspective we chose to conduct a wealth effects analysis. Overall the differences between the two methodologies were minimal. However, we did observe larger effect sizes in the differences between the wealth effects of immunity and non-immunity firms. This insight sheds further light on the importance of including reactions which can compound over time and thus the use of a difference-in-difference approach in event studies. With the CAAR and the wealth effects study in mind, we can reject the null hypothesis related to H_1 with 95% confidence.

By comparing this result with the other event windows used, we can conclude that the $-3/+5$ days event window seems to be appropriate in terms of minimizing the effect of interfering factors such as market imperfections and noise in the stock data. By using a smaller event window, e.g., $+/-1$ day, one disregards the effect of knowledge leakages and consequent market imperfections. A longer event window, while including more potentially leaked information also involves stock market reactions to other firm-level news that are not connected to receiving leniency or not, introducing more noise to the data.

The results so far suggest the importance of information leakages and market imperfections including insider trading. This can firstly be concluded from the results seen in Table 2, where the effect sizes and significance levels increase with the event window used. It can also be seen in the results from the test in section 6.3, where the stock market effect of receiving leniency can be observed to materialize before the announcement is made public by the EC. This effect could weaken the impact of receiving immunity from fines if this is revealed outside of the event windows used in this paper. Information of leniency can be revealed either officially through an announcement by the whistleblowing firm or unofficially through information leakages. One example of this being the case is the truck cartel including, among others, MAN SE and Mercedes-Benz. The market knew that MAN SE was the whistleblower and would receive immunity long before the observed window of this paper. (Oliver and Campbell, 2016) Thus, for that case, the only speculation was regarding the fines to be put on the other firms. This effect,

of leniency being announced before the event window used to observe changes in stock prices would theoretically be most prevalent for the largest cartel cases, e.g., the truck cartel, since they would involve the most amount of scrutiny and speculation. To solve this, there are a few ways one could adapt the methodology. Firstly, one would have to pinpoint the moment when the announcement of the whistleblower was revealed in the media. This way, one could add this date to the dataset and observe stock market reactions with a similar event window as used for t_i and t_d . It might, however, be difficult to determine the exact date at which it was revealed in the media as it would most likely include more speculative articles from less trustworthy sources before larger news sites start to write about it. Secondly, one could observe the stock market data for the entire investigation period, i.e., from the initiation of the investigation to the fine announcement. This way, one could control for insider information and the difficulty of pinpointing the exact moment the whistleblower was revealed in the media. The problem with this method is the event window for which data would be needed. Carree et al. (2009) found that antitrust investigations by the EC take on average 20 months. The length of event windows for which stock prices would have to be observed would lead the data to be even noisier which would require significantly larger sample sizes to get conclusive evidence.

Related to H_2 we will specifically look at the MLR results from test 6.4. The variable of interest in this case is the fine avoided as a percentage of market capitalization. The results of this variable can give a more compelling outcome due to it being a running variable, unlike the binary variable of receiving immunity or not, which is reserved for one firm within each cartel. The variable of fine avoided therefore more accurately represents the level of cooperation of firms. Given that this looks at fines explicitly, which are announced at the final decision, we specifically looked at dataset D. When clustering the results, which is highly relevant to observe within-case variation and looking at event windows of ± 5 days and above, we can see that an increase in fine size avoided in relation to a firm's size is associated with positive stock market reactions. This, again significant at a 95% significance level. Relating back to the two types of cooperation, this test specifically observes the second type. This occurs when one firm has already come forward so the possibility of receiving immunity is retracted but the risk of being caught is significantly higher. At this moment, firms can be incentivized to cooperate through the potential reduction in fines of up to 50%. These results speak in favor of this type of cooperation being incentivized by the leniency program. From a policy perspective, the results from test 6.3 and 6.4 are important findings as they show that the market values cooperation with investigators due to the incentive of receiving fine reductions and the market rewards firms that blow the whistle on the cartel and cooperate up until conviction.

Having received these significant results in line with our hypothesis in test 6.4 using larger event windows, we must also note the results seen from the event window of $-3/+5$ days which show the opposite sign of the coefficient for the same variable, also at a significant level. If one were to judge this result at face value, it suggests that a higher fine avoided is associated with a decrease in stock value around the final decision using an event window of $-3/+5$ days. This goes against logical reasoning as well as the other findings in the same table. While this is difficult to rationalize, one explanation of this could be due to dataset D's inability to incorporate the immunity reveal for certain cases when using the shorter event windows. Thus, it is more relevant to observe the longer time periods, accounting for a larger pricing of immunity status and thereby fine sizes avoided. In conclusion, as the results vary depending on time intervals used, we must state that the evidence in support of H_2 is promising but inconclusive.

A few additional points to be made is with regard to differences in effect across industries. This can be seen in the appendix showing the MLR results including the industry variables. The main reason for including industry classifications in the MLR is to control for differences in stock reactions between industries. The coefficients of each industry control variable should be interpreted carefully. This is because they are given values that are related to a particular industry classification. This industry is communication services, which happens to be the least common industry in our sample. Not surprisingly, by using this as a benchmark we are given very biased coefficients for the rest of the industry classification variables.

The reaction of an investor towards a firm being convicted of cartel participation and on the question of leniency will also depend on the risk preferences of the investor and on the possibility of investor activism. Firstly, a firm consisting of investors with a lower risk tolerance or with a particular focus on ESG issues might be more likely to apply for leniency if already involved in a cartel. Additionally, the presence of these investors might decrease the risk of the firm joining the cartel in the first place. The reason for both of these being the desire for social responsibility of acting in accordance with the law and

the decreased risk of having to pay high fines. Secondly, investors that are particularly concerned of ESG issues or have low risk tolerance might refrain from firms with a history of cartel participation or from industries with a higher risk of collusion. The presence of these kinds of investors could increase the role of the market signal effect on the share prices as their value is not only based on financial returns but on matters related to governance and responsibility. However, to empirically test these theories and how they are related to leniency lies beyond the scope of this paper. We will discuss the potential use of integrating qualitative interview and survey data into the analysis in section 7.3.

Although we did not account for these qualitative differences, we did receive important results regarding the investors' valuation of the fine decision disregarding the fine size. By the statistically negative residual we can tell that investors awaited harsher fines. The interpretation of this figure is understanding that investors fear the EC and respect its ability in punishing firms that collude and gain an unfair advantage. It is however important to understand that this residual can be viewed as a market imperfection and thus the EC must maintain this preconception. If the EC is unable to do so, the market will correct its understanding of the policy's rigor, possibly decreasing the potential investor activism effects.

To conclude, the main purpose of this paper was to evaluate the incentives of cooperation provided by the current European leniency program. The incentives should exist at all times during the lifespan of the cartel. Initially, when the secrecy of the cartel is upheld and there are no investigations threatening the cartel's dissolution, the incentives for cooperation must be very strong. The prospect of receiving total immunity from fines and the many times this has happened since 2006 could by itself provide enough incentives. When observing the stock market reactions to firms receiving this immunity as done in this paper, we can see additional evidence in support of these incentives. The second period in the life of the cartel at which there must be incentives for firms to cooperate is from the moment a different cartel firm steps forward. From this time, the prospect of receiving total immunity from fines is retracted as it has been reserved for the first firm to come forward. There are, however, more incentives of cooperation as the probability of the cartel's survival is reduced significantly. What remains is the possibility of leniency reductions of up to 50% of the fine, which at its own should provide incentives. The MLR results suggest this to be the case when it comes to stock returns as well. This is due to the significant positive results from the variable showing the fine avoided in relation to market cap at the event windows beyond -3/+5 days. These two findings are the most prominent in this paper when analyzing the incentives of cooperation throughout the cartel's lifetime.

7.2 Limitations:

Our study, whilst presenting unique figures and results that have previously not been researched aiding the understanding of the EU's leniency policy effectiveness in terms of providing incentives for cooperation, has faults that impact the findings' validity and usability. These limitations include using benchmark indexes that involve the observed firms, inadequate choice of method for calculating expected returns, the lack of acknowledgement of increases in volatility during the event window, failure to perform robustness tests, and only looking at the financial effects.

