Assessing the comparative performance of competition authorities

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Abstract

Finding an effective way of assessing the performance of a competition authority is an objective that recently has been widely debated by academics and practitioners. Although several methods of evaluation exist, the issue that still remains unsolved is how the assessment could be done systematically. This thesis consists of one descriptive, and four substantive chapters, the substantive chapters (3-6) includes one theoretical and three empirical, all centred on the assessment of competition law and policy enforcement. The first empirical chapter (3) studies the determinants of the reputation of a competition authority (used as a proxy for performance). In the theoretical chapter (4), a model is developed to understand how an age profile of the number of cartels detected by a competition authority can reflect the combined effects of increasing detection efficiency and greater success of deterrence over time. The second empirical chapter (5) builds on the theoretical model and studies the age profile of cartel cases detected across time and between different competition authorities. Finally, the last chapter (6) empirically examines the possible interactions between the different types of competition cases (mergers, cartels, abuse) in the presence of a competition authority which is budget constrained, and therefore must choose how to allocate its resources between these different areas.

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Chapter 1 Introduction

Never mistake activity for achievement.

John Wooden, 2010

Performance has always been one of the key concerns of individuals, and profit as well as non-profit institutions. But the question commonly asked is how to assess such performance? Performance of individuals can normally be assessed using a metric usually tied to whether or not they performed a task and the amount of output they generated by doing so (key performance indicators). Performance of financial institutions can easily be measured by a host of financial indicators (price earnings ratio, Tobin q ratios, among others). But, when it comes to measuring the performance of non-profit institutions, more specifically competition authorities (CAs), it is not so straight forward. The mandate of CAs to detect (measurable) and deter (unmeasurable) anti-competitive conducts, makes it difficult for researchers and policy makers to come up with clear and well-defined standards to assess the performance of CAs.

"Performance, per se, is not a factor which can be isolated in a normal organizational system and there is no satisfactory qualitative model of the relationship between quality and efficiency of the organization" (Ciobanica, 2016). As highlighted by Petru (2007), it remains a priority to identify principles that could design and implement an effective system of performance management which in turn, could lead to excellence in the field of activity in which the organization operates. Therefore, by assessing how well a CA is doing, it will enable the latter to identify its weaknesses, develop the appropriate institutional and legal framework to progress and achieve the ultimate aim of competition policy[1] and law that is maximising consumer welfare.

Although the first competition law dates back to over 100 years, it is only recently that governments around the world have been focusing in promoting a competitive environment to make markets work well. In the last two decades, there has been a drastic increase in the number of countries establishing competition authorities (more than 120) around the world. CAs are increasingly attempting to review mergers, investigate alleged monopolisations and abuses of dominance, or join in the fight against cartels. But, the obvious question that now arises is how successful have CAs been in the enforcement of competition law and policy?

[1] Competition policy refers to government policy to prevent and reduce abuse of monopoly power, cartels and anti-competitive mergers. It encourages efficiency, creates a wider choice for consumers and helps reduce prices and improve quality (European Commission, 2016). As defined by Motta (2004), page 30, competition policy is 'the set of policies and laws which ensure that competition in the market place is not restricted in such a way as to reduce economic welfare'.

Although, it remains a difficult task to assess the performance of CAs, several attempts have been made by researchers and policymakers to come up with effective methodologies. Some of these are summarised in OECD (2005) and critically reviewed by Huschelrath & Leheyda (2010) and Davies & Ormosi (2012). The most extensive is the Competition Policy Index developed by Buccirossi et al (2009) and peer review.

This thesis belongs to this tradition, but hopefully adds to the existing work of the academics and experts in competition economics and policies such as Davies & Ormosi (2010, 2014, 2015), Hüschelrath & Leheyda (2010) and Kovacic (2009, 2011). It provides hopefully a significant contribution to the existing economics literature by firstly applying the count activity with a theoretical framework. Under count activity methodology, performance of a CA is directly related to the level of activity; the more cases the CA investigates, the better the performance. But when deterrence occurs it is likely to have a negative impact on the number of investigations. Secondly, this thesis looks at detection and deterrence at the same time. Thirdly, the use of the panel dataset brings both a time series and cross country dimension to the literature where the time series looks into the evolution of performance over time and the cross-sectional study enables the assessment of performance across countries. By enabling the identification of the countries which are doing well and doing poorly, those doing poorly can learn from those doing well to improve their performance. And fourthly, in contrast with other studies, I contribute to the literature by looking at the three measures of activity (cartel, monopoly abuse and mergers) alongside each other, within a system of equations.

This thesis is presented as five interrelated papers (as well as this brief introduction and a very short concluding chapter). One is descriptive in nature (chapter 2), three (chapters 3, 5 and 6) are empirical studies and the theoretical paper (chapter 4) provides the background for empirical studies carried out in chapter 5. Within each substantive chapter, there is a literature review which places the study into the context of the broader discipline.

Chapter 2 is preparatory in that it introduces the data to be used in succeeding empirical papers. This comprises a dataset of 35 countries for a period of 9 years (2006-2014); all of which have been compiled from secondary sources. Data was initially gathered from competition authorities' annual reports and website, and reports from international organisations, but due to inconsistencies in terms of reporting across the different competition authorities and to ensure consistency, I opted for the data reported in the Global Competition Review (GCR) annual enforcement reports. The initial data gathered was then used to cross check the GCR data especially where inconsistencies were identified.

Chapter 2 describes the basic features of the data used in the thesis to allow simple interpretation of the data. They provide the background information on the competition authorities found in the database to enable the better understanding of the findings of the chapters. The data on the number of competition cases and budget used in our analysis are shown. I also report and explain the anomalies in the data.

Chapter 3 which is a joint work with Professor Bruce Lyons empirically studies the national and institutional framework that provides the foundation for a good performance of a CA. We argue that a widely known 'star rating' measure of reputation to be highly correlated with genuine performance. This rating is available annually from 2006-2014 for 35 competition authorities across 32 countries. An econometric model is developed to explain the reputation of competition authorities to highlight features of a successful institutional design. We find significant roles for national governance culture, 'economies of scale', common law legal systems and (endogeneous) budget in positively influencing reputation.

In Chapter 4, jointly with Professor Stephen Davies and Dr. Franco Marriuzzo, we assess the success of a CA in detection and deterrence of cartelised behaviour. A theoretical model of a CA that administers a deterrence based competition policy is developed. This model is then used to look into the behaviour of competition authorities and to unravel the functional form of the age profile for the number of cartels convicted over time which can be interpreted in terms of both its efficiency in detection and success in deterrence. It is found that the age profile of a CA's convicted cartels depends on the magnitude of the detection efficiency of the CA and the deterrence effects of competition law and policy. While an increase in detection efficiency is likely to cause a CA to increase its effort in initiating investigations, and detecting cartels, a successful deterrence policy is likely to cause cartels to reduce their prices and/or break, hence reducing the possibility of being detected by the CA. Detection and deterrence thus have opposite effects on the age profile of cartels convicted of a CA. The number of cartels convicted will increase if the effects of the detection efficiency outweighs that of deterrence, and will decrease if the effects of deterrence is stronger than the detection efficiency. This consequently results to an expected inverted U-shape of the age profile of convicted cartels.

Chapter 5 empirically tests the theory put forward in Chapter 4 by studying the age profile of cartel cases convicted. Using the dataset, the random effects maximum likelihood estimations and the age period cohort analysis, the performance of CAs is assessed by looking at both detection and deterrence over age profiling of cartels cases. The results reveal that age of the cartel law does have an impact on the number of cartels convicted over time – the number first tends to increase rapidly, before slowing

down and then flattening off over the life of the CA. This result is interpreted as evidence of increasing deterrence as a consequence of the increased efficiency of detection. Thus, initially and potentially for many years, the CA is observed to successfully convict more cartels as a consequence of its growing experience. However, this greater efficiency also increasingly deters cartels from forming. Eventually, the latter outweighs the former, and we observe a downturn in cartel cases convicted. It is important to stress that this interpretation indicates that competition authorities are successful in deterring cartels, even though the number of cases eventually declines and flattens. Further empirical findings show that (i) previous budget allocated is important in determining the number of cartels convicted by a competition authority, (ii) leniency does influence the number of convicted cartels, (iii) number of mergers notifications positively influences the CA's convicted cartels, (iv) countries with a common law prosecute less cartels than those with civil law, (v) institutional design does not matter and, (vi) fines and imprisonment do deter cartelised behaviour.

Chapter 6 goes beyond cartels, and empirically looks into the interaction that may exist between cartels, monopoly abuses and mergers given an allocated budget and the CA's allocation decision. I apply a two stage least square estimation and use an instrumental variable econometric methodology to address the endogeneity problems that may arise in budget allocation. The instruments obtained are then used to correct the endogeneity in budget variable. It consequently enables the better understanding of the behaviour and the strategies by CAs and firms. Budget is found to play a very important role in determining the level of activity of CAs. Only budget allocation to cartels seems to have a contemporaneous impact on in-depth merger investigations; allocation decisions appear to take more time before impacting on cartels and monopoly abuse cases. Interestingly, a causal relationship is also identified to exist between merger investigations and convicted cartels cases. Moreover, a degree of substitutability is also observed between cartels and monopoly abuse cases.

Finally, Chapter 7 concludes the thesis by summarising its main findings. The possible extensions of the chapters are also discussed.

Chapter 2 Descriptive Statistics

The purpose of this chapter is to describe the basic features of the data used in the making of this thesis, so as to allow simple interpretation of the data. It provides the background on the competition authorities and the data to better understand the findings of the chapters.

2.1 Data collection

Data has mostly been collected from the Global Competition Review (GCR) annual reviews, World Bank Indicator Catalogue, American Bar Association Book on Competition Law and Policy, Common Law Jurisdictions by Tetley (2000), The Design of Competition Law Institutions by E. Fox and M.J. Trebilcock and competition authorities' websites to fill the gaps[2]. A small amount of interpolation has been made for missing years.

Given the structural change when Brazil Competition Authority, Brazil Secretariat of Economic Law (SDE) and Brazil Secretariat for Economic Monitoring (SEAE) integrated to Brazil CADE in 2012, the data set caters for Brazil SDE as a missing value for year 2012. GCR did not report information for Slovenia for 2012, 2013 and 2014 which has also been treated as a missing value in our analysis. In the case of the UK, given that there were two institutions -- the Office of Fair Trading (OFT) and the Competition Commission (CCUK) -- that were engaged in the enforcement of competition law and policy before 2014, only data pertaining to the OFT has been included. Since the CCUK was engaged in conducting in-depth mergers referred by the OFT, inclusion of mergers of the CCUK would double count the merger data.

2.2 Sample data

A sample dataset of 37 competition authorities from 35 jurisdictions (including EU) over a period of 9 years, from year 2006 to 2014, has been used across this thesis. The countries included are based on the availability of data. Our dataset includes competition authorities from every continent, although more than half of them are from Europe as shown in Table 2.1. Some jurisdictions have multiple agencies and in the next section I explain how I dealt with such in this thesis. For example, the Competition Commission of UK (CCUK) is excluded because all of the mergers it investigated were first investigated in phase 1 by the OFT. So to include them would lead to the double counting of merger

[2] The idea initially was to collect data from the CA's annual reports and website, but due to inconsistencies and accuracy in reporting of the figures across the CA, we choose to use the GCR annual reports.

cases. Moreover, it also creates a good transition to the establishment of the CMA from the fusion of the CCK and OFT. However, the sample slightly varies across the chapters based on specific requirement.

Table 2.1: List of jurisdictions

Asia	Israel, Japan, Korea, Pakistan
Europe	Austria, Belgium, Czech Republic, Denmark, EU, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Switzerland, United Kingdom (OFT) [3]
North America	Canada, Mexico, United States (FTC and DOJ)
South America	Brazil, Chile
Africa	South Africa
Oceania	Australia, New Zealand

2.3 Compilation of data

There are a few countries which have several bodies enforcing competition law and policy. I next explain how these issues have been tackled in the analysis throughout this thesis.

Belgium

Prior to 3rd April 2013, the Competition Authority of Belgium comprised of the Competition Tribunal, the College of Competition Prosecutors, the Directorate-General for Competition, and the Registry. The Competition Tribunal was the main decision-making body and its decisions had the force of res judicata (final decision). The Competition Tribunal made the final decision as to the finding of an infringement on the basis of an investigation carried out by the College of Competition Prosecutors.

The College of Competition Prosecutors was responsible for receiving complaints and requests for interim measures concerning practices that restrict competition. If it decided that a complaint or request was inadmissible or groundless, it had the power to close the file by reasoned decision. When an investigation was completed, the College of Competition Prosecutors drafted a Statement of Objections (SO) and submitted it to the Competition Tribunal. The drafting of the SO played a crucial role because the decision making power of the Competition Tribunal was restricted in scope to the anticompetitive practices listed in the SO. The Directorate-General for Competition detected and examined anticompetitive practices (e.g., abuse of dominance, cartels, merger concentrations) under

[3] The Competition Commission of UK is excluded in the database as the CCUK made in-depth (phase II) merger investigations following recommendations by the OFT. Hence, including CCUK's merger data would be double counting.

the authority of the College of Competition Prosecutors, which designated officials of the Directorate-General to participate in inspections carried out by officials of the European Commission. The Directorate-General of Competition thus helped the Competition Prosecutors perform its functions and carry out its investigations.

Then, in 2013, the new Belgian Competition Act (the Act) established an independent Competition Authority with a simplified structure and introduced significant procedural changes in competition proceedings. The new Competition Authority became an autonomous legal entity, managed by a board of directors consisting of the president of the Competition Authority, the Prosecutor General, the Chief Economist and the General Legal Counsel. Although the Authority is fully integrated in one autonomous institution, there is still a division between the decision-making body, the Competition College, and the service in charge of the investigation, which is composed of the Prosecutor General and his staff of prosecutors. The new Competition College replaced the Competition Council, the former decision-making body, and is composed of the President of the Authority and two assessors. We therefore used data from the competition council up to 2013.

Brazil

Brazil had three bodies that formed the Brazilian Competition Policy system, namely (i) the SDE which concentrated on anticompetitive agreements and abuse of dominance (ii) the SEAE which concentrated on merger analysis and (iii) CADE which complemented investigations conducted by SDE and SEAE in either conduct or merger cases, until 2011. For the purpose of the analysis and to prevent duplication of data, data from SDE and SEAE only was used. As from year 2012, SEAE data was used, following the amendment to the competition law in terms of (i) a restructuring of the antitrust authorities[4]; (ii) new merger control review rules and criteria; and (iii) a new definition of anticompetitive behaviours and the penalties imposed for violation.

European Union (EU)

We also include the European competition commission (EC) in our database. The EC basically pursues trans-EU cases. When violation of competition rules happens within just one country, the national CA would normally handle the case. But if the anti-competitive effects are also felt in many countries across the EU and beyond, then the EU commission handles these cases. The Commission has the power not only to investigate but also to take binding decisions and impose substantial fines. The

[4] SDE merged with CADE to form a single body which has been nicknamed “Super CADE”. CADE is formed by the Administrative Economic Defence Tribunal, the General-Superintendence and the Department of Economic Studies. SEAE will continue to exist along with "Super CADE", although the former will play a "competition advocacy" role (MONDAQ, 2012).

Commission enforces the EU competition rules together with the NCAs of the EU countries. All EU countries have these authorities with the power to enforce EU competition law, with essentially the same powers as the European Commission. These authorities and the European Commission exchange information on implementing EU competition rules through the European Competition Network (ECN). This network makes it easier to identify which authority should be dealing with particular issues, and which others could provide assistance. The network helps to ensure effective and consistent application of EU competition rules. Through the ECN, the competition authorities inform each other of proposed decisions and take on board comments from other competition authorities. In this way, they can pool their experience and identify best practices (European Union, 2014).

United Kingdom (UK)

For the UK, the competition data for the Office of Fair Trading which was established by the Fair Trading ACT 1973 and enforced both consumer protection and competition law until 2013 was reported. Following the provisions under the Enterprise and Regulatory Reform Act 2013 and with the establishment of the Competition and Markets Authority (CMA)[5] on 1 April 2014, data from the CMA was used for the UK for year 2014. Data from the Competition Commission of the UK (CCUK)[6] was not included in the database as the CCUK would make in-depth (phase II) merger investigations following recommendations by the OFT. Hence, including CCUK's merger data would be double counting.

United States (US)

For the US, data from both the Federal Trade Commission (FTC) and the Department of Justice Antitrust Division (DoJ) was included in our database, as they complement one another. This is because the FTC caters for the elimination and prevention of anticompetitive business practices, such as coercive monopoly and anti-competitive mergers and the DoJ has exclusive authority for criminal enforcement at the federal level, and it shares civil enforcement authority with the FTC. "Over the years, the agencies have developed expertise in particular industries or markets. For example, the FTC devotes most of its resources to certain segments of the economy, including those where consumer spending is high: health care, pharmaceuticals, professional services, food, energy, and certain high-tech industries like computer technology and Internet services. Before opening an investigation, the agencies consult with one another to avoid duplicating efforts" (Federal Trade Commission, 2016). In chapter 3, separate data from FTC and DOJ was used. In Chapter 5, since it deals with detection and

[5] The CMA combined many functions of the OFT and the UK Competition Commission.
[6] The CCUK was responsible for investigating mergers, markets and other enquiries related to regulated industries under competition law in the UK.

deterrence of cartels, only data from DOJ was included in our panel data and in Chapter 6, the combined data of both institutions was used.

2.4 Legal and institutional framework

In this section, an overview of the legal and institutional framework within which the competition authorities operate is provided. Table 2.2 describes the indicators used in Table 2.3 to show the different legal and institutional specificities of the different CAs. The information shown has mostly been collected from the world competition database of the George Washington Competition Law Center (GWCLC), Competition Laws Outside the US, Volume 1 by S. Harris (Harris,2001), the CA's website and Annual Reports (AR), and Annual competition reports from OECD.

In addition to the Table 2.3, we find that the decisions of all the CAs are subject to judicial review and have a leniency program.

Table 2.2: Description of indicators

Indicator	Details	Source
First C Law	Year CA adopted first competition law-regulating anti-competitive law	OECD, CA's web site and AR
Plaw	Year CA adopted principal law- modern competition law[7]	Harris (2001) and CA's website
CA year	Year the CA established	Harris (2001) and CA's website
Mandate	CA has exclusive mandate on competition or multiple mandates. Multiple mandates-1, exclusive mandate-0	GWCLC
Judicial review	Decisions of the CA are subject to judicial review. Yes-1, No-0	GWCLC
Nbudget	There is a provision of the national budget allocated by law to the CA to ensure its proper functioning. Yes-1, No-0	GWCLC
Financed own means	The CA can be financed by its own means (notification fees, fines, etc.). Yes-1, No-0	GWCLC
Minister appoint heads	A minister appoints the heads. Yes-1, No-0	GWCLC
Aresponsible	Number of agencies responsible for competition enforcement. One agency- OA, Multiple agencies- MA	GWCLC
Cpunishment	The CA has powers to seek criminal punishment. Yes-1, No-0	GWCLC

(continued)

[7] Modern competition law which includes anti-competitive agreements, abuse of monopoly situations and merger controls.

Table 2.2: Description of indicators (Continued)

Indicator	Details	Source
CA investigate and prosecute cases	The CA makes the decision to investigate and to prosecute cases. Yes-1, No-0	GWCLC
Single body	There is a single body that carries out the investigation and the guilty findings within the CA. Yes-1, No-0	GWCLC
Appeal to court	The CA's decisions can be appealed to a court. Yes-1, No-0	GWCLC
Investigate and prosecute	There are different authorities that make the decision to investigate and to prosecute cases. Yes-1, No-0	GWCLC
Separate entity/Tribunal	Disputes are presented for decision to a separate entity/tribunal. Yes-1, No-0	GWCLC

Table 2.3: Legal and institutional information on competition authorities

Authority	First Claw	Plaw	CA year	Mandate	Nbudget	Financed own means	Minister appoint heads	Aresponsible	Cpunish	CA investigate and prosecute	single body	appeal to court	investigate and prosecute	separate entity/ tribunal
Australia	1890	1974	1974	0	1	0	0	Ma	1	1	0	1	0	0
Austria	1988	1999	2002	1	1	0	1	oa	1	0	0	0	1	1
Belgium	1960	1991	1991	1	1	0	0	oa	0	1	0	1	0	0
Brazil	1962	1994	1994	0	1	1	0	oa	1	1	0	1	0	0
Canada	1889	1986	1986	1	1	0	1	oa	1	0	0	0	1	1
Chile	1980	1980	2004	0	1	0	1	Ma	0	0	0	0	1	1
Czech Rep	1948	1991	1991	1	1	0	1	Oa	0	1	1	1	0	0
Denmark	1937	1998	1955	1	1	0	1	Oa	0	1	0	1	0	0
EU	1951	1962	1962	1	1	0	0	Oa	0	1	1	1	0	1
Finland	1958	1992	1988	0	1	0	0	Oa	0	1	1	1	0	0
France	1791	1986	1987	0	1	0	1	Ma	1	1	0	1	0	0
Germany	1922	1958	1958	0	1	0	1	Ma	0	1	1	1	0	0
Greece	1977	1991	1995	0	1	1	1	Oa	1	1	0	1	0	0
Hungary	1990	1996	1996	1	1	1	1	Oa	0	1	0	1	0	0
Ireland	1996	1991	2002	1	1	0	1	Oa	1	1	1	1	1	0
Israel	1959	1988	1994	0	1	0	0	Oa	1	1	1	1	0	0
Italy	1990	1990	1990	1	1	1	0	Oa	0	1	1	1	0	0
Japan	1947	1947	1947	0	1	0	1	Oa	1	0	0	1	1	1
Korea	1975	1980	1981	1	1	0	1	Oa	1	1	0	1	0	0
Lithuania	1992	2002	1999	1	1	0	1	Oa	0	1	0	1	0	0
Mexico	1993	1993	1993	0	1	0	1	Oa	1	1	0	1	0	0
Netherlands	1958	1998	1998	1	1	0	1	Oa	0	1	0	1	0	0
N. Zealand	1986	1986	1986	1	1	1	1	Oa	0	1	0	1	0	0

(continued)

Table 2.3: Legal and institutional information on competition authorities (*continued*)

Authority	First Claw	Plaw	CA Year	Mandate	Nbudget	Financed own means	Minister appoint heads	Aresponsible	Cpunish	CA investigate and prosecute	single body	appeal to court	investigate and prosecute	separate entity/ tribunal
Norway	1920	1993	1994	0	1	0	1	Oa	1	1	1	1	0	0
Pakistan	1970	2007	2007	1	1	1	1	Oa	1	1	1	1	0	0
Poland	1926	1990	1990	1	1	0	1	Oa	0	1	1	1	0	0
Portugal	2003	1993	2003	0	0	1	1	Oa	0	1	0	1	0	0
Russia	1990	1990	1991	1	1	0	1	Oa	0	1	0	1	0	0
Slovakia	1990	1994	1990	0	1	0	1	Oa	0	1	1	1	0	0
South Africa	1955	1998	1998	0	1	1	1	Oa	0	0	0	0	1	1
Spain	1963	1989	1963	0	1	1	1	Ma	0	1	0	1	0	0
Sweden	1925	1993	1992	1	1	0	1	Oa	1	1	1	1	0	0
Switzerland	1962	1995	1996	0	1	0	1	Oa	1	n/a	n/a	n/a	n/a	n/a
UK (OFT)	1918	1998	1973	1	1	1	1	Ma	1	1	0	0	0	0
US (DoJ)	1887	1914	1903	1	1	0	1	Ma	1	1	0	1	0	0
US (FTC)	1887	1914	1914	1	1	0	1	Ma	1	1	0	1	0	0

OA- One agency, MA- Multiple agencies

2.5 Database

2.5.1 GCR ratings

Since the subject of interest is the assessment of the performance of a CA, the GCR ratings (Global Competition Review), used in Chapter 3 as a proxy for performance for the different CA's for period between 2006 and 2014 are shown in Table 2.4. It should be noted that the index ranks CAs in a scale of 1 to 5 (See Appendix 3.A).

Table 2.4: GCR ratings

Countries	2006	2007	2008	2009	2010	2011	2012	2013	2014
Australia	4	4	4	4	4	4	4	4	4
Austria	3	3	3	3	3	3	3	3	3
Belgium (CC)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Brazil (CADE)	3	3	3	3	3.5	3.5	4	4	4
Brazil (SDE)	3	3	3	3	3	3			
Brazil (SEAE)	3	3	2.5	2.5	2.5	2.5			
Canada	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Chile			2	2	2.5	2.5	2.5	2.5	3
Czech Rep	3	3	3	3	3	3	3	2.5	2.5
Denmark	3.5	3.5	3.5	3.5	3.5	3	2.5	2.5	2.5
EU	5	5	4.5	4.5	5	5	5	5	4.5
Finland	3.5	3.5	3.5	3.5	3	3	3	3	3
France	4	4	4	4	4.5	5	4	5	5
Germany	4	4	4	4	4.5	5	5	5	5
Greece	2	2	2	2.5	2.5	2.5	3	3	3.5
Hungary	3	3	3	3	3	3	3	3	3
Ireland	3.5	3	3	2.5	2.5	2.5	3	3	2.5
Israel	2.5	3	3	3	3	3	3	3	3
Italy	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Lithuania				2	2	2	2	2	3
Japan	3.5	3.5	3.5	3.5	4	4.5	4.5	4.5	4.5
Korea	3.5	3.5	3.5	4	4	4	3.5	4	4.5
Mexico	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	3

(Continued)

Table 2.4: GCR ratings (*continued*)

Countries	2006	2007	2008	2009	2010	2011	2012	2013	2014
Netherlands	3.5	3.5	3.5	3.5	4	4	4	3.5	3.5
New Zealand	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3
Norway	3	3	3	3	3	3	3	3.5	3.5
Pakistan					2.5	2.5	2.5	2.5	
Poland	3	2.5	2.5	2.5	2.5	3	3	3	3
Portugal	3.5	3	3	3	3	3	3	3	3
Russia	2	2.5	2.5	3	3	3	3	3	3
Slovakia	2.5	2.5	2.5	2.5	2	2			
South Africa	2.5	3	3.5	3.5	3.5	3	3	3	3
Spain	3	3	3.5	3.5	3.5	4	4	4	4
Sweden	3	3	3	3	3	3	3	3	3
Switzerland	3	3	3	3	3	3	3	3	3
UK (CC)	5	5	5	5	5	5	5	4.5	
UK (OFT/CMA)	4	4.5	4.5	4.5	4.5	4	4	4	4
US (DoJ)	4.5	4.5	5	5	5	5	5	5	5
US (FTC)	5	5	5	5	5	5	5	5	5

Source: GCR Annual enforcement reports

2.5.2 Competition authorities output and budget data

The time series data for number of cartel decisions ($\#cartel$), number of monopoly abuse cases closed ($\#abuse$), number of in-depth merger investigations ($\#indepth$), number of mergers notified to the CA ($\#merger$), and the budget allocated to the CA (in million Euros) are presented in Table 2.5. These data have mostly been used in Chapter 5 and 6.

Table 2.5: Time series of CA's investigations and budget allocated

Country	Variables	2006	2007	2008	2009	2010	2011	2012	2013	2014
Australia	$\#cartel$	10	6	4	6	2	2	2	2	4
	$\#abuse$	15	10	10	26	27	11	17	12	20
	$\#indepth$	14	31	24	40	159	104	76	13	21
	$\#merger$	375	432	410	348	321	379	269	296	323
	$budget$	38.7	35.5	32.5	41.7	47.9	58.5	62.9	55.0	37.8
Austria	$\#cartel$	2	20	0	15	41	34	73	10	33
	$\#abuse$	22	19	15	16	10	23	33	0	23
	$\#indepth$	12	15	10	7	7	9	5	10	3
	$\#merger$	274	341	275	213	238	281	307	299	323
	$budget$	1.4	2.0	2.1	2.4	2.4	2.6	2.7	2.7	2.8
Belgium	$\#cartel$	2	15	6	11	9	1	6	3	5
	$\#abuse$	1	10	6	6	2	4	14	3	2
	$\#indepth$	8	1	4	0	1	1	5	2	2
	$\#merger$	17	20	13	7	19	20	17	24	16
	$budget$	0.3	3.8	3.4	2.9	2.5	2.0	2.0	8.9	8.4
Brazil	$\#cartel$	26	9	4	3	4	16	15	13	14
	$\#abuse$	46	18	116	117	94	33	87	38	67
	$\#indepth$	100	137	182	121	162	116	109	43	69
	$\#merger$	430	594	638	460	660	758	626	377	423
	$budget$	5.6	7.1	7.7	13.5	6.7	6.7	10.8	11.0	10.2
Canada	$\#cartel$	2		8	14	4	4	8	5	5
	$\#abuse$	18		20	11	11	14	11	5	6
	$\#indepth$	30		17	22	7	4	31	25	31
	$\#merger$	259	268	228	207	216	218	204	212	250
	$budget$	24.0	22.0	21.8	28.6	28.4	31.7	30.8	26.4	29.5
Chile	$\#cartel$			3	2	2	3	2	2	6
	$\#abuse$			56	34	14	20	30	57	21
	$\#indepth$			0	6	9	18	14	15	17
	$\#merger$			12	12	11	10	2	0	3
	$budget$	0.0	3.7	4.3	5.3	5.7	6.3	24.0	6.0	9.5
Czech	$\#cartel$	4	11	4	10	3	5	1	1	10
	$\#abuse$	6	3	2	3	1	1	1	0	1
	$\#indepth$	4	2	3	2	1	2	3	4	5
	$\#merger$	61	61	57	40	45	49	53	35	45
	$budget$	3.0	5.5	1.8	5.1	5.1	8.4	9.5	9.2	8.8
Denmark	$\#cartel$	0	0	4	3	1	3	0	5	17
	$\#abuse$	1	2	1	1	2	3	2	13	25
	$\#indepth$	1	2	2	1	2	2	2	3	1
	$\#merger$	8	14	14	11	10	34	36	41	35
	$budget$	8.0	5.5	7.9	8.1	9.0	12.1	11.5	9.7	11.1

(Continued)

Table 2.5: Time series of CA's investigations and budget allocated (*continued*)

Country	Variables	2006	2007	2008	2009	2010	2011	2012	2013	2014
EU	$\#cartel$	7	8	7	6	7	4	5	4	10
	$\#abuse$	46	133	111	54	58	48	28	49	58
	$\#indepth$	13	15	10	5	4	8	10	10	8
	$\#merger$	356	402	347	259	274	309	283	277	303
	$budget$	97.0	71.7	78.2	89.4	90.8	93.5	91.5	94.5	94.4
Finland	$\#cartel$	6	1	0	6	0	1	17	2	1
	$\#abuse$	20	116	140	206	97	97	73	7	8
	$\#indepth$	2	1	1	1	2	2	3	3	1
	$\#merger$	42	35	22	19	17	28	22	20	30
	$budget$	5.0	5.2	5.3	5.7	5.3	6.2	6.2	11.3	6.2
France	$\#cartel$	24	21	14	11	12	8	8	5	4
	$\#abuse$	18	15	11	7	10	9	19	21	30
	$\#indepth$	5	3	1	2	2	2	3	2	1
	$\#merger$	143	140	130	137	246	255	214	214	192
	$budget$	11.4	12.8	19.4	19.4	20.4	20.0	20.2	20.6	20.7
Germany	$\#cartel$	2	3	7	8	8	16	17	12	15
	$\#abuse$	16	67	79	32	45	29	38	50	29
	$\#indepth$	34	30	15	26	15	15	16	18	22
	$\#merger$	1821	2231	1675	1000	987	1100	1127	1091	1188
	$budget$	17.0	17.0	18.3	22.0	23.0	25.0	25.8	26.8	27.6
Greece	$\#cartel$	21	6	5	11	10	5	5	5	2
	$\#abuse$	13	23	21	7	8	18	29	36	27
	$\#indepth$	1	1	1	4	7	4	3	6	8
	$\#merger$	17	32	19	89	108	47	15	19	16
	$budget$	11.0	15.0	21.5	10.9	10.9	9.8	8.9	9.1	9.5
Hungary	$\#cartel$	10	10	6	14	12	5	5	15	13
	$\#abuse$	33	32	31	15	14	6	4	5	7
	$\#indepth$	10	7	2	4	4	5	6	5	6
	$\#merger$	42	44	45	36	49	23	37	31	31
	$budget$	7.0	6.0	8.0	7.7	9.3	6.2	7.5	0.0	7.6
Ireland	$\#cartel$			2	10	1	3	6	0	1
	$\#abuse$	6		0	0	112	92	107	89	56
	$\#indepth$	4	3	2	2	2	1	0	0	1
	$\#merger$	98	72	38	27	46	40	33	37	35
	$budget$	6.0	6.1	6.7	4.7	5.1	4.6	5.1	4.9	4.9
Israel	$\#cartel$	6	1	3	4	3	0	4	1	6
	$\#abuse$	3	2	2	2	2	0	1	0	2
	$\#indepth$	57	32	28	19	21	27	15	20	18
	$\#merger$	219	237	181	157	149	195	135	163	149
	$budget$	4.0	4.0	3.7	4.6	4.9	4.9	8.8	10.2	12.9

(Continued)

Table 2.5: Time series of CA's investigations and budget allocated (*continued*)

Country	Variables	2006	2007	2008	2009	2010	2011	2012	2013	2014
Italy	$\#cartel$	3	8	3	11	9	5	4	8	15
	$\#abuse$	5	6	10	5	14	7	10	5	4
	$\#indepth$	19	22	19	23	12	14	26	2	4
	$\#merger$	717	864	844	503	495	532	459	57	45
	$budget$	37.0	44.0	52.8	52.6	67.3	57.7	58.8	59.3	48.9
Japan	$\#cartel$	6	15	17	18	18	12	19	14	12
	$\#abuse$	0	1	3	4	1	0	0	0	1
	$\#indepth$	2	2	0	0	6	3	5	3	6
	$\#merger$	1160	1261	1117	983	390	256	348	284	271
	$budget$	50.0	50.0	55.3	71.1	67.8	79.1	65.5	61.5	84.0
Korea	$\#cartel$	58	44	65	35	35	45	24	33	60
	$\#abuse$	1	55	18	14	19	27	9	10	15
	$\#indepth$	20	3	5	62	60	52	54	25	27
	$\#merger$	774	857	556	425	499	543	651	585	571
	$budget$	31.1	24.0	39.2	52.6	50.3	53.4	64.4	62.2	95.2
Lithuania	$\#cartel$	4	4	3	3	6	11	1	0	2
	$\#abuse$	6	6	6	1	6	7	2	0	2
	$\#indepth$	0	0	0	4	0	6	3	2	8
	$\#merger$	61	78	54	42	40	46	29	31	52
	$budget$	0.0	0.0	0.0	1.2	1.0	1.3	0.9	1.0	1.6
Mexico	$\#cartel$	11	3	0	2	8	9	7	6	2
	$\#abuse$	13	55	6	5	4	3	3	13	1
	$\#indepth$	8	32	14	15	15	6	15	20	7
	$\#merger$	164	176	119	93	91	111	96	145	129
	$budget$	11.0	9.7	9.9	10.9	9.9	10.7	12.8	16.4	28.9
Nether-lands	$\#cartel$	19	7	6	17	14	10	13	6	1
	$\#abuse$	2	5	1	2	2	2	1	1	4
	$\#indepth$	8	5	4	4	4	6	8	2	3
	$\#merger$	19	21	20	5	12	10	12	85	75
	$budget$	22.0	15.8	15.8	16.3	17.6	17.6	16.5	15.4	15.5
New Zealand	$\#cartel$	0	4	5	11	21	15	11	5	3
	$\#abuse$	21	18	9	7	10	1	0	3	3
	$\#indepth$	19	20	20	5	12	10	12	12	14
	$\#merger$	872	561	444	294	415	461	415	12	14
	$budget$	5.0	4.4	3.8	4.7	4.5	4.4	8.6	9.2	8.0
Norway	$\#cartel$	12	2	6	3	0	2	0	1	0
	$\#abuse$	76	48	36	49	50	95	45	1	16
	$\#indepth$	10	9	3	0	5	6	13	5	4
	$\#merger$	872		444	294	415	461	415	395	89
	$budget$	10.0	10.1	9.0	10.5	10.9	11.1	11.6	12.5	11.0

(continued)

Table 2.5: Time series of CA's investigations and budget allocated (*continued*)

Country	Variables	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pakistan	$\#cartel$					3	6	3	2	
	$\#abuse$					10	3	8	10	
	$\#indepth$					1	3	1	0	
	$\#merger$	310	310	197	144	222	205	194	54	
	$budget$	0.0	0.0	0.0	0.0	1.8	1.7	1.6	1.5	0.0
Poland	$\#cartel$	32	9	12	16	10	14	8	15	13
	$\#abuse$	171	112	84	89	76	73	73	64	48
	$\#indepth$	310	310	197	144	222	205	194	206	195
	$\#merger$	310	310	197	144	222	205	194	206	195
	$budget$	7.0	7.9	6.7	11.8	12.7	13.2	13.0	13.0	4.8
Portugal	$\#cartel$	3	7	3	2	1	2	2	1	0
	$\#abuse$	0	6	23	9	10	5	4	3	8
	$\#indepth$	3	1	4	1	0	3	2	2	2
	$\#merger$	44	72	71	36	37	28	22	40	43
	$budget$	7.5	7.6	8.4	9.1	8.6	7.5	6.4	7.3	8.2
South Africa	$\#cartel$	1	7	10	9	7	9	13	30	26
	$\#abuse$	5	50	106	58	80	99	52	74	79
	$\#indepth$	98	24	25	31	31	38	37	33	30
	$\#merger$	399	425	451	228	217	288	321	335	358
	$budget$	5.0	11.0	11.5	13.6	16.2	17.6	19.5	14.3	22.0
Spain	$\#cartel$	16	7	6	44	61	57	47	54	9
	$\#abuse$	16	9	10	23	40	35	36	61	74
	$\#indepth$	9	7	3	2	3	1	3	4	2
	$\#merger$	132	115	89	43	57	63	36	59	82
	$budget$	10.0	10.0	12.0	13.4	13.5	12.6	12.8	52.7	59.0
Sweden	$\#cartel$	0	29	32	18	3	12	21	17	14
	$\#abuse$	52	33	20	14	18	5	8	1	8
	$\#indepth$	1	0	3	2	1	4	3	3	2
	$\#merger$	29	45	40	26	34	30	28	48	67
	$budget$	10.0	9.2	11.6	13.5	14.5	14.8	16.1	14.8	18.9
Switzer-land	$\#cartel$	5	3	4	5	2	5	5	4	4
	$\#abuse$	3	5	4	1	1	0	0	2	2
	$\#indepth$	3	5	3	5	1	1	0	0	1
	$\#merger$	135	108	129	90	83	98	91	32	30
	$budget$	4.0	4.8	4.5	8.4	7.4	8.8	10.2	9.4	9.1
UK (OFT)	$\#cartel$	4	0	0	2	1	2	1	7	0
	$\#abuse$	4	2	2	0	1	1	2	3	2
	$\#indepth$	13	12	7	6	3	11	14	9	2
	$\#merger$	150	104	96	66	77	100	98	76	60
	$budget$	80.0	65.3	45.6	45.9	40.1	37.5	38.7	21.0	48.8

(continued)

Table 2.5: Time series of CA's investigations and budget allocated (*continued*)

Country	Variables	2006	2007	2008	2009	2010	2011	2012	2013	2014
US (DoJ)	$\#cartel$	33	40	54	37	60	90	67	51	45
	$\#abuse$	3	3	4	1	2	1	0	1	0
	$\#indepth$	17	32	22	23	28	37	37	26	26
	$\#merger$	1768	2201	1726	713	1166	1450	1429	1326	1635
	$budget$	107.0	94.5	118.0	127.4	109.7	125.0	122.8	114.0	139.4
US (FTC)	$\#cartel$									
	$\#abuse$	2	1	2	5	14	25	13	19	19
	$\#indepth$	28	31	28	15	20	24	20	25	28
	$\#merger$	1746	2108	1656	684	1128	1414	1400	1286	1618
	$budget$	64.0	60.6	75.8	84.9	92.1	103.4	103.9	93.0	129.5

Source: GCR Annual Enforcement Reports

2.5.3 Explaining the data

The following notes identify and account for any apparent anomalies or gaps in the GCR data.