The choice of index, which is the benchmark used to estimate the expected return during the event window, was the country indexes created by the FTSE Russell group. The main reason for using these indexes was to provide a consistent measure for all of the companies, with one exception noted in section 5.1.2. Therefore, despite the large sample group of 188 companies, we obtained a uniform benchmarking solution. A problem with using these indexes is that they are market-cap-based and that there are instances of the companies being a part of their respective index. The worry is that this can give rise to endogeneity issues since the event pricing of individual securities is included in the expected return and thus masks the true nature of the effects. One example which can shed light on this issue is the usage of the FTSE Germany Index (^WIDEU) in the estimation of the expected return of Daimler (MBG), BMW (BMW) and Volkswagen Group (VOW3). Daimler accounted for 4.56%, Volkswagen for 2.79% and BMW for 2.07% of the index in July of 2021, at the time of immunity and fine publication relating to the Car Emissions case. When 9.42% of the index is composed of the affected companies, the expected return is calculated using a benchmark that already contains elements of the pricing of the information for which we seek to value the impact. This causes endogeneity issues as the error term, AR, will be correlated with the benchmark and thereby taints the true value of the event since the effect becomes subdued as a result. Because we use market-cap based indexes this issue is heightened when the number

of companies in the indexes becomes smaller and the companies in our sample become larger. As 53% of our sample is made up of large-cap companies this causes large risks. To mitigate these risks, improved benchmarks can be created, excluding the compromised firms.

Another solution to mitigate these risks is using alternatively weighted indexes for each of the companies. This could be in the form of equal weighting, as shown by DeMiguel et al. (2009), Jacobs et al. (2013), Plyakha et al. (2014). For minimum variance portfolios, see Clarke et al. (2006), Scherer (2010) and Xing et al. (2014). For fundamental weighting, see Arnott et al. (2005), Blitz et al. (2011) and Clare et al. (2013). Furthermore, for the adjusted market return method which relies on the CAPM, we should include the robustness through the usage of different expected return calculations. We could for example use the three model factor by Fama and French (2015) including size, and value effects. Another method is the mean return model, which only takes into consideration the previous performance of the same individual security as the below shows:

$$R_{it} = \alpha_i + u_{it}$$

Furthermore, instead of the T-test methodology, we could have used the BMP test approach, developed by Kolari and Pynnönen (2010), based on standardized tests developed by Boehmer et al. (1991). This approach uses scaled CAARs, an unbiased estimator of the standard deviation and accounts for average sample cross-correlation. Due to likely autocorrelation and the existence of heteroskedasticity in our data as a result of time fixed effects of cases in terms of severity, trading volumes, trading volatility, etc. Kolari and Pynnönen (2010) show that the robustness of the results can be improved by using this method.

The inclusion of this methodology could potentially change the distribution of the errors. Kothari and Warner (1997) discuss the importance that the normal distribution of errors has on the ability to use an empirical strategy, largely based on the OLS framework such as our MLR reliant on these assumptions. Thereby, a change would require future researchers to observe the distribution and take a stance on the usability of data and possible reliance on the central limit theorem.

Although many authors of works using a similar empirical strategy to the one explained in section 5.2 use double-blind placebo tests, it is difficult to conduct these tests for all of the 188 observations of unique viewed prices. Though possible and shown to be useful in countless papers, in order to assess how robust the observations in a sample are, the procedure is time consuming as it requires a lot of manual work, thereby also opening for human error. However, given the smaller and noisy immunity sample, it may be worth conducting these tests anyways. Our data collection and method of calculating the expected returns, abnormal returns and CAARs were made manually. The issue is that we are prone to making mistakes, thereby threatening the reliability of the input. However, to mitigate this we triple-checked the data points entered by hand and the calculations made. Having mentioned this, there is still a chance for human error affecting the input and thus the validity of the output.

Additionally, there may be more control variables which should have been included in our MLR regressions. As shown by Bosch and Eckard (1991) and Gunster and Van Dijk (2016), media coverage can have significant impacts on the stock price performance and thereby an impact on the CAAR. In case of more time and chance for further research, it would be beneficial to see how media coverage can impact the CAARs of the observations. One could possibly use media coverage as a mediating variable on the immunity and fine size avoided variables.

Kothari and Warner (1997) discuss the issue of using the market return approach in event studies. The issue is that event periods are associated with increased uncertainty and thereby increased volatility. Using historical prices might understate the volatility and thereby neglect some fixed event period volatility not directly resulting from the event. Therefore the statistical significance of the event-window abnormal returns can be overstated, see Brown and Warner (1980) and (1985), and Collins (2013). One way to counteract this is to estimate the increase in variability in returns during the event and non-event period and take a ratio of the variances. Thereafter, you incorporate the ratio into the analysis to adjust for the statistically biased expected return. The methodology of the above is laid out in Bouchev et al. (2012).

Finally, a limitation of our paper is the scope of only including financial impacts of the leniency and fine event-related information. As discussed in section two and shown in studies such as by García et al. (2022), there are social impacts that we disregard. The leniency and immunity policy needs to reduce the negative impacts mentioned and thereby allow for the positive impacts that improvements in

economic conditions can have on society and the environment. Although this was outside the scope of our study.

7.3 Future Research

Given the present literature, the scope of this paper, and the limitations to our methodology, there are a few available directions for future research within the area of antitrust policy and leniency programs. Initially, there are ways in which the methodology of this paper could be developed for future papers. In this paper, we use stock performance as the only dependent variable of interest. One could observe other performance measures or decisions taken by firms that are associated with cartel participation and leniency applications. When obtaining the data we noted the active presence of repeat offenders, which would indicate weak deterring effects of the current policies. For future papers, repeat offenses could be used as a dependent variable in determining the deterrence of the policy. Additionally, as described in the limitations of our study, there are other independent variables that one could use to build on from this paper, for example, media coverage. As stated in the limitations section, previous research has found media coverage to be effective in determining stock reactions to cartel convictions. In the context of leniency policy, this is also relevant as the timing of the whistleblowing firm revealed in the media would be an important period around which to observe the stock market reactions. Media coverage and other relevant variables could be included in the MLR tests in observing differences in CAAR.

A second way of evaluating the current leniency policy would be to include data from before the current policy regime came into place. In this paper, we exclusively use data from after 2006 so we get an unbiased view over the effects of the current policy program. However, if one were to empirically compare different policy programs, one would need data from both periods. In the case of using stock performance as a measure of policy effectiveness, this could be done with a similar methodology as used in this paper. However, this includes the risk of omitted variable bias when comparing data from different times or places. If one were to compare cartel data from now with data from prior to 2006, there are different economic factors that could be difficult to control for. This is also the case if one were to compare two different regions, for example, the EU's leniency program with 'The United States'. This includes differing institutional regimes that would require creative econometric methods to control for. An example of this is (Borrell et al., 2013) comparing the effectiveness of countries differing leniency policies, using executives' business sentiment as an output variable. This would also solve the problem of having too small samples of firms receiving immunity. In our study, we have a total of 38 observations of total immunity. In order to increase this, one might have to go across institutional lines by including observations from other countries' antitrust policies.

Finally, one could conduct a more qualitative study on the actions and decisions of stakeholders associated with cartel firms related to antitrust investigations and leniency. This includes investors, as they are involved in determining the stock value of firms involved in cartel investigations. By holding interviews with investors, one could gain an in-depth understanding of how they view the different costs associated with cartel participation and in particular whistleblowing. This way, one could determine whether the actions of investors are consistent with what the current theory suggests, and how the different costs associated with cartel participation are weighed into the value of the firm. Further, this would lead to insights regarding the role of information leakages, which have proven to be of importance in this paper. Qualitative studies could also be done with managers and employees to get in touch with their view of whistleblowing. Previous research including Jimenez et al. (2023) have looked at the characteristics of firms applying for leniency, which is relevant for policymakers in developing incentives for firms to blow the whistle. Qualitative insights on the individuals within cartel firms and the decisions taken by them would be beneficial for building incentives for individual people to come forward, against the recommendation of their company.

Bibliography

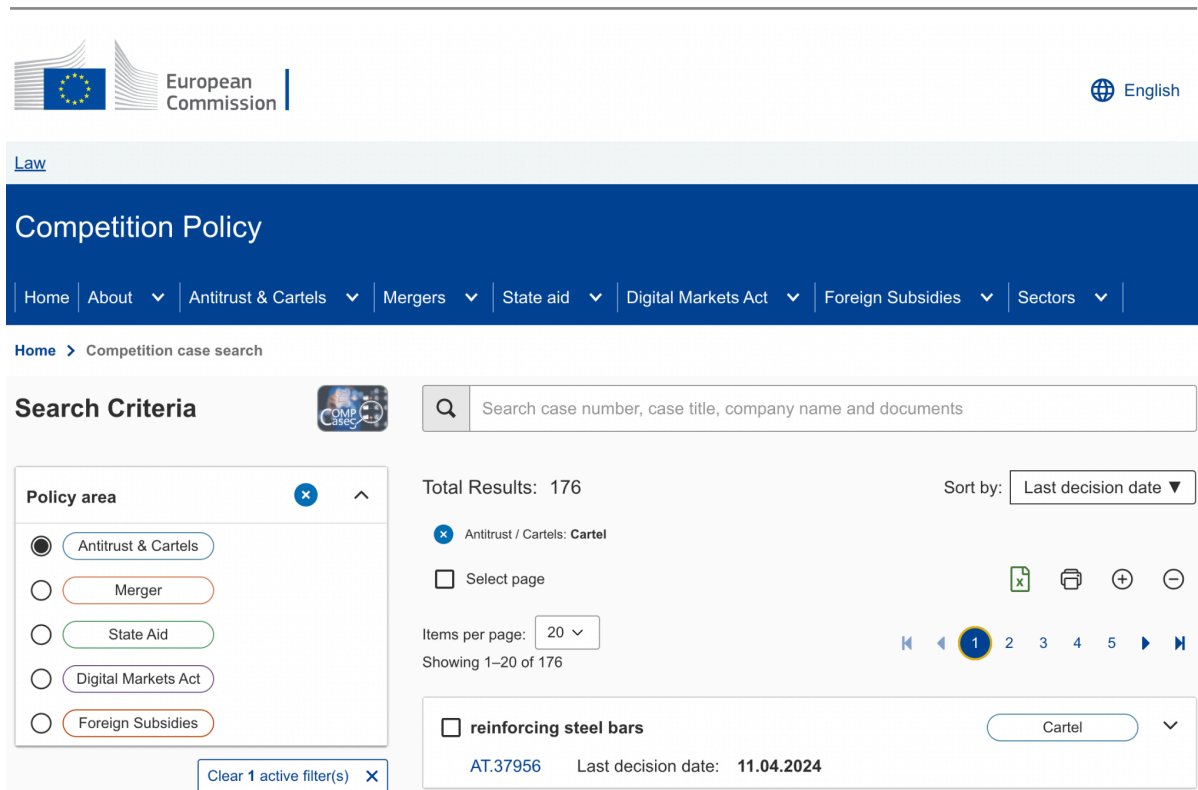
- Aguzzoni, L., Langus, G. and Motta, M. (2013) 'The effect of eu antitrust investigations and fines on a firm's valuation', *The Journal of Industrial Economics*, 61(2), pp. 290–338.
- Ahern, K.R. (2017) 'Information networks: Evidence from illegal insider trading tips', *Journal of Financial Economics*, 125(1), pp. 26–47.
- ANDERSEN, M.L. and DEJOY, J.S. (2011) 'Corporate Social and financial performance: The role of size, industry, risk, R&D and advertising expenses as control variables', *Business and Society Review*, 116(2).
- Article 101 Investigations (no date) Competition Policy. Available at: https://competition-policy.ec.europa.eu/antitrust-and-cartels/procedures/article-101-investigations_en (Accessed: 28 April 2024).
- Asness, C. S., Frazzini, A. & Pedersen, L. H. (2013). Quality Minus Junk. Working Paper.
- Arnott, R. D., Hsu, J. C., & Moore, P. (2004). Fundamental indexation. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.604842>
- Aubert, C., Rey, P. and Kovacic, W.E. (2006) 'The impact of leniency and whistle-blowing programs on cartels', *International Journal of Industrial Organization*, 24(6), pp. 1241–1266.
- Ball, R. and Brown, P. (1968) 'An empirical evaluation of accounting income numbers', *Journal of Accounting Research*, 6(2), p. 159.
- Banz, R.W. (1981) 'The relationship between return and market value of common stocks', *Journal of Financial Economics*, 9(1), pp. 3–18.
- Beyer, C., Kottmann, E. and von Blanckenburg, K. (2020) 'The welfare implications of the European Trucks Cartel', *Intereconomics*, 55(2), pp. 120–126.
- Blitz, D. D., Huij, J. & Martens, M. (2011). Residual momentum. *Journal of Empirical Finance*, 18(3), pp. 506–521.
- Boehmer, E.; Masumeci, J. and Poulsen, A., 1991, 'Event Study Methodology under Conditions of Event Induced Variance', *Journal of Financial Economics*, 30, pp. 253–272.
- Borrell, J.-R., Jimenez, J. L., & Garcia, C. (2013). Evaluating antitrust leniency programs. *Journal of Competition Law and Economics*, 10(1), 107–136. <https://doi.org/10.1093/joclec/nht017>
- Bosch, J.-C. and Eckard, Jr., W., (1991), 'The Profitability of Price Fixing: Evidence from Stock Market Reaction to Federal Indictments', *The Review of Economics and Statistics*, 73, pp. 309–317.
- Bos, I., & Schinkel, M. P. (2006). On the scope for the European Commission's 2006 fining guidelines under the Legal Fine Maximum. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.940107>
- Bouchey, P. et al. (2012) 'Volatility harvesting: why does diversifying and rebalancing create portfolio growth?', *The Journal of Wealth Management*, 15(2), pp. 26–35.
- Bradford, A. et al. (2019) 'The global dominance of European competition law over American antitrust law', SSRN Electronic Journal [Preprint].
- Brenner, S. (2009) 'An empirical study of the European Corporate Leniency Program', *International Journal of Industrial Organization*, 27(6), pp. 639–645.
- Brown, S. J. and Warner, J. B., (1980), 'Measuring Security Price Performance', *Journal of Financial Economics*, 8, pp. 205–258.
- Brown, S. J. and Warner, J. B., (1985), 'Using Daily Stock Returns: The Case of Event Studies', *Journal of Financial Economics*, 14, pp. 3–31.
- Bruneckienė, J. et al. (2015) 'Analysis of the impact of cartels on national economy and Competitiveness', *The Impact of Cartels on National Economy and Competitiveness*, pp. 135–154.
- Burns, J.W. (1958) *A study of the antitrust laws*. New York: Central Book Company.
- Campbell, J.Y., MacKinlay, A.C. and Lo, A.W. (1997) 'The econometrics of Financial Markets', *The Econometrics of Financial Markets* [Preprint].
- Carree, M.A., Guenster, A. and Schinkel, M.P. (2009) 'European antitrust policy 1957-2004: An analysis of commission decisions', SSRN Electronic Journal [Preprint]. doi:10.2139/ssrn.1162145.
- Christophe Carugati Dr. Christophe Carugati was an affiliate fellow at Bruegel on digital and competition issues until December 2023. <https://www.bruegel.org/first-glance/competition-politicisation-not-competition-its-harmful-protectionism> (Accessed: 28 April 2024).
- Clare, A., Motson, N. & Thomas, S. (2013). An evaluation of alternative equity indices - part 2: Fundamental weighting schemes. Working Paper.