GCR started to report information for Chile, Lithuania and Pakistan only from 2008, 2009 and 2010 respectively. In 2014, data for Pakistan was not reported. For Austria, information on the number of monopoly abuse cases that were closed was not available in the GCR reports, we have exceptionally used number of monopoly abuse cases opened to capture information on monopoly abuse data. Where data was not available in GCR, data from annual reports of the CAs or OECD reports were used.

In 2010, a drastic increase in the number of in-depth merger reviewed from 40 to 159 in **Australia** was observed. It should however be noted that in **Australia**, the depth of a merger review is determined on a case-by-case basis and they do not use a structured tiered-based merger review system.

Further to switching to a pre-merger system in 2013 in **Brazil**, a fall in the number of mergers notified was seen. It was then followed by the trimming down of the proportion of mergers that went to in-depth review by CADE. In 2012, the CA of **Chile**, the Fiscalia Nacional Economica (FNE) also introduced a new set of guidelines aimed at fast-tracking merger approvals through courts by encouraging companies to discuss possible mitigation measures ahead of hearings. In-depth mergers reviewed were greater than the number of notified mergers; this was explained by fact that the FNE has a voluntary pre-merger notification and also can initiate in-depth investigations of mergers that are not originally notified by the companies.

While **Canada** adopted more aggressive cartel provisions in 2010, the CA of the **Czech Republic** experienced a general drop in its output. The drop might have been due to the fall in staff level as well

as the possible detraction from competition matters with the CA's mandated duty of monitoring the relationship between the country's supermarkets and their suppliers.

In 2013, **Denmark** amended its competition law with the introduction of prison sentences for convicted cartelists and the multiplication of the maximum fines available by 10. However, the great increase in its number of cartel decisions in 2014 was mostly due to a bid-rigging case in the construction industry where 11 decisions were issued.

Both **Greece** and **Finland** came up with a new Competition Act in 2011. The Greek Antitrust Act came into force to remove the discrepancies between the Greek and European competition law; introducing a system for prioritising cases and strengthening the criminal sanctions for cartelists. The few mergers in **Greece** were mainly due to the economic crisis. **Finland** completed the merger of the country's competition and consumer regulators in 2013. The Finnish CA made use of the provisions on prioritisation contained in the Competition Act to close cases of minor importance in order to enable the authority to better focus its efforts on the most important cases within three years, which might have explained the sudden drop in the monopoly abuse cases.

In **Hungary**, the merger control guidelines were updated with the introduction of a shorter merger review process and a formal pre-notification system in 2011. The new rules enable merging companies to approach the authority before their transactions are officially notified – a practice that was already in place unofficially, but not formalised. The change in management at the end of 2010 and the consequence of the handover period may have been the reason for the fall in output.

In 2010, the CA of **Ireland** experienced various issues such as changes in leadership, where four of the agency's five members had either retired or resigned within a few months of each other, as well as a big fall in its budget allocated. The agency only had enough resources to staff 46 of a possible 59 positions. These issues might have contributed to the fall in the output of the CA.

The fall in the merger notifications in **Italy** and **Japan** in 2012 and 2011 respectively was mostly due to the revision of their merger thresholds and regulatory law. **Norway** later followed in early 2014 by reviewing its merger notification threshold, significantly increasing it from €6 million to €120 million, which consequently caused a fall in the number of mergers notified. The fall in real budget also contributed to the fall in output of its CA. Moreover, **Korea** and **Italy** both experienced a change in leadership for the chairman position in 2009 and 2011 respectively.

Interestingly**, Japan** revised its competition law in 2010 giving the Japan Federal Trade Commission stronger powers. They introduced fines for exclusionary types of private monopolisation, increased fines by 50% for anti-competitive conduct and increased the maximum prison sentences from 3 to 5 years. These changes might have had an impact on the number of competition cases investigated. Furthermore, the fall in the number of mergers notified might have been the result of the introduction of a pre-merger notification system and revised its notification threshold (switched from asset-based thresholds to Japanese turnover based thresholds).

The CA of **Lithuania** adopted the strategy of closing complex cases in the telecoms and other regulated sectors in 2012, which were left open by his predecessor (too weak to guarantee the likelihood of a positive outcome). This might have caused the fall of its output.

In 2006, **Mexico** was mostly engaged in a battle against oligopolies where 25% of its staff worked on dominance or regulated industries matters. Although the CA's emphasis on abuse of dominance cases continued at a slower rate in 2008, the fall in the number of files closed was explained by fewer cases that were launched.

From 2013 onwards, **Netherlands** has been experiencing changes in the trend of its CA's output. One reason might have been due to the change in the CA's structure with the creation of the new Authority for Consumers and Markets, the result of combining the National Competition Authority (NMa) with the consumer protection authority and telecoms regulator.

The surprisingly zero monopoly abuse cases from the CA of **New Zealand** in 2012 was explained by the fact that it did not undertake any enforcement actions in 2011, further to the loss of the market power case against incumbent telecoms company. The latter indicated it did not intend to investigate or enforce misuse of market power rules, other than in exceptional circumstances, until the law is amended.

Both **Poland** and **Portugal** came under new leadership in 2008. Unlike, **Portugal**, in **Poland** all notified mergers undergo an in-depth review. Poland also amended its law in 2014 with the introduction of voluntary cartel settlements, expanded range of remedies on offer, and personal liability for managers involved in price fixing, which might have explained the fall in its competition cases. However, the slowing down of Portugal's processed mergers competition authority was mostly due to the economic slowdown.

South Africa continued to prioritise cartel enforcement, and reported significant successes in its leniency programme in 2009. Moreover, the high number of mergers reviewed is explained by the mandatory pre-merger notification scheme in 2008.

The fluctuations in the data for **Spain** can mainly be explained by the structural changes of the CA, with the combination of the Spain Competition Tribunal and Competition Service in 2007 and in 2013 where the National Competition Commission merged with six sector regulators, creating the National Commission of Markets and Competition (CNMC).

In 2009, the fall in the number of mergers filed in **Switzerland** reflected global economic trends rather than the commission's merger review capabilities. Moreover, in 2011, the abuse of dominance work was slightly slower in **Sweden** mainly because the authority focused its attention on a case it began in 2004 against telecoms company TeliaSonera[8].

There seemed to have been an overall fall in the number of merger notified in the period 2008-2010 across the different countries, which is mostly explained by the global effect of the economic crisis. We also observed the comparatively large amount of merger notifications in **Austria** compared to the other countries found in our database given its country's population. One of the reasons might be due to the low merger filling threshold in **Austria**[9] compared to the merger threshold in Italy[10], Japan[11] or the UK where merger notification is not compulsory.

Moreover, when comparing with the US, Germany and other European countries, it is observed that Korea had investigated a greater number of cartels and monopoly abuse cases. South Africa also had been investigating a greater number of monopoly abuse cases in comparison with other developed

[8] It resulted in a €16 million fine from Stockholm City Court in December – the largest abuse of dominance fine ever levied in Sweden.

[9] The threshold for notifying mergers are (i) worldwide turnover of all undertakings concerned exceeds EUR 300 million, (ii) combined domestic turnover of all undertakings concerned exceeds EUR 300 million and (iii) the individual worldwide turnover of at least two of the undertakings concerned exceeds EUR 5 million (see Thomson Reuters (2016))

[10] The thresholds for merger notification in Italy are (i) the combined aggregate Italian turnover of all undertakings concerned exceeds EUR 492 million in the year preceding the notification and (ii) the aggregate Italian turnover of the target undertaking exceeds EUR 49 million in the year preceding the notification (See Thomson Reuters (2016)).

[11] The thresholds for merger notification in Japan are (i) The aggregate domestic turnover of all corporations within the combined business group of the acquiring corporation must exceed JPY 20 billion, and the aggregate domestic turnover of the target corporation and its subsidiaries must exceed JPY 5 billion to meet the filing requirement and (ii) The acquisition must result in the combined business group of the acquiring corporation newly holding more than 20% or 50% of the total voting rights of all shareholdings of the target (so an acquisition that increases a shareholding from 19% to21% is subject to a filing, while an acquisition that increases a shareholding from 21% to 49% does not require one). A minority ownership of over 20% may be caught regardless of whether or not the acquirer takes control of the target company (See Thomson Reuters (2012)).

countries over the years. For example, in 2014, it closed the highest number of monopoly abuse cases (79) compared to the US (20), Germany (29) and EU (58). The UK on the other hand surprisingly is among the countries which have been issuing the lowest number of cartel decisions. For example in 2014, it issued only one cartel decision compared to Germany, 15, France, 4 or US, 45. I, however, do not have an exact answer to explain these differences, given that there might be different internal (e.g. budget, institutional design, competition law and policy) as well as external factors (e,g. governance issues, political crisis, social unrest among others) which may directly or indirectly have an effect on the CA's output.

2.6. Conclusion

It can thus clearly be seen that different countries have different types of CAs, different legal and regulatory frameworks, as well as performing differently. With the aim of improving the impact of competition law and policy, various countries across the world have reviewed/updated their competition law, their merger thresholds as well as their institutional structure. Moreover, to cater for the individual heterogeneity of the database and consequently avoid biasness in the resulting estimates, a panel data analysis is chosen to be used in the chapters that follow.

Chapter 3 What determines the reputation of a competition authority?*

3.1. Introduction

Competition policy has been introduced at a remarkable pace across the world, especially in the last twenty years. Much has been written on the appropriate antitrust law and economics that should be applied when enforcing policy, and there has been a notable convergence on appropriate theoretical and empirical analysis of competitive effects over the period. However, there has been much less convergence on the design of the institutions charged with implementing this policy. There has also been very little research on what makes for a successful design.

This is a major gap in our knowledge. Most developing countries have been introducing new agencies[13] at the same time as new competition laws. So, which format should they adopt? For example, should it include an investigating agency prosecuting before a separate specialist tribunal, or before a general court? Or should it be an inquisitorial agency with decision making within the same institution, subject to light touch judicial review? Should a competition authority combine antitrust with other roles, such as consumer protection or ex ante regulation? These questions are important not just for developing countries; many long-established institutions in countries with a long antitrust tradition have recently redesigned their competition authorities with apparently little evidence to support the view that this will improve enforcement. For example, the UK merging the OFT and CC to create a single Competition and Markets Agency (CMA). Other recent examples include Belgium, Brazil, France, the Netherlands and Spain. This paper seeks to provide some evidence that takes a step towards answering some the questions and issues raised above.

In principle, it would be desirable to assess these issues by using a direct measure of the quality of an agency's processes, case selection and, especially, decisions. Unfortunately, it is not feasible to create a direct measure that is comparable across CAs. It is becoming accepted best practice for

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[13] We use the terms 'agency' and 'competition authority' interchangeably to refer to the institutions that implement competition policy.

antitrust/competition authorities to review their decisions with a view to evaluating and improving their performance, as well as justifying their budgets. However, this set of methodologies does not permit international comparisons because so few cases are decided in multiple jurisdictions, and when they are, local competitive circumstances often differ substantially. Other approaches are also problematic (see section 3.2).

Our alternative approach is to adopt a less direct measure of peer evaluation. In particular, we investigate the determinants of a well-known star rating of agencies which is conducted by Global Competition Review (GCR). This rating is based on an annual: survey of close observers of each agency (lawyers, economists, in-house counsel, academics and journalists); review of news stories supplemented by interviews; and agency statistics with self-assessment. Each agency's rating is widely anticipated by agency heads across the world. A sceptic might argue that an econometric model of subjective ratings can reveal only what is important to those who contribute to such ratings. We believe this is too cynical. Our view, developed below, is that a good reputation can only be sustained if it is founded on genuinely good performance. As such, our statistical model reveals some of the institutional features that enhance agency performance and so provides the first econometric evidence on the appropriate design of an agency to support better antitrust enforcement.

The paper is organised as follows. In section 3.2 we review the small literature on the appraisal of competition regimes. The theoretical relationship between reputation and performance is discussed in section 3.3 and section 3.4 develops our empirical model of the determinants of CA reputation. Our sample is discussed alongside some descriptive statistics in section 3.5. Section 3.6 sets out our econometric approach and how we deal with the endogeneity of budget setting. This section also includes econometric results on the determinants of the CA's budget. Our main results on the determinants of agency ratings are presented in section 3.7 and section 3.8 provides some concluding remarks.

3.2. Assessing the performance of a competition authority

The measurement of performance is a prerequisite for the understanding of how a CA can be improved. Measurement is the first step towards appraising performance, which is a prerequisite for understanding how a competition authority can be improved. Some of the more established agencies have been attempting this for some years and international organisations such as the Organisation for Economic Cooperation and Development (OECD), International Competition Network (ICN) and United Nations

Conference on Trade and Development (UNCTAD) have also recently emphasised the importance of finding an effective method of evaluating operations and performance of competition authorities. The problem is how to do this systematically.

A number of methodologies have been tried.[14] An easy statistic to collect is a simple count of the number of cases tackled by an agency. Kovacic et al (2011) liken this to a count of airport departures without tracking landings – it conveys nothing about the quality or wider importance of decisions or long-term investments in methods, guidelines, staff training and retention or influence on deterrence or legislative reform. The number of successful appeals may appear to provide an alternative indicator of the quality of individual decisions but there are fundamental biases in this measure. For example, prohibitions are more likely to be appealed than clearances and weak agencies do not take controversial decisions. Careful ex-post reviews of individual cases may appear to be more useful indicators, but they are expensive to conduct properly and even then they are not able to generate cross-agency comparisons. Similar problems affect all case-centric measures of performance because such metrics are incommensurable across CAs. More qualitatively, international organisations such as the OECD, ICN and UNCTAD facilitate and publish occasional peer reviews by other regulators and individual academics, mainly as a means of support to newer jurisdictions, but this process does not come up with a standardised measure of current performance.

An alternative approach is to construct an explicit set of best practice features of an ideal competition agency, then score each agency against these criteria. Buccirossi et al (2009) develop such an approach based on what they consider to be an ideal enforcement policy with a particular emphasis on the deterrence of anticompetitive activity. Their Competition Policy Indexes (CPIs) for 12 OECD countries are based on an assessment of each agency's institutions and enforcement record.[15] The institutional CPI is based on independence, separation of powers, quality of the law, powers during investigations, sanctions and damages. They supplement this by an enforcement CPI based on cases and resourcing. Although an interesting methodology, this approach *assumes* what is supposed to be a good institutional design, so it cannot be used to identify what works in practice. The methodology also measures only what can be relatively easily and objectively measured, and so may omit crucial features that help or hinder actual institutions. For example, independence is a key indicator in this methodology yet an agency may tick the

[14] See OECD (2005) and critical by reviews Huschelrath & Leheyda (2010) and Davies & Ormosi (2012).
[15] In further research (Buccirossi et al, 2012), they find that this index helps to explain differences in productivity growth across sectors and countries.

box of constitutional independence but still operate in awe of the Minister; alternatively it may have to present its decisions to the Minister for formal approval but Ministers may have a long and stable history of non- interference.[16]

A third type of methodology, which can be sensitive to the 'softer' nuances of institutional design, is based on detailed case studies of individual CAs. Fox and Trebilcock (2013) compare nine different jurisdictions using criteria of efficiency and fairness. We return to their classification of CAs below, but a very substantial research effort reveals too many important dimensions of difference for their study to draw any major conclusions on institutional design from their necessarily small sample of countries. A different approach is needed if a more comprehensive dataset is to be collected so that the underlying quality drivers can be identified.

It is partly in response to the weakness of these approaches in answering to the questions we pose in the introduction that we use a measure of reputation to proxy the quality of an agency. However, a long established economics literature provides much more positive reasons for doing so because of the strong causal link between performance and reputation. We turn to this next.

3.3. Performance and reputation

Reputation has been widely analysed across the business-related social sciences. Management researchers see organisational reputation as a valuable intangible asset that contributes to organizational performance (Rindova, Williamson, Petkova, & Sever, 2005), gives them sustainable competitive advantages ((Barney,1991), (Hall,1992)) which influences stakeholder's economic choices towards the organization ((Benjamin & Podolny, 1999), (Dollinger et al, 1997), (Deephouse, 2000). Marketing academics see reputation as the perceptions and beliefs about the firm based on previous interactions ((Campbell, 1999), (Prabhi & Steward, 2001)). Industrial organization economists define reputation as the consumers' expectations and beliefs about a firm's product quality ((Shapiro, 1982,1983), (Allen, 1984)).

The game theoretic literature highlights the importance of credibility if a reputation is to be sustained ((Kreps and Wilson, 1982), (Milgrom and Roberts, 1982)). For example, Klein and Leffler (1981) and Shapiro (1982, 1983) show how reputation enables a premium to be earned on high quality products, and how this

[16] See Hanretty and Koop (2012, 2013) for an analysis of de jure and de facto independence of regulators.

provides the incentive to invest in quality[17]. Although information available to buyers is imperfect, a high reputation cannot be sustained in the absence of genuine underlying quality. Mailath and Samuelson (2013) provide a recent review of the incomplete information game theoretic literature which provides rigorous foundations for how reputations establish links between past behaviour and expectations of future behaviour. This provides a rigorous foundation for the intuition that we expect good service in the future when good service has been provided in the past, and we can expect fair treatment in the future when fairly treated in the past. These models explain how reputation signals information to uninformed players. Jin and Leslie (2009) provide empirical support for some direct predictions from the theory of reputation in the context of restaurant hygiene; for example, restaurant chains have a better hygiene record than independent restaurants because they have more to lose if their standards fall.

The potential loss of reputation or credibility can similarly be the source of motivation for the policy maker to invest in high quality procedures. This investment is valuable due to the repeated interactions that regulators have with the private agents. The regulator benefits from a reputation for high quality case selection, evidence gathering and decision making. She gains direct utility from the admiration of her peers and there are also long term benefits of deterrence which makes her future job easier due to enhanced business compliance. The reputation of an agency feeds back to enable a highly reputed agency to achieve more than if it is held in low regard. Kovacic (2009) makes this point particularly clearly: "Perceptions of a competition agency's quality directly influence judicial decisions about whether to defer to the agency's positions, legislative decisions about the agency's budget and statutory authority, the willingness of companies to comply with laws entrusted to the agency's enforcement, and the agency's ability to hire and retain capable staff. A competition agency that enjoys an excellent brand is also likely to inspire citizen confidence in government by showing that public institutions truly 'work'."[18]

In the context of this chapter, we draw on the above analysis to claim that reputation is highly correlated with genuine quality. We also rely on a further role for reputation, this time for the rating agency. Our direct ratings measure is compiled by a commercial publisher which specialises in reporting on global

[17] Another well-known and influential application of reputation theory is in monetary policy; e.g. Barro et al (1983) and Backus and Driffil (1985). See also Grief (1989) for a historical view of the importance of a reputation for honest trade. Other applications include Beatty (1989) on auditors, Carter et al (1990, 1998) and Fang (2005) on finance.

[18] Management researchers also see organisational reputation as a valuable intangible asset that: contributes to organizational performance (Rindova, et al., 2005); gives them sustainable competitive advantages ((Barney ,1991), (Hall, 1992)); and influences stakeholder's economic choices towards the organization ((Benjamin & Podolny, 1999), (Dollinger, et al., 1997), (Deephouse, 2000)).

competition policy. This raises a potential issue about the incentive for the rating agency to tell the truth. This issue has been explored theoretically by Mathis et al (2009) in the context of credit rating agencies. They show that even an opportunistic rating agency, which is paid by the sellers of financial assets to rate its own products, has the incentive to report truthfully unless a sufficiently large fraction of its income is provided by such payments. In the case of GCR, it relies on the cooperation of agencies to provide it with raw data, but there are no payments by the agency to be rated. GCR is funded by practitioner subscriptions for its specialist news and information service. The annual rating exercise is only a small, though high profile, part of GCR's business. Thus, it is highly unlikely that it would be willing to undermine its wider reputation by publishing ratings that it did not believe were appropriate based on the evidence it gathers from those engaging regularly with the agencies[19]. We conclude that GCR quality ratings are founded on genuine quality.[20]

3.4. Determinants of reputation (and performance)

In this section, we set out some of the features that we expect to influence the performance and so reputation of a competition authority. Some of these are beyond any control by a hypothetical agency designer (e.g. population) and others are clearer choices if only in the long term (e.g. within-agency decision making versus prosecuting cases before a court). Some have clear ex ante predicted signs (e.g. budget) while others are theoretically ambiguous (e.g. specialised competition agency versus agency also encompassing consumer protection and/or regulation). Before considering the specifics of institutional design, we consider two controls for economy- wide features that are hard to change. These follow in the spirit of Douglass North's (1990) work highlighting the role of property rights and the rule of law in economic development.

[19] While it could be thought that there are potential biases from involving private sector evaluations in the rating process (notably a potential bias to rate authorities highly that adopt the same view on behaviour and deals as the private sector) and observing that many checks and balances are put in place by GCR to ensure such biases are not reflected in final results. The GCR sends a detailed questionnaire to the competition authorities canvassing all aspects of enforcement. The head of each agency are also asked to submit their own assessment of their agency's performance for the year. People who know the authority best: antitrust lawyers and economists, in-house counsel, academics, and local journalists who routinely cover the agency's work are then asked for feedback. Those responses are further supplemented by interviews – conducted in person and over the phone – with leading international competition practitioners.

[20] Even if the reader is unconvinced of the link between performance and reputation, she may still find interest in knowing what institutional features result in positive practitioner perceptions of an agency.

Governance

We expect that a CA will be more effective if it is embedded in an economic system with strong positive governance. Governance has been found to be important for other dimensions of economic performance. For example, Rodrik and Subramanian (2003) find that the quality of national institutions is the only significant determinant of international differences in income levels; e.g. economic integration has no additional explanatory power. Institutional quality is measured by a composite indicator that captures features such as the protection afforded to property rights and the strength of the rule of law.

We measure the general quality of institutions in each country by the World Bank governance index. This is a measure based on the control of corruption, political stability, government effectiveness, voice and accountability, regulatory quality and rule of law indicators. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them. Our specific measure is *Governance*, which is the average of the World Bank indicators of control of corruption, political stability, government effectiveness, voice and accountability, regulatory quality and rule of law (see Appendices 3.B).

Common law versus civil law

Another potentially important fundamental institution is the type of legal system. Common law regimes give more rulemaking powers to the judiciary while civil law regimes reserve greater power to the legislature giving less discretion to the judiciary (Dainow, 1966/7). Posner (1973) has claimed that the common law system is superior largely because it can act more like a market in adapting to change. Others support the legal certainty provided by a civil code. There is no a priori expectation of which is better and the benefits of each may be context- specific. For example, Arrunada and Andonova (2005) argue that the common law is good for stable, slowly evolving law in the context of a democracy with independent legally trained judges, while civil law is better for countries where rapid change is necessary, often after a major political change following a long-established autocracy supported by a corrupt judiciary.

We characterise these two legal systems by a simple dichotomous variable, *Common Law*. We use Tetley (1999/2000) for our classification but fully recognise that few systems are pure common law or civil law in practice, so it is mainly a matter of emphasis (see Appendices 3.C). We adopt no prior on whether common law should be better or worse for the implementation of competition policy. Finally, we note that the

common law is strongly associated with Anglo-Saxon countries which may share other characteristics that we do not fully capture in our other variables.

Agency design

Moving down from these macro-institutional measures, we next consider the broad design of the set of institutions specifically responsible for evidence gathering and decision making in competition enforcement. We follow Fox and Trebilcock (2013) in identifying three basic institutional models which we represent as zero-one dummy variables:

a. *Judicial* =1 if the competition agency must go to court for enforcement,

b. *Bifurcated* agency =1 if the agency goes to a specialised tribunal for enforcement, and

c. *Integrated* agency =1 if the first-level adjudication is made within the agency (e.g. by executives or a board of commissioners).

These three classifications embrace another important institutional feature, which is the prosecutorial (or adversarial) versus the inquisitorial approaches. In an adversarial system, the parties to competition litigation produce and present evidence and arguments to an independent judge or jury, who then decide the case. This encourages the agency to emphasise the evidence they find on lessening competition, which is balanced by the incentives for the firms to provide evidence of procompetitive behaviour. In contrast, inquisitorial decision makers rely on an internal information gathering process and its interpretation. This search for the 'truth' is more balanced but it may not reveal as much of the relevant evidence. Froeb and Kobashi (2001, 2012) compare the high incentives that parties have to provide more information in an adversarial system but with greater selection/bias as compared with the inquisitorial system where parties may, however, produce less information. We have no prior that there is an ex ante superior system. The nature of Fox and Trebilcock's three institutional models is that the first two are naturally prosecutorial, while the third is naturally inquisitorial, so we combine judicial and bifurcated agencies to identify *prosecutorial* systems. This dichotomy with the inquisitorial integrated agency is used as an alternative categorisation of institutional designs.

A second feature of agency design is the range of activities the agency has to cover. We define a specialised agency as one which enforces only competition law. Other agencies cover a wider portfolio of activities, sometimes including consumer protection and/or economic regulation of utilities. Standard transaction cost arguments suggest there may be a trade-off between the higher powered incentives to get competition enforcement right in a specialised agency, and the advantages of operating in an agency with

wider scope and access to specialist knowledge. We measure the specialisation of an agency by the percentage of staff devoted to competition.

The third feature we try to capture is institutional knowledge and experience measured by the age of institution, including any natural predecessor independent institution. An older competition authority may achieve a better performance through accumulated institutional memory and fine tuning of design. On the other hand, it may develop a sclerosis and be slow to adapt to new ideas. $cage$ is measured in years since first operation.

Economies of scale

A competition authority in a large country may have four advantages. First, for a given (small) proportion of the population employed by the competition authority, there are more human resources available to consider each market. Second, a larger economy has room for more firms of efficient scale and has fewer pockets of natural monopoly which are hard to deal with effectively using the standard tools of competition policy. This allows large-country competition authorities to focus on activities that are both suitable for appropriate intervention and of international interest.[21] Third, multinational firms can, in principle, walk away from a small market if they consider locally imposed remedies are too onerous, so a small competition authority faces more constraints. Fourth, a larger economy usually enjoys a greater range of economic activities, so the CA may see a wider variety of cases, including those which are more interesting and have a higher profile. *Population* is used to measure potential scale and the associated advantages of large scale.

Resourcing

We expect that the funding of a competition authority will have a major influence on its ability to do its job well. In particular, an agency with a larger budget is better able to recruit high quality staff, conduct research and complete inquiries in a timely manner. It is also likely to have greater continuity in human resources and is better able to perform an advocacy role with consequent advantages for deterrence. A poorly funded competition authority must choose between greater selectivity in pursuing cases (opening it up to Type 2 errors of omission), or reduced depth of economic analysis, data collection and processing (opening up Type 1 decision errors). We use the agency's annual budget to measure its funding.

[21] We note that this ability to invest more in cases of international interest may have an enhanced effect on reputation.

Population and wider institutional features are slow to change and, when they do, it is not due to CA reputation. They are, therefore, likely to be exogenous to our dependent variable. However, budget is unlikely to be exogenous because highly reputed agencies have a stronger voice in arguing for funding. Consequently, we pay particular attention to the endogeneity of budget in our econometrics.

3.5. Sample and data collection

GCR has published its annual assessment of the performance of a substantial number of competition agencies since 2006[22]. These are mostly the larger and more established regimes. GCR's research is based on information provided by the agencies, questionnaires and selected interviews to agencies, and feedback from antitrust lawyers, economists, in-house counsel and academics, mainly through questionnaires. They also draw on presentations and debate at conferences and reports in the GCR daily news review and briefings. The information gathered is then subjectively aggregated by an editorial panel to a star rating on a scale of one to five, sometimes including fractional stars. A full description of the GCR methodology is given in Appendices 3.A.

Our sample consists of 35 competition authorities from 32 countries over a period of 9 years from 2006 to 2014 (see Table 3.1). This is the full set of available countries with at least six years of data.

Table 3.1: Sample jurisdictions

Australia	Finland	Korea	Spain
Austria	France	Mexico	Sweden
Belgium (CC)	Germany	New Zealand	Switzerland
Brazil (CADE)	Greece	Norway	Netherlands
Brazil (SDE)	Hungary	Poland	UK (CC)
Canada	Ireland	Portugal	UK (OFT)
Czech Republic	Israel	Russia	US (DoJ)
Denmark	Italy	Slovakia	US (FTC)
EU (EC)	Japan	South Africa	

[22] See Global Competition Review (2013).

3.5.1. Descriptive statistics

Data sources and variable definitions are given in Table 3.2[23]. The full set of GCR ratings is reported in Table 2.4 and Table 3.3 shows the main evolution for the highest and lowest rated agencies between 2006 and 2012.

Table 3.2: Definition of variables and data sources (yearly data)

Variables	Proxy Used in Analysis	Data Source
$rating$	GCR Ordinal Star Ratings	GCR Annual Reviews
$ln\#pop$	Natural log of population	GCR Annual Reviews
$lnbudget$	Natural log of budget in million euros	GCR Annual Reviews
$lnGNIPC$	Natural log of gross national income per capita	World Bank
$governance$	Average estimate of control of corruption, political stability, government effectiveness, voice and accountability, regulatory quality and rule of law index	World Bank
$commonlaw$	Common law= 1 Civil Law= 0	Mixed Jurisdictions: Common Law v. Civil Law by W. Tetley[24]
$bifurcated$	Bifurcated Agency =1 Judicial =0 Integrated Agency (Base case =0)	The Design of Competition Law Institutions by E. Fox and M.J. Trebilcock
$judicial$	Judicial Agency =1 Bifurcated Agency =0 Integrated Agency (Base case =0)	The Design of Competition Law Institutions by E. Fox and M.J. Trebilcock
$prosecutorial$	Prosecutorial =1: If Bifurcated =1 Judicial = 1	The Design of Competition Law Institutions by E. Fox and M.J. Trebilcock
$lncage$	Natural log age of the CA	Competition Laws Outside the US, Volume 1 by S. Harris[25] and CA's website
$specialisation$	% staff devoted to competition	GCR Annual Review

[23] A small amount of interpolation was required for missing years of some independent variables. Brazil's SDE and SEAE integrated to form CADE in 2012, so SDE is a missing value for that year. Also, GCR did not report information for Slovakia for 2012, 2013 and 2014.
[24] See Tetley (1999-2000).
[25] See Harris (2001).

The EC and the US FTC have maintained their Elite performance throughout the 9 years while there has been a big improvement to the reputation of France, Germany and US (DOJ). There has been more turbulence in the lowest rankings. The main movers were Brazil, France, Germany, Greece, Japan, Korea, Spain and Russia each of which moved up by 1*. Denmark and Ireland experienced the greatest fall (one full star) but four other fell by a half star. Overall, 12 out of 35 competition authorities had changed ratings during the 9-year period.

The evolution of GCR rating for each competition authority for period 2006 to 2014 used in our analysis is reported in Table 2.4.

Table 3.3: GCR * Rating in 2014 and 2006

Elite 5*(Highest Rating)		**Fair $2\frac{1}{2}$*[26]**		**Movers**	
2014	**2006**	**2014**	**2006**	**UP(+1)**	**DOWN (-$\frac{1}{2}$)**
EC	EC	Belgium	Greece (2*)	Brazil	Czech
France	UK CC	Czech	Russia (2*)	France	Denmark (-1*)
Germany	US FTC	Denmark	Belgium	Germany	Finland
US DOJ		Ireland	Israel	Greece (+1.5*)	Ireland (-1*)
US FTC		Lithuania	Mexico	Japan	New Zealand
			Slovakia	Korea	Portugal
			South Africa	Spain	
				Russia	

Source: GCR Annual review

Table 3.4 provides pooled summary statistics for all our variables. Note that $commonlaw$, $bifurcated$, $judicial$ and $prosecutorial$ are time invariant.

[26] Greece and Russia were the two jurisdictions having a 2* rating in 2006.

Table 3.4: Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
$rating$	Overall	3.456	0.782	2.000	5.000	N = 308
	Between		0.749	2.333	5.000	n = 35
	Within		0.271	2.678	4.401	T = 8.8
$ln\#pop$	Overall	3.385	1.394	1.411	6.590	N = 312
	Between		1.411	1.452	6.059	n = 35
	Within		0.104	1.746	3.917	T = 8.914
$lnbudget$	Overall	2.633	1.116	-1.386	4.937	N = 305
	between		1.095	0.408	4.712	n = 35
	Within		0.360	0.267	4.112	T-bar = 8.714
$lnGNIPC$	Overall	10.303	0.690	8.457	11.555	N = 314
	between		0.686	8.778	11.399	n = 35
	Within		0.126	9.683	10.644	T = 8.971
$governance$	overall	1.053	0.638	-0.740	1.910	N = 315
	between		0.644	-0.722	1.856	n = 35
	Within		0.063	0.786	1.332	T = 9
$commonlaw$	overall	0.286	0.452	0.000	1.000	N = 315
	between		0.458	0.000	1.000	n = 35
	Within		0.000	0.286	0.286	T = 9
$bifurcated$	overall	0.171	0.377	0.000	1.000	N = 315
	between		0.382	0.000	1.000	n = 35
	Within		0.000	0.171	0.171	T = 9
$judicial$	overall	0.171	0.377	0.000	1.000	N = 315
	between		0.382	0.000	1.000	n = 35
	Within		0.000	0.171	0.171	T = 9
$prosecutorial$	overall	0.343	0.475	0.000	1.000	N = 315
	between		0.482	0.000	1.000	n = 35
	Within		0.000	0.343	0.343	T = 9
$lncage$	overall	3.132	0.697	1.099	4.710	N = 315
	between		0.685	1.868	4.673	n = 35
	Within		0.166	2.363	3.662	T = 9
$specialisation$	overall	0.650	0.293	0.000	1.000	N = 315
	between		0.251	0.010	1.000	n = 35
	Within		0.157	0.014	1.335	T = 9

Table 3.5 provides simple correlations with the GCR rating. The highest correlations are with the age of institution, budget and population. As we shall see, however, our regression results suggest some of these correlations may be misleading so we offer no further discussion at this stage.

Table 3.5: Linear correlation with rating

Variables	$rating$
$lnbudget$	0.674
$lnGNIPC$	0.369
$ln\#pop$	0.520
$governance$	0.293
$commonlaw$	0.371
$prosecutorial$	-0.123
$bifurcated$	-0.213
$judicial$	0.056

3.6. Methodology

The star ratings provide a discrete ordinal dependent variable so we adopt a random effects ordered probit model. We use random effects because we have panel data and some of our key independent variables of interest ($commonlaw$, $bifucated$, $judicial$ and $prosecutorial$l) have no time series variation so we would not be able to identify their contribution if we used fixed effects estimation.

3.6.1. Random effects ordered probit

An ordered probit is a generalization of the probit analysis to the case of more than two naturally ordered outcomes. It assumes no cardinality in the number of stars awarded. The ordered probit is built around a latent regression in the same manner as the binomial probit model (Greene, 2003) and is normally estimated using maximum likelihood:[27]:

$$y_{it}^{*} = x_{it}\beta + \epsilon_{it} + u_i, \;\; \epsilon_i \sim N(0,1), \text{ for } i = 1, \ldots\ldots, N, \text{ where } t = 1, \ldots\ldots\ldots, T$$

where y^{*} is the latent variable (unobserved) exact and u_i is the random disturbance characterising the *i*th observation and is constant through time (i.e allows between-agency variation). y_i is the observed ordinal variable which takes on values 0 through m according to the following scheme:

[27] See Green (2003) and Jackman (2000).

$$y_i = j \Leftrightarrow \mu_{j-1} < y_i^* \leq \mu_{j,}$$

Where $j = 0, \ldots, m$ having the probabilities of each ordinal outcome as

$$p[y_i = m] = \Phi(\mu_m - \beta' x_i) - \Phi(\mu_{m-1} - \beta' x_i)$$

$$= 1 - \Phi(\mu_{m-1} - \beta' x_i) \qquad \text{For } j = m \text{ (the highest category.)}$$

In our case, $y^*$is the latent index of reputation, y_i is the ordinal GCR rating (2, 2.5,3, 3.5, 4, 4.5 and 5); x_i is the vector of independent variables (national, budget and institutional design characteristics), β is the vector of regression coefficients and m = 7.

Our two central specifications differ only in the classification of agency design. Integrated agency (= inquisitorial model) is the excluded category in both cases. We call the following the ratings equations:

Specification 1

$$Rating_{it} = \beta_1 + \gamma_1 lnbudget_{it} + \beta_2 ln\#pop_{it} + \beta_3 governance_{it} + \beta_4 commonlaw_i + \beta_5 bifucated_i + \beta_6 judicial_i + \beta_7 cage + \beta_8 specialisation_{it} + \varepsilon_{it} + u_i \qquad \textit{Equation 3.1}$$

Specification 2

$$Rating_{it} = \delta_1 + \mu_1 lnbudget_{it} + \delta_2 ln\#pop_{it} + \delta_3 governance_{it} + \delta_4 commonlaw_i + \delta_5 prosecutorial_i + \delta_6 cage_{it} + \delta_7 specialisation_{it} + \omega_{it} + \varphi_i \qquad \textit{Equation 3.2}$$

In specification 2, the $bifurcated$ and $judicial$ variables are combined to obtain the prosecutorial variable.