- Clarke, R., De Silva, H. & Thorley, S. (2006). Minimum-variance portfolios in the U.S. equity market. *The Journal of Portfolio Management*, 33(1), pp. 10-24.
- Collins, John Parnell, "Comparison of Methods for Estimating Stochastic Volatility. " Master's Thesis, University of Tennessee, 2013.
- Combe, E. and Monnier, C. (2009) 'Fines against Hard Core Cartels in Europe: The myth of over enforcement', SSRN Electronic Journal [Preprint]. doi:10.2139/ssrn.1431644.
- DeMiguel, V., Garlappi, L. & Uppal, R. (2009). Optimal versus naive diversification: How inefficient is the 1/n portfolio strategy? *Review of Financial Studies*, 22(5), pp. 1915-1953.
- Dick, A.R. (1996) 'Identifying contracts, combinations and conspiracies in restraint of Trade', *Managerial and Decision Economics*, 17(2), pp. 203-216.
- Dinlersoz, E. et al. (2018) Leverage over the life cycle and implications for firm growth and shock responsiveness [Preprint].
- Eugene F. Fama and Kenneth R. French (2015). A five-factor asset pricing model.
- European Commission 'Competition case search'. (n.d). <https://competition-cases.ec.europa.eu/search?caseInstrument=AT&caseCartel=true&sortField=caseLastDecisionDate&sortOrder=DESC>
- European Commission. (2016). 'Antitrust: Commission fines truck producers € 2.93 billion for participating in a cartel'. https://ec.europa.eu/commission/presscorner/detail/en/IP_16_2582
- European Commission. (2017). 'Antitrust: Commission fines Scania €880 million for participating in trucks cartel'. https://ec.europa.eu/commission/presscorner/detail/en/IP_17_3502
- European Union, (2012) 'Treaty on the functioning of the European Union' (2012) [Preprint].
- Fama, E.F. (1970) 'Efficient Capital Markets: A review of theory and empirical work', *The Journal of Finance*, 25(2), p. 383.
- Fama, E.F. et al. (1969) 'The adjustment of stock prices to new information', *International Economic Review*, 10(1), p. 1.
- Garcia, C. (2022) 'Cartelization: Is it worth it?', SSRN Electronic Journal [Preprint].
- Geradin, D. and Henry, D. (2005) 'The EC fining policy for violations of Competition Law: An Empirical Review of the commission decisional practice and the community courts' judgments', SSRN Electronic Journal [Preprint]. doi:10.2139/ssrn.671794.
- Gunster, A. and Van Dijk, M.A. (2016) 'The impact of European antitrust policy: Evidence from the stock market', SSRN Electronic Journal [Preprint].
- Günster, A., Carree, M., & van Dijk, M. (2010). Do cartels undermine economic efficiency? 4th CLEEN Workshop, Amsterdam, Netherlands, 21 April 2010.
- Hüschelrath, K. and Veith, T. (2015) 'Cartelization, cartel breakdown, and price behavior: Evidence from the German Cement Industry', *Journal of Industry, Competition and Trade*, 16(1), pp. 81-100.
- Jacobs, H., Mueller, S. & Weber, M. (2013). How should individual investors diversify? an empirical evaluation of alternative asset allocation policies. Working Paper.
- Jiménez, J.L., Ojeda-Cabral, M. and Ordoñez de Haro, J.M. (2023) 'Who blows the whistle on cartels? finding the leniency applicant at the European Commission', SSRN Electronic Journal [Preprint].
- Kolari, J. and Pynnönen, S., 2010, 'Event Study Testing with Cross-Sectional Correlation of Abnormal Returns,' *Review of Financial Studies*, 23, pp. 39-96.
- Kothari, S.P. and Warner, J.B. (1997) 'Measuring long-horizon security price performance', *Journal of Financial Economics*, 43(3), pp. 301-339.
- Levenstein, M.C. and Suslow, V.Y. (2002) 'What determines cartel success?', SSRN Electronic Journal [Preprint].
- LSEG. (2023). Building a better US equity benchmark: Russell us indexes. <https://www.lseg.com/en/ftse-russell/research/building-better-benchmark-practical-guide-effective-market-representation>
- Marvão, C. (2015) 'The EU leniency programme and recidivism', *Review of Industrial Organization*, 48(1), pp. 1-27.
- Oliver, C. and Campbell, P. (2016) EU set to impose record cartel fine on Truckmakers, *Financial Times*. Available at: <https://www.ft.com/content/eba2818c-23f8-11e6-9d4d-c11776a5124d> (Accessed: 28 April 2024).
- Plyakha, Y., Uppal, R. & Vilkov, G. (2014). Equal or value weighting? Implications for asset-pricing tests. Working Paper.

- Polo, M. and Motta, M. (1999) 'Leniency programs and Cartel prosecution', SSRN Electronic Journal [Preprint].
- Scherer, B. (2010). A new look at minimum variance investing. Working Paper.
- Snedecor, G. W., & Cochran, W. G. (1989). Statistical Methods (8th ed.). Iowa State College Press.
- Spagnolo, Giancarlo. "Divide et Impera. Optimal Deterrence Mechanisms against Cartels and Organized Crime." RePEc: Research Papers in Economics, 11 Aug. 2004.
- Sproul, M.F. (1993) 'Antitrust and prices', Journal of Political Economy, 101(4), pp. 741–754. doi:10.1086/261895.
- Standard & Poor's Capital IQ, (n.d.) 'S&P Capital IQ' <https://www.capitaliq.com/>
- Stephan, A. (2007) 'Survey of public attitudes to price-fixing and cartel enforcement in Britain', SSRN Electronic Journal [Preprint].
- Symeonidis, G. (2018) 'Collusion, profitability and welfare: Theory and evidence', Journal of Economic Behavior & Organization, 145, pp. 530–545.
- Veljanovski, C. (2007) 'Cartel fines in Europe—law, practice and deterrence', World Competition, 30(Issue 1), pp. 65–86.
- Wils, W.P. (2006) 'Optimal antitrust fines: Theory and practice', World Competition, 29(Issue 2), pp. 183–208. doi:10.54648/woco2006014.
- Wurmnest, W. (2023) 'Assessing antitrust damages in follow-on actions against cartels', Cambridge Yearbook of European Legal Studies, pp. 1–17.
- Xing, X., Hu, J. & Yang, Y. (2014). Robust minimum variance portfolio with l-infinity constraints. Journal of Banking & Finance, 46, pp. 107–117.

Appendix

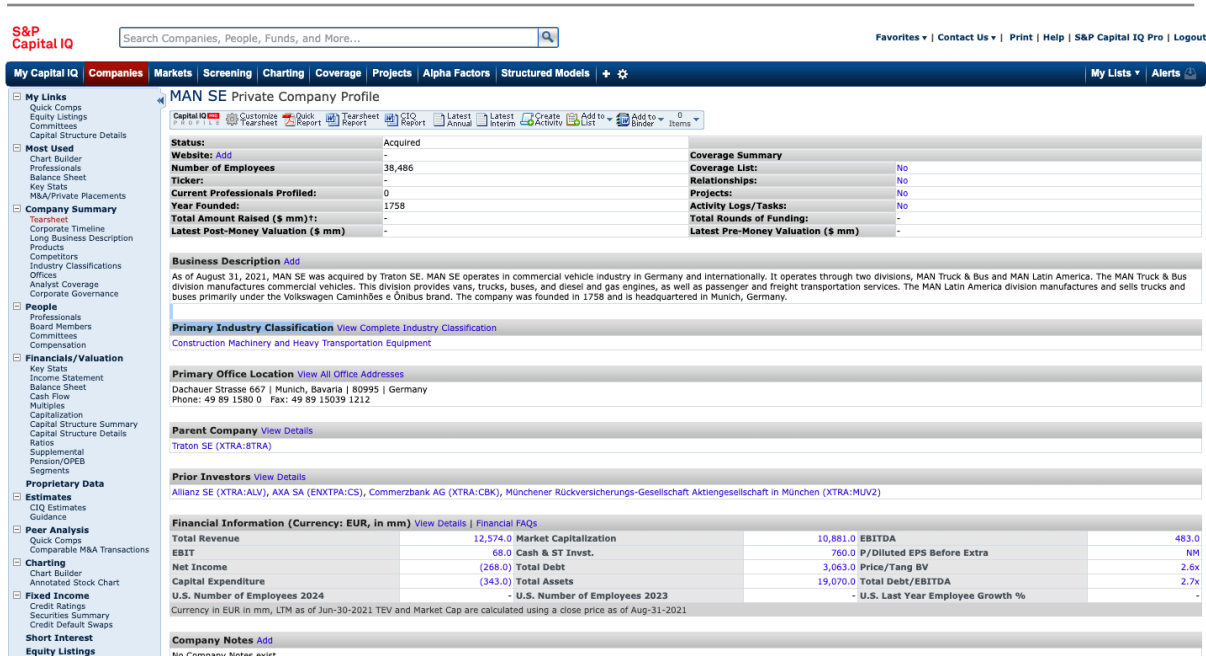
Appendix Figure 1: Screenshot of the European Commission Competition Policy Website



The screenshot shows the European Commission Competition Policy Website. The header includes the European Commission logo and the word "English". The main navigation bar lists various policy areas: Home, About, Antitrust & Cartels, Mergers, State aid, Digital Markets Act, Foreign Subsidies, and Sectors. Below this, a search bar is present with the text "Search case number, case title, company name and documents". The search results show 176 total results, sorted by "Last decision date". The search criteria are set to "Antitrust / Cartels: Cartel". The results list includes "reinforcing steel bars" with case number "AT.37956" and a last decision date of "11.04.2024".