3.6.2. Endogeneity of budget

Although budget is widely considered to be important for high quality enforcement, it is also possible that a high reputation helps in the political process of budget allocation. This potentially creates an econometric bias due to a correlation between $budget$ and the error term.

We therefore adopt an instrumental variable approach. We first estimate a budget equation by OLS and use that to create predicted values ($budgethat$) for use in the ordered probit ratings equation. The key to such an estimator is to find a variable that is both an informative determinant of $budget$ and is valid in the sense that it is uncorrelated with the error term in the ratings equation. Our identifying instrument is $GNIPC$. The wealthier the country, the more funding the government is able to provide to a competition

agency to perform its function. However, we have no reason to expect gross national income per capita ($GNIPC$) to be a direct determinant of the performance of a competition agency, other than through being a determinant of the agency's budget. We therefore use $GNIPC$ as our identifying instrument in the $budget$ equation alongside all the other independent variables.

We also considered an alternative method, the control function methodology (see Wooldridge, 2010), to solve the endogeneity problem. Since the estimated budget equation residuals are significant in our control function estimates so it can be claimed that they correct for endogeneity.[28] The results are shown in the Table 3.8.

Given the nature of our variables, we provide the estimates under both the random and fixed effects. More specifically, under the random effects, we regress $budget$ against the explanatory variables for each specification so as to get the best fitted budget instrument and is given by[29]:

Specification 1

$$lnbudget_{it} = \propto_1 lnGNIPC_{it} + \propto_2 ln\#pop_{it} + \propto_3 governance_{it} + \propto_4 commonlaw_{it} + \propto_5 bifucated_{it} + \propto_6 judicial_{it} + \propto_7 lncage_{it} + \propto_8 specialisation_{it} + \omega_{it} + u_i \quad \textit{Equation 3.3}$$

Specification 2

$$lnbudget_{it} = \theta_1 lnGNIPC_{it} + \theta_2 ln\#pop_{it} + \theta_3 governance_{it} + \theta_4 common\ Law_{it} + \theta_4 prosecutorial_{it} + \theta_5 lncage_{it} + \theta_6 specialisation_{it} + \varepsilon_{it} + \vartheta_i \quad \textit{Equation 3.4}$$

and under the fixed effects, we regress $budget$ against the explanatory variables excluding the time invariant ones i.e $common\ law$, $judicial$ and $bifurcated$ for specification 1 and $prosecutorial$ for specification 2. For the US, we used the budget which was separately allocated to each agencies (FTC and DOJ) and the GNIPC of the US for each agency. As for EU, the budget of allocated to DG com and the GNIPC from World Bank database were used.

[28] The control function is another way of dealing with endogeneity issue in models which are linear in parameters. It first estimates the model of endogenous regressors as a function of instruments, like the 'first stage' of 2SLS, then use the residuals from this model as an additional regressor in the main model. It relies on the same kinds of identification conditions as IV/2SLS. The difference is that in the 2SLS, we use the predicted value of the endogeneous variables and under the control function approach we include residuals to control for the endogeneity of the dependent variable in the original equation.

Our estimates for the first stage $budget$ regressions for both random and fixed effects are reported in Table 3.6. The two regressions complement the two specifications for the ratings equation according to the inclusion of either $prosecutorial$ or $bifurcated$ and $judicial$ separately. In this chapter, we have not attempted to specify a full structural equation grounded in the political economy of budget setting. Nevertheless, the results do have some intrinsic interest.

Table 3.6: Budget equations results

Dependent Variable: $lnbudget$				
	Specification 1		**Specification 2**	
Variables	**RE**	**FE**	**RE**	**FE**
$lnGNIPC$	1.059***	1.143***	1.073***	1.143***
	(0.168)	(0.244)	(0.170)	(0.244)
$ln\#pop$	0.393***	0.137	0.381***	0.137
	(0.082)	(0.098)	(0.085)	(0.098)
$governance$	-0.627**	-0.047	-0.565**	-0.047
	(0.247)	(0.462)	(0.262)	(0.462)
$commonlaw$	0.609*		0.626*	
	(0.337)		(0.348)	
$prosecutorial$			-0.606*	
			(0.334)	
$bifurcated$	-0.834**			
	(0.389)			
$judicial$	-0.354			
	(0.366)			
$lncage$	0.296*	0.370	0.304*	0.370
	(0.171)	(0.223)	(0.176)	(0.223)
$specialisation$	-0.220	-0.288	-0.223	-0.288
	(0.334)	(0.359)	(0.337)	(0.359)
$constant$	-9.717***	-10.530***	-9.909***	-10.530***
	(1.536)	(2.298)	(1.518)	(2.298)
Observations	305	305	305	305
Number of agencies	35	35	35	35
Number of time periods	9	9	9	9
Wald chi2 (RE)/F test (FE)	185.61	13.12	118.41	13.12
Prob > chi2	0.000	0.000	0.000	0.000
Within	0.254	0.273	0.257	0.273
Between	0.707	0.276	0.681	0.276
Overall	0.658	0.243	0.635	0.243

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

As expected, the coefficients on country size ($ln\#pop$) and wealth ($GNIPC$) are both positive and highly significant. Interestingly, the coefficient on $GNIPC$ indicates an elasticity of $budget$ with respect to

$GNIPC$ that is not significantly different to one. This contrasts with a much lower elasticity with respect to $ln\#pop$. This may reflect the availability of economies of scale even when workload rises in a larger economy.

We also find a significant negative effect of good governance on *budget*, which is consistent with a view that good governance is consistent with a more law-abiding business community that is also more cooperative with competition authorities (who therefore require less resourcing). We further find that $commonlaw$ countries are more generous in their funding. This may reflect the requirement for more detailed analysis in a less codified legal system. $prosecutorial$ systems, especially those with a bifurcated agency model, are less well funded than integrated/investigative agencies. In part, this may reflect that the agency does not have to fund the decision makers at the tribunal. The positive estimated coefficient on the age of the agency ($lncage$) provides weak evidence that budget creep increases funding over the years, but this effect is only marginally significant. Finally, we find no budgetary effect of $specialisation$ so there is no evidence of any dilution of funding due to the aggregation of activities.

3.7. Econometric results

While these budget results have some intrinsic interest, our main purpose of estimating a budget equation is to facilitate the estimation of our ratings model. In the following section, we draw on the above results for our IV estimators. Table 3.7 reports results using predicted budget, $budgethat$, which should be independent of the error term in the ratings equation. We also report results using the control function (CF) approach in the same table. We report both random effects (RE) and fixed effects (FE) estimates. Under fixed effects, the time invariant variables in the model cannot be estimated separately. Table 3.7 presents our main results and Table 3.8 reports the marginal effects. Bearing in mind that the ordered probit is calibrated in units of 'half a star', the marginal effects can be understood in terms of the impact of a unit rise in an explanatory variable on marginal 'half stars'.

Turning to factors that are specific to CAs, we find that the most easily adjusted of our variables, $budget$, has a highly significant positive impact on how a CA is rated. Once the endogeneity of budget is taken into account, we find that an 80% increase in budget results in an extra half-star rating. This is a much greater impact than is suggested by the simple ordered probit that ignores the endogeneity issue. This may be because the political process provides an enhanced budget for inherently weaker CAs in order to (partially)

compensate for their deficiencies. The IV and CF estimates take account of this and provide a better estimate of the positive impact of an exogenous change in budget.

Finally, we find much very much weaker evidence that the design features of the specific institutions of competition enforcement affect their reputation once the above factors have been taken into account. There is a consistent pattern of negative signs associated with $prosecutorial$ systems (and with $bifurcated$ and $judicial$ systems separately), but these estimated coefficients are not statistically significant. Variables measuring the age of institutions ($lncage$) and their $specialisation$ were never significant so are not included in our Table 3.7 models and results.[30] We conclude that no robust evidence is found to claim that one type of institutional design is inherently better than another.

[30] Results including these variables are reported in Appendices, Table 3.D.1 and Table 3.D.2.

Table 3.7: Set of regressions results

Variables	Dependent Variable: rating									
	Specification 1					Specification 2				
	No IV	2SLS		Control function		No IV	2SLS		Control function	
		RE	FE	RE	FE		RE	FE	RE	FE
$lnbudget$	0.510**			1.304**	1.363***	0.522*			1.301**	1.363***
	(0.259)			(0.541)	(0.318)	(0.238)			(0.521)	(0.318)
$lnbudgethat$		1.275**	1.290***				1.277**	1.290***		
		(0.555)	(0.316)				(0.533)	(0.316)		
$vhat$				-1.007*	-1.055***				-0.992*	-1.055***
				(0.569)	(0.347)				(0.559)	(0.347)
$ln\#pop$	1.394***	1.028***	1.356***	1.017***	1.248***	1.383***	1.030***	1.354***	1.022***	1.248***
	(0.175)	(0.311)	(0.207)	(0.304)	(0.217)	(0.162)	(0.293)	(0.207)	(0.288)	(0.217)
$governance$	2.269***	1.826***	1.253*	1.873***	1.431**	2.313***	1.805***	1.253**	1.848***	1.431***
	(0.487)	(0.564)	(0.510)	(0.595)	(0.519)	(0.439)	(0.554)	(0.510)	(0.577)	(0.519)
$commonlaw$	1.661***	1.264*		1.219*		1.662***	1.260*		1.213*	
	(0.606)	(0.686)		(0.681)		(0.607)	(0.704)		(0.692)	
$prosecutorial$						-1.054*	-0.493		-0.459	
						(0.560)	(0.769)		(0.752)	
$bifurcated$	-1.201	-0.438		-0.376						
	(0.859)	(1.122)		(1.104)						
$judicial$	-0.909*	-0.556		-0.550						
	(0.507)	(0.587)		(0.597)						
cut1_cons	3.824***	4.076***	4.274***	4.143***	4.318***	3.867***	4.067***	4.274***	4.128***	4.318***
	(0.748)	(0.792)	(0.891)	(0.790)	(0.886)	(0.679)	(0.715)	(0.891)	(0.709)	(0.886)
cut2_cons	5.609***	5.917***	6.168***	5.987***	6.217***	5.651***	5.906***	6.168***	5.971***	6.217***
	(0.960)	(0.898)	(0.870)	(0.919)	(0.866)	(0.906)	(0.843)	(0.870)	(0.857)	(0.866)
cut3_cons	7.980***	8.292***	8.599***	8.380***	8.663***	8.026***	8.289***	8.599***	8.367***	8.663***
	(1.129)	(1.033)	(0.910)	(1.082)	(0.907)	(1.075)	(0.980)	(0.910)	(1.017)	(0.907)

cut4_cons	10.040***	10.411***	10.720***	10.531***	10.81***	10.08***	10.406***	10.720***	10.519***	10.809***
	(1.265)	(1.151)	(1.011)	(1.200)	(1.011)	(1.233)	(1.115)	(1.011)	(1.158)	(1.011)
cut5_cons	11.740***	12.169***	12.401***	12.292***	12.498***	11.776***	12.160***	12.402***	12.276***	12.498***
	(1.437)	(1.320)	(1.092)	(1.369)	(1.092)	(1.411)	(1.292)	(1.092)	(1.335)	(1.092)
cut6_cons	12.700***	13.185***	13.362***	13.299**	13.453***	12.736***	13.171***	13.363***	13.280***	3.453***
	(1.436)	(1.306)	(1.137)	(1.353)	(1.137)	(1.414)	(1.282)	(1.137)	(1.323)	(1.137)
sigma2_u_cons	0.940**	1.123*	1.196**	1.095**	1.175**	0.939**	1.136*	1.196**	1.097**	1.175**
	(0.350)	(0.438)	(0.386)	(0.424)	(0.380)	(0.351)	(0.444)	(0.386)	(0.425)	(0.380)
Observations	305	305	305	305	305	305	305	308	305	305
Number of agencies	35	35	35	35	35	35	35	35	35	35
Number of time periods	9	9	9	9	9	9	9	9	9	9
Wald chi2	114.09	133.32	112.47	133.54	115.29	113.29	131.22	112.47	134.35	115.29
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log pseudolikelihood	-280.242	-277.7432	-279.689	-276.429	-278.517	-280.333	-277.975	-279.689	-276.521	-278.517

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Table 3.8: Marginal effects

Dependent Variable: rating										
Variables	**Specification 1**					**Specification 2**				
	No IV	**2SLS**		**Control function**		**No IV**	**2SLS**		**Control function**	
		RE	**FE**	**RE**	**FE**		**RE**	**FE**	**RE**	**FE**
$lnbudget$	0.510**			1.304**	1.363***	0.522*			1.301**	1.363***
	(0.259)			(0.541)	(0.318)	(0.238)			(0.521)	(0.318)
$lnbudgethat$		1.275**	1.290***				1.277**	1.290***		
		(0.555)	(0.316)				(0.533)	(0.316)		
$vhat$				-1.007*	-1.055***				-0.992*	-1.055***
				(0.569)	(0.347)				(0.559)	(0.347)
$ln\#pop$	1.394***	1.028***	1.356***	1.017***	1.248***	1.383***	1.030***	1.354***	1.022***	1.248***
	(0.175)	(0.311)	(0.207)	(0.304)	(0.217)	(0.162)	(0.293)	(0.207)	(0.288)	(0.217)
$governance$	2.269***	1.826***	1.253*	1.873***	1.431**	2.313***	1.805***	1.253**	1.848***	1.431***
	(0.487)	(0.564)	(0.510)	(0.595)	(0.519)	(0.439)	(0.554)	(0.510)	(0.577)	(0.519)
$commonlaw$	1.661***	1.264*		1.219*		1.662***	1.260*		1.213*	
	(0.606)	(0.686)		(0.681)		(0.607)	(0.704)		(0.692)	
$prosecutorial$						-1.054*	-0.493		-0.459	
						(0.560)	(0.769)		(0.752)	
$bifurcated$	-1.201	-0.438		-0.376						
	(0.859)	(1.122)		(1.104)						
$judicial$	-0.909*	-0.556		-0.550						
	(0.507)	(0.587)		(0.597)						

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

3.8. Conclusion

We argue that it is important to measure the success of competition authorities in order to inform the debate on agency design and funding. In the absence of any feasible direct measures of performance, peer ratings are highly informative. Although our measure of reputation is necessarily subjective, we have argued that there is good theoretical backing for this to be highly correlated with actual performance. In the absence of any other objective measures of agency quality, we believe this chapter provides some much needed objective guidance to countries considering reform. Many countries have recently made major changes to the design of their competition enforcement institutions and their range of activities (e.g. Belgium, Brazil, France, the Netherlands, Spain, UK). There has been very little research to guide these major changes.

Some of our findings relate to the importance of deeply embedded institutions that are fundamental to a country's legal system. These national features are almost impossible to change and, anyway, no country is going to switch from civil law to common law to improve its competition enforcement rating! Nevertheless, it is important to understand that there are important economies of scale in competition enforcement so small population countries find it harder to excel. We also find general good governance institutions to be highly influential on performance. It further appears that common law regimes have an advantage.

Other factors are easier to change. For example, there is a serious medium term choice to be made between designing a prosecutorial or an inquisitorial system. This choice was hotly debated in the run-up to the recent UK reforms, particularly in relation to the enforcement of antitrust (i.e. anticompetitive agreements and abuse of dominance). The debate was based more on opinion than fact and it was a very close decision to continue with an inquisitorial, integrated agency approach. Many countries have also considered the advantages of either specialised or encompassing institutions (e.g. competition law enforcement alongside consumer protection). Our findings suggest that there would be little benefit to making disruptive changes.

Finally, a CA's budget is normally set annually and in this sense it is the easiest feature to change. We find that budget allocation has a very direct payoff in terms of improving a CA's effectiveness/reputation.

Appendices

3.A The GCR - Introduction

Research

Each year, *GCR* sends a detailed questionnaire to the competition authorities canvassing all aspects of enforcement. The data covers everything from the size of the authority to the average age and tenure of the staff, as well as the methodology for setting priorities and ensuring transparency, stability and procedural fairness. We also ask for information about the number of merger filings an agency has received and how it has handled those deals, as well as obtaining a detailed breakdown of cartel and abuse of dominance work. Those statistics help to paint a picture of the authority as we begin to assess the results of its work. We also ask the head of each agency to submit their own assessment of their agency's performance in 2012. Next, we seek feedback from the people who know the authority best: antitrust lawyers and economists, in-house counsel, academics, and local journalists who routinely cover the agency's work. Local competition counsels were asked to fill out an online survey airing their views on the authority's performance in each of its enforcement duties, as well as the level of professionalism and independence at the agency. Those responses were supplemented by interviews – conducted in person and over the phone – with leading international competition practitioners.

Add to that information gathered by *Global Competition Review* during the course of the year. We publish more than 1,500 news stories annually through our daily briefing. Those articles cover developments at competition authorities the world over, from the launch of the COMESA Competition Commission in Africa to the Google investigations in the US and the EU. The breadth and depth of our news coverage provides an unparalleled resource for determining the strengths and weaknesses of the agencies we review.

Global Competition Review also conducts monthly surveys of the competition landscape in different jurisdictions, meeting with prominent figures in the local antitrust bar and interviewing the head of the national competition agency. Since the last edition of *Rating Enforcement*, we have visited or surveyed Argentina, Australia, Belgium, Brazil, Canada, Denmark, Germany, Indonesia, Italy, Japan, Malaysia, Mexico, Poland, Portugal, Singapore, South Africa, Taiwan, the United Kingdom and, in the United States, California, Miami, New York, and Washington, DC.

We also attend every major competition conference, including the International Competition Network meeting, as well as hosting our own conferences in Europe, the USA and Asia.

Reading the results

We begin our analysis by rating each authority on a scale of one to five. The results show how each authority compares to its international counterparts. Though no authority is perfect, we believe those that earned five stars are at the forefront of antitrust enforcement worldwide. Similarly, a low ranking doesn't indicate that an authority is failing or ineffectual – quite the opposite. Appearing in the survey at all is an indication that the authority is a meaningful enforcer.

But it is impossible to compare all authorities on an absolute scale. Each agency has different responsibilities and vastly differing resources at its disposal. The combined budgets of the two US antitrust agencies, for example, is more than double the combined budgets of the 20 most poorly funded authorities.

Although the survey we give agencies is a one-size-fits-all template, we understand that the performance of each agency is pegged to its budget, resources and the competition culture in each country. As such, in our write-up of each agency, we also include a performance indicator in addition to our star ranking. If an agency is thought to make excellent use of its resources and has surpassed its previous accomplishments, this is indicated with an "up" arrow. Horizontal arrows show that an authority performed as expected, while a "down" arrow reflects a disappointing year.

Our analysis of the quantitative data collected this year includes comparative tables, which show how the authorities measure up in terms of size, budget, staff retention, mergers challenged, fines imposed and the length of investigations. We also include information on other influential factors such as a country's population or its gross national product, to place the raw data in a more useful context. All monetary statistics are presented in euros for comparative purposes.

The remainder of the report consists of individual statistical analyses of each country's performance in 2012, supplemented by a commentary.

Where we present staffing statistics, we are referring to the number of non-administrative, competition-focused employees, unless otherwise stated. Also, where we break down the number of staff departures into those who retired and who remained in the civil service, our percentages are a proportion of the staff departure figures, rather than the entire organisation.

Furthermore, where we provide figures for dawn raids and for cartel decisions, we are referring to the number of separate matters, not the number of companies involved.

3.B Governance index[31]

Governance consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them.

Voice and Accountability

Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

Political Stability and Absence of Violence

Political stability and absence of violence measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism.

Government Effectiveness

Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Regulatory Quality

Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

Rule of law

Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

[31] See World Bank (2013).

Control of Corruption

Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private Interests.

3.C Civil v/s Common Law

From Dainow (1966-1967), page 424:

a) Legislation as the basis of the civil law

Generally, in civil law jurisdictions the main source or basis of the law is legislation, and large areas are codified in a systematic manner. These codes constitute a very distinctive feature of a Romanist legal system, or the so-called civil law. Although in the form of statutes duly enacted by the proper legislative procedure, these codes are quite different from ordinary statutes. A civil code is a book which contains the laws that regulate the relationships between individuals. Generally it contains the following topics: persons and the family, things and ownership, successions and donations, matrimonial property regimes, obligations and contracts, civil responsibility, sale, lease, and special contracts, as well as liberative prescription (statute of limitations) and acquisitive prescription (adverse possession).A code is not a list of special rules for particular situations; it is, rather, a body of general principles carefully arranged and closely integrated. A code achieves the highest level of generalization based upon a scientific structure of classification. A code purports to be comprehensive and to encompass the entire subject matter, not in the details but in the principles, and to provide answers for questions which may arise.

b) Judicial decisions as the basis of the common law

Looking at the law in England, the picture is a totally different one. During the formative period of English legal history, there was no strong central legislative body, but there were the powerful king's courts. When a court decided a particular case, its decision was not only the law for those parties, but had to be followed in future cases of the same sort, thereby becoming a part of the general or common law. Thus, the common law, as a body of law, consisted of all the rules that could be generalized out of judicial decisions. New problems brought new cases, and these enriched the rules of the common law. Actually, the common l aw was conceived as being all-inclusive and complete; if a rule had not already been formulated, it was the judge's responsibility to declare it. Thus, judicial decisions were both the source and the proof of the

law, pronounced in connection with actual cases. What gave stability and continuity to this system was the doctrine of "precedent”. Once a point had been decided, the same result had to be reached for the same problem; the judge was obliged to "follow" the earlier decision, the precedent. However, since courts are jealous of their prerogatives, the rule of precedent was applied only to the "ratio decidendi" or the exact point which was indispensable and necessary to reach a decision. Non-essential points were classified as "obiter dicta" and were not binding. If a new situation resembled a prior case but was not exactly the same, then two possibilities were open to the judge. If he felt that it would be the socially desirable result to have the same solution, he could "apply" the rule of the earlier case. However, if the judge felt the other way, he could "distinguish" the previous decision and leave its application limited to the specific fact situation which it con-trolled. In extreme situations, a court could brand an earlier case as erroneous and "overrule" it, thereby providing a new precedent for the point involved.

3.D Regression results

Table 3.D.1: Regression results- age of competition authority and specialisation

Variables	Dependent Variable: $rating$							
	Specification 1				Specification 2			
	2SLS		Control function		2SLS		Control function	
	RE	FE	RE	FE	RE	FE	RE	FE
$lnbudget$			1.352**	1.285***			1.351*	1.285***
			(0.592)	(0.432)			(0.565)	(0.432)
$lnbudgethat$	1.335**	1.240***			1.332**	1.240***		
	(0.602)	(0.435)			(0.572)	(0.435)		
$vhat$			-1.052*	-0.977**			-1.040	-0.977**
			(0.553)	(0.461)			(0.541)	(0.461)
$ln\#pop$	1.029***	1.366***	1.023***	1.252***	1.031***	1.366***	1.029***	1.252***
	(0.293)	(0.217)	(0.290)	(0.228)	(0.275)	(0.217)	(0.274)	(0.228)
$lngovernance$	1.829***	1.290**	1.877***	1.482***	1.804***	1.290**	1.850**	1.482***
	(0.573)	(0.535)	(0.607)	(0.544)	(0.551)	(0.535)	(0.574)	(0.544)
$commonlaw$	1.268*		1.229*		1.262*			1.222
	(0.678)		(0.675)		(0.700)			(0.687)
$prosecutorial$					-0.490		-0.467	
					(0.728)		(0.715)	
$bifurcated$	-0.426		-0.378					
	(1.098)		(1.089)					
$judicial$	-0.568		-0.569					
	(0.567)		(0.577)					
$lncage$	-0.094	0.028	-0.086	0.074	-0.101	0.028	-0.090	0.074
	(0.534)	(0.419)	(0.523)	(0.419)	(0.547)	(0.419)	(0.530)	(0.419)
$specialisation$	-0.059	-0.190	-0.096	-0.173	-0.051	-0.189	-0.093	-0.173
	(0.516)	(0.473)	(0.493)	(0.473)	(0.521)	(0.473)	(0.494)	(0.473)

cut1_cons	3.901***	4.181***	3.957***	4.301***	3.884***	4.181***	3.936***	4.301***
	(1.080)	(1.091)	(1.065)	(1.084)	(1.071)	(1.091)	(1.050)	(1.084)
cut2_cons	5.744***	6.074***	5.802***	6.198***	5.725***	6.074***	5.780***	6.198***
	(0.962)	(1.070)	(0.935)	(1.066)	(0.954)	(1.070)	(0.914)	(1.066)
cut3_cons	8.121***	8.501***	8.196***	8.639***	8.111***	8.501***	8.178***	8.639***
	(0.976)	(1.098)	(0.964)	(1.096)	(0.964)	(1.098)	(0.932)	(1.096)
cut4_cons	10.245***	10.627***	10.350***	10.790***	10.233***	10.627***	10.340***	10.790***
	(1.129)	(1.174)	(1.108)	(1.174)	(1.130)	(1.174)	(1.097)	(1.174)
cut5_cons	12.003***	12.304***	12.110***	12.470***	11.985***	12.304***	12.090***	12.470***
	(1.292)	(1.245)	(1.279)	(1.246)	(1.297)	(1.245)	(1.272)	(1.246)
cut6_cons	13.018***	13.262***	13.120***	13.420***	12.997***	13.262***	13.090***	13.420***
	(1.273)	(1.286)	(1.255)	(1.286)	(1.283)	(1.286)	(1.251)	(1.286)
_cons	1.137*	1.176**	1.106*	1.149**	1.151*	1.176**	1.108*	1.149**
	(0.459)	(0.388)	(0.440)	(0.380)	(0.463)	(1.286)	(0.440)	(0.380)
Observations	305	305	305	305	305	305	305	305
Number of agencies	35	35	35	35	35	35	35	35
Number of time periods	9	9	9	9	9	9	9	9
Wald chi2	151.64	113.99	150.91	116.54	145.86	113.43	150.5	116.54
Prob > chi2	0	0	0	0	0	0	0	0
Log pseudolikelihood	-277.702	-281.069	-276.375	-278.441	-277.932	-279.610	-276.467	-278.441

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Table 3.D.2: Marginal effects results- age of institution and agency specialisation

Variables	Dependent Variable: $rating$							
	Specification 1				Specification 2			
	2SLS		Control function		2SLS		Control function	
	RE	FE	RE	FE	RE	FE	RE	FE
$lnbudget$			1.352**	1.285***			1.351*	1.285***
			(0.592)	(0.432)			(0.565)	(0.432)
$lnbudgethat$	1.335**	1.240***			1.332**	1.240***		
	(0.602)	(0.435)			(0.572)	(0.435)		
$vhat$			-1.052*	-0.977**			-1.040	-0.977**
			(0.553)	(0.461)			(0.541)	(0.461)
$ln\#pop$	1.029***	1.366***	1.023***	1.252***	1.031***	1.366***	1.029***	1.252***
	(0.293)	(0.217)	(0.290)	(0.228)	(0.275)	(0.217)	(0.274)	(0.228)
$lngovernance$	1.829***	1.290**	1.877***	1.482***	1.804***	1.290**	1.850**	1.482***
	(0.573)	(0.535)	(0.607)	(0.544)	(0.551)	(0.535)	(0.574)	(0.544)
$commonlaw$	1.268*		1.229*		1.262*			1.222
	(0.678)		(0.675)		(0.700)			(0.687)
$prosecutorial$					-0.490		-0.467	
					(0.728)		(0.715)	
$bifurcated$	-0.426		-0.378					
	(1.098)		(1.089)					
$judicial$	-0.568		-0.569					
	(0.567)		(0.577)					
$lncage$	-0.094	0.028	-0.086	0.074	-0.101	0.028	-0.090	0.074
	(0.534)	(0.419)	(0.523)	(0.419)	(0.547)	(0.419)	(0.530)	(0.419)
$specialisation$	-0.059	-0.190	-0.096	-0.173	-0.051	-0.189	-0.093	-0.173
	(0.516)	(0.473)	(0.493)	(0.473)	(0.521)	(0.473)	(0.494)	(0.473)

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Chapter 4 Modelling the time path of cartel detection and deterrence**

4.1. Introduction

Over recent years, competition authorities and academic researchers have become increasingly interested in the evaluation of competition policy. Nearly always, evaluations are based on counts of activities – the number of cartels or abuses detected and prohibited, and the number of anti-competitive mergers remedied or prohibited in a period of time. However, competition policy involves more than just policing actual antitrust cases and violations; it also involves deterrence (Barros, Clougherty & Seldeslachts, 2010). As Buccirossi et al (2009) wrote "…the most effective competition policy regime is one in which the competition authority (CA) achieves total deterrence and, hence, never has to block a merger, never has to uncover a cartel or any other anticompetitive agreement, and never has to condemn a firm for abusing its dominant position. In an ideal regime firms do not dare to propose an anticompetitive merger, do not attempt to form a cartel, never enter into an anticompetitive agreement."[33] This raises obvious doubts about evaluation methods based solely on counts of cases convicted. While a CA that detects many cases might be interpreted as efficient, this may be the result of very weak deterrence. Other CAs which are better at deterring may investigate fewer cases because fewer transgressions occur. Ideally then, an evaluation of policy should aim to measure success in deterrence, as well as purely counting how many cases the CA intervenes. But, of course, this is intensely difficult because it requires measuring how the law has impacted on intentions, which have not been materialised into actions.

While a number of recent studies have made important contributions to understanding the role of deterrence in competition policy and its impact on cartels (see section 4.2), none has attempted to assess the success of CAs in detection and deterrence. The purpose of this chapter is to help fill this gap, by providing a theoretically understanding of how the age profile of the number of cartels convicted by a CA can be interpreted in terms of both its efficiency in detection and success in deterrence. A theoretical model of a competition authority that administers a deterrence based-

** Joint paper with Professor Stephen Davies and Dr. Franco Mariuzzo, School of Economics and Centre for Competition Policy, University of East Anglia, NR4 7TJ, Norwich, United Kingdom.

[33] But they add the footnote "There is no reason to believe that the ideal competition policy regime is the one that a jurisdiction should strive for. Indeed the ideal regime, even if it were feasible, would entail very high implementation costs, and those are probably much higher than the ones society would be rationally willing to bear: the ideal competition policy regime may not be the most efficient one."

competition policy in the presence of uncertainty is developed- using a framework that allows risk-neutral firms and the CA take uncertainty into account when deciding their actions. The model is then tailored to provide predictions about the age profile of the number of cartels convicted, whose empirical analysis is the core of next chapter.

The remainder of the chapter is organised as follows: Section 4.2 reviews the literature on cartel deterrence and detection. Section 4.3 develops a theoretical model of composition-based deterrence. Section 4.4 expands this to encompass frequency deterrence. Section 5 concludes.

4.2. Literature review

"Deterrence is a central theme in the theory and practice of law enforcement, and the enforcement of competition law is no exception" (Buccirossi et al, 2009). The aim of any competition law is to promote a healthy environment where market competition is maintained by forbidding and regulating any type of anti-competitive conduct (cartels, abuses of monopoly position and anti-competitive mergers). The CA has the main mission of enforcing its competition law and policy effectively, by detecting and deterring any anti-competitive behaviour. As a CA grows and acquires experiences, it is expected to become more efficient in detecting cartels, preventing repeating offenders and deterring individuals/firms from engaging in anti-competitive conducts over time. Cartels may be of two types: cartels that are easy to capture and sophisticated cartels, which require experience in order to be tackled.

There has recently been an increasing amount of studies looking at the different aspects of cartel detection and deterrence effect of competition laws and policies when assessing how good a CA is in achieving its aims. Among the various methods employed to evaluate the performance of a CA, the count activity remains the most common and easiest one (Davies & Ormosi, 2012). It involves a simple counting of the number of cartels detected and investigated (investigation rate). This method has however been victim of criticism (Kovacic, 2011) and one should be cautious when interpreting the results of this analysis.

When analysing the detection efficiency of CA, a rise in the investigation rate implies that the CA is very efficient in detecting cartels and a fall in detection indicates that the CA is not very efficient. On the other hand, from the deterrence angle, a rise in the number of cartel cases indicates that the CA has failed to deter them and a fall shows that the CA is successful in deterring cartels and is doing well. So, how can one interpret a rise in the number of cartels convicted, given that both efficiencies contradict each other?

The existing literature actually looks at both detection and deterrence efficiencies but not usually together, which is what we attempt to do in this study. Although, the literature surveys are still at an early stage, numerous attempts have recently been made to measure these efficiencies.

As a CA establishes, it starts working towards detecting competition cases. The secretive nature of cartels makes it very difficult for CAs to detect, prove[34] and consequently measure in full their performance. Despite the non-availability of data of cartels that go undetected, few attempts have nevertheless been made in estimating the probability of cartel detections. Bryant & Eckard (1991) use a model on statistical birth and death process to base their estimations on conspiracy durations in the US.[35] Using the same methodology Combe et al (2008) then later use detection durations, birth and death processes to estimate the probability of a cartel getting caught in the EU.[36] Miller (2009) uses a different method to show that the introduction of leniency programme in 1993 increased cartels' detection rate. More recently, drawing from a capture-recapture analysis, Ormosi (2014) estimates time-dependent cartel discovery rates, while allowing for heterogeneity across firms[37].

Detection plays an essential role in the enforcement of competition law and policy as it leads to deterrence (Bryant & Eckard (1991) and Combe et al (2008)). A CA detecting cartels successfully will also have the effects of preventing cartelised behaviour from firms. The deterrence theory states that people do not commit crimes because they are afraid of getting caught, rather than being motivated by some deep moral sense. Thus, for deterrence to be successful, it is essential that the law is effectively enforced and that punishment is sufficiently severe so that individuals/firms are deterred from breaking the law.

According to Buccirossi et al (2009), deterrence depends on three features of the competition law and policy, namely: (i) the level of the loss that firms and individuals expect to suffer if they are convicted; (ii) the perceived probability of wrongdoers being detected and convicted; and (iii) the perceived probability of being wrongly convicted. It therefore largely depends on the probability of getting caught and the magnitude of the punishment (Baker, 2003). In these studies, Connor (2007) found that in order to ensure optimal deterrence of global cartels, total financial sanctions should be four times the expected global cartel profits (the overcharge). More recently, Connor & Lande (2011)

[34] Only a fraction of them are detected (Bryant and Eckard (1991), Combe et al. (2008) and Werden, Barnett, & Hammond (2012)).
[35] The estimated probability of price fixing conspiracies getting caught was between 13% and 17% in a given year in the US between 1961 and 1988.
[36] They estimate the annual probability of cartels getting caught as between 12.9 and 13.3% in the EU.
[37] His results suggest that the European Commission's detection rate was 15%-20% between 1967 and 2007.

suggest that the collective level of existing sanctions should be multiplied by a factor of at least five so as to protect cartel victims.

Alternatively, advocacy[38] and education of firms and consumers can also contribute to deterrence of cartelised behaviour. In their paper, Davies & Ormosi (2012) argue that the benefits of advocacy activities may exceed those from enforcement actions. The more people and firms will be aware of the competition policy and risks involved when breaching the law, the less likely they will be to engage in anti-competitive conduct.

4.3. A model of composition deterrence

4.3.1. The model

The purpose of this chapter, then, is to model the behaviour of competition authorities and firms in order to unravel the functional form of how the number of cartels convicted changes over the lifetime of the CA. This will depend on the interaction between detection and deterrence.

We distinguish between frequency-based and composition-based deterrence. Frequency-based deterrence refers to a case where a potential cartel is deterred from even forming, while composition-based deterrence refers to the case where the cartel is not deterred from forming, but chooses to change its behaviour (typically, through reducing price) so as to avoid being caught. Initially, in this section, we focus on composition-based deterrence and then in section 4.4, we model two alternative frameworks to study frequency-based deterrence.

The model that is proposed is based on a two-stage game. In stage one, the CA chooses the effort to put in investigating cartels– its aim is to maximise consumer welfare. Its effort then determines, the probability that a cartel is investigated. In stage two, the cartel firms take this uncertain probability into account when setting output to maximise their expected profit. We examine how deterrence changes over time, as the CA becomes more efficient in convicting cartels.

[38] Competition advocacy refers to those activities conducted by the CA related to the promotion of a competitive environment for economic activities by means of non-enforcement mechanisms, mainly through its relationships with other governmental entities and by increasing public awareness of the benefits of competition (Advocacy Working Group, 2002). Advocacy is therefore closely linked to communication functions carried out by authorities to promote a competitive environment among government agencies, legislators and courts, as well as among business and consumer associations, academics and society as a whole.

We consider a single cartelised market. Budget is allocated by the government and is independent of CA's performance. Both firms and the CA are risk-neutral agents. The CA's objective is to maximise consumer welfare, which, in this context, means limiting cartel abuse.
Throughout the chapter, we denote random variables with tilde.

Demand side

The inverse demand function for a given market is:

$$p = 1 - q, \qquad \textit{Equation 4.1}$$

where q as the total industry output.

The investigation probability

The CA receives and monitors various signals from different players in the economy in the form of complaints from customers, rivals or other trade sources. These sources of complaint are combined in our model into one single signal and are assumed to increase with the price set by the cartel. The probability that the CA instigates an investigation also increases with the 'effort', g, which the CA chooses to expend on investigation of cartels.

The conviction probability

Once the firms are investigated, they are prosecuted and successfully convicted with probability γ, with $0 < \underline{\gamma} \leq \gamma \leq 1$. The parameter γ is treated as exogenous, with value known to the firms and to the CA. If convicted, the cartel is punished (via a fine or/and imprisonment), denoted by f.

Thus, the expected fine faced by a cartel is given by

$$E(fines) = \tau(p)\gamma f \qquad \textit{Equation 4.2}$$

where $\tau(p)$ is the probability that a cartel is investigated. Firms know the probability distribution that a cartel is investigated, which is:

$$\tau(p) = gp, \text{ with } 0 \leq g \leq 1, \qquad \textit{Equation 4.3}$$

where g is the CA's decision variable and captures the CA's effort. The greater the 'effort' put in by the CA, the higher the probability that a cartel is investigated. The higher the price the higher the probability the CA investigates the cartels.