(European Commission, n.d.)

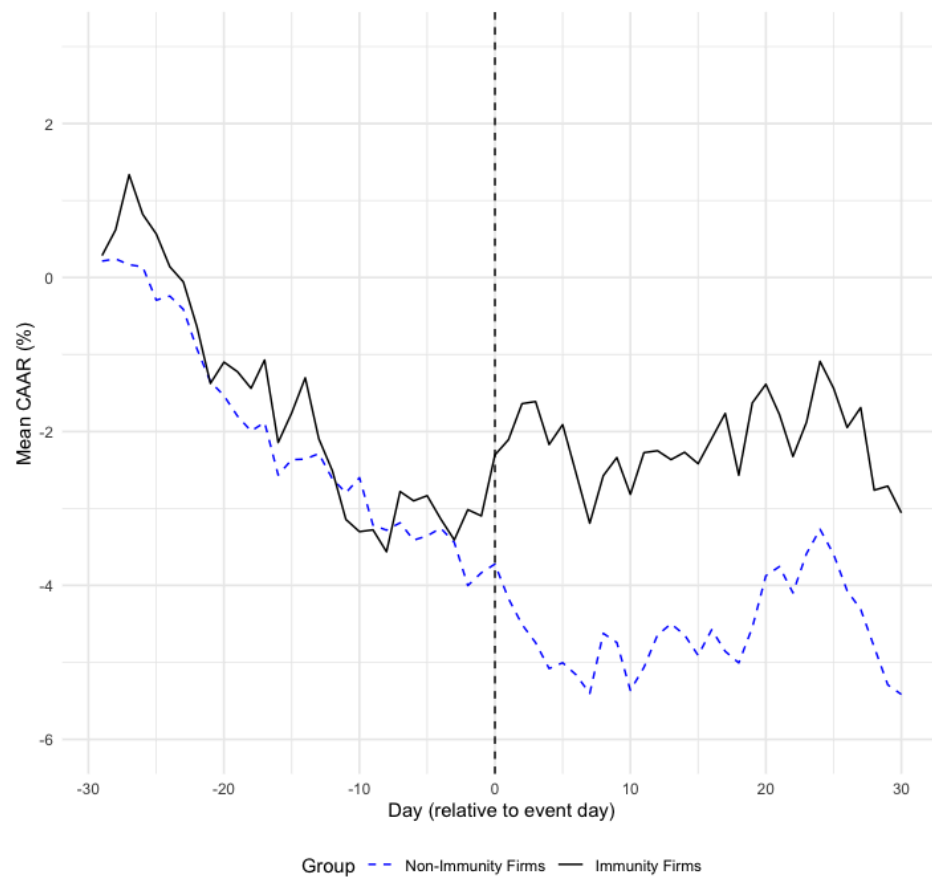
Appendix Figure 2: Screenshot of The S&P Capital IQ Website



The screenshot shows the S&P Capital IQ website. The header includes the S&P Capital IQ logo and a search bar. The main navigation bar lists various sections: My Capital IQ, Companies, Markets, Screening, Charting, Coverage, Projects, Alpha Factors, Structured Models, and My Lists. The main content area displays the "MAN SE Private Company Profile". The profile includes sections for Status, Coverage Summary, Business Description, Primary Office Location, Parent Company, Prior Investors, Financial Information, and Company Notes. The Financial Information section shows key metrics such as Total Revenue, EBIT, Net Income, Capital Expenditure, and Market Capitalization.

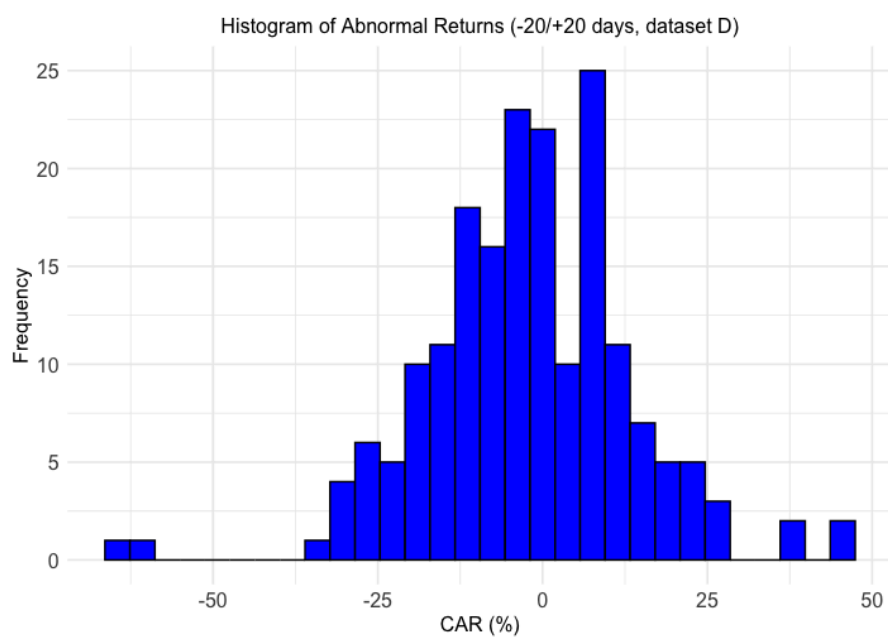
Note: We utilized the Broadset Industry Classification and Chart Builder (Dividend-Adjusted Share price and Mkt. Cap information) functions (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 3: CAAR time series (Immunity and non-immunity) Comparison - Dataset D



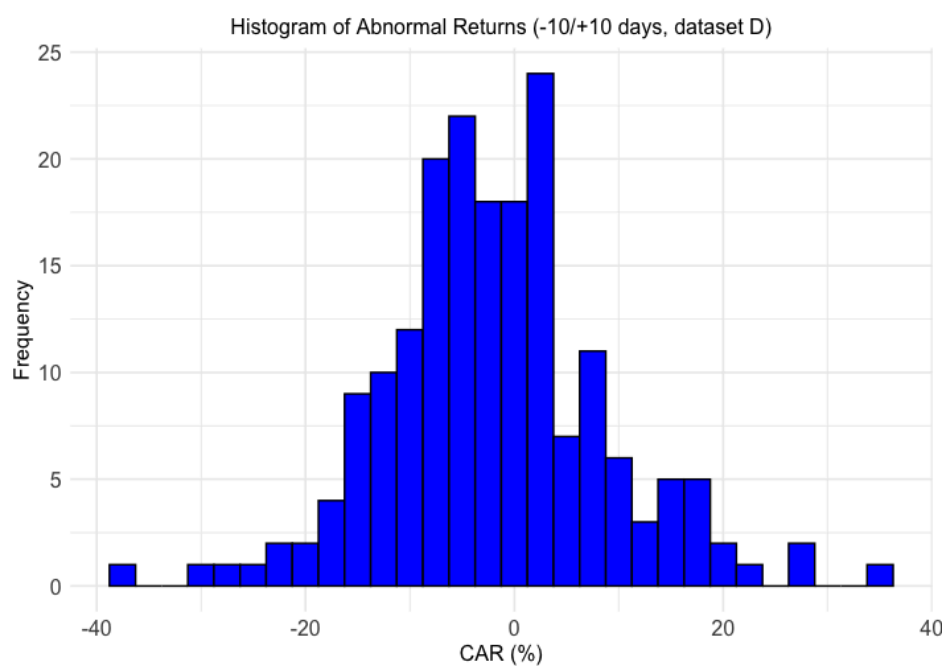
(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 4: CAAR (+/-20 days) distribution - Dataset D