Firms' behaviour

Cartelists are risk neutral and maximise their joint expected profit $E[\tilde{\pi}]$. For expositional simplicity, and without loss of generality, we set the marginal cost of production to be zero. The expected profit function for the cartel is then given by:

$$\pi \triangleq E[\tilde{\pi}] = pq - E(fines) \qquad \textit{Equation 4.4}$$

and substituting Equation 4.1, 4.2 and 4.3 into Equation 4.4, yields the expected profits:

$$\pi \triangleq E[\tilde{\pi}] = (1-q)q - (1-q)g\gamma f. \qquad \textit{Equation 4.5}$$

The first order condition for expected profit maximisation is

$$\frac{\partial \pi}{\partial q} = 1 - 2q + g\gamma f = 0. \qquad \textit{Equation 4.6}$$

And the second order derivative is

$$\frac{\partial^2 \pi}{\partial q^2} = -2.$$

The level of optimal output for the cartel is:

$$q(g) = \frac{1}{2}(1 + g\gamma f) \qquad \textit{Equation 4.7}$$

Where quantity is increasing in g, as shown below:

$$\frac{dq(g)}{dg} = \frac{\gamma f}{2} > 0. \qquad \textit{Equation 4.8}$$

Thus, if the CA increases its 'effort' (g), the cartel will increase its output and hence lower its price.

Competition authority's problem

In deciding how much effort to expend, it is assumed the CA aims to maximise consumer welfare, net of its enforcement costs. Its costs are assumed to be a strictly convex function of g, and given by $\frac{g^2}{2}$. The explanation for cost convexity is that an investigation becomes increasingly costly once the relatively easy first steps have been completed.

$$w(q(g)) \triangleq E(\tilde{w}(q(g)) = \int_0^{q(g)} [p(q) - p(g)]\, dq - \frac{g^2}{2} \qquad \textit{Equation 4.9}$$
$$= \int_0^{q(g)} [(1-q) - (1-q(g))]\, dq - \frac{g^2}{2}.$$

Substituting $q(g)$ (from Equation 4.7) in Equation 4.9 and integrating yields:

$$= \frac{1}{8}((1 + g\gamma f)^2 - 4g^2).$$

Solving for optimal g, and setting the first order condition equal to zero gives:

$$\frac{dw(q(g))}{dg} = -g + \frac{\gamma f(1+g\gamma f)}{4} = 0.$$

The second order derivative for consumer welfare maximization is satisfied, as

$\frac{\partial^2 w}{\partial g^2} = (\frac{\gamma^2 f^2}{4} - 1)<0$.

The solution

Summing up, the optimal effort set by the CA is:

$$g^* = \frac{\gamma f}{4-\gamma^2 f^2} \qquad \textit{Equation 4.10}$$

Substituting Equation 4.10 into Equation 4.7, the optimal quantity (q^*) produced by firms is

$$q^* = \frac{2}{4-\gamma^2 f^2}. \qquad \textit{Equation 4.11}$$

Finally, substituting Equations 4.10 and 4.11 into Equation 4.3, the optimal probability of detection is:

$$\tau^* = \frac{\gamma f(2-\gamma^2 f^2)}{(4-\gamma^2 f^2)^2} \qquad \textit{Equation 4.12}$$

and it follows that the optimum probability that a cartel is convicted is

$$PC^* = \tau^* \gamma \qquad \textit{Equation 4.13}$$

and substituting Equation 4.12 into Equation 4.13,

$$PC^* = -\frac{\gamma^2 f(\gamma^2 f^2-2)}{(\gamma^2 f^2-4)^2} \qquad \textit{Equation 4.14}$$

Proposition 1: As the CA gains more experience, (i.e. γ rises), this increases both the probabilities of investigation and detection. This results in an unambiguous increase in the probability of conviction.

Proof: Increased experience leads to an increased probability of investigation: from Equation 4.12: $\frac{d\tau^*}{d\gamma} = \frac{f(\gamma^4 f^4+6\gamma^2 f^2-8)}{(\gamma^2 f^2-4)^3} > 0$, and as both Υ and τ increase, so must PC*: from Equation 4.13: $\frac{\partial \mathrm{PC}^*}{\partial \gamma} = \frac{4\gamma f(3\gamma^2 f^2-4)}{(\gamma^2 f^2-4)^3} > 0$.

The intuition for this is that an increase in the efficiency of conviction is equivalent to an increase in the expected fine, prompting an increase in output, $\frac{\partial q^*}{\partial \gamma} = \frac{4\gamma f^2}{(\gamma^2 f^2-4)^2} > 0$ and subsequent drop in prices. This also leads to:

Corollary 1: Increased CA experience leads to increased output and lower price, and thus increased consumer welfare: $\frac{dw^*}{d\gamma} = \frac{\gamma f^2}{(\gamma^2 f^2 - 4)^2} > 0$.

To summarise, the CA sets its investigation effort so as to maximise consumer welfare (net of CA costs). This determines the probability of triggering a cartel investigation (τ), which depending on the CA's exogenous efficiency, determines the probability that the cartel is convicted. If effort is optimised, it is shown that an increase in the CA's conviction efficiency (or an increase in the fine), will lead to increased effort, and probabilities of investigation and conviction. This results in a lower cartel price and increased consumer welfare.

We also present an alternative way of modelling the behaviour of CAs and firms in the presence of detection and deterrence, in Appendices 4.C. This model differs in terms of its non-deterministic the demand function, the composition of the probability that a cartel is investigated and the cost function. It is also found that as the CA becomes more efficient in detecting and convicting cartels, the probability that cartels are convicted increases. This consequently causes cartels to reduce their prices so as not to be detected. The age profile of cartels convicted is also expected to be of an inverted U-shape.

4.3.2. The implications for the number of cartels convicted and age of CA

In spite of its static nature this model provides straightforward predictions for how things might change over time, as the CA develops, and gains more experience.

In general, we would expect any CA to gather more experience over time, and in this context we can model this simply as increased efficiency in detection. If so, the above comparative statics with respect to the probability of a successful investigation,γ , translate directly into the following dynamic predictions. With the passage of time, as the CA gains more experience, its detection efficiency increases. This causes it to increase its effort (as $\frac{dg^*(t)}{dt} > 0$), and the probabilities of investigation and conviction will both increase. Hence, the probability that a given cartel will be convicted increases over the lifetime of the CA.

4.3.3. Changes in the CA's budget over time

However, this way of introducing the time dimension might be misleading if there are other factors changing simultaneously over time. The most relevant such other factor is the CA's budget: we should also expect the CA's budget to impact on its efficiency probability (γ). A CA with a relatively generous

budget is more likely to have the necessary resources to train its staffs and hence exploit its greater potential efficiency in detecting more cartels. This suggests that inter-temporally, γ may not necessarily always increase at the same rate over time. More realistically, this could be reversed, or the rate of increase in efficiency slowed, in times of tightened CA budget constraints, and vice versa of course.

This, although it is reasonable to assume that in general a CA may acquire increasing experience overtime, in the presence of limited financial resources, the rate of increase may also be sensitive to changes in its budget allocation. Indeed, in extreme cases of extreme budget cuts, experience may even decay. We will capture this possibility in the econometric estimation of the next chapter.

4.4. Modelling frequency deterrence

In this section, we study the second form of deterrence: frequency-based deterrence - where the fear of detection and punishment deters cartels from forming, or persuades them to disband where they already exist.

4.4.1. Identical cartels

We proceed by extending the model of section 4.3 to a multi-market economy. The probability that a given cartelised market is convicted is denoted by PC.

In the economy there are M markets, which are either cartelised or deterred from cartelising. Denoting the number of deterred markets by D(t), the expected number of convicted cartels (ENC) is then given by:

$$ENC(t) = PC(t)\{M - D(t)\}. \qquad \textit{Equation 4.15}$$

Deterrence is assumed to be increasing in $PC(t)$: the higher is the probability of conviction, the more cartels are deterred from forming: thus, $D(t)$ is some increasing function of $PC(t)$, $\frac{dD}{dPC} > 0$.

Special case

For expositional simplicity, assume

$$D\big(PC(t)\big) = \beta PC(t) \qquad \textit{Equation 4.16}$$

where $\beta > 0$ measures the strength of the deterrence effect.

Substituting Equation 4.16 into Equation 4.15, then

$$ENC(t) = PC(t)\{M - \beta PC(t)\}. \qquad \textit{Equation 4.17}$$

Proposition 2: The expected number of convicted cartels is a quadratic function of PC(t), with a maximum at $PC = \frac{M}{2\beta}$*. Since* $PC(t)$*, is continuous and strictly increasing in* t *(as shown in Proposition 1); this means that over time ENC(t) will first increase up some maximum and thereafter decrease.*

Proof:

$\frac{dENC}{dPC} = M - 2\beta PC = 0$ where $ENC = \frac{M}{2\beta}$ and $\frac{\partial^2 ENC}{\partial PC^2} < 0$ and any higher order derivative is zero.

Summary of results

We therefore find that the final effect on the age profile of the number of cartel cases convicted by the CA will depend on the magnitude of detection, efficiency and deterrence: the number convicted cartels first increases because the effect of the detection efficiency outweighs that of deterrence, but after some point, this reverses and the number of convicted cartels decreases.

4.4.2 Heterogeneous cartels

An alternative way in which deterrence can be modelled is to allow for market-level heterogeneity, in which the firms choose whether or not to leave the cartel, and opt instead for oligopolistic competition. In this way, as will be seen, we make deterrence depend endogenously on PC, rather than merely assuming it as above.

There are different ways of introducing market asymmetries; the one that we opt for here allows market structure to vary across different markets.[39] Consider the situation where each market *m* has $N_m \geq 2$ firms, allocated according to the probability mass function $h(N)$. For simplicity, we assume that within each market, firms are symmetric, hence, the number of firms in the market is the only source of heterogeneity. Firms prefer to coordinate their behaviour if the collusive market profit is greater than the oligopoly market profit, otherwise they compete 'à la Cournot'. This is the only source of instability we allow for, but at the end of the section we will discuss another cause of cartel instability.

Maintaining the assumption of a unitary (linear) demand and zero marginal cost of production, a cartel is preferred by its members to oligopoly competition, if and only if, the cartel profit (π), is larger than the aggregate Cournot N-poly profit. We express the oligopoly profit in terms of total number of firms

[39] Another possibility is to include heterogeneous demand shocks across markets.

(N), and leave, momentarily, the cartel profit undetermined (See Appendices 4.B for proof). Hence, the inequality of interest is

$$\pi \geq \frac{N}{(N+1)^2}. \qquad \textit{Equation 4.18}$$

Solving for N, it is easily shown that $N(t) = \frac{1-2\pi(t)}{2\pi(t)} + \frac{\sqrt{1-4\pi(t)}}{2\pi(t)}$ is the positive root of the inverse function of the equality form of Equation 4.18. $N(t)$ is a function of time because it depends on the cartel expected profit ($\pi(t)$) via $\gamma(t)$. The top left panel in Figure 4.1 depicts this relationship. If the cartel profit is above the curve, then firms prefer a cartel for a given market structure (number of firms), otherwise they are deterred. This clearly shows that as the expected cartel profits fall, fewer cartels will form, especially those in small number markets.

Moreover, one can easily show that the cartel profit is a decreasing function of the conviction probability ($\frac{\partial \pi}{\partial(\gamma)} < 0$) when combining Equation 4.5[40], and Equations 4.10- 4.12[41]. This relationship is displayed in the top right panel of Figure 4.1, which is drawn for a fine set to 1.4.

Now, remember that the market structure follows a well behaved distribution function, $H(N)$ which is concave and non-decreasing in N. An example of a realistic and well-behaved function we choose is a poisson distribution with lamda = 3 (but of course, in principle, any value of lambda, indeed any well behaved distribution could have been chosen). The cumulative density of the discrete Poisson distribution function is shown in the bottom left panel of Figure 4.1.

As the cartel profit $\pi(t)$ is a function of the time varying conviction probability, $PC(t)$,as shown in Equation 4.5, $N(t)$ can, in turn also be formulated as function of the probability that a cartel is convicted, following the equality $N(t) = \frac{1-2\pi(t)}{2\pi(t)} + \frac{\sqrt{1-4\pi(t)}}{2\pi(t)}$. The monotonically strictly decreasing and convex relationship between market structure and cartel profit displayed in the top panel of Figure 4.1 guarantees that a value of $N(t)$ has a corresponding value of $\pi(t)$. Given the linear (and negative) relationship between cartel profit and conviction probability $N(t)^{N(t)}$ has an analogous value of $PC(t)$. $^{PC(t)}$. It follows that the density function of the market structure can itself be represented as a function of $PC(t)$.

This yields $H\big(PC(t)\big)$, which is the cumulative density function of cartels breakdown i.e the firms that stops to be cartels and start competing in the oligopolistic profit. The logic is the following. Assume

[40] $\pi \triangleq E[\tilde{\pi}] = (1-q)q - (1-q)g\gamma f$.

[41] Where $g^* = \frac{\gamma f}{4-\gamma^2 f^2}$, $q^* = \frac{2}{4-\gamma^2 f^2}$ and $\tau^* = \frac{\gamma f(2-\gamma^2 f^2)}{(4-\gamma^2 f^2)^2}$.

then that for an initial value of PC, say $PC = 0$, the cartel is above the function plotted in the top left panel of Figure 4.1 for any market structure >1. Then follow PC to increase steadily until the cartel profit drops to a level that guarantees the equality $N(t) = \frac{1-2\pi(t)}{2\pi(t)} + \frac{\sqrt{1-4\pi(t)}}{2\pi(t)}$. The first time the quality is met with is with the lowest market structure>1, say duopoly in the discrete case. This implies that there exists a low enough value of conviction probability that satisfies $2{=}1{-}2\pi PC(t)2\pi(PCt){+}1{-}4\pi PC(t)2\pi PC(t)$, telling us that for that level of conviction probability, duopolies are no longer profitable: $H(2)$ proportion of cartels are deterred. For a sufficiently higher value of the conviction probability we have $3 = \frac{1-2\pi(t)(PC(t)}{2\pi(t)} + \frac{\sqrt{1-4\pi(t)}}{2\pi(t)}$n indicating that $H(3)$proportion of cartels are deterred, and so on. The formula for the expected number of convicted cartels in the period (Equation 4.15) can be adjusted to accommodate to this deterrence rule:

$$ENC(t) = PC(t)[1 - H\big(PC(t)\big)]. \qquad \textit{Equation 4.19}$$

We plot the lifetime dynamics of the expected number of cartels detected and convicted on the bottom right panel of Figure 4.1. We notice an inverse U-shape functional form, which can be explained as follows. There is a steady growth in the number of cartels detected at the beginning of the period because of increasing efficiency. It is the duopolies which are first deterred, because duopolies earn higher profits in oligopoly than do larger oligopolies. They are also more likely to charge higher prices (Fonseca & Normann, 2014), which increases their probability of being detected and convicted. Hence, with a higher probability of being caught, they are likely to be the first ones to be deterred in the existence of the enforcement of competition law and policy (Davies et al, 2014). Then increasing efficiency continues to affect the number of cartel detected until triopolies are discouraged. The process continues until deterrence dominates efficiency, causing an overall drop in the number of cartels detected over time. With the intervention of CA, as cartelised profits fall, more firms are deterred from forming cartels and the economy moves to the competitive market. The process gives an invert U-shape as when efficiency raises sufficiently the expected number of cartel convicted, deterrence of duopolies kicks in and brings the number down. Then when efficiency continues to grow, triopolies are discouraged, but interestingly the increase in efficiency to deter triopoly is less than that needed to discourage duopolies, and even less the one required to dissuade quadriopolies. This asymmetry is the reason behind the inverse U shape. This is the result stated in the following proposition.

Proposition 3: For cartels with heteregenous market, if $G(\mathrm{PC(t)}) \equiv [1 - \mathrm{H(PC(t))}]$ be a decreasing and strictly convex function of the probability of conviction and let $\mathrm{PC(t)}$ be strictly increasing over

time, then the expected number of cartels detected and convicted reaches an inverse U-shape function over time.

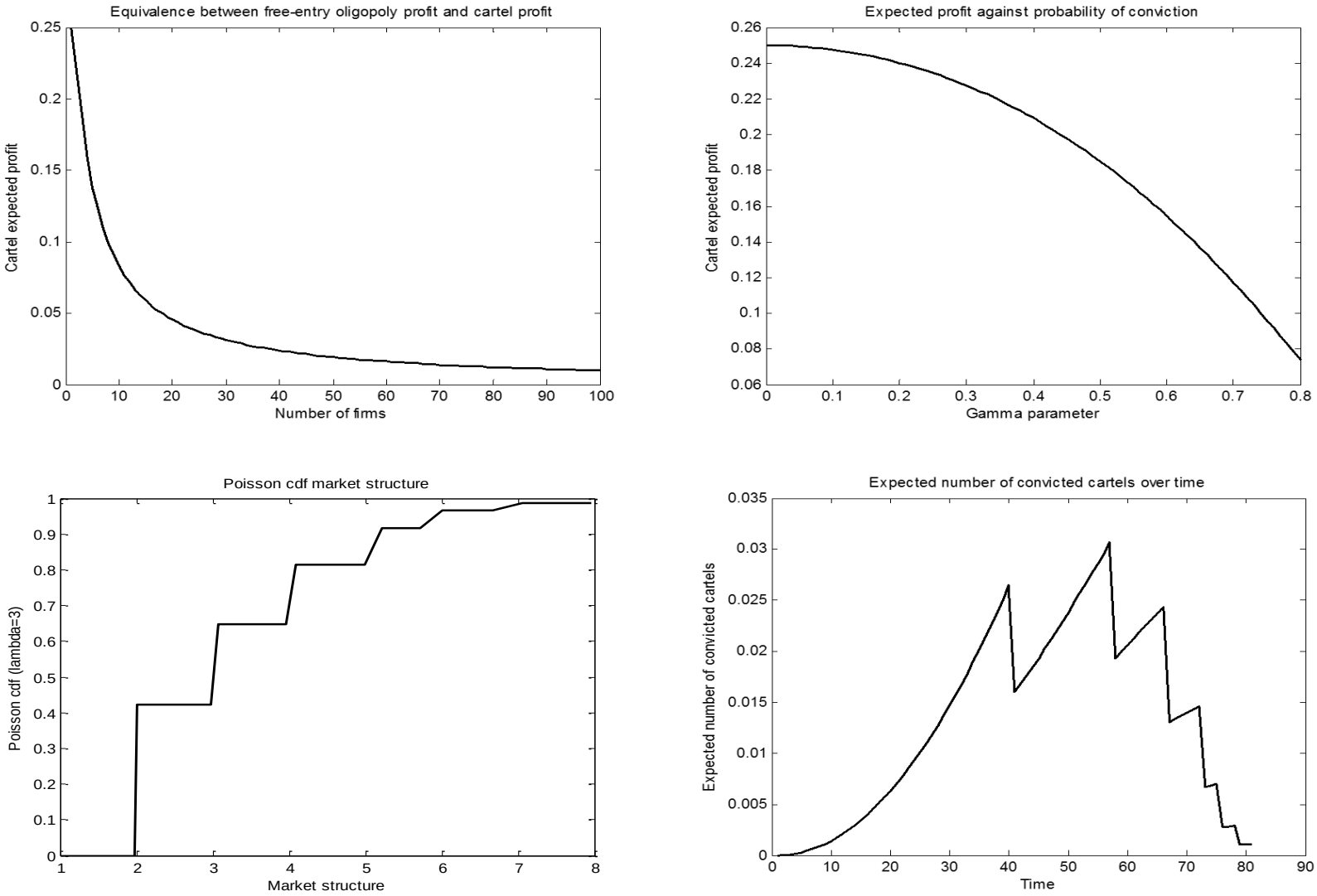
Proof: First notice that $\frac{\mathrm{dPC(t)}}{\mathrm{dt}} > 0$ by construction. Thus, it is a continuous and strictly increasing function of t. Then, note that the probability of conviction has a maximum at a certain value of PC. This is confirmed as the first order condition of the expected number of convicted cartels with respect to the probability that a cartelised market is convicted has internal solution, $G = -PG'$, and negative second order derivative by reason of the strict convexity of G. It follows that the expected number of convicted cartels has a maximum at a certain number of periods after CA's establishment.

Note that in this explanation of deterrence, it is the small number cartels which are deterred first, because their oligopoly profits are the largest. In itself, this result is interesting. Although superficially counter-intuitive, it is consistent with the well-established finding in the previous literature that duopolistic cartels are relatively infrequent (Levenstein & Suslow (2006), Fonseca & Norman (2014)[42]).

Acknowledging one of the main findings in the existing literature: that large cartels are more unstable because of the higher gains from deviation. This change brings in interesting results. In this situation, we expect cartels with an intermediate number of firms to be more resistant to a deterrence effect. As previously explained, duopolies tend to enjoy more profit than larger cartels. However, with the intervention of the CA, if caught, duopolies run the risks of paying heavy fines which may even offset the benefits obtained from being a cartel. With an effective competition enforcement, smaller cartels are therefore more likely to be first detected due to the high profit and deterred due to the offsetting effect of being caught over the cartelised profit.

[42] They found that four-firm oligopolies form more cartels than duopolies.

Figure 4.1: Relationship between cartel profit (π) and the number of firms (N)



On the other hand, as the number of firms in the cartels increases, the more unstable the cartels due to the benefits they may derive form deviating. Bigger cartels tend to get lower profits than smaller cartels, hence if caught, the loss that they may incur is not substantial compared to the profit that they make by staying in the cartel. This consequently makes the intermediate cartels more resistant to deterrence effects. However, it is only with time that they are deterred as the CA gains detection efficiency and enforces its competition law and policy.

Thus, although a CA is efficient in detecting cartels, the CA will only progressively be able to deter the larger cartels in the markets. As the CA detects cartels, it is first able to deter smaller cartels and then progressively deters the intermediate cartels in the markets. For a sufficiently large interaction between the probability of detection, conviction and level of fines, the relationship between deterrence and the market structure (number of firms in the market) has a U shape when the detection efficiency is outweighed by the deterrence effects.

4.5. Conclusion

This chapter models the behaviour of competition authorities and firms under imperfect incomplete information to unravel the functional form of how the number of cartels convicted changes over the life of the CA. A theoretical model of a competition authority that administers a deterrence based-competition policy in the presence of uncertainty is developed. It provides a theoretical understanding of how the age profile of the number of cartels convicted by a CA can be interpreted in terms of both its detection efficiency and success in deterrence. In this chapter, we distinguish between frequency-based and composition-based deterrence but also look at the heterogeneous deterrence.

First, focusing on a composition-based deterrence and considering a single cartelised market, the proposed model is based on a two-stage game. In stage one, the CA chooses the effort to put in investigating cartels – its aim is to maximise consumer welfare. In stage two, firms take the CA's effort into account when setting output to maximise profit as a cartel.

Next, the model is widened with the second form of deterrence- frequency based. We then consider a multi-market economy. The possibility that not all markets are cartelised is now allowed for.

Lastly, deterrence is alternatively modelled by allowing for market-level heterogeneity and internalisation of cartelist firms' decision on whether or not to disband the cartel for oligopolistic

competition. This model accommodates for market asymmetries that allow for market structure to vary across different markets.

Across the three ways of modelling deterrence, the results reveal that, while an increase in the detection efficiency pushes up the count of convicted cartels, the existence of deterrence effects has the opposite effect. The outcome on the age profile of cartel cases is found to depend on the magnitudes of deterrence effects and efficiency. While the efficiency acquired outweighs the deterrence effects, the CA will experience a positive influence in the number of cartels convicted. On the other hand, eventually deterrence effects outweigh detection efficiency, and the number of convicted cartel cases is expected to fall over time. If a CA is successful in its detection and deterrence policy, the age profile of cartel cases of a CA can then be expected to have an inverse U-quadratic shape.

This chapter therefore provides the theoretical background which may explain the age profile of cartel cases convicted by a CA by looking at the interactions of detection efficiency and deterrence effects. In the next chapter, this theoretical background is tested empirically to determine the age profile of competition authorities.

Appendices

4.A Comparative statics results

This section relates to the proof of Proposition 1 of section 4.3, page 71. We show the workings for the first and second order derivatives for the optimum solutions of (i) price threshold (g^*), (ii) quantity produced by firms (q^*), (iii) probability of convicting a cartel by the CA (τ^*), (iv) number of cartel convicted (PC^*) and (v) welfare function (w^*) with respect to the probability that a cartel is detected (γ) and the level of fines (f) in Table 4.A.1.

Table 4.A.1: Comparative statics

Optimum Solutions	**First-order derivative with respect to γ**	**Second-order derivative with respect to γ**	**First-order derivative with respect to f**	**Second-order derivative with respect to f**
$g^* = -\frac{\gamma f}{\gamma^2 f^2 - 4}$ for $0 < g^* < 1$	$\frac{dg^*}{d\gamma} = \frac{f(\gamma^2 f^2+4)}{(\gamma^2 f^2-4)^2} > 0$	$\frac{d^2 g^*}{d\gamma^2} = -\frac{2\gamma f^3(\gamma^2 f^2+12)}{(\gamma^2 f^2-4)^3} > 0$.	$\frac{dg^*}{df} = \frac{\gamma(\gamma^2 f^2+4)}{(\gamma^2 f^2-4)^2} > 0$	$\frac{d^2 g^*}{df^2} = -\frac{2\gamma^3 f(\gamma^2 f^2+12)}{(\gamma^2 f^2-4)^3} > 0$
$q^* = \frac{2}{4-\gamma^2 f^2}$ for $0 < q^* < 1$	$\frac{dq^*}{d\gamma} = \frac{4\gamma f^2}{(\gamma^2 f^2-4)^2} > 0.$	$\frac{d^2 q^*}{d\gamma^2} = -\frac{4f^2(3\gamma^2 f^2+4)}{(\gamma^2 f^2-4)^3} > 0.$	$\frac{dq^*}{df} = \frac{4\gamma^2 f}{(4-\gamma^2 f^2)^2} > 0$	$\frac{d^2 q^*}{df^2} = -\frac{4\gamma^2(3\gamma^2 f^2+4)}{(\gamma^2 f^2-4)^3} > 0$
$\tau^* = -\frac{\gamma f(\gamma^2 f^2-2)}{(\gamma^2 f^2-4)^2}$	$\frac{d\tau^*}{d\gamma} = \frac{f(f^4\gamma^4+6\gamma^2 f^2-8)}{(\gamma^2 f^2-4)^3} > 0$	$\frac{d^2\tau^*}{d\gamma^2} = -\frac{2\gamma^3 f^5(\gamma^2 f^2+20)}{(\gamma^2 f^2-4)^4} < 0.$	$\frac{d\tau^*}{df} = \frac{\gamma(\gamma^4 f^4+6\gamma^2 f^2-8)}{(\gamma^2 f^2-4)^3} > 0$	$\frac{d^2\tau^*}{df^2} = -\frac{2\gamma^5 f^3(\gamma^2 f^2+20)}{(\gamma^2 f^2-4)^4} < 0$
$PC^* = -\frac{\gamma^2 f(\gamma^2 f^2-2)}{(\gamma^2 f^2-4)^2}$	$\frac{dPC^*}{d\gamma} = \frac{4\gamma f(3\gamma^2 f^2-4)}{(\gamma^2 f^2-4)^3} > 0$ for $(0 < \gamma \leq \frac{2}{3}(-2+\sqrt{7}), 0 < f < 1)$ and $(\frac{2}{3}(-2+\sqrt{7}) < \gamma < 1, 0 < f < \frac{2}{3}\sqrt{7}\sqrt{\frac{1}{\gamma^2}-\frac{4}{3\gamma}})$	$\frac{d^2 PC^*}{d\gamma^2} = -\frac{4f(9\gamma^4 f^4+16\gamma^2 f^2-16)}{(\gamma^2 f^2-4)^4} < 0$ for 2 $imaginary\ roots$.	$\frac{dPC^*}{df} = \frac{\gamma^2(\gamma^4 f^4+6\gamma^2 f^2-8)}{(\gamma^2 f^2-4)^3} > 0.$	$\frac{d^2 PC^*}{df^2} = -\frac{2\gamma^6 f^3(\gamma^2 f^2+20)}{(\gamma^2 f^2-4)^4} < 0$
$w^* = \frac{1}{8}(\frac{4\gamma f}{\gamma^2 f^2-4})^2 + (1 - \frac{\gamma^2 f^2}{\gamma^2 f^2-4})^2)$	$\frac{dw^*}{d\gamma} = \frac{\gamma f^2}{(\gamma^2 f^2-4)^2} > 0$	$\frac{d^2 w^*}{d\gamma^2} = -\frac{f^2(4+3\gamma^2 f^2)}{(\gamma^2 f^2-4)^3} > 0$	$\frac{dw^*}{df} = \frac{\gamma^2 f}{(\gamma^2 f^2-4)^2} > 0$	$\frac{d^2 w^*}{df^2} = -\frac{\gamma^2(3\gamma^2 f^2+4)}{(\gamma^2 f^2-4)^3} > 0$

4.B Expressing the oligopoly profit in terms of total number of firms (N)

Let,

Firm i's output: q_i

Total output: $q = q_1 + q_2 + \cdots \ldots \ldots + q_n$

Opponent's output: $q_{-i} = q - q_i = \sum_{j \neq i} q_i$

Constant marginal costs of firm i: c is assumed to be zero

The inverse demand function is $p(q)$.

The firm i' s profit is then given by:

$$\pi_i(q_{-i}, q_i) = (p(q) \times q_{i\,)} q_i = (p(q_{-i} + q_i))q_i$$

Assuming that the demand function is linear: $p = 1 - q = 1 - (q_{-i} + q_i)$.

The first order condition is

$\frac{d\pi_i}{dq_i} = -q_i + (1 - q)$.

Cournot-Nash equilibrium

1. Every firm maximizes profit given her expectation of q_{-i}.

2. The expectation is correct.

This yields the simultaneous system of equations

For all $i = 1, \ldots., n$.

In the linear case the FOC yields $q_i + q_{-i} = q$.

$$-q_1 + (1 - q) = 0$$
$$-q_2 + (1 - q) = 0$$
$$.$$
$$.$$
$$-q_n + (1 - q) = 0$$

The summation for total number of firms (n) in the industry yields

$$-q + n(1 - q) = 0.$$

Thus, we can deduce that the total quantity produced and the price in the market is

$$(n + 1)q = n$$
$$q = \frac{n}{n + 1}$$
$$p = 1 - q = 1 - \frac{n}{n + 1}$$
$$= \frac{1}{n + 1}.$$

Therefore, the profit function is

$$\pi = pq = \frac{n}{n+1} \times \frac{1}{n+1} = \frac{n}{(n+1)^2}.$$

4.C Alternative theoretical model

In this section, we look at an alternative way of modelling composite deterrence. In this model, uncertainty is brought in the demand function as sketched in Martin (2000). The relationship between the demand function and the probability of being convicted, will be determined by the cumulative density function of demand function. In this model, the uncertainty in the demand function is first assumed to follow a triangular distribution and the model is later presented using a quadratic distribution. However, since non-linear solutions are obtained, the calculations get more complicated as shown below.

This model also differs in terms of

(i) the composition of the probability that a cartel is investigated.

In the previous model, the probability that a cartel is investigated was a positive function of CA's effort whereas in this model, it a function of a price threshold which is set by the CA and is negatively related. It is such that the lower the CA sets its price threshold, the higher will be the probability that a cartel is investigated.

(ii) the cost function.

In the previous model, costs are assumed to be a strictly convex function of the CA's effort, g, and given by $\frac{g^2}{2}$. The explanation for cost convexity is that investigation becomes increasingly costly once the relatively easy first steps have been completed. However, in this model, cost is assumed to be a strictly convex function of g, the price threshold, but is given by $\frac{(1-g)^2}{2}$. This is explained by the fact that in the real world as the CA decreases its price threshold, it investigates more complex cartels. This situation causes the CA to incur higher costs of investigation given the nature of these cartels. Hence, the lower the price threshold, the greater the number of cartels the CA investigates and detects, the higher investigation cost it incurs.

We find that as the CA becomes more efficient in detecting and convicting cartels, the probability that cartels are convicted increases. This consequently causes cartels to reduce their prices so as not to be detected. The age profile of convicted cartels is found to be determined by the magnitude of detection and deterrence efficiency. The age profile of the convicted cartels increases when detection efficiency

offsets the deterrence effects and decreases if the latter outweighs the detection efficiency. Hence overtime, the age profile is expected to be of an inverted U-shape.

a. Triangular distribution

The discussion of the model begins with the demand side.

Demand side

We describe the inverse demand function for each market to be separable in an observable component of inverse demand, $p(q)$, and a random element, ε:

$$\tilde{p}(q, \varepsilon) = p(q) + \varepsilon, \qquad \textit{Equation I}$$

with $p' < 0, p'' \geq 0$. The total industry output is denoted by q, and the random variable ε is described by a well-behaved density function $g(\varepsilon)$, with zero mean, and defined over the interval $-\infty < \underline{\varepsilon} \leq \varepsilon \leq \overline{\varepsilon} < \infty$. The lower limit $\underline{\varepsilon}$ is such that the price is not less than the marginal cost if the quantity supplied is sufficiently small, that is, $p(0) + \underline{\varepsilon} \geq c$, where c is the firms' constant marginal cost of production (later on set to zero).

In practice, the CA receives and monitors various signals from different industries in the economy in terms of complaints from customers, rivals or other trade sources. All these sources of complaint are combined in our model into one single signal, which is the optimal price chosen by the firms. Below we describe how the threshold price leads to the detection probability.

The detection probability

Suppose that the competition agency chooses the threshold price g for potential competition breaches (only cartels in this model). The competition authority investigates the market if the optimal price chosen in that market is greater than the threshold price g. Then, the probability of detection is given by:

$$\tau \triangleq pr\left[\underbrace{p(q) + \varepsilon}_{\tilde{p}} \geq g\right] = 1 - PR[g - p(q)], \text{ with } 0 \leq \tau \leq 1, \qquad \textit{Equation II}$$

where pr and PR denote the probability density function and cumulative density function, respectively.

Thus, the detection probability, τ, is a function of the difference between the price threshold set by the competition authority and the price chosen by the cartelized firms. A low price threshold g leads to a high probability of detection τ, which, all else equal, results in a larger number of cartel

investigations, and vice-versa. The threshold g is the strategic variable in the model under the control of the CA, whose behaviour will be further discussed.

The conviction probability

Once the firms are detected in a cartel illegal behaviour, they are prosecuted and successfully convicted with probability γ, with $\underline{\gamma} \leq \gamma \leq 1$, with $\underline{\gamma} > 0$. If convicted, the cartel is punished (via a fine or/and imprisonment), denoted by f. The parameters γ and f are treated as exogenous, hence determined outside the model, with values known to the firms and to the CA.

To retain simplicity, we exclude the possibility that the CA makes type I and type II errors in the model[43].

Firms' behaviour

The expected profit function for the risk –neutral cartel is given by:

$$\pi \triangleq E[\tilde{\pi}] = pq - \tau\gamma f. \qquad \textit{Equation III}$$

For analytical tractability, it is assumed that the random noise ε has support $[-a, a]$, where $-a \equiv \underline{\varepsilon} \leq 0 \leq \bar{\varepsilon} \equiv a$ and follows a triangular probability distribution given by

(i) $PR(\varepsilon) = \frac{(\varepsilon+a)^2}{2a^2}$ for $-a \leq \varepsilon \leq 0$ *Equation IV (a)*

(ii) $PR(\varepsilon) = 1 - \frac{(a-\varepsilon)^2}{2a^2}$ for $0 \leq \varepsilon \leq a$. *Equation IV (b)*

In more general terms the random variable ε could take different forms. The triangular distribution has the nice feature to be a discrete approximation of a Gaussian distribution, hence it gives lower probability to extreme values. One easier functional form would be the uniform distribution. However, when we tried that distribution we found it was problematic, as it did not allow for a linkage between the price threshold set by the competition authority and the cartelized firms' output. We also attempted to use the uniform distribution by allowing fines to be a function of revenue but became too complex when calculating for optimal price threshold (g)[44]. Other distributions would require the use of simulations and numerical solutions, which would complicate the calculus, without adding much

[43] Type I errors refer to the probability that the CA acquits wrongdoers. Type II errors refer to the probability that agents are unjustly sanctioned despite having complied with the law.

[44] We obtained two levels of optimum output (i) $q = \frac{-2a+4\gamma\phi-2g\gamma\phi-\sqrt{-12\gamma\phi(-a+\gamma\phi-g\gamma\phi)+(2a-4\gamma\phi+2g\gamma\phi)^2}}{6\gamma\phi}$ for $\frac{dq}{dg} < 0$ and (ii) $q = \frac{-2a+4\gamma\phi-2g\gamma\phi+\sqrt{-12\gamma\phi(-a+\gamma\phi-g\gamma\phi)+(2a-4\gamma\phi+2g\gamma\phi)^2}}{6\gamma\phi}$ for $\frac{dq}{dg} > 0$. (i) is chosen for $\frac{dq}{dg} < 0$.

insight. In the next section, the results relying on a U-quadratic probability distribution, which has the opposite shape of the triangular distribution[45] are replicated.

Letting the demand function being unit linear we have that the probability of detection given in Equation ii can be written as

$$\tau = 1 - PR(g - 1 + q), \qquad \textit{Equation V}$$

and substituting Equations *IV(a)* and *IV(b)* into Equation *V* yields the probabilities a cartel is detected, depending on which side of the modal value of the distribution we are:

(i) $\tau = 1 - \frac{(a-1+g+q)^2}{2a^2}$ *Equation VI(a)*

(ii) $\tau = \frac{(a+1-g-q)^2}{2a^2}$. *Equation VI(b)*

Next, substituting Equations *VI(a)* and *VI(b)* into Equation *II* yields the expected profits:

(i) $\pi = (1-q)q - [1 - \frac{(a-1+g+q)^2}{2a^2}]\gamma f$ *Equation VII(a)*

(ii) $\pi = (1-q)q - \frac{(a+1-g-q)^2}{2a^2}\gamma f$. *Equation VII(b)*

As it can be seen above, one side effect of using the triangular distribution is that there are two possible values for the expected profits. The cartel monopolist chooses its optimal output under the constraints of non-negative demand and prices, $0 \leq q \leq 1 + a$, $(1 - a) \geq c = 0$.

The two first order conditions for the expected profit maximisation are

$\frac{\partial \pi}{\partial q} = 1 - 2q + \frac{(a-1+g+q)\gamma f}{a^2} = 0$

$\frac{\partial \pi}{\partial q} = 1 - 2q + \frac{(a+1-g-q)\gamma f}{a^2} = 0.$

And the corresponding second order derivatives for the profit maximisation are

(i) $\frac{\partial^2 \pi}{\partial q^2} = -2 + \frac{\gamma f}{a^2}$

(ii) $\frac{\partial^2 \pi}{\partial q^2} = -2 - \frac{\gamma f}{a^2}$.

From (i) above it is noticed that a sufficient condition for a maximum is that $a \geq \frac{\sqrt{\gamma f}}{\sqrt{2}}$, which holds if either the range of the random variable is large (large value of the left hand side of the inequality), or if the fines or the conviction probability are low (small value of the right hand side of the inequality).