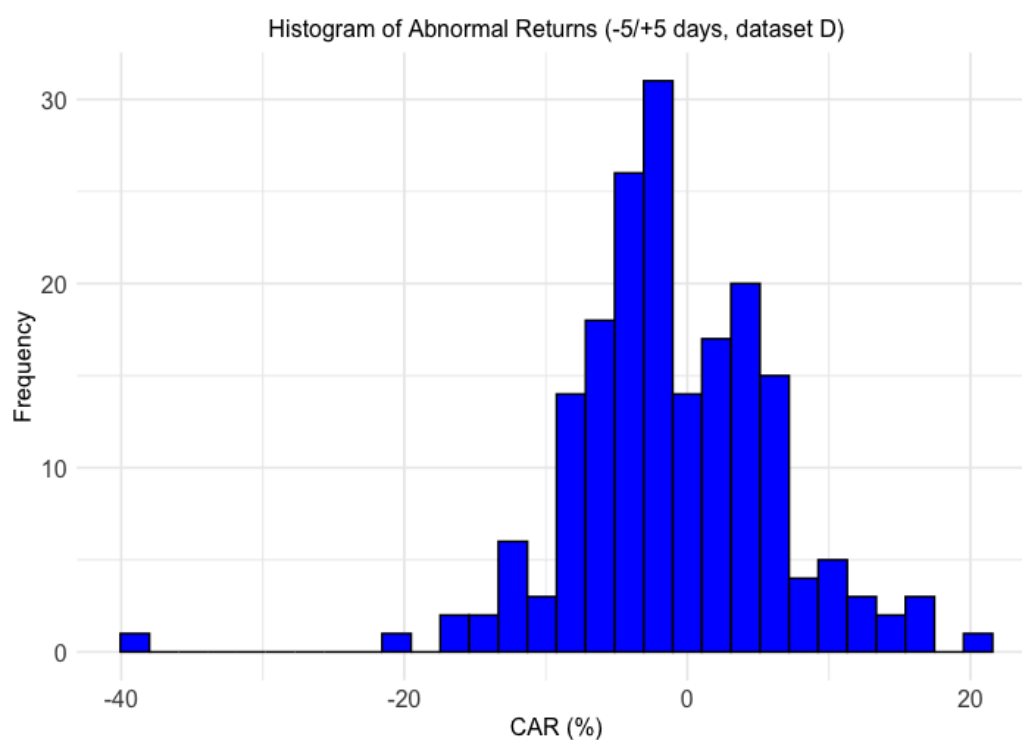
(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 5: CAAR (+/-10 days) distribution - Dataset D



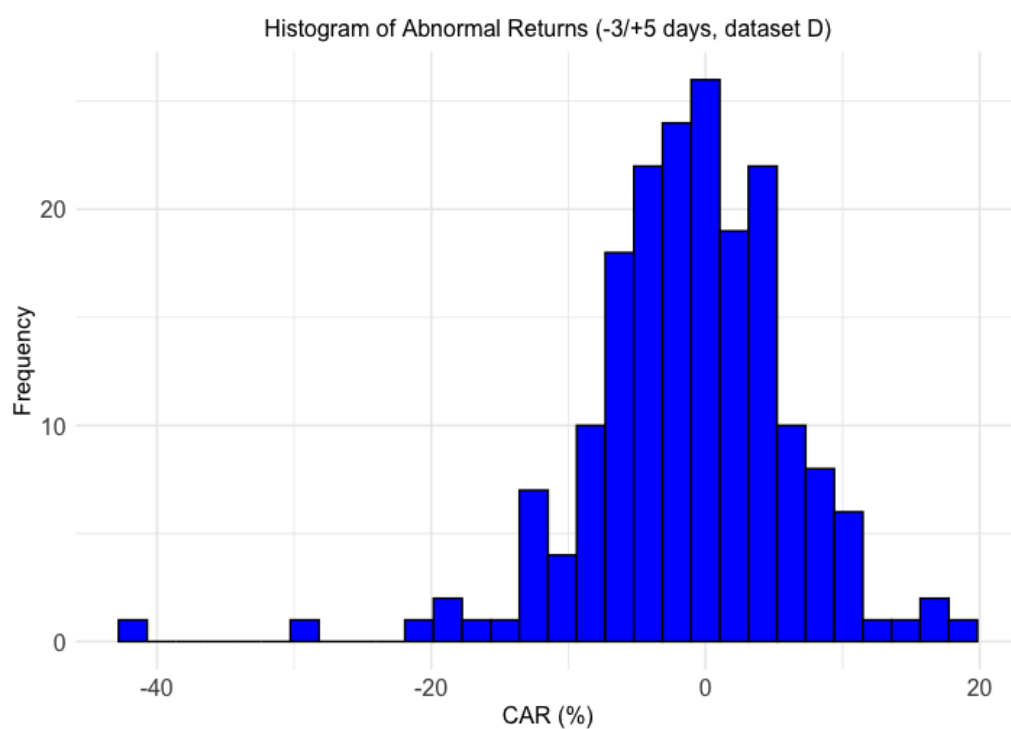
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Appendix Figure 6: CAAR (+/-5 days) distribution - Dataset D



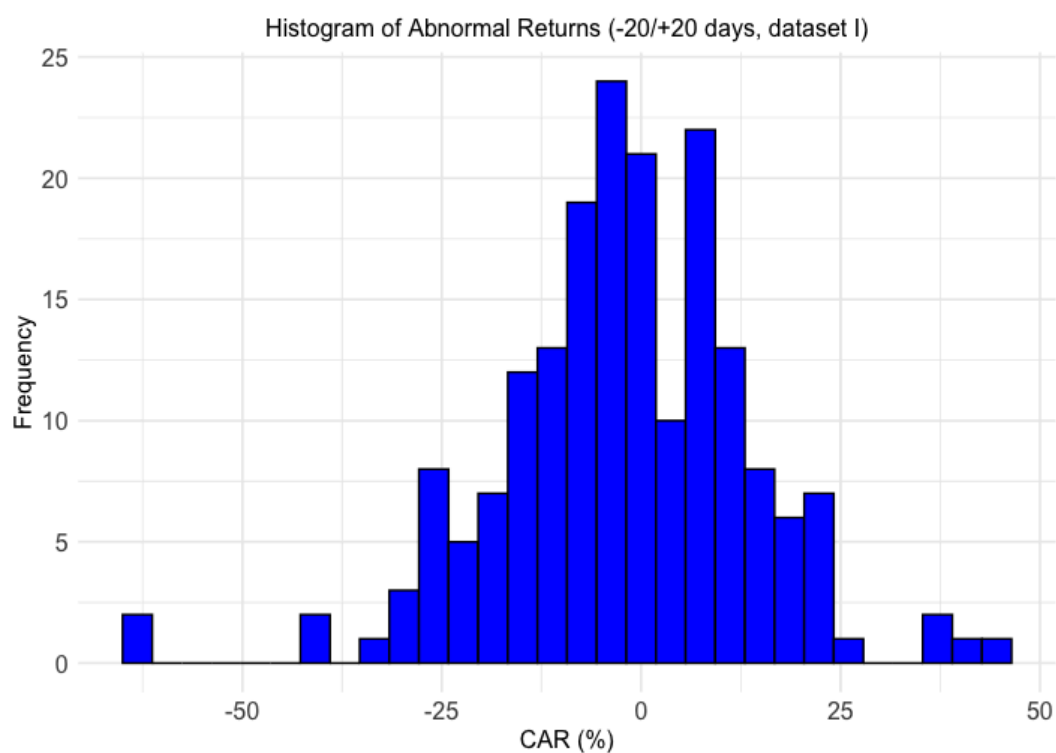
(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 7: CAAR (-3/+5 days) distribution - Dataset D



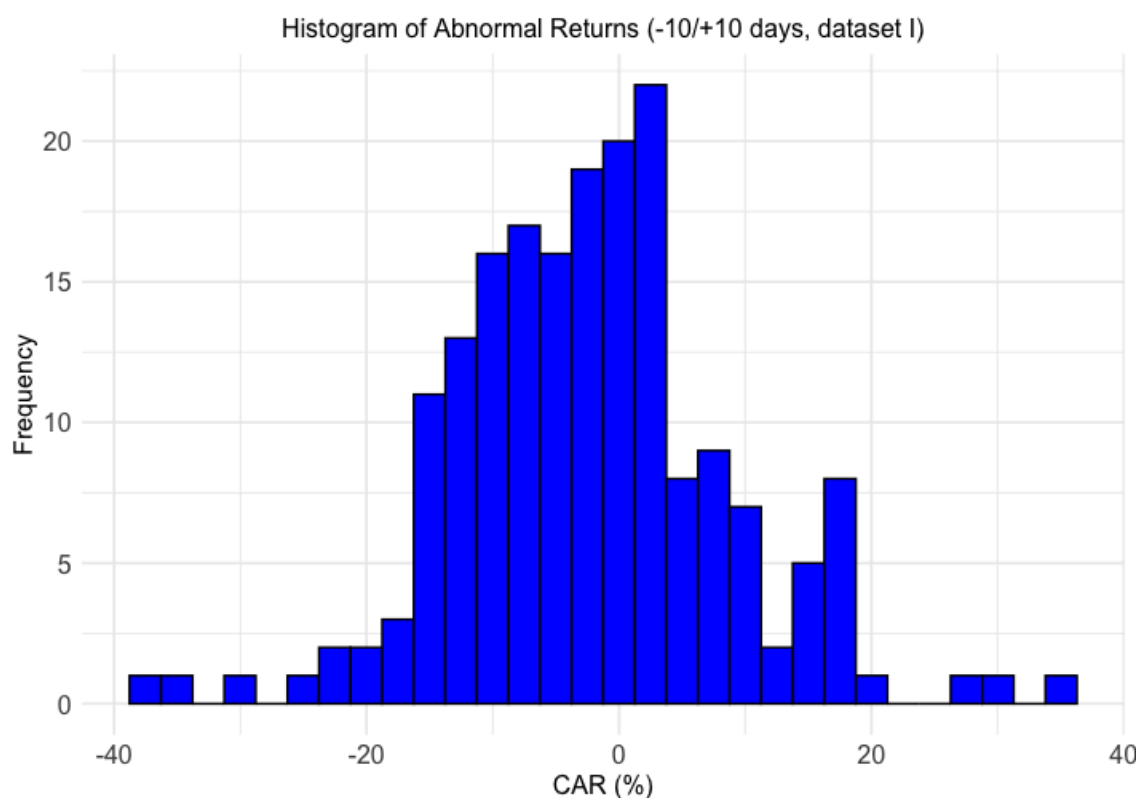
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Appendix Figure 8: CAAR (+/-20 days) distribution - Dataset I



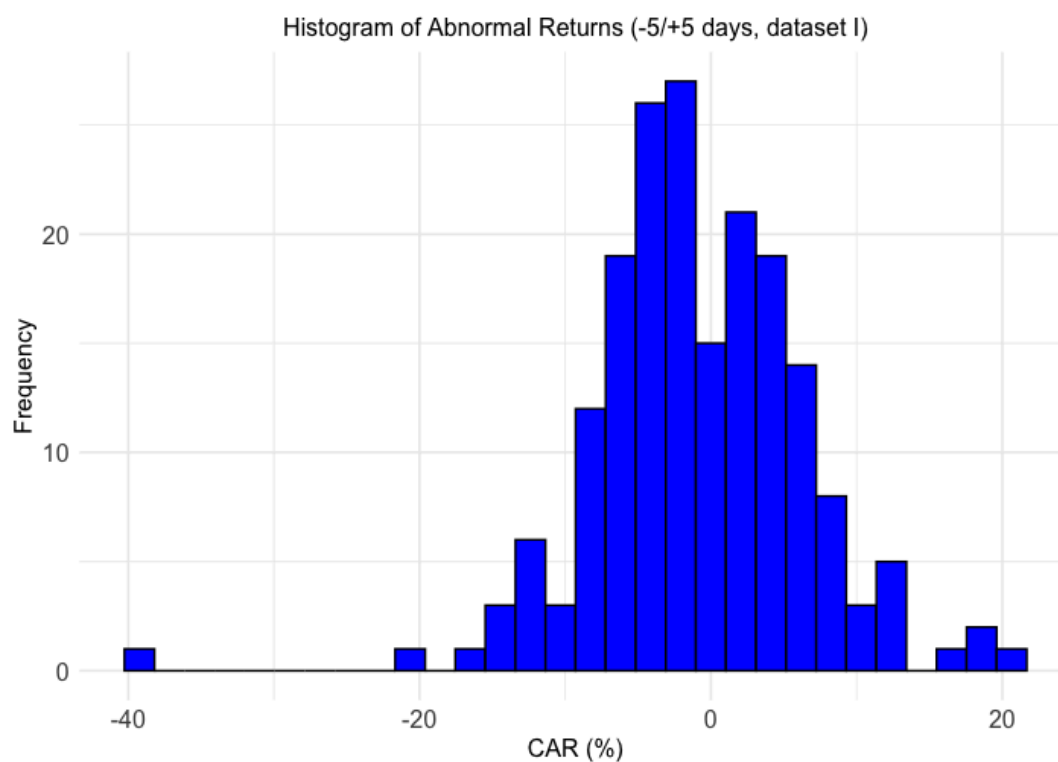
(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 9: CAAR (+/-10 days) distribution - Dataset I



(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Figure 10: CAAR (+/-5 days) distribution - Dataset I



(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 1: SLR Results (without Clustering) - Dataset D

Consolidated Simple Linear Regression Results for Dataset 'D' Type Across Event Windows - Without Clustering of Standard Errors				
	CAAR			
	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity Dummy	0.0297* (0.0135)	0.0258 (0.0132)	0.0289 (0.0193)	0.0251 (0.0287)
Constant	-0.0175** (0.0061)	-0.0159** (0.0059)	-0.0257** (0.0087)	-0.0252 (0.0129)
Observations	188	188	188	188
R ²	0.0254	0.0202	0.0119	0.0041
Adjusted R ²	0.0202	0.0149	0.0066	-0.0012
Residual Std. Error (df = 186)	0.0743	0.0726	0.1063	0.1579
F Statistic (df = 1; 186)	4.8520*	3.8342	2.2462	0.7667
<i>Note:</i>		* p<0.05; ** p<0.01; *** p<0.001		

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 2: SLR Results (without Clustering) - Dataset I

Consolidated Simple Linear Regression Results for Dataset 'I' Type Across Event Windows - Without Clustering of Standard Errors				
	CAAR			
	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity Dummy	0.0347* (0.0136)	0.0284* (0.0131)	0.0264 (0.0198)	0.0170 (0.0290)
Constant	-0.0161** (0.0061)	-0.0143* (0.0059)	-0.0282** (0.0089)	-0.0254 (0.0130)
Observations	188	188	188	188
R ²	0.0340	0.0245	0.0095	0.0019
Adjusted R ²	0.0288	0.0193	0.0042	-0.0035
Residual Std. Error (df = 186)	0.0747	0.0723	0.1089	0.1596
F Statistic (df = 1; 186)	6.5481*	4.6705*	1.7842	0.3459
<i>Note:</i>		* p<0.05; ** p<0.01; *** p<0.001		

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 3: SLR Results (with Clustering) - Dataset D

**Consolidated Simple Linear Regression Results for Dataset 'D' Type
Across Event Windows - With Clustering of Standard Errors**

	CAAR				
	+/- 1 day	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity dummy	0.0108 (0.0074)	0.0297* (0.0133)	0.0258 (0.0144)	0.0289 (0.0221)	0.0251 (0.0299)
Constant	-0.0017 (0.0031)	-0.0175** (0.0061)	-0.0159** (0.0057)	-0.0257** (0.0082)	-0.0252* (0.0127)

Note: *p<0.05; **p<0.01; ***p<0.001
Robust standard errors are clustered by case.