[45] Although this has an appropriate shape, it brings the complexity of having a cumulative density function which changes shape at the modal value.

On the other hand, the second condition (ii) always leads to a maximum. Hence the problem has potentially two maxima, with one of the two perhaps being a global maximum. We remain temporarily agnostic on which of the two solutions may be the global maximum and solve for the optimal threshold set by the competition authority. Only then the implications of the two maxima are discussed.

The two levels of optimal output produced by the cartel are:

(i) $q(g) = \frac{a^2-\gamma f+a\gamma f+g\gamma f}{2a^2-\gamma f}$ *Equation VIII(a)*

(ii) $q(g) = \frac{a^2+\gamma f+a\gamma f-g\gamma f}{2a^2+\gamma f}$. *Equation VIII(b)*

We are interested in studying the relationship between the optimal output produced by the firms and the threshold set by the competition authority. Hence, below the sign of the change in the optimal level of q as a response to a change in g are studied:

(i) $\frac{dq(g)}{dg} = \frac{\gamma f}{2a^2-\gamma f} < 0$, which holds for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$. *Equation IX (a)*

(ii) $\frac{dq(g)}{dg} = -\frac{\gamma f}{2a^2+\gamma f} < 0$. *Equation IX (b)*

The above inequalities suggest that if the CA reduces the price threshold of detection, the cartel will increase its output and hence lower its price. This is the first source of deterrence captured by the model.

Competition authority's problem

The cost incurred by a CA when investigating and detecting cartels plays a very important role in determining the efficiency and the effective running of CA's operations. The cost of detecting a cartel is assumed to be a strictly convex function of g, and given by $\frac{(1-g)^2}{2}$. One possible explanation for the cost being strictly convex in the price threshold is that, in the real world as the CA decreases its price threshold, it investigates more complex cartels. This situation causes the CA to incur higher costs of investigation given the nature of these cartels. Hence, the lower the price threshold, the greater the number of cartels the CA investigates and detects, the higher investigation cost it incurs.

It is assumed that the aim of the competition authority is to maximise consumer welfare net of enforcement cost. The total welfare generated in the economy in the cartelised markets in a period is consumer welfare minus cost of investigations given by

$$w(q(g)) \triangleq E(\tilde{w}(q(g)) = \int_0^{q(g)}[p(q) - p(g)]\,dq - \frac{(1-g)^2}{2} \qquad \textit{Equation X}$$

$$= \int_0^{q(g)}[(1-q) - (1-q(g))]\,dq - \frac{(1-g)^2}{2}.$$

It is noted that the competition authority deals with contingent welfare maximization depending on which side of the error term the realization of the error is drawn from. This is due to the fact that when the cartel maximizes its profit it does choose a different optimal output during recessions (random draws from the left side of the random demand side) than during booms (random draws from the right side of the random demand).

Substituting $q(g)$ (from Equations *VIII(a) and VIII(b)* respectively) in Equation *X*, we solve for the optimal g and set it to zero, and get the equalities

(i) $\frac{dw(q(g))}{dg} = 1 - g + \frac{\gamma f(a^2+\gamma f(a+g-1))}{(\gamma f-2a^2)^2} = 0$

(ii) $\frac{dw(q(g))}{dg} = 1 - g - \frac{f\gamma\left(a^2+af\gamma-f\gamma(g-1)\right)}{(2a^2+f\gamma)^2} = 0.$

The corresponding second order derivatives for the consumer welfare maximization are

(i) $\frac{\partial^2 w}{\partial g^2} = -1 + \frac{\gamma^2 f^2}{(\gamma f-2a^2)^2}.$

(ii) $\frac{\partial^2 w}{\partial g^2} = -1 + \frac{\gamma^2 f^2}{(2a^2+\gamma f)^2}.$

The first of the two second-order conditions is a maximum for $a \geq \sqrt{f\gamma}$. The second one is a maximum for any value of a. The optimal equilibrium thresholds set by the CA are:

(i) $g^* = \frac{4a^3-3a\gamma f+\gamma^2 f^2}{4a^3-4a\gamma f}$ *Equation XI (a)*

(ii) $g^* = \frac{4a^3+3a\gamma f-\gamma^2 f^2}{4a^3+4a\gamma f}.$ *Equation XI (b)*

As mentioned earlier, I opted for remaining agnostic about the optimal output chosen by the cartel and solved accordingly for the optimal threshold chosen by the CA. From Equation *X(a)*, it is known that a low threshold set by the competition authority leads to a low output chosen by the cartel (for the case the cartel maximizes the profit, i.e. for $a \geq \frac{\sqrt{\gamma f}}{\sqrt{2}}$). In this situation the best the CA can do to increase the output and decrease prices is not to set any threshold. This intuition is proven by the optimal threshold in Equation g* (i), which is always >1 for $a \geq \sqrt{\gamma f}$. Not only this is true, but also we have that the optimal quantity found in Equation *IX(i)* is a local maximum for $a \geq \frac{\sqrt{\gamma f}}{\sqrt{2}}$, hence the cartel

will prefer the second solution (Equation *IX(ii)*) to the first one (for any value of g). Onwards, only the second solution is retained and the first one is disregarded.

Substituting Equation *XI(ii)* into Equation *XIII(ii)*, the optimal quantity (q^*) produced by firms is

(ii) $q^* = \frac{(a+\gamma f)(2a^2+\gamma f)}{4(a^3+a\gamma f)}$. *Equation XII*

Next, substituting Equations *XI* and *XII* into Equation *VI(b)*, the optimal probability of detection τ^*obtained is

(ii) $\tau^* = \frac{(a-2a^2-\gamma f)^2}{8(a^2+\gamma f)^2}$. *Equation XIII*

Finally, substituting Equations *XIII* into Equation *I*, the optimal probability of cartels convicted y^* retrieved is

(ii) $y^* = \frac{\gamma(a-2a^2-\gamma f)^2}{8(a^2+\gamma f)^2}$. *Equation XIV*

To summarise, the CA sets its cartel threshold price by choosing a value of g which maximises total consumer welfare. This determines the probability of triggering a cartel investigation (τ), which combined with the efficiency of conviction, leads to the number of cartels convicted. The nature of the relationship between g and τ depends on the cumulative density function PR(g) through the distribution of ε. Here it is assumed that the random error term ε has a triangular distribution. If so, g will also have a triangular distribution and there will be a mapping between $PR[g]$ and $PR[\tau]$.

Lemma 1: As the CA becomes more efficient in detecting and convicting cartels, the probability that cartels are convicted increases. This consequently causes cartels to reduce their prices so as not to be detected.

Comparative statics results

The workings for the first and second order derivatives for the optimum solutions are shown as:

The optimum price threshold (g^*) is

$$g^* = \frac{4a^3+3a\gamma f-\gamma^2 f^2}{4a^3+4a\gamma f} \text{ for } 0 < g^* < 1 .$$

The first-order and second-order derivative of g^* with respect to γ are

$\frac{dg^*}{d\gamma} = -\frac{f(a^3+2a^2\gamma f+\gamma^2 f^2)}{4a(a^2+\gamma f)^2} < 0$, for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

$\frac{d^2g^*}{d\gamma^2} = -\frac{(a-1)a^2f^2}{2(a^2+\gamma f)^3} < 0$, for $f > \frac{2}{\gamma}, 1 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of g^* with respect to f are

$\frac{dg^*}{df} = -\frac{\gamma(a^3+2a^2\gamma f+\gamma^2 f^2)}{4a(a^2+\gamma f)^2} < 0$, for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

$\frac{d^2g^*}{df^2} = -\frac{(a-1)a^2\gamma^2}{2(a^2+\gamma f)^3} > 0$, for $f > \frac{2}{\gamma}, 1 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of g^* with respect to a are

$\frac{dg^*}{da} = \frac{\gamma f(2a^3+3a^2\gamma f+\gamma^2 f^2)}{4(a^3+a\gamma f)^2} > 0$, for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

$\frac{d^2g^*}{da^2} = -\frac{\gamma f(3a^5-a^3\gamma f+6a^4\gamma f+3a^2\gamma^2 f^2+\gamma^3 f^3)}{2(a^3+a\gamma f)^3} > 0$, for $0 < \gamma \leq \frac{1}{2400}, 0 < f < 1,$

$a\ between\ 2\ imaginary\ roots$ or $\frac{1}{2400} < \gamma < 1, 0 < f < \frac{1}{2400\gamma},\ a\ between\ 2\ imaginary\ roots.$

2. The optimum quantity produced by firms (q^*) is

$$q^* = \frac{(a+\gamma f)(2a^2+\gamma f)}{4(a^3+a\gamma f)} \text{ for } 0 < q^* < 1 + a.$$

The first-order and second-order derivative of q^* with respect to γ are

$\frac{dq^*}{d\gamma} = \frac{f(2a^4-a^3+2a^2\gamma f+\gamma^2 f^2)}{4a(a^2+\gamma f)^2} > 0$ for $0 < \gamma \leq \frac{1}{50}, 0 < f < 1, 0 < a < one\ imaginary\ root$ or $\frac{1}{50} < \gamma < 1, 0 < f < \frac{1}{50\gamma}, 0 < a <\ one\ imaginary\ root$ or $\frac{1}{50} < \gamma < \frac{1}{32}(-17 + 7\sqrt{7}, 0 < f < \frac{1}{50\gamma}, 0 < a < one\ imaginary\ root$ or $(\frac{1}{50\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(\frac{1}{32}(-17 + 7\sqrt{7}) \leq \gamma < 1, ((0 < f < \frac{1}{50\gamma}, 0 < a < one\ imaginary\ root$ for $(\frac{1}{50\gamma} \leq f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))).$

$\frac{d^2q^*}{d\gamma^2} = -\frac{a^2f^2(a-1)}{2(a^2+\gamma f)^3} > 0$ for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of q^* with respect to f are

$\frac{dq^*}{df} = \frac{\gamma(2a^4-a^3+2a^2\gamma f+\gamma^2 f^2)}{4a(a^2+f\gamma)^2} < 0$ for $(0 < \gamma \leq \frac{1}{50}, 0 < f < 1, one\ imaginary\ root\ < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$ or $(\frac{1}{50} < \gamma < 1, 0 < f < \frac{1}{50\gamma}, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$.

$\frac{d^2q^*}{df^2} = -\frac{(a-1)a^2\gamma^2}{2(a^2+\gamma f)^3} > 0$, for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of q^* with respect to a are

$\frac{dq^*}{da} = -\frac{\gamma f(-2a^3+2a^4+a^2\gamma f+\gamma^2 f^2)}{4(a^3+a\gamma f)^2} > 0$ for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1,\ one\ imaginary\ root\ < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$ or $(\frac{1}{8} < \gamma < 1, 0 < f < \frac{1}{8\gamma}, one\ imaginary\ root\ < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$.

$\frac{d^2q^*}{da^2} = \frac{\gamma f(-3a^5+2a^6+a^3\gamma f+3a^2\gamma^2 f^2+\gamma^3 f^3)}{2(a^3+a\gamma f)^3} > 0$ for $(0 < \gamma \leq \frac{1}{288}(61 - 23\sqrt{7}), 0 < f < 1,$

$one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$ or $(\frac{1}{288}(61 - 23\sqrt{7}) < \gamma \leq \frac{1}{242}, ((0 < f \leq -\frac{23}{288}\sqrt{7}\sqrt{\frac{1}{\gamma^2}} +$

$\frac{61}{288\gamma}, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$or $(-\frac{23}{288}\sqrt{7}\sqrt{\frac{1}{\gamma^2}}+\frac{61}{288\gamma} < f < 1, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})))$ or $(\frac{1}{242} < \gamma < 1, ((0 < f \leq -\frac{23}{288}\sqrt{7}\sqrt{\frac{1}{\gamma^2}}+\frac{61}{288\gamma},\ one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$ or $(-\frac{23}{288}\sqrt{7}\sqrt{\frac{1}{\gamma^2}}+\frac{61}{288\gamma} < f < \frac{1}{242\gamma}, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})))$.

3. Optimum probability of detecting a cartel by the CA (τ^*) is

$$\tau^* = \frac{(a-2a^2-\gamma f)^2}{8(a^2+\gamma f)^2}.$$

The first-order and second-order derivative of $\tau^*$with respect to γ are

$\frac{d\tau^*}{d\gamma} = -\frac{(a-1)af(2a^2+\gamma f-1)}{4(a^2+\gamma f)^3} > 0$ for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, 0 < a < \frac{1}{4}-\frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8} < \gamma < 1, ((0 < f \leq \frac{1}{8\gamma}, 0 < a < \frac{1}{4}-\frac{1}{4}\sqrt{1-8\gamma f})$or $(\frac{1}{8\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$.

$\frac{d^2\tau^*}{d\gamma^2} = \frac{(a-1)af^2(5a^2+2\gamma f-3a)}{4(a^2+\gamma f)^4} < 0$ for $(0 < \gamma \leq \frac{2}{9}, 0 < f < 1, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9} < \gamma \leq \frac{9}{40}, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < 1, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f}$ or $\frac{3}{10}+\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))))$ or $(\frac{9}{40} < \gamma < 1, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < \frac{9}{40\gamma}, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f}$ or $\frac{3}{10}+\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(f == \frac{9}{40\gamma}, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f}$or $\frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(\frac{9}{40\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})))$.

The first-order and second-order derivative of τ^* with respect to f are

$\frac{d\tau^*}{df} = -\frac{(a-1)a\gamma(2a^2+\gamma f-1)}{4(a^2+\gamma f)^3} > 0$ for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, 0 < a < \frac{1}{4}-\frac{1}{4}\sqrt{1-8\gamma f})\ or (\frac{1}{8} < \gamma < 1, \left(\left(0 < f \leq \frac{1}{8\gamma}, 0 < a < \frac{1}{4}-\frac{1}{4}\sqrt{1-8\gamma f}\right)\middle|\middle|\left(\frac{1}{8\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)\right)\right)$.

$\frac{d^2\tau^*}{df^2} = \frac{(-1+a)a\gamma^2(-3a+5a^2+2\gamma f)}{4(a^2+\gamma f)^4} < 0$ for $(0 < \gamma \leq \frac{2}{9}, 0 < f < 1, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9} < \gamma \leq \frac{9}{40}, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < 1, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f} or\ \frac{3}{10}+\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(\frac{9}{40} < \gamma < 1, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < \frac{9}{40\gamma}, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f} or\ \frac{3}{10}+\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(f == \frac{9}{40\gamma}, (0 < a < \frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f}$or $\frac{3}{10}-\frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$ or $(\frac{9}{40\gamma} < f < 1, 0 < a < \frac{\sqrt{f\gamma}}{\sqrt{2}})$.

The first-order and second-order derivative of τ^* with respect to a are

$\frac{d\tau^*}{da} = \frac{(-a+2a^2+\gamma f)(a^2-\gamma f+2a\gamma f)}{4(a^2+\gamma f)^3} > 0$ for $\left(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$ or $\left(\frac{1}{8} < \gamma < 1,\right)$or $\left(0 < f < \frac{1}{8\gamma}, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$ or $\left(\frac{1}{8\gamma} < f < 1, -\gamma f + \sqrt{\gamma f + \gamma^2 f^2} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$.

$\frac{d^2\tau^*}{da^2} = \frac{20a^3\gamma f - 4a^5 + a^4(3-12\gamma f) + 2a^2\gamma f(\gamma f - 4) + \gamma^2 f^2(1+2\gamma f)}{4(a^2+\gamma)^4}$ for $\left(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$ or $(\frac{1}{8} < \gamma < 1, 0 < f < \frac{1}{8\gamma}, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$.

4. The optimum probability that a cartel is convicted (PC^*) by the CA is

$$PC^* = \frac{\gamma(a-2a^2-\gamma f)^2}{8(a^2+\gamma f)^2}$$

The first-order and second order derivative of PC^* with respect to γ is

$\frac{dPC^*}{d\gamma} = \frac{(2a^2+\gamma f-a)(-a^3+2a^4+a\gamma f+a^2\gamma f+\gamma^2 f^2)}{8(a^2+\gamma f)^3}$>0 for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8} < \gamma < 1, \left(\left(0 < f \leq \frac{1}{8\gamma}, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f}\right) \middle|\middle| \left(\frac{1}{8\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)\right)\right)$.

$\frac{d^2PC^*}{d\gamma^2} = -\frac{(a-1)a^2 f(-2a^2+4a^3+\gamma f+a\gamma f)}{4(a^2+\gamma f)^4} > 0$ for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of PC^* with respect f is

$\frac{dPC^*}{df} = -\frac{(a-1)a\gamma^2(2a^2+\gamma f-a)}{4(a^2+\gamma f)^3} < 0$ for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{1}{4} + \frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8} < \gamma < 1, 0 < f < \frac{1}{8\gamma}, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{1}{4} + \frac{1}{4}\sqrt{1-8\gamma f})$.

$\frac{d^2PC^*}{df^2} = \frac{(a-1)a\gamma^3(-3a+5a^2+2\gamma f)}{4(a^2+\gamma f)^4}$ for $(0 < \gamma \leq \frac{2}{9}, 0 < f < 1, 0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9} < \gamma \leq \frac{9}{40}, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < 1, (0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f}$ or $\frac{3}{10} + \frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$ or $(\frac{9}{40} < \gamma < 1, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{9}{40} < \gamma < 1, ((0 < f \leq \frac{2}{9\gamma}, 0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f})$ or $(\frac{2}{9\gamma} < f < \frac{9}{40\gamma}, (0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f}$ or $\frac{3}{10} + \frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{9}{40\gamma}$ or $(0 < a < \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f}\ \frac{3}{10} - \frac{1}{10}\sqrt{9-40\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$.

The first-order and second-order derivative of PC^* with respect to a are

$\frac{dPC^*}{da} = \frac{\gamma(2a^2+\gamma f-1)(a^2-\gamma f+2a\gamma f)}{4(a^2+f\gamma)^3} < 0$ for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}})$ or $(\frac{1}{8} < \gamma < 1,$

$\left(\left(0 < f < \frac{1}{8\gamma}, \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right) \middle|\middle| \left(\frac{1}{8\gamma} < f < 1, -\gamma f + \sqrt{\gamma f + \gamma^2 f^2} < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)\right)$

$\frac{d^2PC^*}{da^2} = \frac{\gamma(20a^3\gamma f - 4a^5 + a^4(3-12\gamma f) + 2a^2\gamma f(\gamma f - 4) + \gamma^2 f^2(1+2\gamma f))}{4(a^2+\gamma f)^4} > 0$, for

$\left(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$ or $\left(\frac{1}{8} < \gamma < 1, 0 < f < \right.$

$\left.\frac{1}{8\gamma}, one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}\right)$.

4. The optimum function maximising total welfare $(w(q))$ is

$$w^* = \frac{(a+\gamma f)^2}{8(a^2+\gamma f)}.$$

The first-order and second-order derivative of $w^*$with respect to γ are

$\frac{dw^*}{d\gamma} = \frac{f(a+\gamma f)(2a^2+\gamma f-a)}{8(a^2+\gamma f)^2} > 0$, for $(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8} < \gamma < 1, ((0 <$

$f \leq \frac{1}{8\gamma}, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$.

$\frac{d^2w^*}{d\gamma^2} = \frac{(a-1)^2a^2f^2}{4(a^2+\gamma f)^3} > 0$, for $f > \frac{2}{\gamma}, 1 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first-order and second-order derivative of $w^*$with respect to f are

$\frac{dw^*}{df} = \frac{\gamma(a+\gamma f)(2a^2-a+\gamma f)}{8(a^2+\gamma f)^2} > 0$, for $\left(0 < \gamma \leq \frac{1}{8}, 0 < f < 1, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f}\right)$ or $(\frac{1}{8} < \gamma < 1, ((0 < f \leq$

$\frac{1}{8\gamma}, 0 < a < \frac{1}{4} - \frac{1}{4}\sqrt{1-8\gamma f})$ or $(\frac{1}{8\gamma} < f < 1, 0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}))$.

$\frac{d^2w^*}{df^2} = \frac{(a-1)^2a^2\gamma^2}{4(a^2+\gamma f)^3} > 0$, for $f > \frac{2}{\gamma}, 1 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

The first –order and second-order derivative of $w^*$with respect to a are

$\frac{dw^*}{da} = -\frac{(a-1)f\gamma(a+\gamma f)}{4(a^2+\gamma f)^2} > 0$, for $0 < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

$\frac{d^2w^*}{da^2} = \frac{\gamma f(2a^3 - 6a\gamma f + \gamma f(1-\gamma f) + 3a^2(\gamma f - 1))}{4(a^2+\gamma f)^3} < 0$ for $one\ imaginary\ root < a < \frac{\sqrt{\gamma f}}{\sqrt{2}}$.

b. Quadratic distribution

It is now assumed that the uncertainty in the demand function follows a quadratic distribution. The same assumptions under the triangular distribution are applied.

Firms' Behaviour

The expected profit function for the risk –neutral cartel is given by:

$$\pi \triangleq E[\tilde{\pi}] = pq - \tau\gamma f \qquad \textit{Equation a}$$

It is assumed that the random noise ε has support $[-a, a]$, where $-a \equiv \underline{\varepsilon} \leq 0 \leq a \equiv \bar{\varepsilon}$ and follow a U-quadratic distribution given by

$$PR(\varepsilon) = \frac{1}{2a^3} \ (\varepsilon^3 + a^3) \text{ for } -a < \varepsilon < a \qquad \textit{Equation b}$$

Letting the demand function being unit linear, the probability of detection given in Equation 2 can be written as

$$\tau = 1 - PR(g - 1 + q), \qquad \textit{Equation c}$$

and substituting Equation *b* into Equation *c* yields the probabilities a cartel is detected:

$$\tau = 1 - \frac{1}{2a^3}\{[g - 1 + q]^3 - a^3\} = 1 - \frac{(g+q-1)^3+a^3}{2a^3}. \qquad \textit{Equation d}$$

Next, substituting Equations *c* into Equation *a* yields the expected profits

$$\pi = (1 - q)q - [1 - \frac{(g+q-1)^3+a^3}{2a^3}]\gamma f. \qquad \textit{Equation e}$$

The first order conditions for the expected profit maximization are

$$\frac{\partial \pi}{\partial q} = 1 - 2q + \frac{3(g+q-1)^2\gamma f}{2a^3} = 0.$$

And the corresponding second order derivatives for the profit maximization are

$$\frac{\partial^2 \pi}{\partial q^2} = -2 + \frac{3(-1+g+q)\gamma f}{a^3} \leq 0, \quad \text{for} \quad (0 < q \leq 1, 0 < g \leq 1 - q) \text{or} \quad (1 - q < g < 1, a > one\ imaginary\ root) \quad \text{or} \quad (q > 1, (\left(0 < f \leq \frac{-2+6q-6q^2+2q^3}{-3\gamma+3g\gamma+3q\gamma}, a > -1 + q\right) \quad \text{or} \quad (f > \frac{-2+6q-6q^2+2q^3}{-3\gamma+3g\gamma+3q\gamma}, a > one\ imaginary\ root).$$

The two levels of optimal output produced by the cartel are:

Either (i) $q(g) = \frac{2a^3+3\gamma f-3g\gamma f-\sqrt{2}\sqrt{2a^6+3a^3\gamma f-6a^3g\gamma f}}{3\gamma f}$ *Equation f(i)*

Or (ii) $q(g) = \frac{2a^3+3\gamma f-3g\gamma f+\sqrt{2}\sqrt{2a^6+3a^3\gamma f-6a^3g\gamma f}}{3\gamma f}$. *Equation f(ii)*

The change in the optimal q as a response to a change in g are:

$\frac{dq(g)}{dg} = -1 + \frac{a^3}{\sqrt{a^6-\frac{3}{2}a^3\gamma f(2g-1)}} < 0$, which holds for $0 < g < \frac{1}{2}, 0 < \gamma < 1, a > 0$.

Equation g(i)

(i) $\frac{dq(g)}{dg} = -1 + \frac{\sqrt{2}\sqrt{a^3(2a^3+3(1-2g)\gamma f)}}{-2a^3+3(2g-1)\gamma f} < 0$ which holds for $0 < g \leq \frac{1}{2}, 0 < \gamma < 1, a > 0$ and $(\frac{1}{2} < g < 1, 0 < \gamma < 1, a > one\ imaginary\ root)$. *Equation g(ii)*

The above relationships suggest that if the CA reduces the price threshold of detection, the cartel will increase its output and hence lower its price. This is the first source of deterrence captured by the model.

We want $0 \leq g \leq 1$, and from Equation *g(i)* and *g(ii)*, q is a decreasing function of g. It is known that a low threshold set by the competition authority leads to a high output chosen for the cartel, hence decreasing prices. The preferred q is Equation *f(ii)* and is retained onwards. Equation *f(i)* is disregarded.

Competition Authority's problem

The total welfare generated in the economy in the cartelised markets in a period is consumer welfare minus cost of investigations given by

$$w(q(g)) \triangleq E(\widetilde{w}(q(g)) = \int_0^{q(g)}[(1-q)-(1-q(g))]\,dq - \frac{(1-g)^2}{2}. \qquad \textit{Equation h}$$

Substituting $q^*(g)$ (from Equation *f(ii)*, the optimal g is solved and set it to zero, and get the equalities $\frac{dw(q(g))}{dg} = -\frac{a^3(4\sqrt{2}a^3+3\sqrt{2}f(2-3g)\gamma+4\sqrt{a^3(2a^3+3\gamma f-6g\gamma f)})}{3\gamma f\sqrt{a^3(2a^3+3(1-2g)\gamma f)}} = 0.$

The corresponding second order derivatives for the consumer welfare maximization are

$\frac{\partial^2 w}{\partial g^2} = \frac{\sqrt{2}a^6(2a^3+3(1-3g)\gamma f)}{(a^3(2a^3+3(1-2g)\gamma f))^{3/2}} \leq 0$ for $\left(\frac{1}{3} < g \leq \frac{1}{2}, 0 < a < one\ imaginary\ root\right)$and $\left(\frac{1}{2} < g < 1, a\ between\ 2\ imaginary\ roots\right)$.

Hence the optimal equilibrium thresholds set by the CA are:

(i) $g^* = \frac{2(2a^3+9\gamma f-\sqrt{2}\sqrt{2a^6-9a^3\gamma f})}{27\gamma f}$ *Equation i(i)*

(ii) $g^* = \frac{2(2a^3+9\gamma f+\sqrt{2}\sqrt{2a^6-9a^3\gamma f})}{27\gamma f}$. *Equation i(ii)*

The preferred solution is $g^* = \frac{2(2a^3+9\gamma f+\sqrt{2}\sqrt{2a^6-9a^3\gamma f})}{27\gamma f}$, Equation *j* for $\frac{dg}{d\gamma} < 0$.

Substituting Equation *i(ii)* into Equation *f(ii)*, we find that the optimal quantity (q^*) produced by firms is

$$q^* = \frac{14a^3+9\gamma f-2\sqrt{4a^6-18a^3\gamma f}+3\sqrt{2}\sqrt{a^3(10a^3-9\gamma f-4\sqrt{4a^6-18a^3\gamma f})}}{27\gamma f}. \qquad \textit{Equation j}$$

Next, substituting Equations *i(ii)* and *j* into Equation *c*, the optimal probability of detection τ^* obtained is

$$\tau^* = 1 - \frac{a^3+\frac{\left(6a^3+\sqrt{2}\sqrt{a^3\left(10a^3-9\gamma f-4\sqrt{4a^6-18a^3\gamma f}\right)}\right)^3}{729\gamma^3 f^3}}{2a^3}. \qquad \textit{Equation k}$$

Finally, substituting Equations *k* into Equation *a*, the optimal probability of convicted PC^*retrieved is

$$PC^* = \left(1 - \frac{a^3 + \frac{(6a^3 + \sqrt{2}\sqrt{a^3(10a^3 - 9\gamma f - 4\sqrt{4a^6 - 18a^3\gamma f})})^3}{729\gamma^3 f^3}}{2a^3} \right) \gamma. \qquad \textit{Equation I}$$

Chapter 5 The age profile of the number of convicted cartels by a competition authority: Empirical evidence

5.1. Introduction

Various studies have shown that detection and deterrence are closely linked. Empirically, however, there is an obvious measurement problem. While the detection rate can easily be captured through the count of activities, it is more difficult to assess deterrence, given that it is unobservable. Different methods such as surveys, count of activities, difference-in-differences or econometric impact studies or surveys have been used to assess the performance of a CA in deterring cartels.

As stated by Bryant & Eckard (1991) and Combe et al (2008), detection plays an essential role in the enforcement of competition law and policy as it leads to deterrence. A CA successfully detecting cartels will also have the effects of preventing cartelised behaviour from firms. Although an increasing amount of work has recently been done by researchers and academics in looking at the role of deterrence in competition policy, very few empirical studies have been made in assessing either detection or deterrence or both across the different competition authorities. As a follow up to the theoretical model of the previous chapter, in this chapter, I study the age profile of cartel cases detected and convicted by a CA, in order to deduce results concerning efficiency in detection and success in deterrence over time.

In terms of the different methodologies used in assessing the detection of cartels, Bryant & Eckard (1991) estimated the conspiracy durations in the US[46] by using a model on statistical birth and death process. Combe et al (2008) then later used the same methodology, the birth process, death process and detected process to estimate the probability of a cartel getting caught in the EU[47]. Miller (2009) used a different method to show that the introduction of leniency programme in 1993 increased the cartels' detection rate. More recently, drawing from a capture-recapture analysis, Ormosi (2014) estimates time-dependent cartel discovery rates, while allowing for heterogeneity across firms[48].

Moreover, still remaining as a very difficult task to obtain an absolute value for the number of cases deterred, researchers have attempted to measure deterrence by mostly making inferences about

[46] They estimated probability of price fixing conspiracies getting caught is estimated to be at most between 13% and 17% in a given year in the US between 1961 and 1988.
[47]They estimated the annual probability of cartels getting caught to fall between 12.9 and 13.3% in the EU.
[48] His results suggest that the European Commission's detection rate has improved to 15%-20% between 1967 and 2007.

changes in the 'unobservables' based on observed changes in the number of detected cartels (Miller (2009)) like ours, using difference-in-differences (Buccirossi et al., 2006), econometric impact studies or surveys (Harding (2011) and Davies and Majumdar (2002), OFT (2011)[49], and NMa (2011)[50]). Moreover, Buccirossi et al (2011) developed the Competition Policy Indexes (CPIs), a set of indicators of the quality/intensity of competition policy to measure the deterrence effects of a competition policy in a jurisdiction. The CPIs is then applied to 13 OECD jurisdictions capturing any changes than happened between years 1995-2005[51]. In investigating how anti-cartel enforcement deters consumer harm, Davies and Ormosi (2014) found that (i) the harm detected by the CA really is only the tip of the iceberg, accounting for only a small fraction (at most one sixth) of total potential harm; (ii) deterrence is at least twice as effective as detection as a means for removing harm; and (iii) undetected harm is at least twice as large as detected harm.

In this chapter, I empirically assess the magnitude of detection and deterrence by looking at competition authorities' age profile of cartel cases detected and convicted. The study of age profile is very commonly used in social sciences to analyse consumers, firms and institutions behaviour. Famous economic theories such as the product life cycle by Vernon (1966) and the life cycle theory of consumption by Modigliani and Brumberg (1954) have been developed based on age profiling. Political scientists have also used age profiling theories when studying regulatory authorities (Lierson (1949), Bernstein (1955), Huntington (1966) and Downs (1967)[52]). Kahn (1988)[53] and Martimort (1999)[54] reported that regulatory authorities do also tend to go through a life cycle.

The empirical analysis is based on a panel data set of 32 countries over 9 years (2006-2014). I use the random effects maximum likelihood estimator and include an age, period cohort analysis (to better isolate the impact of the CA's age, as opposed to the other time dimensions of time itself and the

[49] In the UK, the Office of Fair Trading found that for every cartel case investigated, 28 large firms were deterred [See (OFT, 2011), page 7].

[50] In the Netherlands, 60% of cartels were deterred and about a third of the undeterred cases was detected [Survey conducted by der Noll et al. (2011)].

[51] They identified sanctions and damages; 2) financial and human resources; 3) powers during the investigation; 4) quality of the law; 5) independence; and 6) separation of power as the factors that are likely to affect the degree of deterrence. See page 6-22 for structure of CPI.

[52] They put forward that government efficiency should be judged and be understood as a dynamic rather than a static phenomenon over time.

[53] According to Kahn (1988), regulatory agencies would start out as "vigorous, imaginative, and enthusiastic protagonists of the public interest" and "defining their responsibilities broadly and creatively". They would then gradually becoming devitalized, limited in their perspective, routinized and bureaucratized in their policies and procedures and increasingly solicitous and protective of the interests of the companies they are supposed to regulate, resistant to changes, wedded to status quo and organizations for collective action over time.

[54] Martimort (1999) adopted a dynamic perspective to explain the life cycle of regulatory agencies overtime also found that agencies start to behave in the public interest and then become increasingly inefficient, bureaucratized and more eager to please private interests.

cohort to which the CA belongs). It is found that the age of the cartel law does impact on the number of convicted cartels over time. The results indicate that there is an inverted U-shape trend in the number of cartels prosecuted over the life of the CA. Importantly, it is observed that this result remains robust once changes over time in the CA's budget is controlled for. This is interpreted as evidence of increasing deterrence as a consequence of the increased efficiency of detection. Thus, over time, initially and potentially for many years, the CA is observed to successfully convict more cartels as a consequence of its growing experience. However, this increased efficiency also increasingly deters new cartels from forming. Eventually, the latter outweighs the former, and a downturn in cartel cases convicted is observed. It is important to stress that this interpretation indicates that competition authorities are successful in deterring cartels, even though the number of cases eventually declines.

The remainder of the chapter is organised as follows: Section 5.2 recalls the theoretical model of the previous chapter to establish hypotheses and explanatory variables. Section 5.3 presents the data and descriptive statistics. Section 5.4 explains the empirical model and methodology. Section 5.5 reports the results and discusses the implications, and this is followed by concluding remarks in Section 5.6.

5.2. Hypotheses and explanatory variables

As captured by the propositions of the main theoretical result from the previous chapter, over the CA's lifetime, the number of cartels convicted rises for (potentially many) years, before hitting a ceiling and thereafter declining. The period of decline can be interpreted as a maturity stage, in which the fruits of deterrence are dominant.

Although this is the main prediction, the theoretical model also includes some pointers as to other potential explanatory variables. Below, these are identified as (i) potential resource constraints, (ii) penalties, and (iii) legal/institutional features of the jurisdiction which might affect the efficiency of CAs.

5.2.1. Potential resource constraints

Budget

Most obviously, appropriate budget is essential in order for a CA to be able to perform its day to day activity and achieve its objectives. This will have a direct effect on the level of detection efficiency of a CA (refer to page 71 of Chapter 4). A generous budget enables a CA to more effectively and efficiently enforce its law, train its staff and be engaged in advocacy. It is normally very costly to run a cartel investigation given that it may take many years to gather evidence and conclude one. Budget can be

expected to be both positively and negatively related to the number of cartel cases. While, a higher budget is likely to enable the CA to convict more cartels, a higher budget can also help a CA to be more efficient in deterring cartels (perhaps by engaging in more aggressive compliance programmes) hence reducing the number of cartels available to be convicted.

Merger cases

In most countries, merging firms are obliged to notify the CA if the merger is beyond a certain threshold. The CA then has no choice than to go through every merger case notified (Phase I) and launch investigations (Phase II) if need be. Merger referrals can therefore be considered to be exogenous to the CA. And since in the real world, CAs operate with resource (including human and financial) constraints, the number of merger cases referred to the CA might negatively impact on its ability to convict cartels. The higher the number of mergers notified, the lower the number of cartel cases the CA is likely to detect and convict. On the other hand, if the CA has a generous budget, merger cases are unlikely to have any impact on the number of convicted cartels.

Fines and imprisonment

A CA can also exercise its powers to impose punishment such as fines and imprisonment so as to discourage firms from engaging in anti-competitive behaviour. Elzinga & Breit (1973), Posner (1985), Shavell (1985) and Werden, Barnett, & Hammond(2012) found that monetary sanctions are best ways to deter cartels. Moreover, years of imprisonment give an indication to firms of what they risk if they are caught to be guilty when engaged in cartels. The higher is the maximum number of years of imprisonment that firms risk, the less likely they are to engage in cartels. Equation 4.4 of Chapter 4 clearly demonstrates how an increase in the level of punishment impacts negatively on the level of profit of cartels. This consequently causes firms to reduce their prices so as not to be detected.

Institutional/legal characteristics

Leniency policy

Leniency policy[55] is now the most important tool either for detecting cartels or for developing the necessary evidence to convict them (Werden, Barnett, & Hammond (2012), Bos (2006) and Motta & Polo (2003)). Firms will come forward under the leniency program only if their chance of being successfully prosecuted is sufficiently high (Chang & Harrington, 2008). Leniency is believed to increase the rate of detection at substantially lower cost, so that enforcement resources are saved (Bos (2006),

[55] Leniency programs provide cartel members with the opportunity to report their collusive practices in exchange for a reduction of fines or even full amnesty.

Miller (2009)). At the early years of the adoption of the leniency policy, a positive relationship between leniency policy and convicted cartel cases can be expected.

On the other hand, if the leniency policy is successful in deterring cartels, it can be expected to be negatively related to the number of convicted cartel overtime. Miller (2009)[56] empirically theoretically found that the number of discoveries increases immediately following the leniency introduction and then falls below pre-leniency levels. Therefore, leniency policy can be expected to have both a positive or/and negative influence on the cartel activities of a CA overtime.

Legal system- Common law versus civil law

The type of legal system adopted by a country may also affect the number of cartels convicted. As explained in chapter 3, page 32, common law regimes give more rulemaking powers to the judiciary while the civil law regimes reserve greater power to the legislature giving less discretion to the judiciary (Dainow, 1966/7). Posner (1973) has claimed that the common law system is superior, largely because it can act more like a market in adapting to change. Others support the legal certainty provided by a civil code. There is no a priori expectation of which is better and the benefits of each may be context-specific. We therefore adopt no prior on whether common law should be better or worse for competition policy in deterring cartels.

Agency design- prosecutorial versus integrated agency

The broad design of the set of institutions responsible for evidence gathering and decision making in competition enforcement is also considered. Following Fox and Trebilcock (2013), three basic institutional models are identified:

(i) judicial, if the competition agency must go to court for enforcement
(ii) bifurcated if the agency goes to a specialised tribunal for enforcement
(iii) integrated agency[57] if a commission within the agency makes the first-level adjudication.

These three classifications embrace another important institutional feature, which is the prosecutorial (or adversarial) versus the inquisitorial approaches. The nature of Fox and Trebilcock's three institutional models is that the first two are naturally prosecutorial, while the third is naturally inquisitorial, so we combine judicial and bifurcated agencies to identify prosecutorial systems. This

[56] Cartel detection rate increased by about 62% and that the rate of cartel formation fell by about 59% between 1985 and 2005 after leniency policy was introduced.
[57] See chapter 3, page 33.

dichotomy with the inquisitorial integrated agency is used as an alternative categorisation of institutional designs and used in this study. We have no prior that there is an ex ante superior system.

5.3. Data and descriptive statistics

A panel data set of 34 competition authorities from 33 countries[58] (plus the EU) over the period 2006 – 2014 is used. It is the full set of available countries with at least six years of country data, with the exception of Pakistan which set up its CA in 2010, and Chile where CA data is available from 2008. Data has mainly been collected from the GCR Enforcement reports, the World Bank, the George Washington Competition Law Center Database (GWCLC), and the website and annual reports of the competition authorities. The variables have been downloaded based on their availability.

The definitions and data sources of the variables are shown in Table 5.1[59] (refer to chapter 2 for detailed information pertaining to the data).

Table 5.1: Definition of variables and data sources (yearly data)

Dependent variable	Definition	Form[60]	Source
$\#cartel$	Number of cartel decisions: It is used as a measure of the number of cartel prosecuted by the CA.	Log[61]	GCR
Independent variables			
age	Number of years a country has had a cartel law.	Level	Annual reports and CA's website
$leniency$	Whether or not the country has a leniency programme in the year concerned[62]	1 or 0	Annual reports and CA's website
$\#merger$	Number of mergers notified to the CA	Log	GCR
$fines$	Three year moving average of fines (million Euros)[63]	Log	GCR
$prison$	Maximum number of years of imprisonment for individuals found guilty of engaging in cartels	Log	GCR

[58] The jurisdictions are Australia, Austria, Belgium, Brazil, Canada, Chile, Czech, Denmark, EU, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Lithuania, Mexico, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, South Africa, Slovakia, Spain, Sweden, Switzerland, UK and US (D0J).

[59] A small amount of interpolation was required for missing years of some independent variables. Also, GCR did not report information for Slovenia for 2012, 2013 and 2014.

[60] The form of the variables has been chosen based on the most robust results.

[61] To avoid losing observations when the number of cartel decisions are converted in log form, one is added to the number of cartel decisions.

[62] An alternative measure - the number of years the CA has had a leniency policy - is infeasible given extreme multicollinearity with the age of the of the cartel law.

[63] A three year moving average of average fine is used because of huge variations in the data over the years.

$\boldsymbol{commonlaw}$	Common law =1 v/s Civil Law=0	1 or 0	Mixed Jurisdictions: Common Law v. Civil Law by W. Tetley[64]
$\boldsymbol{prosecutorial}$	Prosecutorial =1, Integrated =0	1 or 0	The Design of Competition Law Institutions by E. Fox and M.J. Trebilcock
$\boldsymbol{budget}$	CA expenditure (millions of euros)	Log	GCR

Table 5.2 provides the pooled summary statistics for these variables. US is the oldest and Pakistan is the youngest CA in the database. US made the highest cartel decisions, 90 in 2011, while Germany had the highest number of merger notified in 2007. EU in 2010 had the highest average fine. Canada is the country having the highest number of years of imprisonment if found guilty of being engaged in cartels. In 14 countries[65], there is no imprisonment punishment for cartels. US is the country which had its first leniency policy in 1993.

Table 5.2: Summary statistics

Variables	Obs	Mean	Median	Std. Dev.	Min	Max
$\#cartel$	300	11.777	7	14.1665	1	91
age	306	39.529	32.5	25.419	3	124
$leniency$	306	8.552	8	5.866	0	37
$\#merger$	301	269.973	115	377.129	0	2231
$fines$	275	63.882	2	63.8817	0	471
$prison$	298	3.279	2	3.936	0	14
$commonlaw$	305	0.266	0	0.442	0	1
$prosecutorial$	305	0.354	0	0.479	0	1
$budget$	294	2.507	2.389	1.123	-1.386	4.937

Figure 5.1 shows the year that countries first established their cartel laws. The US was the first in 1890, followed by Norway in 1926. Most big European countries then followed by 1965. However, 50% of the countries in our database introduced their first cartel law after 1980 and 33% after 1990.

[64] See Tetley (1999-2000).

[65] They are Austria, Belgium, EU, Finland, Lithuania, Netherlands, New Zealand, Pakistan, Poland, Portugal, South Africa, Slovakia, Sweden and Switzerland.

Figure 5.2 shows the number of cartel prohibition decisions taken by a sample of the CAs, 2006-2014. Only a sample of countries is used - as illustrative and to maintain clarity of the figure. Thus, the oldest, youngest and average aged CA have been selected. It is observed that US had the highest number of cartel decisions (reflecting the size of economy of the US) and the UK has the lowest number.

Figure 5.1: Evolution of cartel law establishment

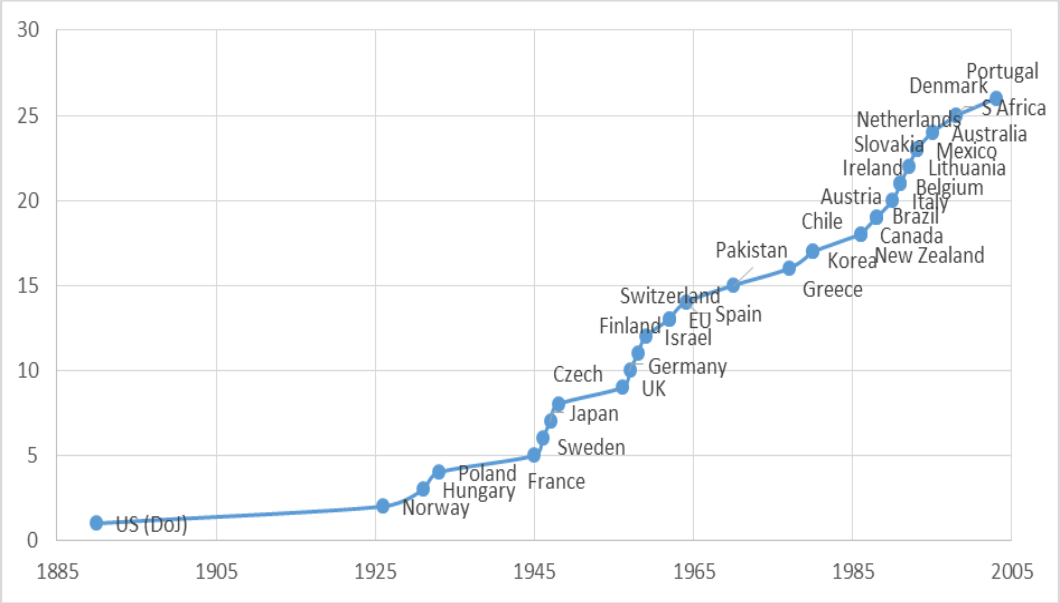
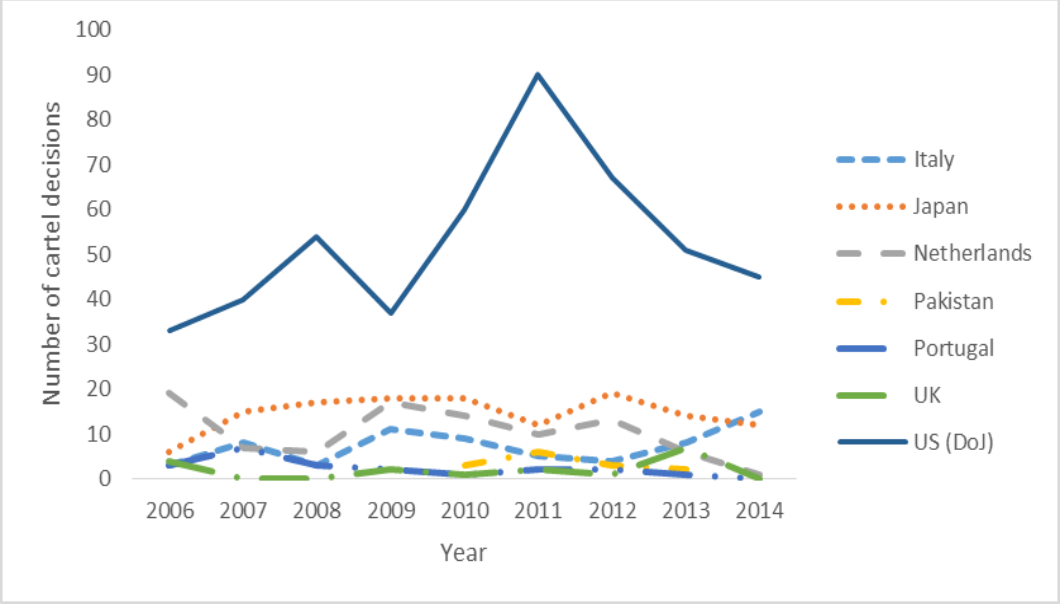


Figure 5.2: Number of cartel decisions (2006-2014)



However, when standardising the number of cartel decisions by GDP, it is found that Netherlands and Pakistan are well above the rest of countries as seen in Figure 5.3**.** This can be explained by the fact that cartels have recently become illegal in Pakistan and Netherlands. Since, it is only recently that cartels are illegal in these countries, it can be expected that cartel population would be greater

compared to the rest of countries. The greater cartel population also implies a higher probability that cartels are being detected, hence resulting to a greater number of detected cartels.

Figure 5.3: Number of cartel decisions/Billion GDP (US$) (2006-2014)

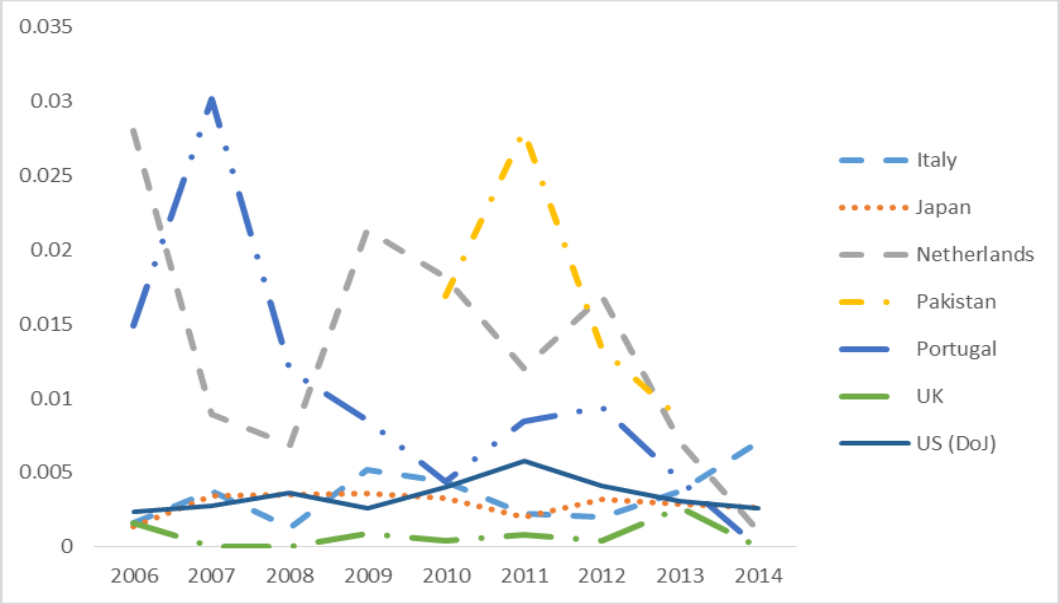
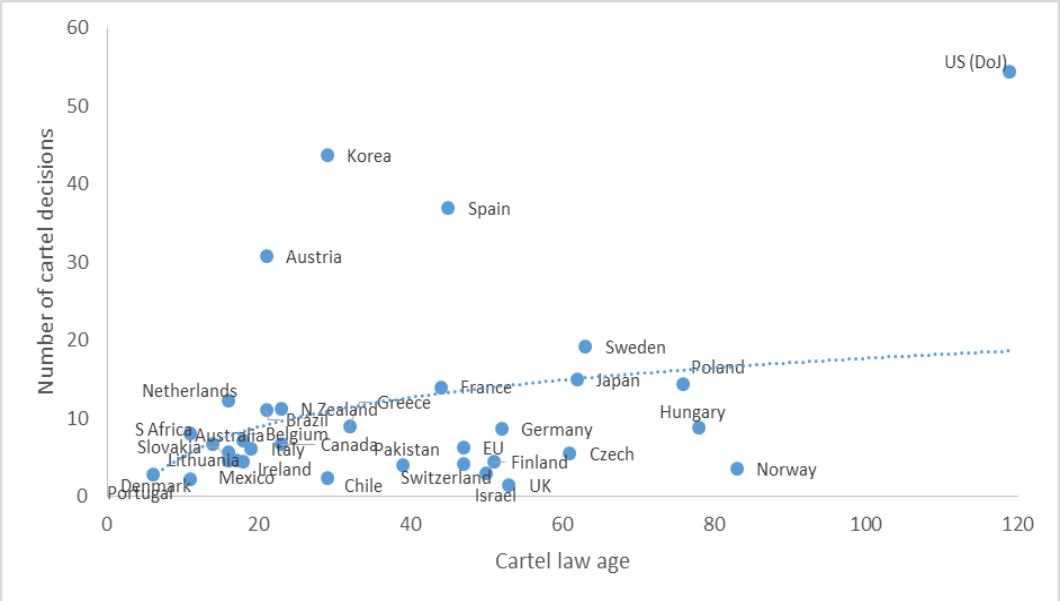


Figure 5.4 presents a scatter diagram of the #cartel variable across countries, taking the number per annum. This suggests a positive but probably non-linear relationship, but is, of course, not multivariate – it is included here merely to set the scene.

Figure 5.4: Number of cartel decisions p.a. v/s Cartel law age



The strength and direction of a relationship between the different variables are also shown in the correlation matrix in Appendices, Table 5.A.1. It is observed there seems to be almost no correlation between (i) cartel and abuse and fines, prison, common, law and prosecutorial. Some moderate positive correlation if however found between cartel and age, leniency, merger and budget.

5.4. The empirical model and methodology

To empirically study the age profile of the cartel cases prosecuted by a CA, the maximum likelihood random effects estimators (MLE) is used[66]. The random effects is applied because I have a panel data and the individual specific effects are assumed to be uncorrelated with the independent variables.

5.4.1. Age, period and cohort effects

One important feature of our empirical model is the application of age-period-cohort analysis. Given that the focus of this chapter is to determine the age profile of cartel cases prosecuted, and I have panel data such that that the CA's established their cartel law at different times, and are observed at several point in time, and come from different cohorts, it is important that the age effects are not confounded with a cohort effects.

The age-period-cohort analysis serves as a general methodology for cohort analysis when all three factors, age, period and cohort are of interest (Yang, Fu, & Land, 2004). In this chapter, age effects are the consequences of the CA growing older in terms of having its first cartel law (age one is the first year after the cartel law is implemented). Period effects are the consequences of influences that vary through time e.g. the financial crisis which occurred in 2008 and might have impacted on the number of cartel cases. The cohort effects are the consequences of a group of CA setting up in particular periods and sharing a particular event together during a particular time span e.g. change in trade or competition policy (commonality of competition laws), free trade between countries.

For example, UK established its first cartel law in 1956. Therefore, in observation year 2014, age = 58 and the cohort is 1956. All the CAs which established their cartel law in the same period might share common features as a result of circumstances in 1956.

[66] I have used maximum likelihood estimator to estimate the number of cartels equations. I have compared the results of an econometric model based on a parametric Poisson, Negative Binomial and Gaussian probability distribution. Based on the robustness of the results, the Gaussian distribution was chosen.

Normally, an arbitrary five-year interval is used for cohorts. But, since we have key dates where there have been main changes in the global laws and regulations with CA's sharing the common likelihood of experiencing the changes, the age data is grouped into the following four cohorts:

- Cohort 1- Before 1957 – before the EC treaty
- Cohort 2- Between 1958 to 1986 – After the treaty and before the EU single Act
- Cohort 3- Between 1987 to 1996– Between the introduction of the EU single Act and the launching of WTO competition project
- Cohort 4- After 1997 – After the launching of the WTO competition project

However, one well known problem that arises when using the age-period-cohort model is the identifiability problem. This occurs due to the exact relationship between the three variables (cohort=period-age). It is impossible to empirically deal with one without also dealing with others given their closely interrelated effects[67]. The cohort effects are then modelled as a step function with each step corresponding to an interval.

To solve for the identification problem and to capture the age, period and cohort effects, we use the same approach used in Levin & Stephan (1991) and Hall, Mairesse, & Turner (2007). The parameters are restricted by omitting both of one of the cohort dummies and one of the year dummies to break the exact collinearity and identification problem present in the model.

5.4.2. Empirical model

The model to be estimated is given by:

Specification I (without budget)

$$ln\#cartel_{it} = \beta_0 + f(age_{it}|\beta_1) + \beta_2 leniency_{it} + \beta_3 ln\#merger_{it} + \beta_4 lnfines_{it} + \beta_5 lnprison_{it} + \beta_6 commonlaw_i + \beta_7 prosecutorial_i + v_i + \varepsilon_{it} \quad \textit{Equation 5.1}$$

where i is the competition authority and t is the year (t =2006, 2007,…., 2014). $ln\#cartel$ is the natural log of the number of cartel decisions and is the dependent variable, all explanatory variables are defined in Table 5.1. v_i is the unit-specific unobserved heterogeneity that differs across countries, but remains constant over time for any particular country and ε_{it} is the remainder of the disturbance.

Thus specification I captures the age profile of the CA's cartels prosecuted based mostly on the experience acquired overtime. However, detection efficiency and deterrence do not only depend on

[67] See Hall, Mairesse, & Turner (2007), page 4.

experience but very importantly also on budget. The day to day operations of a CA including investigating cartels, or any other type of anti-competitive behaviours or engaging in advocacy, will inevitably depend on the level of budget. Therefore, in order to net out the age effects of a CA on the number of prosecuted cartel given the CA's budget, a budget variable is added to the model in specification II. Specifications I and II will enable us to compare the age profile of a CA's prosecuted cartels in the absence and the presence of a budget constraint.

Specification II (including budget)

$$ln\#cartel_{it} = \theta_0 + f(age_{it}|\theta_1) + \theta_2 leniency_{it} + \theta_3 ln\#merger_{it} + \theta_4 lnfines_{it} + \theta_5 lnprison_{it} + \theta_6 commonlaw_i + \theta_7 prosecutorial_i + \theta_8 lnbudget_{it} + \theta_9 lnbudget_{it-1} + \theta_{10} lnbudget_{it-2} + u_i + \vartheta_{it} \quad \textit{Equation 5.2}$$

Where $lnbudget$ is the natural log of budget, u_i is the unit-specific unobserved heterogeneity that differs across countries, but remains constant over time for any particular country and ϑ_{it} is the remainder of the disturbance. Lagged budget up to two periods are included so as to account for the time required by the CA to detect, investigate and convict cartels.

I am aware that $lnbudget$ may in fact be endogenous which would lead to inconsistent estimators: for example, while budget can influence the number of prosecuted cartels, the latter can also have an impact on the budget to be allocated to the CA. However, this endogeneity issue is hopefully avoided if the relationship runs from lagged budget to cartels convicted.

5.5. Results and implications

This section presents the core results with particular focus on the age variable. The results for Equation 5.1 (excluding explicit allowance for any budget constraints) and for Equation 5.2 when budget is incorporated to the model are shown. This is a largely presentational device which serves to establish that the key result on age is robust to the inclusion of budget: in other words, the time profile we identify is not merely reflecting an omitted variable which perhaps declines after some point.

Since the theory (chapter 4) does not provide precise predictions about the exact mathematical form of the actual age profile (it shows that an inverse U-shape profile is possible under certain functional forms), the model is tested with different order of age polynomials. This will enable me to obtain the most robust results to derive the age profile of cartel cases convicted. The results are illustrated up to age polynomial of order 4 – inclusion of even higher order polynomials would complicate the analysis

and provide less robust results. The preferred equation under both specifications is selected based on the Akaike Information Criterion (AIC) test[68]. Stock and Watson (2007) recommend using the AIC rather than Bayesian Information Criterion (BIC) as choice criterion, by arguing that including more parameters is better than omitting significant parameters. The results for specifications I and II are shown in Table 5.3 and Table 5.4 respectively.

Table 5.3: Specification I (excluding budget)

Dependent variable[69]: $ln\#cartel$				
Equation	**(i)**	**(ii)**	**(iii)**	**(iv)**
$ageh$[70]	1.381***	0.157	7.829**	4.736
	(0.448)	(1.431)	(3.592)	(8.186)
$ageh^2$		1.131	-14.29**	-3.851
		(1.256)	(6.805)	(25.730)
$ageh^3$			8.389**	-4.746
			(3.643)	(31.42)
$ageh^4$				5.361
				(12.73)
$leniency$	1.435**	1.414**	1.480**	1.473**
	(0.685)	(0.686)	(0.686)	(0.685)
$ln\#merger$	0.168***	0.159**	0.150**	0.152**
	(0.064)	(0.064)	(0.062)	(0.062)
$fines$	-0.003*	-0.003*	-0.003**	-0.003**
	(0.002)	(0.002)	(0.002)	(0.002)
$lnprison$	-0.0860	-0.0912	-0.126	-0.120
	(0.110)	(0.109)	(0.103)	(0.104)
$commonlaw$	-0.943***	-0.938***	-0.929***	-0.945***
	(0.297)	(0.293)	(0.274)	(0.277)
$prosecutorial$	0.585**	0.530**	0.406*	0.420*
	(0.248)	(0.253)	(0.241)	(0.245)
$Cohort\ 2$	0.398	0.520	0.527	0.552
	(0.375)	(0.394)	(0.366)	(0.373)
$Cohort\ 3$	-0.615*	-0.508	-0.430	-0.399
	(0.345)	(0.361)	(0.337)	(0.347)
$Cohort\ 4$	-0.233	-0.194	-0.130	-0.106
	(0.413)	(0.411)	(0.383)	(0.389)
$Y2009$	0.394**	0.395**	0.379**	0.383**
	(0.177)	(0.177)	(0.178)	(0.178)
$Y2010$	0.093	0.099	0.072	0.078
	(0.173)	(0.173)	(0.174)	(0.174)

[68] The Akaike Information Criterion (AIC) test measures the relative quality of statistical models for a given set of data. It estimates the quality of each model, relative to other models given a collection of models for the data. It also deals with the trade-off between the goodness of fit of the model and the complexity of the model. The model with the lowest AIC is the preferred one.

[69] Note: Dependent variable is log of 1+number of cartels.

[70] $ageh$ is age divided by 100.

$Y2011$	0.128	0.137	0.102	0.109
	(0.171)	(0.171)	(0.172)	(0.172)
$Y2012$	0.169	0.181	0.134	0.143
	(0.172)	(0.172)	(0.173)	(0.174)
$Y2013$	-0.011	0.002	-0.053	-0.040
	(0.181)	(0.181)	(0.183)	(0.185)
$Y2014$	0.063	0.082	0.031	0.048
	(0.184)	(0.185)	(0.186)	(0.190)
$constant$	-0.449	-0.215	-1.115	-0.882
	(0.839)	(0.875)	(0.941)	(1.093)
$sigma\_u\ Constant$	0.484***	0.476***	0.431***	0.433***
	(0.080)	(0.080)	(0.074)	(0.075)
$sigma\_e\ Constant$	0.627***	0.627***	0.627***	0.627***
	(0.035)	(0.035)	(0.035)	(0.035)
Number of country	200	200	200	200
Observations	34	34	34	34
chi2	35.47	36.27	41.21	41.39
P-value	0.003	0.004	0.001	0.002
Chi2- Joint significance of age	9.49	10.56	17.66	17.70
P-value	0.002	0.005	0.001	0.001
AIC	469.380	470.579	467.637	469.459
BIC	532.048	536.545	536.902	542.022
Chi2- joint significance of cohorts	11.77	12.4	12.22	11.91
P-value	0.003	0.002	0.002	0.003
Time effects	Yes	Yes	Yes	Yes

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Table 5.4: Specification II (including budget)

Dependent variable: $ln\#cartel$				
Equation	**(i)**	**(ii)**	**(iii)**	**(iv)**
$ageh$	1.215***	0.433	8.598**	6.803
	(0.435)	(1.414)	(3.480)	(8.076)
$ageh^2$		0.729	-15.620**	-9.588
		(1.253)	(6.568)	(25.330)
$ageh^3$			8.853**	1.292
			(3.503)	(30.870)
$ageh^4$				3.082
				(12.500)
$leniency$	1.451**	1.444**	1.482**	1.483**
	(0.684)	(0.684)	(0.684)	(0.683)
$lnmerger$	0.150**	0.144**	0.135**	0.136**
	(0.063)	(0.063)	(0.061)	(0.061)
$fines$	-0.004**	-0.004**	-0.005***	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)
$lnprison$	-0.141	-0.142	-0.183*	-0.179*
	(0.109)	(0.108)	(0.101)	(0.103)

$commonlaw$	-0.927***	-0.926***	-0.916***	-0.925***
	(0.287)	(0.286)	(0.263)	(0.267)
$prosecutorial$	0.633***	0.596**	0.470**	0.478**
	(0.240)	(0.247)	(0.232)	(0.236)
$lnbudget$	-0.082	-0.080	-0.079	-0.083
	(0.167)	(0.167)	(0.167)	(0.167)
$lnbudget_{t-1}$	-0.063	-0.077	-0.043	-0.045
	(0.193)	(0.195)	(0.194)	(0.194)
$lnbudget_{t-2}$	0.369**	0.367**	0.353**	0.354**
	(0.148)	(0.148)	(0.147)	(0.147)
$Cohort\ 2$	0.495	0.569	0.577*	0.591*
	(0.363)	(0.382)	(0.350)	(0.356)
$Cohort\ 3$	-0.322	-0.270	-0.171	-0.157
	(0.359)	(0.369)	(0.340)	(0.346)
$Cohort\ 4$	0.025	0.0312	0.125	0.134
	(0.430)	(0.428)	(0.394)	(0.397)
$Y2009$	0.352*	0.352*	0.340*	0.342*
	(0.182)	(0.182)	(0.182)	(0.182)
$Y2010$	0.035	0.040	0.013	0.016
	(0.175)	(0.176)	(0.176)	(0.176)
$Y2011$	0.038	0.045	0.010	0.013
	(0.175)	(0.175)	(0.176)	(0.176)
$Y2012$	0.125	0.134	0.087	0.092
	(0.177)	(0.178)	(0.178)	(0.179)
$Y2013$	-0.084	-0.073	-0.131	-0.123
	(0.184)	(0.185)	(0.186)	(0.188)
$Y2014$	-0.050	-0.034	-0.090	-0.079
	(0.190)	(0.192)	(0.192)	(0.197)
$constant$	-0.922	-0.741	-1.731*	-1.588
	(0.855)	(0.908)	(0.962)	(1.125)
$sigma\_u\ constant$	0.460***	0.458***	0.404***	0.407***
	(0.078)	0.078	(0.073)	(0.742)
$sigma\_e\ constant$	0.620	0.619	0.620	0.619
	(0.035)	(0.035)	(0.035)	(0.035)
Observations	196	196	196	196
Number of country	34	34	34	34
chi2	43.65	43.99	49.86	49.92
P-value	0.001	0.002	0.001	0.001
Chi2 -Joint significance of age	7.79	8.2	16.31	16.25
P-value	0.005	0.017	0.001	0.0027
AIC	460.471	462.134	458.270	460.209
BIC	532.590	537.530	536.944	542.161
Chi2 – joint significance of cohorts	7.53	7.79	7.33	7.24
P-value	0.023	0.020	0.026	0.027
Time effects	Yes	Yes	Yes	Yes

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

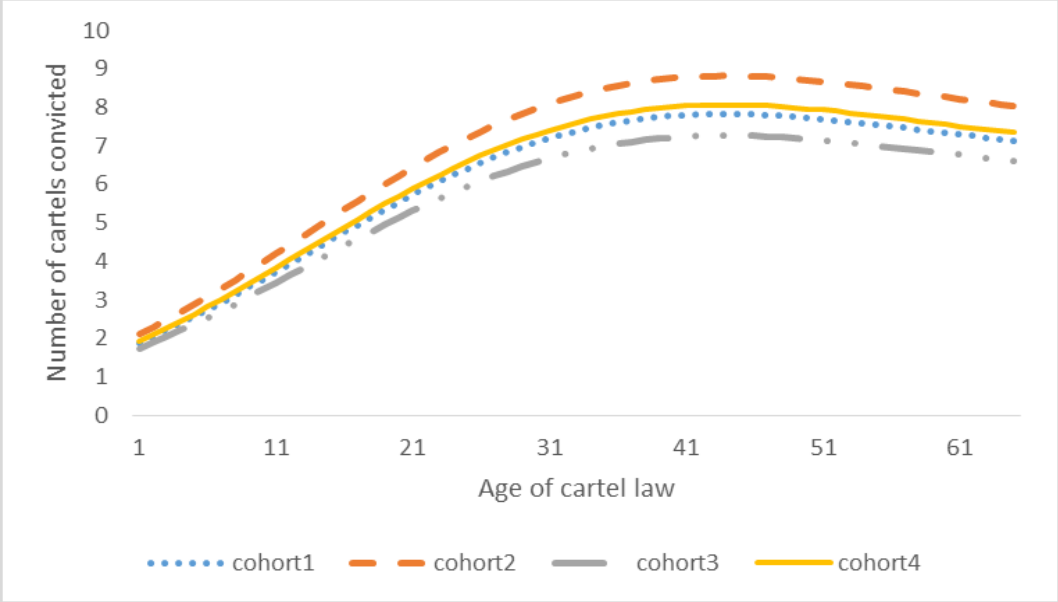
Based on the results from the above tables, the age polynomial function of order 3 (equation (iii)) is preferred since it has (a) the lowest AIC value and (b) the highest joint significance in age at 1% level, in both specifications. Having said this, the differences in AIC between the different functional forms of age are very small.

Figure 5.5 shows the predicted age profile of convicted cartel cases by competition authorities for each cohort, holding the other explanatory variables constant at sample mean values.

Figure 5.5: Prediction of age profile (specification I)

Figure 5.6 shows the same for specification II, i.e. including the budget constraint.

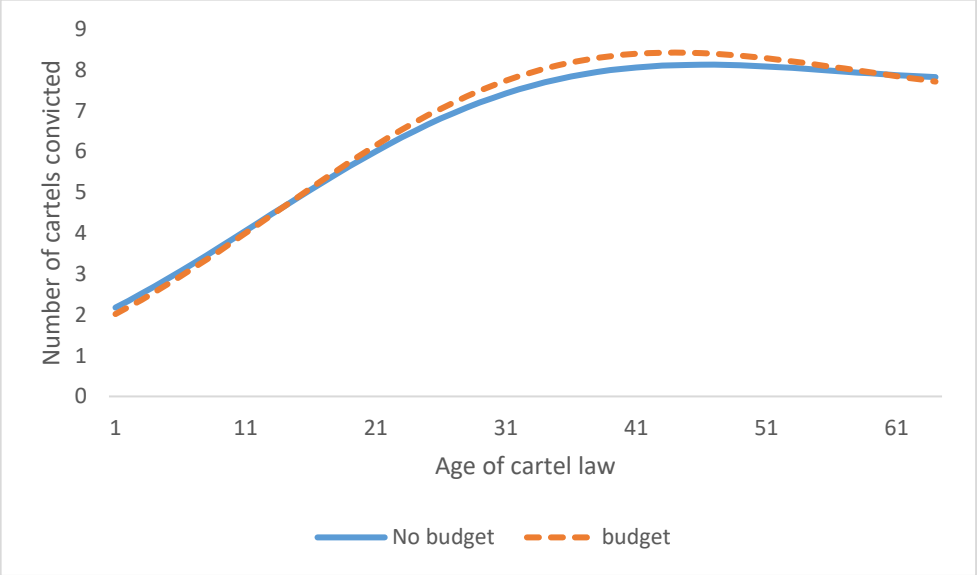
Figure 5.6: Prediction of age profile (specification II)



These show that although deterrence is present throughout the entire period, it only begins to outweigh increasing detection (because of increased efficiency) after 40 years which illustrated by the flattening of the slope of the age profile.

Figure 5.7 summarises by showing the average (weighted across cohorts) age profile, and comparing the two specifications. An inverted U-shape of the age profile is again obtained.

Figure 5.7: Prediction of age profile for average cohort



The age profile shows that there is a peak in year 46 and 44 in specifications I and II, respectively. There is therefore evidence the CAs age profile can be explained by the interaction of detection efficiency and deterrence. As a CA acquires experiences and becomes more efficient in convicting cartels, it produces deterrence of cartelised behaviour. Hence, as detection rate increases, it also influences the effects of deterrence. The fact that a cubic, rather than a simple quadratic, fits best can be explained by the shape of the curve after the turning point. Figures 5.5-5.7 show that there is a downturn, but only very slight – more like a flattening off into a plateau. The implication is that the deterrent effect is sufficiently strong to balance increased efficiency in detection, but not sufficiently strong to seriously reverse the trend in the number of cases detected.

Turning now to results on the other explanatory variables, I find that cohorts do impact on the number of convicted cartels over time. Although individually insignificant except for cohort 2, the cohorts are found to be jointly significant at 1% and 5% level for specification 1 and 2 respectively. For example for specification I, when comparing cohorts for specification I, CAs which have set up between 1958 and

1986, i.e are in cohort 2, are likely to convict 53% more cartels than the CA established before 1957, cohort 1. On the other hand, CAs set up between 1987 and 1996, cohort 3, are likely to convict 43% less cartels than those in cohort 4 (established after 1996). The profile of the cohort is shown in Appendices, Figures 5.B.1 and 5.B.2. It is observed that under both specifications, the cohort profile displays an inverse U-shape.

Interestingly, it is found that when budget is included there are only very slight changes in the age coefficients. This result confirms that the profile observed is not the result of systematic changes in budget over the typical CA's lifetime. However, this is not to deny the importance of budget in determining the level of convicted cartels of a competition authority. Moreover, the actual number of convicted cartels tend to be the results of previously allocated budget rather than current period budget. A 1% increase in budget in two previous periods $(t-2)$ enables the CA to detect and convict 0.35% more cartels. This may be due to the fact that cartel cases are normally very time consuming, involve the use of a lot of resources (both human and financial) and may take years before they are completed. Therefore, given the nature of such cases, CAs are unlikely to obtain the immediate results from increasing budget. The budget allocated in the period will impact on future cartels detected and convicted.

In addition to age and budget, the number of convicted cartels is also influenced by the other factors such as leniency policy, the number of merger notified, the level of punishment, the type of law and institutional design.

The results show that one additional period of leniency policy is likely to increase convicted cartels by 1.47% at 10% significance level. This confirms the effectiveness of using the leniency policy as a tool to detect cartels. It indicates that firms are willing to take advantage of the immunity offered by being an informant. Moreover, number of mergers notified is also found to be positively related to convicted cartels at 10% level. A 1% increase in number of mergers notified is likely to cause number of cartels prohibited to increase by 0.15% and 0.13% for specification I and II respectively. One reason explaining such relationship may be the when mergers occur in a particular industry, it may be giving an indication to the CA about industries which may be problematic and that should be investigated, hence leading to increase in the convicted cartels.

The type of law adopted by a country as well as the type of institutional design is also shown to have an effect on the number of convicted cartels by a CA at 1% and 10% significant level respectively. CA's functioning in countries adopting a civil law tend to boost up the number of convicted cartels, contrary

to those in countries which follow common law. On the other hand, a CA's adopting an inquisitorial system approach is less likely to convict more cartels than those adopting a prosecutorial approach.

There is also evidence that punishments both in terms of imprisonment and fines do deter cartelised behaviour. As the level of fines increases by 10%, the number of convicted cartels is likely to fall by 0.03% under specification I and 0.05% under specification II. Interestingly, if the maximum imprisonment increases by 10% i.e 1.2 months, convicted cartels fall by 1.3% and 1.8% when faced with a budget constraint. This consequently produces deterrence effects which reduces the incentives for cartels to form and ultimately decreases the number of cartels that the CA can convict. The findings confirm the theories in the literature put forward by Elzinga & Breit (1973), Posner (1985), Shavell (1985) and Werden, Barnett, & Hammond (2012).

Based on the above discussions, the results from both specifications confirm the theoretical findings of our previous chapter. They show that CAs have a stronger cubic age profile when they are faced with a budget constraint. CAs therefore do enjoy the benefits of detection efficiency (economies of scale) and of their deterrence policy over time. As a CA starts its operations, it becomes more efficient in detecting and convicting cartels overtime is explained by the upward trend in the number of convicted cartels until it reaches a peak where deterrence start to outweigh the detection efficiency hence causing the number of convicted cartel to fall and flatten.

5.6. Conclusion

This chapter aimed at testing the theoretical model developed in Chapter 4, to study the age profile of cartel cases convicted by a CA. We empirically assessed the success of a CA in deterrence and demonstrated that CAs have indeed been successful in producing deterrence.

The empirical results clearly show that by displaying a cubic age profile, age of cartel law does impact on the number of cartels cases convicted by a CA. The findings are in line with the theoretical model developed in chapter 4. As the competition authority starts its operations, it becomes more efficient in detection and hence deterrence. The CA consequently experiences an increase in the number of cartels detected, but at a diminishing rate until the deterring effects outweighs the detection efficiency. At this point, the CA will then experience a fall in its number of cartels convicted.

While the focus of this chapter is mainly determining the age profile of convicted cartels by a CA, the results also confirm the important role of budget in determining the level of convicted cartels of a CA. It is found that in a CA is likely to be more efficient in convicting cartels when the budget is larger.

Moreover, the actual outcome of a CA tends to be the results of previously allocated budget rather than actual budget. Further empirical findings indicates that (i) leniency policy positively impacts on the number of prohibited cartels (ii) mergers positively influence the CA's prohibited cartels (iii) countries with a common law prosecute less cartels than those with civil law, (iv) CAs having a prosecutorial tend to prohibit more cartels than those having an integrated agency and (v) fines and imprisonment do deter cartelised behaviour.