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 4: SLR Results (with Clustering) - Dataset I

**Consolidated Simple Linear Regression Results for Dataset 'I' Type
Across Event Windows - With Clustering of Standard Errors**

	CAAR				
	+/- 1 day	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity dummy	0.0137 (0.0074)	0.0347* (0.0133)	0.0284 (0.0144)	0.0264 (0.0221)	0.0170 (0.0299)
Constant	-0.0034 (0.0031)	-0.0161** (0.0061)	-0.0143** (0.0057)	-0.0282** (0.0082)	-0.0254* (0.0127)

Note: *p<0.05; **p<0.01; ***p<0.001
Robust standard errors are clustered by case.

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 5: MLR Results (with Clustering) - Dataset D

Consolidated MLR Results for "D" Type Across Event Windows - Including Clustering of Standard Errors

	CAAR			
	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity dummy	0.0207 (0.0134)	0.0092 (0.0145)	0.0091 (0.0211)	-0.0009 (0.0305)
Fine avoided % of Mkt. Cap	-0.1003*** (0.0298)	0.1415*** (0.0268)	0.1314** (0.0431)	0.2938*** (0.0676)
Fine % of Mkt. Cap	-0.3045*** (0.0877)	-0.3977*** (0.0968)	-0.4339*** (0.1197)	-0.2278 (0.3079)
Repeat Offence Dummy	-0.0062 (0.0123)	-0.0090 (0.0124)	0.0107 (0.0212)	0.0168 (0.0300)
Settlement Notice dummy	0.0152 (0.0105)	0.0101 (0.0109)	-0.0106 (0.0178)	0.0126 (0.0274)
Days involved	0.000004 (0.000003)	-0.000000 (0.000003)	-0.000002 (0.000005)	-0.000002 (0.00001)
Mid Cap	0.0057 (0.0144)	0.0023 (0.0144)	0.0197 (0.0219)	0.0689* (0.0284)
Small Cap	-0.0052 (0.0165)	-0.0026 (0.0172)	0.0246 (0.0271)	0.0624 (0.0470)
Industry: Consumer Discretionary	-0.0502* (0.0214)	-0.0561* (0.0235)	-0.2178*** (0.0384)	-0.1278 (0.0669)
Industry: Consumer Staples	-0.0109 (0.0231)	-0.0148 (0.0247)	-0.0937* (0.0455)	0.0431 (0.0712)
Industry: Energy	-0.1596*** (0.0445)	-0.0973* (0.0444)	-0.2585*** (0.0418)	-0.1145 (0.0731)
Industry: Financials	-0.0342 (0.0221)	-0.0528* (0.0237)	-0.1856*** (0.0376)	-0.0978 (0.0623)
Industry: Health care	-0.0281 (0.0204)	-0.0411 (0.0326)	-0.1725*** (0.0406)	-0.0496 (0.0517)
Industry: Industrials	-0.0364* (0.0175)	-0.0408* (0.0188)	-0.1673*** (0.0335)	-0.1327* (0.0536)
Industry: Information Technology	-0.0374 (0.0246)	-0.0217 (0.0249)	-0.1489*** (0.0381)	-0.0638 (0.0580)
Industry: Materials	-0.0353 (0.0221)	-0.0383 (0.0286)	-0.1442** (0.0479)	-0.1109 (0.0780)
Industry: Utilities	-0.4399 (0.2900)	-0.0469 (0.3187)	0.0326 (0.5205)	0.0674 (0.8723)
Constant	0.0245 (0.0220)	0.0391 (0.0236)	0.1549*** (0.0440)	0.0460 (0.0666)

Note:

* p<0.05; ** p<0.01; *** p<0.001

Robust standard errors are clustered by case.

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 6: MLR Results (without Clustering) - Dataset D

Consolidated MLR Results for "D" Type Across Event Windows - Not Including Clustering of Standard Errors				
	CAAR			
	-3/+5 days	+/- 5 days	+/- 10 days	+/- 20 days
Immunity dummy	0.0207 (0.0136)	0.0092 (0.0139)	0.0091 (0.0202)	-0.0009 (0.0312)
Fine avoided % of Mkt. Cap	-0.1003 (0.0795)	0.1415 (0.0811)	0.1314 (0.1180)	0.2938 (0.1816)
Fine % of Mkt. Cap	-0.3045* (0.1250)	-0.3977** (0.1276)	-0.4339* (0.1855)	-0.2278 (0.2857)
Repeat Offence Dummy	-0.0062 (0.0120)	-0.0090 (0.0122)	0.0107 (0.0178)	0.0168 (0.0274)
Settlement Notice dummy	0.0152 (0.0114)	0.0101 (0.0116)	-0.0106 (0.0169)	0.0126 (0.0260)
Days involved	0.000004 (0.000003)	-0.000000 (0.000003)	-0.000002 (0.000005)	-0.000002 (0.00001)
Mid Cap	0.0057 (0.0136)	0.0023 (0.0139)	0.0197 (0.0202)	0.0689* (0.0311)
Small Cap	-0.0052 (0.0164)	-0.0026 (0.0167)	0.0246 (0.0243)	0.0624 (0.0375)
Industry: Consumer Discretionary	-0.0502 (0.0733)	-0.0561 (0.0748)	-0.2178* (0.1087)	-0.1278 (0.1674)
Industry: Consumer Staples	-0.0109 (0.0844)	-0.0148 (0.0861)	-0.0937 (0.1253)	0.0431 (0.1929)
Industry: Energy	-0.1596* (0.0751)	-0.0973 (0.0766)	-0.2585* (0.1114)	-0.1145 (0.1715)
Industry: Financials	-0.0342 (0.0742)	-0.0528 (0.0757)	-0.1856 (0.1101)	-0.0978 (0.1695)
Industry: Health care	-0.0281 (0.0772)	-0.0411 (0.0788)	-0.1725 (0.1146)	-0.0496 (0.1764)
Industry: Industrials	-0.0364 (0.0723)	-0.0408 (0.0738)	-0.1673 (0.1073)	-0.1327 (0.1652)
Industry: Information Technology	-0.0374 (0.0733)	-0.0217 (0.0748)	-0.1489 (0.1088)	-0.0638 (0.1675)
Industry: Materials	-0.0353 (0.0741)	-0.0383 (0.0756)	-0.1442 (0.1099)	-0.1109 (0.1692)
Industry: Utilities	-0.4399 (0.3522)	-0.0469 (0.3594)	0.0326 (0.5227)	0.0674 (0.8048)
Constant	0.0245 (0.0748)	0.0391 (0.0763)	0.1549 (0.1110)	0.0460 (0.1708)
Observations	188	188	188	188
R ²	0.2352	0.1607	0.1644	0.0955
Adjusted R ²	0.1587	0.0768	0.0809	0.0051
Residual Std. Error (df = 170)	0.0689	0.0703	0.1022	0.1574
F Statistic (df = 17; 170)	3.0755***	1.9146*	1.9680*	1.0559

Note:

* p<0.05; ** p<0.01; *** p<0.001

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)

Appendix Table 7: Wealth effects - Dataset I and D

Combined Wealth Effects Results - Without Distinction Between Immunity and Non-Immunity					
Event Window	Mean Value	T Value	Std. Deviation	P Value	Dataset
+/- 1 day	-0.0834	-0.3318	3.4458	0.7404	I
-3/+5 days	-0.6160	-1.3581	6.2193	0.1761	I
+/- 5 days	-0.6756	-1.4680	6.3100	0.1438	I
+/- 10 days	-1.2567	-2.0039	8.5987	0.0465	I
+/- 20 days	0.0885	0.1155	10.5049	0.9082	I
+/- 1 day	-0.3511	-1.3690	3.5169	0.1727	D
-3/+5 days	-0.7493	-1.6998	6.0441	0.0908	D
+/- 5 days	-0.8099	-1.8110	6.1320	0.0717	D
+/- 10 days	-1.5080	-2.4333	8.4972	0.0159	D
+/- 20 days	-0.0954	-0.1255	10.4238	0.9003	D

(European Commission, n.d.) and (Standard & Poor's Capital IQ, n.d.)