Appendices

5.A Correlation Matrix

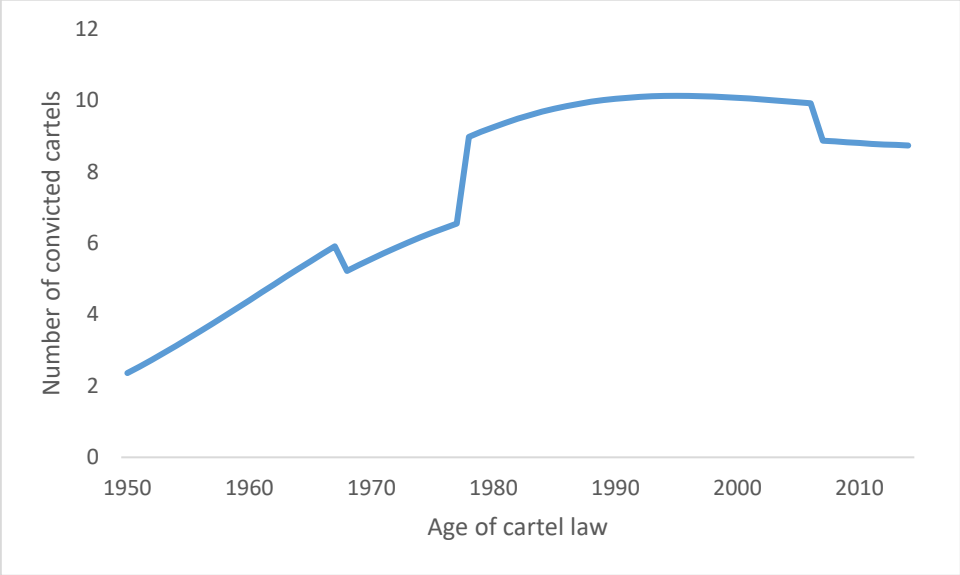
Table 5.A.1: Correlation matrix

	$\#cartel$	age	$leniency$	$\#merger$	$fines$	$prison$	$commonlaw$	$prosecutorial$	$budget$
$\#cartel$	1								
age	0.325	1							
$leniency$	0.487	0.439	1						
$\#merger$	0.395	0.360	0.556	1					
$fines$	-0.046	0.110	0.262	0.130	1				
$prison$	0.089	0.146	0.267	0.234	-0.088	1			
$commonlaw$	-0.008	0.008	0.216	0.127	-0.046	0.423	1		
$prosecutorial$	0.112	-0.127	0.239	0.091	-0.140	0.282	0.533	1	
$budget$	0.425	0.403	0.646	0.525	0.494	0.217	0.201	-0.025	1

5.B Age, period and cohorts effects

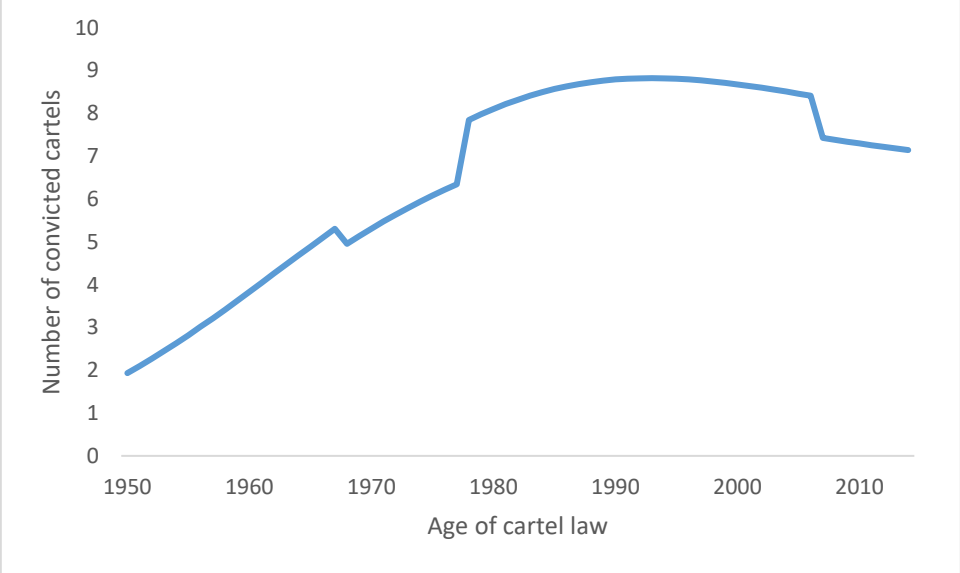
Specification I

Figure 5.B.1: Specification I-cohort profile



Specification II

Figure 5.B.2: Specification II-age profile



Chapter 6 Impact of budget allocation on the performance of competition authorities

6.1. Introduction

Just like other institutions, competition authorities (CAs) face limited resources when they perform their day-to-day activities. They are subject to constraints in terms of human capital, time management, and most importantly for this study, the level of budget they receive. Put together, these restraints can press CAs to be selective in the choice of which tasks to carry out especially when they have control on the budget allocation across the different types of anticompetitive behaviour.

In this chapter, I am interested in understanding how the level of budget, more particularly its allocation, impacts on the number of competition cases the CA investigates. Controlling for the level of budget along with the age of the competition authority (which proxies for experience), I am keen in addressing the research question: "Does the level of budget together with its allocation among alternative types of anticompetitive behaviour (such as number of in-depth merger investigations, number of cartels detected, and number of abuses discovered) trigger substitutability or complementarity"?

To answer this question I apply the panel dataset assembled for the previous chapters, which spans the period 2006-2014 (9 years) and apply a two-stage least squares estimator, so as to deal with the endogeneity of budget allocation (chosen by the CA) and the level of budget selected by the government.

The main hypothesis to be tested is whether a change in the budget allocation on one area of anticompetitive behaviour impacts on other areas of anticompetitive behaviours. For example, assuming that the level of overall budget remains unchanged, does a shift in the allocation of budget from cartels to abuses affect the number of abuse and cartel decisions taken by the CA in the same or subsequent periods, and similarly are there effects on the number of in-depth merger investigations undertaken?

In fact, whether the number of cartel and abuse decisions rises or not after the change in budget allocation depends on the combined effects of detection efficiency and deterrence. Deterrence now can take a new configuration, as it is possible that changes by the CA in its budget allocation may change the nature of anti-competitive behaviour by firms, so an increase in spending on detecting one type of behaviour may impact (in due course) on the likelihood that firms will turn to an alternative

form of anti-competitive behaviour. Thus, the analysis of deterrence is further developed beyond the narrower focus of the previous chapter.

Of course, the strength of this new source of deterrence depends to some extent, on firms' awareness of the CA budget allocation. One may question how feasible is it that a breakdown of a cartel, perhaps induced by augmented invigilation by the competition authority (triggered by additional budget or budget allocation), would revert to an abuse of dominant position or a horizontal merger or sequence of mergers? The underlying idea is that, after a cartel breaks down, firms face tougher competition. More efficient firms respond to competition positively and grow in size, becoming dominant firms in the market and then, later on, may exploit their dominant position in the market illegally. Alternatively, cartelists might react to breakdown by instigating a sequence of mergers, designed to re-establish quieter competition (perhaps tacit collusion). These are logical possibilities, and this chapter investigates whether the evidence confirms substitutabilities (or complementarities) which can be explained in these terms.

Previous research related to this topic has mostly focused on the effectiveness of competition enforcement. To the best of my knowledge, no attention has been given to the understanding of the relationship between different types of anti-competitive behaviour. The closer studies to this work are by Davies et al (2014), who empirically assess whether or not cartel breakdowns provoke a period of intensive merger activity amongst the former cartelists, and the research by Cosnita-Langlais et al (2013), who determine theoretically the connection between cartels and mergers (CA's intervention).

However, none of those works have considered the link between all the three types of anti-competitive behaviour, triggered by changes in the budget and its allocation. This research enables the understanding of the behaviour and the strategies by CAs and firms, which can contribute to the strengthening of competition law and policies. An anticipation of the main findings indicates that budget plays very important role in determining the level of CAs' activities. A causal relationship is observed between cartel and merger cases. In the presence of a budget constraint, CAs are tempted to substitute in-depth merger cases to cartel cases. Moreover, the total budget allocated to each CA seems to influence the detection of cartels cases, and not monopoly abuse cases or in-depth mergers investigations. A weak link has been found between cartels and monopoly abuses. Changes in the level of budget or budget allocation are also likely to take time and impact on the activity of the CA.

The remainder of this chapter is organised as follows. Section 6.2 reviews the existing background literature. Section 6.3 discusses the data and sample selection. Section 6.4 explains the empirical

methodology followed by section 6.5, which reports the main findings. Section 6.6 concludes and offers a discussion of the main policy implications.

6.2. Background literature

Since the last couple of decades, there has been a massive increase in the number of CAs established around the world. This is an indication that more and more countries have now realised the importance of a CA in promoting a healthy and competitive environment. A CA enforces its competition law and policy by preventing, restricting and deterring firms from being engaged in anti-competitive conduct such as cartels, anti-competitive mergers and monopoly abuses.

According to International Competition Network (ICN (2008)),
'*The success of a competition agency depends heavily upon its skill in selecting priorities and designing a strategy for applying its authority.'* It goes further, *'Without a conscious process of setting priorities and ranking possible activities according to their legal and economic significance, the competition authority is less likely to focus on what truly matters. Without a strategy, the agenda of the competition authority is prone to be governed entirely by external impulses in the form of complaints from consumers, requests for action by business operators, or queries from legislatures and other government ministries. These impulses sometimes might channel a competition agency's efforts toward matters of the greatest significance, but this is not invariably or even routinely the case'*.
CAs annually deploy a great amount of resources to carry out their main activities i.e., investigating cartels, anti-competitive mergers and abuses of monopoly power. However, no CA enjoys unlimited funds and this forces CAs to make choices and set priorities to ensure that the funding is allocated effectively. According to UNCTAD (2013), setting priorities and allocating resources should be at the forefront of any competition agency in their operation.

Cartels are viewed as the supreme evil of antitrust, overcharging consumers many billions of dollars each year, as documented in Connor & Lande (2011). They have no legitimate purposes and serve only to rob consumers of the tangible blessings of competition (Werden, Barnett, & Hammon, 2012). According to Hüschelrath & Smuda (2012), a perfectly functioning cartel is expected to lead to the same market outcome as a monopoly, causing similar allocative, productive and dynamic inefficiencies.

Mergers can harm or benefit consumers (Crandall & Winston, 2003). While mergers can create cost efficiencies (economies of scale, economies of scope) and facilitate technological progress, allowing the merged firm to produce at a cheaper price than before the merger, they can also lead to increase

market concentration, which may result in increased post-merger price, with subsequent negative effects on consumer welfare and often also on total welfare.

Monopoly power can bring advantages to the firms and the consumers, but the harm occurs when a monopoly exploits its power to raise prices and/or exclude its rivals from the market to earn higher profits at the expense of allocative efficiency. The monopolist will seek to extract a price from consumers that is above the cost of resources used in making the product. And higher prices mean that consumers' needs and wants are not being satisfied, as the product is being under-consumed.

As stated in UNCTAD (2013), '*This, for example, could be for an authority to note that, before priority setting, it observes that investigations are roughly one third merger, one third abuse and one third cartel. The authority might accept that this is a reasonable allocation. But there is still substantial room for useful priority setting related to resource allocation.*

The following citation from *UNCTAD 2013,* page 14*,* corroborates the above example:
One story might go something like this: cartel cases take more resources per case, so they will get, say 45 per cent of resources. Merger cases require speedy and instant progress, let's say by law, while abuse cases can have variable speeds, so we will combine staff for both types of cases (like the reorganization of Directorate General of Competition of the EU, DG COMP, in 2003). At the same time advocacy is an important activity with rewards that can substantially outweigh costs. So we will maintain resources for advocacy that would lie within the realms allowed by parliament. This might yield 10 per cent for advocacy and, by elimination, 45 per cent for the joint merger/abuse area.'

These views clearly show that important questions arise if the CA is to allocate its resources effectively. Allocation varies over time and reflects particular needs that vary over time. Yet, up to date very few studies have actually looked into the role of budget and its allocation in determining the level of activities of a CA. CAs normally devotes a great amount budget on cartel cases given they have most harmful effects on consumers. Cosnita-Langlais & Tropeano (2013) find that if coordinated effects are taken into account in mergers, then for a sufficiently large effect the agency may optimally have to refrain from controlling mergers, and instead spend all resources on fighting cartels. Moreover, according to Kumar et al (2015), CAs should consider mergers as potential 'second-best' alternative to cartels, which implies that resource (re)allocation in competition authorities, law practices and economic consultancies may become necessary to handle the increase in merger cases. On the other hand, the nature of monopoly cases makes it impossible for a CA to analyse them in mass. If they had to, CAs would require a great amount of resources. For example, the US investigated less than 20 abuse

monopoly cases a year compared to above 45 cartels decisions that were issued in 2013 and 2014. UK investigated only 3 abuse cases compared to 7 cartel cases in 2013.

Just like CAs need to make a choice and decide how to allocate their budget across their various policing activities, firms also have a choice to make about their business strategy, so as to maximise profit. Whichever, the anti-competitive behaviour that firms choose to adopt, it depends on the effectiveness of the CA in enforcing its competition law and policy, detecting and deterring such behaviours. Mehra (2007) theoretically models the decision of a firm to either join a cartel or a merger by incorporating the effect of market structure, industry characteristics and considering their impact on the profit accruing from merger and cartel. She finds that in the absence of cartel fines, a firm always prefers a cartel to merger, when the latter does not involve any efficiency gains. Moreover, Cosnita-Langlais & Tropeano (2013) find that a tougher anti-cartel action triggers more mergers, and vice versa. The costs involved in mergers (large capital requirements) also make firms to prefer to be cartelised than to consider merging (Stigler, 1950). Cartels are cheaper, as coordination is only needed in times of low demand (Bittlingmayer, 1985). Kumar et al. (2015) suggest that a key benefit of cartel formation versus merger is that a cartel can take advantage of customer beliefs that the policing action of competition is in place.

Furthermore, studies investigating the impact of cartels breakdown on mergers find evidence that after the breakdown of cartels, the level of merger activities in the respective industries increases ((Davies et al, 2014), Kumar et al (2012[71], 2015[72]) and Hüschelrath & Smuda (2012)). Findings about the relationship that they share are rather mixed. Using a sample of 84 EC cartels, Davies et al. (2014) find that mergers are indeed more frequent post-cartel breakdown, especially in markets that are less concentrated. Coordinated effects may not only motivate this, but also be a consequence of market restructuring. The same authors also find that in markets where mergers do no occur, the post-cartel structure is consistent with potential dominance. Cosnita-Langlais & Tropeano (2013) argues that the two branches of anti-competition behaviours are complement, and Bittlingmayer (1985) and Mehra

[71] Kumar et al. (2012) find evidence of post-cartel merger activity in eight out of ten largest US manufacturing industries around the time of the adoption of the Sherman Act in 1890.

[72] Kumar et al. (2015) show that 45% of cartels detected by the EC between 2001-2010, were followed by mergers in following years, and that this high percentage was twice as likely in markets where buyers were fragmented. They find that, first, the average number of all merger transactions increase by up to 51 percent when comparing the three years before the cartel breakdowns with the three years afterwards. Second, for the subset of horizontal mergers, merger activity is found to increase even more – by up to 83 percent – after the cartel breakdowns.

(2007)[73] show evidence of cartels and mergers used as alternative arrangements to increase profitability.

To sum up, much of the existing literature has focused on the connection between cartels and mergers, but limited or no attention has been given to the understanding of the relationship between budget and its allocation decision and all the three types of anti-competitive behaviour. By identifying this gap, in this chapter, I therefore attempt to assess the substitutability and/or complementarity between the three branches of anti-competitive behaviour via the budget allocation decision and budget.

6.3. Intuitive theoretical framework

In this section, the intuition of the theoretical mechanism that justifies the empirical methodology that is planned to be used are provided. The idea is similar to that developed in chapter 4, but here is extended to allow for alternative sources of illegal behaviour and a thorough role of budget. This extension brings in additional complexities, as discussed below.

Following the logic of chapter 2, an economy composed of a collection of markets M is considered. In each market there are N_m firms that either compete with each other or avoid competition via some sort of anticompetitive behavior. Three alternative sources of illegal anticompetitive conduct are examined: cartel, abuse of dominant position in the market, and merger.

Firms are rational agents and maximize their expected profits given the uncertainty of being caught in an illegal conduct. It is assumed that firms know the probability distribution of being discovered in each of the illegal anticompetitive demeanours and choose the illegal conduct that generates the highest expected profit to the firm in that industry. The profitability of illegal activities varies by market and market structure, and so does the probability of detection by the CA. A shift rightwards in the probability distribution of one of the anticompetitive behaviours may be sufficiently large to deter that conduct in certain markets. Once an illegal activity becomes less profitable it may no longer be preferred to an alternative demeanour, which non-necessarily is the legal competitive behaviour.

Thus, the underlying framework seems prone to justify a certain degree of substitutability between anticompetitive behaviours. Incidentally, I am interested in testing empirically whether or not the intensification of detection by the competition authority in one of the anticompetitive branches

[73] She argues that the choice between the two forms is determined by factors such as the structure of industry, organization of firms, and, last but not least, existing antitrust laws.

relative to other illegal anticompetitive activities produces a direct effect in the detection of that illegal behaviour, and possibly indirect effect on other anticompetitive conducts.

Of course, it is legitimate to wonder how realistic the assumption of substitutability between anticompetitive behaviours is. For example, how is it possible that a breakdown of a cartel induced by augmented invigilation by the competition authority, may revert to an abusive of dominant position? One way to explain this shift is to think this reversion as a response to an intensification of competition. After a cartel breakdown, firms face tougher competition and it may well happen that more efficient firms respond to competition positively and grow in size, becoming dominant firms in the market and subsequently exploit their dominant position in the market illegally. Of course, a more immediate reversion mechanism is a cartel breakdown followed by mergers, proposed as tool to reduce the number of players in the market and gain market efficiency/power. There are plenty of other channels that can explain how substitution between illegal conducts occurs. In this chapter I remain agnostic on how the substitution process takes place, and simply study its implications to substitutability empirically. I study the role of budget allocation and furthermore how a change in the budget allocation may trigger substitutability between "competing" anticompetitive behaviours.

The level of budget is decided by the government, partly based on the performance of the competition authority and partly relying on political reasons. The competition authority chooses the budget allocation, i.e. how the budget is allocated across the different activities undertaken by the competition authority. Both a possible change in the level of budget and of its allocation is examined. The effect of the latter is of particular interest because is under the control of the competition authorities, whereas the level of budget is often under the jurisdiction of the government.

The competition authority has objective of maximising consumer welfare and to that aim sets the fines and chooses the effort upon which to conduct an investigation in each of the anticompetitive areas. Experience is taken as given and the success of a conviction for illegal conduct is beyond the control of the competition authority, as it depends on the decision of the Court and the evidence provided by the parties involved. One important variable at discretion of the competition authority is the share of budget (the share only because the total amount is chosen by the government) to allocate to punish the various types of illegal activities. Hence, indirectly the competition authority has control on which illegal activity prioritize via the budget allocation. If the competition authority were to select not to allocate money to investigate abuses, then all abuses would be undetected, but more money would be left to detect the other two types of illegal activities. A certain number of cartels would be punished,

and a number of anticompetitive mergers would be blocked.[74] Abuses would become a cheaper option of misconduct and I could expect their number to rise in the future, but yet remain undetected until the CA does not allocate budget to detect abuses.

In the econometric section, the number of convictions by activity the CA has produced in a period is estimated. Among the explanatory variables, the contemporaneous and past level of budget (in logs), as well as the contemporaneous and past share of budget allocated to mergers, abuses and cartels will be included. The aim is to understand how the budget (decided by the government) and its allocation decided by the CA will impact on the substitutability across different conducts, following the mechanism described in this section.

The ultimate goal of including budget and its allocation in the number of convictions for cartel, abuse, and in depth merger is to test the following conjectures empirically.

Conjecture 1: Changes in the level of budget or in the budget allocation have a contemporaneous impact (or almost contemporaneous impact) on in depth mergers, whereas they take some time to impact cartels and abuses.

There are two reasons for a delayed impact on abuses and cartels. A first reason is that it takes some time to punish a cartel or an abuse of dominant position because of the lengthy process to assemble the evidence and wait for a Court decision. The second explanation is that shifting towards one of these two illegal conducts may not happen overnight. On the other side in depth merger decisions are taken within a year or so and also one can expect the movement towards these activities (not per se illegal) will be faster. In the empirical part, this conjecture is tested by adding lags in the budget allocation and level in each on the anticompetitive behaviour allocations.

Conjecture 2: An increase in the level of budget does not spread its effect equally among the anticompetitive conducts.

This conjecture is silent about the budget allocation - held constant - and hence is all about the level of budget. The reason behind the lack of symmetry is that the different activities undertaken by the CA are, prior to the increase of budget, subject to different intensities of budget constraint. In some activities the budget may be very tight, in others it may be loose. Furthermore, certain activities are harder to be discovered even with additional budget, thus creating further asymmetries. In the

[74] Of course there is a certain lag between the change in budget allocation and the effect of the change in budget on the number of cartel punished, as cartel-related investigations are well known to last few years.

empirical results whether the level of budget and its lags (and similarly for the budget allocation) have different effects in the anticompetitive activities will be checked.

Conjecture 3: Substitutability of cartels to merger and monopoly abuses to mergers occur more often than the vice versa.

When a merger is notified, a CA is obliged to look into the merger (Phase I) to identify if there are any anti-competitive issues, normally in a limited time frame. The number of mergers that is notified is therefore not within the control of the CA and is therefore exogenous. The CA will then decide to whether to proceed to Phase II investigation or clear the merger based on the findings of Phase I. CAs very often make such decisions based on the available resources. Moreover, given the limited time frame to come up with a decision in a merger investigation, a CA may decide to substitute cartels and abuse cases to mergers cases in the short run. This conjecture will empirically be investigated by comparing the coefficients of the budget allocation (and its lags) to in depth merger investigation in either the cartel or abuse equation with those of the budget allocation to cartels and monopoly abuses in the merger equation.

Moreover, from the firm's perspective, based on the literature put forward in the literature review section, it can be expected that with an increase in the detection efficiency of the CA, firms are likely to formalise their agreements into mergers to avoid being caught. While there is limited literature on the relationship that may exist between monopoly abuse cases and other anti-competitive conducts, I remain agnostic about this relationship.

Conjecture 4: Substitutability or complementarity of cartels to monopoly abuse cases and monopoly abuse to cartel cases may occur following a change in the budget allocation decisions.

Given a budget constraint, if a CA decides to increase the budget allocated to cartels, holding constant the proportion of budget allocated to mergers and the residual category, it will imply a corresponding drop in the budget allocated to monopoly abuse cases. If this does not produce deterrence, the change in budget can be expected to positively affect the number of cartels detected and negatively the number of monopoly abuses discovered. Thus, the CA may then be detecting cartels at the expense of monopoly abuse cases. The same effect may apply to any other couple of budget displacement.

On the other hand, an increase in the proportion of budget allocated to cartels, may increase its ability to detect more cartels and lead to deterrence of cartelists. This deterrence effect may also spread to

the monopolists abusing their power hence causing the number of monopoly abuse detected to fall over time.

6.4. Data and econometrics

In this section, I first describe the dataset used in this chapter and then define the econometric model and the estimation methodology. The same sample of panel data of 34 competition authorities from 34 countries[75] over the period 2006 – 2014 described in chapter 2, complemented with the variables listed in the Table 5.1 is used. The definition of the relevant variables and data sources are documented in Table 6.1.[76]

Table 6.1: Definition of variables and data sources (yearly data)

Variables	Definition	Source
$\#cartel$	Number of cartel decisions: It is used as a measure of the number of cartel prosecuted by the CA.	GCR
$\#abuse$	Number of abuse cases closed: It is used as a measure of the number of monopoly abuse cases investigated by the CA.	GCR
$\#indepth$	Number of mergers that went for phase II investigation.	GCR
$budget$	Funding available for the CA to perform its day to day activities. It is expressed in millions of euros.	GCR
age	Number of years since a competition authority has been established and started to operate.	Annual reports and CA's website
$\#merger$	Number of mergers notified to the CA	GCR
$fines$	Total cartel fines (million Euros).	GCR
$prison$	Maximum number of years of imprisonment for individuals found guilty of engaging in cartel conduct could face.	GCR
$propbudcartel$	The % of staff devoted to cartel cases is used as a proxy for % of budget allocated to cartel cases.	GCR

[75] The countries are Australia, Austria, Belgium, Brazil, Canada, Chile, Czech, Denmark, EU, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Lithuania, Mexico, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, South Africa, Slovakia, Spain, Sweden, Switzerland, UK and US.

[76] A small amount of interpolation was required for missing years of some independent variables. Also, GCR did not report information for Slovenia for 2012.

$\boldsymbol{propbudabuse}$	The % of staff devoted to abuse cases is used as proxy for % of budget allocated to abuse cases.	GCR
$\boldsymbol{propbudindepth}$	The % of staff devoted to merger cases is used as proxy for % of budget allocated to merger cases.	GCR

6.4.1. Descriptive statistics

Table 6.2 provides pooled summary statistics for all the chosen variables. There is a considerable variation in the panel. For examples, the number of cartel decisions in the year ranges from 0 to 90, with an average of about 11 cartels, the number of monopoly abuse closed ranges between 0 and 206, with an average of 24 abuse cases, the number of in-depth mergers ranging between 0 and 311, with an average of 20 in-depth mergers or number of notified merger ranging between 1 and 2231. Of course most of the variation in the competition cases is explained by differences in size and development across countries, along with a heterogeneous level of experience gained by the competition authorities. In the empirical analysis, natural logs are used to moderate the impact of extreme heterogeneity in sizes[77].

To disaggregate the total budget into expenditures on each category of anticompetitive behaviour we employ proportions of staff to proxy for the allocation of budget. For countries which did not report their staff allocation, average proportion of staffs allocated to the various categories (for countries where data was reported) was used to spread the budget across the various categories. From the Table 6.2, it is found that on average 27%, 22% and 20% of the budget is allocated to cartels, monopoly abuse and in-depth merger cases respectively. One minus the sum of the three proportions of budget allocation documented below is the proportion of budget assigned to other categories.

Table 6.2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$\#cartel$	300	10.777	14.166	0	90
$\#abuse$	300	23.773	32.480	0	206
$\#indepth$	301	19.913	42.943	0	311
$\#merger$	301	269.973	377.126	1	2231
$budget$	294	22.582	27.572	0.25	139.4
$propbudcartel$	294	0.266	0.733	0	0.67
$propbudabuse$	294	0.219	0.068	0	0.49
$propbudindepth$	294	0.203	0.117	0	1

[77] To avoid losing observations when any of $\#cartel$, $\#abuse$ and $\#indepth$ are zero, for which the logarithm is minus infinity, one is substituted.

US took the highest cartel decisions, 90 in 2011 while Germany had the highest number of merger notified in 2007. EU in 2010 imposed the highest fine. The US DOJ was allocated with the highest amount of budget at EUR 139.4 in 2014 while Belgium was allocated with the minimum budget EUR 0.25 million in 2006. US DOJ spent the highest amount of its budget on cartel and the US FTC spent the highest amount of its budget on abuse and merger cases. Of course country size matters in these figures.

6.4.1.1. Cross section and time series variations

The relationships between the (period averages) of cartels, abuse and mergers cases 2006-2014 are shown in Figures 6.1, 6.2 and 6.3.

It can be observed that on average Poland investigated the highest number of mergers[78], while US made the highest number of cartel decisions. In terms of abuse cases, Poland, Finland, South Africa and EU are well above the line of best fit. In terms of the relationship between in-depth merger and monopoly abuse cases, it is found that the model explains 26% of the variations in in-depth mergers and monopoly abuse cases. Moreover, referring to figure 6.2, the line of best fits reveals that the model explains 5% of the variations between cartel and in-depth merger cases. As for the relationship between cartels and monopoly abuse cases, the data explains 0.002% of the variations of the model (Figure 6.3). The low R^2 may indicate that it can be pretty hard to predict the behaviour in terms of activities of CAs. Moreover, a low R^2 may not necessarily be inherently bad if the coefficients are statistically significant and important conclusions can be drawn. See Appendices Table 6.A for acronyms of countries.

[78] Poland investigates all the notified merger.

Figure 6.1: Relationship between abuse cases and in-depth merger cases

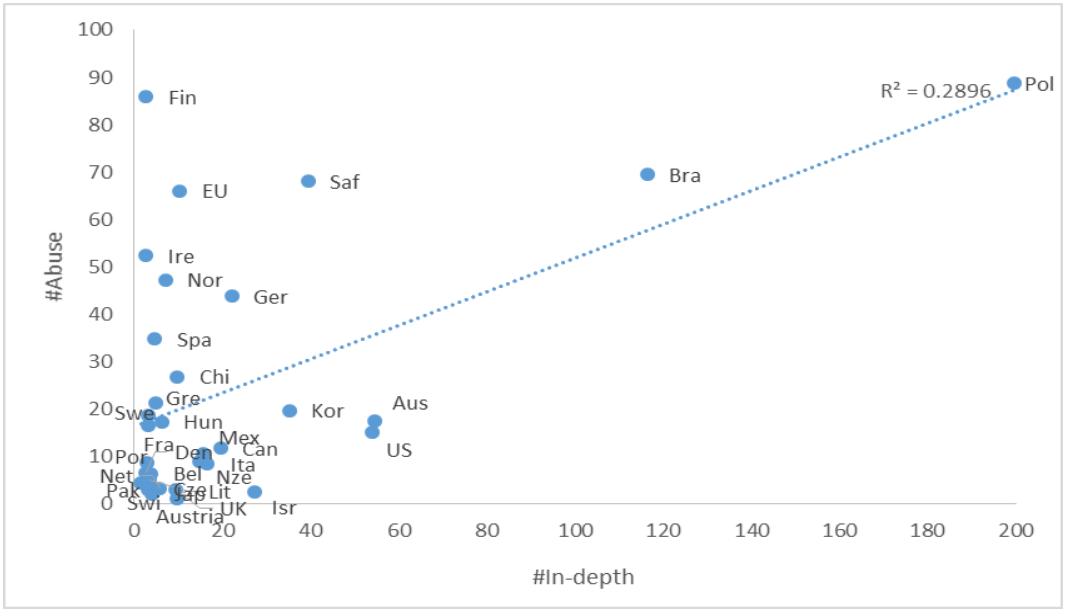


Figure 6.2: Relationship between cartel cases and in-depth merger cases

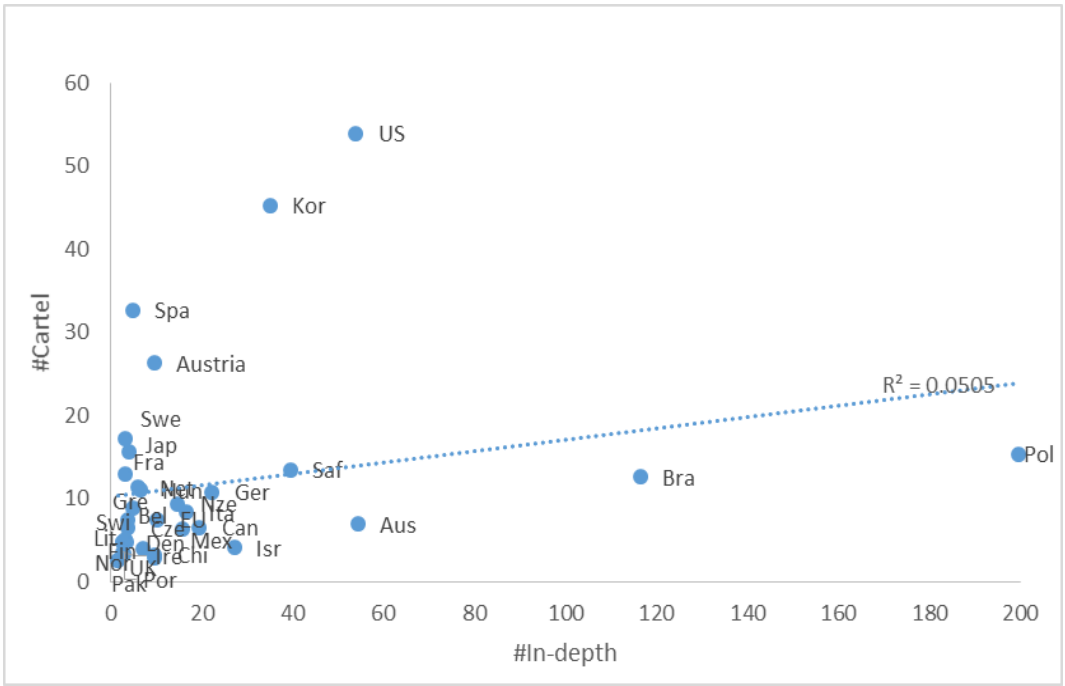
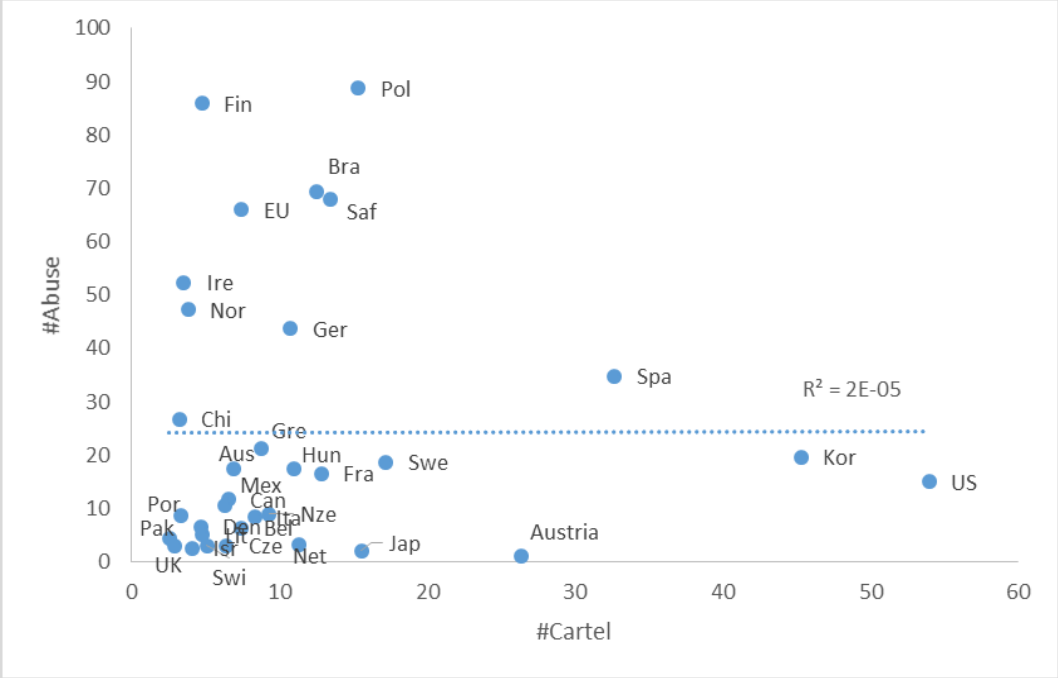


Figure 6.3: Relationship between monopoly abuse and cartel cases



The strength and direction of a relationship between the different variables are also shown in the correlation matrix below, Table 6.3. It is observed there seems to be almost no correlation between (i) cartel and abuse and in-depth merger cases, (ii) in-depth merger cases and budget and the proportion of budget allocated to monopoly abuse case and (iii) budget and the proportion of budget allocated to cartel cases. Interestingly, some correlation is found among the variables (i) cartel cases and budget and (ii) monopoly abuse and in-depth merger cases. A weak positive relationship is found to exist between monopoly abuse cases and the proportion of budget allocated to cartel. Moreover, mergers and the proportion of budget allocated to cartels are found to be negatively weakly linearly related.

Table 6.3: Correlation Matrix

	$cartel$	$abuse$	$indepth$	$budget$	$propbud\ cartel$	$propbud\ abuse$	$propbud\ merger$
$cartel$	1						
$abuse$	0.009	1					
$indepth$	0.094	0.426	1				
$budget$	0.425	-0.074	0.013	1			
$propbudcartel$	-0.116	-0.161	-0.132	-0.039	1		
$propbudabuse$	0.203	0.037	-0.077	-0.167	0.346	1	
$propbudindepth$	-0.024	0.117	0.142	-0.067	-0.400	-0429	1

6.5. Empirical strategy

I perform a regression analysis to explain how size and allocation of budget by a CA can impact on cartels, abuse monopolies and merger cases. The economic specification is made up of 3 equations: cartel, abuse and merger equations. The explanatory variables of interest in the three equations are $lnbudget$, $propbudcartel$, $propbudabuse$, and $propbudindepth$. These variables enable the understanding of the relationship that may prevail between the budget allocated to a CA, the budget allotment decision and the three types of anti-competitive conducts. The estimation will not only enable to study the impact of budget allocation on the number of investigated cases for the same conduct, but also help in examining the inter-relationship that may exist between resources spent on a particular conduct and the detection of other types of conducts (Conjectures 3 and 4). The variables of interest will enable us to test how an increase in budget is likely to spread its effect across the different anti-competitive conducts (Conjecture 2).

In order to study the contemporaneous impact of budget and its allocation by a CA and address Conjecture 1, a regression model with lagged explanatory variables is used. More specifically, I employ a linear distributed lag model of order 3. I have selected 3 lags because this particular length of lags produces better estimates than two or four lags. More than four lags would have not been reasonable with only nine periods and, similarly one lag would have been too short to capture any medium/long-run time effect. The distributed lag model is used to capture changes in $lnbudget$, $propbudcartel$, $propbudabuse$, and $propbudindepth$ beyond the time in which they occurred, for each of the detected cases of a CA. Current and past values of $lnbudget$, $propbudcartel$, $propbudabuse$ and $propbudindepth$ represent one of the phenomena causing changes in the $lncartel$, $lnabuse$ and $lnmerger$, and their lagged coefficients measure the impact of past values on the dependent variables. For example, if CAs decide to increase the proportion of budget allocated to cartels, the effects that it will have on the detection and deterrence of cartels and other conducts will not occur instantaneously, but will be spread over future time periods.

The cartel equation is constructed based on Equation 5.2 of Chapter 5. It explores the relationship between the number of cartels detected and budget allocated to the CA and its budget allocation decision in the current year as well as the previous three years as well as a vector of control variables namely the level of punishment imposed in terms of imprisonment and fines, the years the CA has had a leniency policy, the age of the CA and the number of mergers notified to the CA.

The monopoly abuse equation is analogous and captures the effects of budget and its allocation decision in the current and previous three periods along with control variables, age of the CA and number of merger filed on the number of monopoly abuse cases investigated.

Finally, the merger equation studies the relationship between the number of in-depth merger investigated and budget allocated to the CA and its allocation decision in the current and previous three periods and the control variable, age of the CA and number of merger filed. It should be stressed that merger filed is treated as an exogenous variable – while in-depth mergers reflects the CA's decisions, the number of mergers filed in the economy is outside the CA's control.

Including a time trend to the three equations to capture the time effects, the full econometric model is given by as follows:

$$lncartel_{it} = \beta_0 + \beta_1 age_{it} + \beta_2 leniency_{it} + \beta_3 lnmergerfiled_{it} + \beta_4 fines_{it} + \beta_5 prison_{it} + \beta_6 lnbudget_{it} + \beta_7 lnbudget_{it-1} + \beta_8 lnbudget_{it-2} + \beta_9 lnbudget_{it-3} + \beta_{10} propbudcartel_{it} + \beta_{11} propbudcartel_{it-1} + \beta_{12} propbudcartel_{it-2} + \beta_{13} propbudcartel_{it-3} + \beta_{14} propbudabuse_{it} + \beta_{15} propbudabuse_{it-1} + \beta_{15} propbudabuse_{it-2} + \beta_{15} propbudabuse_{it-3} + \beta_{16} propbudindepth_{it} + \beta_{17} propbudindepth_{it-1} + \beta_{18} propbudindepth_{it-2} + \beta_{19} propbudindepth_{it-3} + v_{1i} + \varepsilon_{1it}$$

Equation 6.1

$$lnabuse_{it} = \theta_0 + \theta_1 age_{it} + \theta_2 lnmergerfiled_{it} + \theta_3 lnbudget_{it} + \theta_4 lnbudget_{it-1} + \theta_5 lnbudget_{it-2} + \theta_6 lnbudget_{it-3} + \theta_7 propbudcartel_{it} + \theta_8 propbudcartel_{it-1} + \theta_9 propbudcartel_{it-2} + \theta_{10} propbudcartel_{it-3} + \theta_{11} propbudabuse_{it} + \theta_{12} propbudabuse_{it-1} + \theta_{13} propbudabuse_{it-2} + \theta_{14} propbudabuse_{it-3} + \theta_{15} propbudindepth_{it} + \theta_{16} propbudindepth_{it-1} + \theta_{17} propbudindepth_{it-2} + \theta_{18} propbudindepth_{it-3} + v_{2i} + \varepsilon_{2it}$$

Equation 6.2

$$lnindepth_{it} = \alpha_0 + \alpha_1 age_{it} + \alpha_2 lnmergerfiled_{it} + \alpha_3 lnbudget_{it} + \alpha_4 lnbudget_{it-1} + \alpha_5 lnbudget_{it-2} + \alpha_6 lnbudget_{it-3} + \alpha_7 propbudcartel_{it} + \alpha_8 propbudcartel_{it-1} + \alpha_9 propbudcartel_{it-2} + \alpha_{10} propbudcartel_{it-3} + \alpha_{11} propbudabuse_{it} + \alpha_{12} propbudabuse_{it-1} + \alpha_{13} propbudabuse_{it-2} + \alpha_{14} propbudabuse_{it-3} + \alpha_{15} propbudindepth_{it} + \alpha_{16} propbudindepth_{it-1} + \alpha_{17} propbudindepth_{it-2} + \alpha_{18} propbudindepth_{it-3} + v_{3i} + \varepsilon_{3it}$$

Equation 6.3

$lncartel$ is natural log of the number of cartel decisions, $lnabuse$ the natural log of number of abuse cases closed, and $lnindepth$ is the natural log of number of mergers investigated. All control variables have been defined in Table 6.1. v_i is the unobserved country-specific effect and ε_{it} is the idiosyncratic error term in each equation.

6.5.1. Endogeneity of budget and budget allocation

Budget and the proportion of budget to be allocated to the different activities by the CA are endogenous variables. Budget is a variable under discretion of the government. Endogeneity arises because I can expect budget to be linked to competition authority's performance. Endogeneity of the budget allocations is more obvious as it is under the direct control of the competition authority and it may depend on targets the authority wishes to meet. To deal with the endogeneity, instrumental variables regression analysis are presented, where budget and the proportion of budget allocated to the different competition cases are instrumented. Instruments used are argued to affect the budget and allocation of budget of a CA, but have no effect on each of the dependent variables, except through their influence on budget and proportion of budget allocated to the different activities anticompetitive activities.

The instruments are constructed from the proportion of budget allocated to the cartel, monopoly abuse and merger cases investigated. To construct the instruments, authorities are first grouped in four groups, depending on the period of establishment of CAs, so to have very old CAs, old CAs, young CAs and very young CAs.[79] Hence, I have Category 1- Before 1957 (before the EC treaty), Category 2- Between 1958 to 1986 (after the treaty and before the EU single Act), Category 3- Between 1987 to 1996 (between the introduction of the EU single Act and the launching of WTO competition project) and Category 4- After 1997 (after the launching of the WTO competition project).

From now on, to enable better understanding of the instrument, I choose to focus our explanation on one activity where budget is allocated, that is, cartel cases. The same concept would apply to the other instruments of $propbudabuse$, and $propbudindepth$.

The average proportion of budget allocated to cartels by other CAs in the same group are employed as instrument for the proportion of budget allocated to cartels. Some sort of co-movement are expected within groups for the budget allocation. The assumption here is that there is some within group common behaviour in the budget allocation, but not on the performance of the CAs, as this

[79] CAs have been grouped based key dates of main changes in the global laws and regulations with CA's sharing the common likelihood of experiencing the changes.

depends on factors that go beyond the grouping, the individual ability of the CA and the country particular industrial structures. In the empirical part the strength and validity of the instruments are tested and country-level unobserved heterogeneity is accounted for.

After constructing the instruments outlined above and further instruments for the level of budget, along the lines of those discussed in previous chapters in this dissertation, I conduct an instrumental variable regression (two-stage least squares estimation, 2SLS), where the first stage asks for the factors affect the CA's budget and allocation of budget and the second stage asks which factors that affect the number of cartel, monopoly abuse cases detected and merger investigated, controlling for the endogeneity of budget and budget allocation in determining the number of competition cases.

The first stage least square results are shown in Table 6.4.

Table 6.4: First stage of 2SLS

	Cartel equation				Abuse equation				Merger equation			
Dependent variables	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$probud\ indepth$	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$propbud\ indepth$	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$propbud\ indepth$
$lngdp$	0.021	0.024***	0.005	0.017*	0.046	0.020***	0.001	0.015	0.043	0.021***	0.002	0.015
	(0.035)	(0.007)	(0.008)	(0.009)	(0.035)	(0.007)	(0.007)	(0.009)	(0.036)	(0.007)	(0.007)	(0.009)
$lnpop$	0.003	-0.025***	-0.008	0.001	0.002	-0.024***	-0.008	-0.003	0.005	-0.025***	-0.008	-0.003
	(0.031)	(0.006)	(0.006)	(0.010)	(0.032)	(0.006)	(0.006)	(0.008)	(0.030)	(0.006)	(0.006)	(0.008)
$lnbudget_{t-1}$	0.747***	-0.016	-0.012	0.027**	0.717***	-0.012	-0.008	0.024*	0.721***	-0.013	-0.008	0.025*
	(0.089)	(0.013)	(0.011)	(0.013)	(0.084)	(0.013)	(0.011)	(0.013)	(0.085)	(0.013)	(0.011)	(0.013)
$lnbudget_{t-2}$	0.073	0.010	0.003	-0.028	0.090	0.008	0.003	-0.023	0.087	0.008	0.003	-0.023
	(0.115)	(0.010	(0.012)	(0.019)	(0.112)	(0.010)	(0.012)	(0.021)	(0.112)	(0.010)	(0.012)	(0.021)
$lnbudget_{t-3}$	0.039	0.007	0.004	-0.013	0.066	0.004	0.000	-0.014	0.066	0.004	0.000	-0.014
	(0.057)	(0.006)	(0.008)	(0.021)	(0.055)	(0.006)	(0.007)	(0.021)	(0.055)	(0.006)	(0.007)	(0.021)
$propbud\ cartel_{t-1}$	0.811	0.701***	-0.029	-0.173	0.700	0.727***	-0.014	-0.194*	0.727	0.725***	-0.015	-0.193*
	(0.690)	(0.177)	(0.125)	(0.118)	(0.700)	(0.174)	(0.123)	(0.110)	(0.694)	(0.174)	(0.121)	(0.108)
$propbud\ cartel_{t-2}$	-1.268***	-0.121	-0.028	0.071	-1.350***	-0.121	-0.029	0.094	-1.367***	-0.119	-0.028	0.093
	(0.413)	(0.128)	(0.113)	(0.096)	(0.417)	(0.119)	(0.119)	(0.088)	(0.396)	(0.120)	(0.119)	(0.087)
$propbud\ cartel_{t-3}$	-0.291	-0.067	-0.017	-0.232*	-0.426	-0.027	0.030	-0.216*	-0.428	-0.027	0.030	-0.217*
	(0.469)	(0.089)	(0.083)	(0.122)	(0.526)	(0.086)	(0.077)	(0.121)	(0.525)	(0.086)	(0.077)	(0.121)
$propbud\ abuse_{t-1}$	-0.219	-0.102	0.649***	-0.235*	0.015	-0.105	0.621***	-0.215	0.038	-0.106	0.620***	-0.214
	(0.487)	(0.133)	(0.145)	(0.138)	(0.514)	(0.138)	(0.140)	(0.133)	(0.507)	(0.136)	(0.139)	(0.132)
$propbud\ abuse_{t-2}$	-0.897	-0.022	-0.253	0.173	-1.326*	-0.011	-0.245	0.099	-1.164*	-0.024	-0.253	0.109
	(0.737)	(0.145)	(0.210)	(0.148)	(0.691)	(0.145)	(0.216)	(0.128)	(0.666)	(0.141)	(0.212)	(0.121)
$propbud\ abuse_{t-3}$	-0.256	0.064	0.032	0.061	-0.117	0.021	-0.016	0.046	-0.144	0.023	-0.015	0.045
	(0.449)	(0.079)	(0.083)	(0.128)	(0.451)	(0.067)	(0.084)	(0.124)	(0.449)	(0.067)	(0.083)	(0.124)
$propbud\ indepth_{t-1}$	0.325	0.011	-0.043	0.641***	0.414	0.010	-0.049	0.644***	0.433	0.009	-0.050	0.645***
	(0.272)	(0.059)	(0.069)	(0.067)	(0.281)	(0.060)	(0.073)	(0.073)	(0.279)	(0.059)	(0.071)	(0.072)
$propbud\ indepth_{t-2}$	-1.400***	-0.038	-0.056	0.055	-1.506***	-0.040	-0.063	0.029	-1.478***	-0.042	-0.064	0.031
	(0.258)	(0.043)	(0.056)	(0.041)	(0.243)	(0.044)	(0.058)	(0.042)	(0.250)	(0.041)	(0.058)	(0.041)
$propbud\ indepth_{t-3}$	0.213	-0.055**	-0.034	0.072	0.199	-0.052*	-0.031	0.070	0.192	-0.051*	-0.030	0.070
	(0.182)	(0.026)	(0.024)	(0.053)	(0.174)	(0.028)	(0.023)	(0.052)	(0.176)	(0.027)	(0.023)	(0.052)

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Table 6.4: First stage of 2SLS (continued)

	Cartel equation				Abuse equation				Merger equation			
Dependent variables	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$probud\ indepth$	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$propbud\ indepth$	$lnbudget$	$propbud\ cartel$	$propbud\ abuse$	$propbud\ indepth$
age	0.010***	0.001	0.002***	-0.001	0.009***	0.001	0.002***	-0.001	0.008**	0.001	0.002***	-0.001
	(0.004)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
age^2	-0.1× 10^{-3}***	0.000	-0.2×10^{-4}***	0.000	-0.0001**	0.000	-0.2×10^{-4}***	0.000	-0.1×10^{-3}*	0.000	-0.1×10^{-4}***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$ln\#merger$	-0.005	-0.004	0.001	0.004	-0.004	-0.004	0.002	0.005	-0.005	-0.004	0.002	0.005
	(0.027)	(0.003)	(0.003)	(0.003)	(0.027)	(0.003)	(0.003)	(0.003)	(0.028)	(0.003)	(0.003)	(0.003)
$lnfine$	0.030	-0.003	-0.005	-0.006*								
	(0.024)	(0.006)	(0.004)	(0.004)								
$dfinemis$	0.196*	-0.051***	-0.044**	0.013								
	(0.109)	(0.012)	(0.019)	(0.016)								
$prison$	0.010	0.000	0.000	0.001								
	(0.007)	(0.001)	(0.001)	(0.001)								
_cons	2.100*	0.070	0.062	-0.112	1.722	0.091	0.082	-0.074	1.894	0.078	0.074	-0.064
	(1.197)	(0.205)	(0.203)	(0.157)	(1.136)	(0.204)	(0.199)	(0.182)	(1.160)	(0.207)	(0.189)	(0.178)
Observation	178	178	178	178	185	185	185	185	186	186	186	186
Number of clusters	34	34	34	34	34	34	34	34	34	34	34	34
F test of excluded instruments												
F (14, 33)	5.05	8.22	14.33	78.63	2.87	7.63	37.93	33.12	3.67	7.8	36.32	33.6
Prob > F	0.0001	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Sanderson-Windmeijer multivariate F test of excluded instruments:												
F (11, 33)	2.13	3.51	3.5	33.99	1.64	4.29	2.46	18.65	1.82	4.18	2.6	19.99
Prob > F	0.046	0.003	0.003	0.000	0.133	0.001	0.022	0.000	0.091	0.001	0.017	0.000

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

6.6. Empirical results

The regressions estimated based on the two-stage least squares are reported in Table 6.4. Only the results of the key variables are presented. At the bottom of the table, the results of various tests of hypotheses related to strength and validity of the selected instruments are displayed. The list of the chosen instruments is given in a note to the table. The F-tests, as well as the under identification and the weak identification (also based on an F-statistic) tests get the unambiguous message across that instruments are strong (except for the equation $ln\#abuse$). Also, instruments are valid, as confirmed by the J over identification test for all the three equations.

The full set of results is shown in the Appendices (Table 6.B.1). The regressions are also estimated using the Ordinary least squares (OLS) (See Appendices, Table 6.B.2), the seemingly unrelated regression estimator (SURE) (See Appendices, Table 6.B.3) and ultimately our preferred regression: the 2SLS regression. In that table, we also compare the 2SLS estimates with those based on a biased Ordinary least squares (OLS) estimator and the seemingly unrelated regression estimator (SURE), to choose for the most robust results.

Comparing the results, $lnbudget$ is found to be significant in determining the number of in-depth mergers and cartel cases using the OLS estimations and only in-depth mergers under the SURE estimations with the IV. $lnbudget$, $lnbudget_{t-1}$ and $lnbudget_{t-3}$ are significant in determining only the number of cartels cases in the 2SLS but not in the OLS estimation. The SURE estimations however reveal that while $lnbudget_{t-1}$ positively impacts on cartels cases, $lnbudget_{t-2}$ negatively determines the number of monopoly abuse cases. Moreover, the proportion of budget allocated in the previous period is found to be significant in determining the level of cartel cases under the OLS and SURE estimations but not when using the 2SLS. On the other hand, the proportion of budget allocated to cartels is found to be significant to impact on the level of in-depth mergers with the IV and SURE estimations but not when using the OLS. Comparing the results, a number of inconsistencies and biasness is observed when using the OLS estimation. Moreover, given the budget endogeneity, it is found that the 2SLS provides the most robust results. Hence, the preferred regression is the 2SLS regression.

In this section, only the main results, which are drawn from the 2SLS regression are therefore discussed. The equations in the statistical model are observed to 'fit' the data well with uncentered[80]

[80] When a model does not have a constant, R^2 can take negative values when the model because the 2SLS suppress the printing of an R^2. The latter consequently has little meaning in this case. In such situations, the

R^2 ranging between 0.74 and 0.81. Budget is found to be indeed a very important element in the decision making of CA. The results reveal that holding the budget allocation decision constant, budget is positively significant in influencing the number of cartels, but not monopoly abuse and merger investigations. In the short run, one percentage increase in the level of budget is likely to cause CA to increase detection of cartel cases by 2.14%. Interestingly, it is found that an increase budget allocated in the previous period causes the number of cartels detected to decrease. This may indicate the presence of deterrence effects. As CAs experiences an increase in their level of budget, they increase detection of cartel cases. Detection can generate deterrence, and this consequently causes the number of detections to fall, due to a drop in that type of anti-competitive behaviour by firms. In the long term, holding budget allocation decision constant, a 1% in increase in allocated budget is likely to increase detection of cartels by 0.39% at 10% level.

On the other hand, the level of budget is not found to have significant effects on the monopoly abuse and in-depth merger cases, neither in the short nor the long term. The results seem to provide evidence that an increase in the level of budget is not likely to spread equally among the anticompetitive conducts (Conjecture 2).

While the coefficients of $propbudcartel$, $propbudabuse$ and $propbudindepth$ do not individually impact on the number of cartels detected, $propbudcartel$ and $propbudindepth$ are found to be jointly significant. A one per cent increase in the share of budget allocated to cartels associated with a corresponding drop in the residual category, is likely to have a negative long run effect on cartels by 2.87% (conjecture 1). Moreover, a 1% increase in the budget allocated to mergers following a 1% drop in the budget allocated to cartels, is likely to cause cartel detection to fall by 1.20%. On the other hand, overtime cartel detection is likely to fall by 1.13% following a 1% increase in the budget allocated to mergers and a 1% drop in the budget allocated to monopoly abuse. These indicate that in the long run, there may be a degree of substitutability between cartels and in-depth merger cases which is in line with Conjecture 3.

Incidentally, although the number of monopoly abuse cases are expected to be influenced by the individual proportion of budget allocated to abuse cases in the previous two periods, the effect of budget allocated to abuses is found to be neither individually nor jointly significant. The results however show that in the long run a one per cent increase in the budget allocated to cartels is likely to cause a fall in monopoly abuse cases by 7.61%. This confirms Conjecture 1, the delayed impact of

uncentered R^2 is used such that the values of dependent variable are not centered (mean that has been removed from the series) around the mean.

budget allocation decisions on the number of abuse cases as well as the substitutability that may exist between the cartels and monopoly abuse cases (Conjecture 4).

Furthermore, in the short run, the proportion of budget allocated to cartels is found to be negatively related to in-depth mergers. This result further confirms Conjecture 3 such that if a CA increases its budget their budget allocated to cartels, less resources will be available to finance in-depth mergers in the same year, hence reducing the number of in-depth merger cases in the short term. However, in the long-run, only the proportion of budget allocated to monopoly abuses and in-depth mergers are found to be jointly significant in determining the number of in-depth mergers. Holding the allocated budget constant, a 1% increase in the proportion of budget allocated to mergers, following a 1% drop in the budget allocated to monopoly abuse cases is likely to cause in-depth mergers to fall by 2.90% in the long term. The results also show that following a 1% increase in the proportion of budget allocated to monopoly abuse cases and a fall in the proportion of budget allocated to mergers, in-depth merger investigations is likely to fall by 12.49% overtime. On the other hand, a 1% increase in budget allocated to merger cases and a 1% drop in the budget allocated to cartel cases is likely to cause in-depth merger investigations to increase by 0.40%. A 1% increase in budget allocated to monopoly abuse cases and a 1% drop in the budget allocated to cartel cases is likely to cause in-depth merger investigations to fall by 9.19%.

These findings therefore indicate that there may be a substitution between resources allocated to monopoly abuse cases and mergers cases to be investigated by the CAs in the long run. For instance, if a CA decides to increase the budget allocated to in-depth merger cases, this is also likely to impact on their efficiency in deterring anti-competitive mergers hence reducing the number of in-depth mergers. However, in respect to Conjecture 3, the proportion of budget allocated to cartel cases is not found to impact on the number of mergers investigated in the long -run. These results consequently emerge to an interesting finding of a causal relationship that may exist between in-depth merger and cartel cases in the long-run. It is such that assuming allocated budget to be constant, if a CA decides to increase the budget allocated to mergers, it is likely to inversely affect the convicted cartels. On the other hand, an increase in the proportion of budget to be allocated to cartels increases, it is not likely to impact on the investigated mergers.

The results further reveal that there may be a degree of substitution between monopoly abuse cases convicted and number of cartels detected in the long run. As CAs increase their proportion of budget allocated to cartels, the number of monopoly abuse falls when the allocated budget is held constant. This may be explained by two reasons. The first one is the fact that as CAs increase their proportion of

budget allocated to cartels, they detect more cartels, which may also have a deterrent effect on firms engaged in monopoly abuses, causing the monopoly abuse cases to fall. Another reason is that holding the level of budget fixed, when CAs increase the share of budget allocated to cartels, less budget becomes available to be spent on other competition cases, which include monopoly abuse cases, hence causing the latter to fall.

Table 6.5: Estimation results based on 2SLS

DEPENDENT VARIABLES	$ln\#cartel$	$ln\#abuse$	$ln\#indepth$
$lnbudget$	2.137**	1.887	0.016
	(1.052)	(1.533)	(1.374)
$lnbudget_{t-1}$	-1.515*	-1.511	0.013
	(0.897)	(1.191)	(1.147)
$lnbudget_{t-2}$	0.063	-0.016	0.232
	(0.206)	(0.389)	(0.276)
$lnbudget_{t-3}$	-0.293**	-0.085	-0.224
	(0.147)	(0.314)	(0.345)
$propbudcartel$	-6.901	-9.112	-14.63**
	(4.479)	(7.492)	(6.239)
$propbudcartel_{t-1}$	1.420	1.822	8.846*
	(4.120)	(6.521)	(5.018)
$propbudcartel_{t-2}$	-0.694	2.677	-0.267
	(2.079)	(2.210)	(2.748)
$propbudcartel_{t-3}$	3.303	-3.059	2.759
	(2.434)	(3.718)	(4.447)
$propbudabuse$	-3.508	-2.247	0.190
	(5.248)	(5.236)	(7.184)
$propbudabuse_{t-1}$	3.621	0.575	-2.152
	(4.342)	(4.363)	(5.744)
$propbudabuse_{t-2}$	3.301	4.847*	-0.503
	(2.477)	(2.773)	(2.770)
$propbudabuse_{t-3}$	-3.479	1.912	-10.02*
	(2.247)	(3.504)	(5.191)
$propbudmerger$	-0.402	-0.717	-6.691
	(2.358)	(4.153)	(4.496)
$propbudindepth_{t-1}$	-3.623	0.421	5.975*
	(2.293)	(3.509)	(3.616)
$propbudindepth_{t-2}$	2.700	3.267	-1.123
	(1.786)	(2.351)	(2.467)
$propbudindepth_{t-3}$	0.130	-0.673	-1.057
	(0.757)	(0.799)	(0.652)
Test of hypotheses			
F-stat $lnbudget$	5.05***	2.87***	3.67***
F-stat $propbudcartel$	8.22***	7.63***	7..80***
F-stat $propbudabuse$	14.33***	37.93***	36.32***
F-stat $propbudindepth$	78.63***	33.12***	33.60***

Under idendification chi2- stat: Kleibergen-Paap rk	14.561	16.014	15.555
Chi-sq(11) P-val	0.204	0.141	0.159
Weak identification Wald F stat: : Cragg-Donald	0.959	1.202	1.213
Kleibergen-Paap rk	1.212	1.011	1.017
Hansen J statistic	8.913	8.715	9.868
Chi-sq(10) P-val	0.540	0.559	0.452
Uncentered R-squared	0.811	0.746	0.750
Joint significance: $lnbudget$ chi2	6.38*	2.01	0.96
$propbudcartel$ chi2	8.39*	10.14**	6.3
$propbudabuse$ chi2	6.6	5.9	25.51***
$propbudindepth$ chi2	13.31***	6.1	11.62**
Observations	178	177	178

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Among the control variables, notified mergers are found to be significant in positively determining the cartels and in-depth merger cases. Age is also found to have an influence on the cartel and in-depth merger cases but not on monopoly abuse cases. Age however is found to have different impacts on the latter, with a U-shape effect on the cartel cases and an inverse U-shape effect on merger cases. Moreover, the level of fines and the maximum years of imprisonment are found to negatively impact on the number of cartels. None of the control variables are however found to affect the number of monopoly abuse cases.

The overall assessment of results reinforces the importance of budget and allocation of budget in determining the level of activity of CAs. They are to some extent in line with the four conjectures put forward for the analysis. Budget allocation decisions are found to more likely have long term rather than short-term effects. The fall in the number CA's activity should however be interpreted with cautiousness, as it can be a result of a fall in detection due to lack of resources or indicate the success of the CAs in deterring anti-competitive conducts. While our simple empirical model certainly has its limitations and casts aside many important questions, it has offered a meaningful frame for further empirical studies.

6.7. Conclusion

This chapter aimed at empirically testing the interaction that may exist between mergers, cartels and abuses given a budget and competition authorities' budget allocation decisions. To deal with the endogeneity of budget and budget allocation, an IV econometric methodology is applied using instruments obtained from behaviour of other institutions in similar groups.

Focusing the analysis on the variables of interest i.e. budget and the budget allocation decisions of CAs, I find that they play an important role in determining the level of cartel, monopoly abuse and merger activities of a CA. Only budget allocation to cartels seems to have a contemporaneous impact on in-depth merger investigations; allocation decisions appear to take more time before impacting of cartels and monopoly abuse cases. A causal relationship is also identified to exist between merger investigations and convicted cartels cases. It is found that while the decision to allocate more budget to merger investigations is likely to reduce the cartel activity of a CA, an increase in budget allocated to cartel cases has no effect on the level of investigated mergers. Moreover, a degree of substitutability is also observed between cartels and monopoly abuse cases. There is also evidence that an increase in budget allocated is not likely to spread its effect equally among the anticompetitive conducts.

While the findings clearly indicate that there exists interactions (although at different intensities) between allocated budget, budget allocation decisions and the different type of anti-competitive conducts, it is however important that the results are interpreted with caution. A fall in the number of cartel, monopoly abuse or in-depth merger cases may not necessarily imply that the CAs is not doing well in detection. It may also be explained by the presence of the effects of deterrence on the activity of the CAs, which would also mean that CAs are successful.

Appendices

6.A List of acronyms

Table 6.A.6: List of acronyms

Countries	Abbreviation	Countries	Abbreviation	Countries	Abbreviation
Australia	Aus	Germany	Ger	New Zealand	Nze
Austria	Austria	Greece	Gre	Norway	Nor
Belgium	Bel	Hungary	Hun	Pakistan	Pak
Brazil	Bra	Ireland	Ire	Poland	Pol
Canada	Can	Israel	Isr	Portugal	Por
Chile	Chi	Italy	Ita	S Africa	Saf
Czech	Cze	Japan	Jap	Spain	Spa
Denmark	Den	Korea	Kor	Sweden	Swe
EU	EU	Lithuania	Lit	Switzerland	Swi
Finland	Fin	Mexico	Mex	United Kingdom	UK
France	Fra	Netherlands	Net	United States	US

6.B Regression results

a. Two stage least square (2SLS) results

Table 6.B.1: 2SLS results

DEPENDENT VARIABLES	$ln\#cartel$	$ln\#abuse$	$ln\#indepth$
$lnbudget$	2.137**	1.887	0.016
	(1.052)	(1.533)	(1.374)
$lnbudget_{t-1}$	-1.515*	-1.511	0.013
	(0.897)	(1.191)	(1.147)
$lnbudget_{t-2}$	0.063	-0.016	0.232
	(0.206)	(0.389)	(0.276)
$lnbudget_{t-3}$	-0.293**	-0.0850	-0.224
	(0.147)	(0.314)	(0.345)
$propbudcartel$	-6.901	-9.112	-14.63**
	(4.479)	(7.492)	(6.239)
$propbudcartel_{t-1}$	1.420	1.822	8.846*
	(4.120)	(6.521)	(5.018)
$propbudcartel_{t-2}$	-0.694	2.677	-0.267
	(2.079)	(2.210)	(2.748)
$propbudcartel_{t-3}$	3.303	-3.059	2.759
	(2.434)	(3.718)	(4.447)
$propbudabuse$	-3.508	-2.247	0.190

	(5.248)	(5.236)	(7.184)
$propbudabuse_{t-1}$	3.621	0.575	-2.152
	(4.342)	(4.363)	(5.744)
$propbudabuse_{t-2}$	3.301	4.847*	-0.503
	(2.477)	(2.773)	(2.770)
$propbudabuse_{t-3}$	-3.479	1.912	-10.02*
	(2.247)	(3.504)	(5.191)
$propbudindepth$	-0.402	-0.717	-6.691
	(2.358)	(4.153)	(4.496)
$propbudindepth_{t-1}$	-3.623	0.421	5.975*
	(2.293)	(3.509)	(3.616)
$propbudindepth_{t-2}$	2.700	3.267	-1.123
	(1.786)	(2.351)	(2.467)
$propbudindepth_{t-3}$	0.130	-0.673	-1.057
	(0.757)	(0.799)	(0.652)
age	-0.063***	-0.015	0.040*
	(0.020)	(0.035)	(0.021)
age^2	0.001***	0.000	-0.001**
	(0.000)	(0.000)	(0.000)
$leniency$	-		
$ln\#merger$	0.221*	0.079	0.403***
	(0.113)	(0.126)	(0.067)
$lnfine$	-0.103		
	(0.103)		
$dfinemis$	-1.289*		
	(0.735)		
$prison$	-0.097***		
	(0.030)		
$time$	-0.012	-0.001	0.022
	(0.051)	(0.066)	(0.056)
$Constant$	2.481	2.096	3.804
	(2.077)	(2.377)	(2.602)
Observations	178	185	186
R-squared	0.048	0.014	0.025

Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.

b. OLS Results

Table 6.B.2: OLS results

VARIABLES	$ln\#cartel$	$ln\#abuse$	$ln\#indepth$
$lnbudget$	0.430*	0.059	0.677**
	(0.252)	(0.374)	(0.299)
$lnbudget_{t-1}$	-0.101	-0.052	-0.460
	(0.320)	(0.480)	(0.384)
$lnbudget_{t-2}$	0.188	0.162	0.165
	(0.269)	(0.413)	(0.331)
$lnbudget_{t-3}$	-0.338	0.023	-0.269
	(0.212)	(0.322)	(0.258)
$propbudcartel$	-0.272	-3.501*	-1.157
	(1.174)	(1.785)	(1.431)
$propbudcartel_{t-1}$	-2.656*	-1.484	-1.377
	(1.575)	(2.402)	(1.924)
$propbudcartel_{t-2}$	-1.572	1.075	0.963
	(1.900)	(2.923)	(2.342)
$propbudcartel_{t-3}$	3.283	-3.559	4.206
	(2.369)	(3.611)	(2.894)
$propbudabuse$	-0.263	2.693	-2.386
	(1.308)	(1.978)	(1.583)
$propbudabuse_{t-1}$	2.439	-1.426	2.353
	(1.779)	(2.685)	(2.152)
$propbudabuse_{t-2}$	1.358	2.933	-2.128
	(2.048)	(3.150)	(2.452)
$propbudabuse_{t-3}$	-4.992**	0.828	-10.700***
	(2.504)	(3.833)	(3.070)
$propbudindepth$	-0.536	0.860	0.051
	(1.110)	(1.674)	(1.340)
$propbudindepth_{t-1}$	-2.816**	0.544	0.982
	(1.272)	(1.934)	(1.550)
$propbudindepth_{t-2}$	0.274	0.549	-0.695
	(1.087)	(1.671)	(1.337)
$propbudindepth_{t-3}$	0.730	-0.191	-1.282
	(0.733)	(1.129)	(0.902)
age	-0.052***	-0.007	0.043***
	(0.014)	(0.021)	(0.017)
age^2	0.001***	0.000	-0.001***
	(0.000)	(0.000)	(0.000)
$leniency$	-		
$ln\#merger$	0.241***	0.100	0.410***
	(0.063)	(0.093)	(0.074)

(continued)

Table 6.B.2: OLS results (*continued*)

VARIABLES	$ln\#cartel$	$ln\#abuse$	$ln\#indepth$
$lnfine$	0.029		
	(0.062)		
$dfinemis$	-0.574		
	(0.474)		
$prison$	-0.075***		
	(0.019)		
$Constant$	2.622**	2.276	1.734
	(1.029)	-1.566	-1.253
Observations	179	186	187
R-squared	0.414	0.218	0.38
Adjusted R-squared	0.331	0.129	0.309
F-test	5.010	2.440	5.380
Prob>F	0.000	0.001	0.000

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

c. SURE results

Table 6.B.3: SURE results

	NO IV						IV					
VARIABLES	$ln\#cartel$		$ln\#abuse$		$ln\#indepth$		$ln\#cartel$		$ln\#abuse$		$ln\#indepth$	
	(ii)	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**
$lnbudget$	-0.188	0.015	0.264	0.237	0.595***	0.855***	0.385	-0.095	-0.658	-0.993	0.492	1.128*
	(0.168)	(0.172)	(0.191)	(0.211)	(0.176)	(0.197)	(0.636)	(0.616)	(0.615)	(0.636)	(0.560)	(0.605)
$lnbudget_{t-1}$	-0.231	-0.304	-0.435**	-0.531**	-0.208	-0.385*	1.191**	0.968*	-0.515	-0.711	-0.103	-0.527
	(0.186)	(0.195)	(0.218)	(0.243)	(0.200)	(0.227)	(0.549)	(0.543)	(0.669)	(0.686)	(0.609)	(0.652)
$lnbudget_{t-2}$	0.460**	0.346*	-0.246	-0.277	0.028	0.308	0.081	-0.160	-1.348*	-1.345*	-0.523	-0.221
	(0.189)	(0.196)	(0.220)	(0.244)	(0.202)	(0.229)	(0.637)	(0.594)	(0.775)	(0.759)	(0.705)	(0.722)
$lnbudget_{t-3}$	0.109	0.033	-0.182	-0.302	0.002	0.162	1.054*	0.405	0.666	1.028	-0.285	-0.032
	(0.157)	(0.152)	(0.181)	(0.189)	(0.167)	(0.177)	(0.579)	(0.559)	(0.704)	(0.721)	(0.641)	(0.685)
$propbudcartel$		0.128		-0.461		0.685		-0.205		-0.640		0.220
		(0.729)		(0.905)		(0.847)		(0.737)		(0.953)		(0.906)
$propbudcartel_{t-1}$		-2.282**		-1.702		-1.550		-1.958**		-1.172		-0.677
		(0.891)		(1.098)		(1.028)		(0.875)		(1.122)		(1.066)
$propbudcartel_{t-2}$		-0.274		2.314*		2.518**		-1.042		1.484		2.533**
		(1.073)		(1.322)		(1.238)		(1.038)		(1.343)		(1.277)
$propbudcartel_{t-3}$		1.633		-1.960		-0.545		1.627		-2.328		-0.523
		(1.487)		(1.846)		(1.729)		(1.495)		(1.917)		(1.822)
$propbudabuse$		-0.180		1.301		-2.677***		-0.353		1.048		-1.809*
		(0.828)		(1.029)		(0.964)		(0.822)		(1.052)		(1.000)
$propbudabuse_{t-1}$		0.508		-1.837		-0.190		-0.301		-2.213*		0.058
		(1.095)		(1.341)		(1.255)		(1.063)		(1.341)		(1.275)

(continued)

Table 6.B.3: SURE results *(continued)*

	NO IV						IV					
VARIABLES	$ln\#cartel$		$ln\#abuse$		$ln\#indepth$		$ln\#cartel$		$ln\#abuse$		$ln\#indepth$	
	(ii)	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**
$propbudabuse_{t-2}$		2.538*		2.796		-1.961		2.518*		2.019		-1.526
		(1.404)		(1.728)		(1.618)		(1.371)		(1.736)		(1.651)
$propbudabuse_{t-3}$		-0.531		1.123		-1.269		-0.672		1.682		-1.819
		(1.605)		(1.981)		(1.855)		(1.600)		(2.054)		(1.952)
$propbudindepth$		-0.223		0.470		0.717		-0.754		0.377		1.412
		(0.753)		(0.930)		(0.871)		(0.780)		(1.009)		(0.959)
$propbudindepth_{t-1}$		-2.695***		-0.169		-1.318		-2.093**		-0.299		-0.176
		(0.946)		(1.167)		(1.093)		(0.888)		(1.142)		(1.085)
$propbudindepth_{t-2}$		1.618**		1.292		0.642		1.194*		0.728		0.242
		(0.692)		(0.863)		(0.808)		(0.671)		(0.869)		(0.826)
$propbudindepth_{t-3}$		1.046**		-0.840		-0.293		1.086**		-0.693		-0.056
		(0.440)		(0.546)		(0.511)		(0.450)		(0.578)		(0.550)
age	-0.148*	-0.125	-0.205**	-0.138	-0.029	-0.103	-0.309***	-0.205**	-0.154	-0.100	0.007	-0.087
	(0.087)	(0.084)	(0.099)	(0.103)	(0.091)	(0.097)	(0.095)	(0.091)	(0.113)	(0.116)	(0.103)	(0.110)
age^2	0.001**	0.001**	0.001*	0.001	0.000	0.000	0.002***	0.002***	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$leniency$	-	-					0.622	3.939				
							(0.499)	(3.020)				
$ln\#merger$	0.054	0.071	0.043	0.085	-0.011	-0.067	0.120	0.060	-0.045	-0.027	0.032	0.015
	(0.074)	(0.073)	(0.084)	(0.089)	(0.078)	(0.084)	(0.085)	(0.082)	(0.098)	(0.099)	(0.090)	(0.095)
$lnfine$	0.022	0.011					-0.022	0.011				
	(0.051)	(0.051)					(0.059)	(0.061)				

(Continued)

Table 6.B.3: SURE results *(continued)*

	NO IV	IV

VARIABLES	$ln\#cartel$		$ln\#abuse$		$ln\#indepth$		$ln\#cartel$		$ln\#abuse$		$ln\#indepth$	
	(ii)	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**	**(ii)**	**(iii)**
$dfinemis$	0.037	0.038					-0.240	0.056				
	(0.346)	(0.318)					(0.323)	(0.330)				
$prison$	0.005	-0.097					0.005	-0.095				
	(0.072)	(0.072)					(0.078)	(0.075)				
$Constant$	4.230	4.408*	10.46***	8.896***	3.157	4.860*	-0.289	0.000	13.410***	12.680***	4.718	5.595*
	(2.767)	(2.623)	(2.953)	(3.025)	(2.715)	(2.833)	(3.157)	(0.000)	(3.543)	(3.577)	(3.224)	(-3.400)
Observations	182	178	182	178	182	178	187	177	187	177	187	177
R-squared	0.760	0.812	0.823	0.844	0.817	0.831	0.752	0.814	0.801	0.834	0.802	0.815
RMSE	0.497	0.443	0.584	0.553	0.537	0.518	0.506	0.442	0.622	0.575	0.566	0.546
Chi2-test	576.82	768.66	846.97	962.87	809.78	874.6	566.49	574.33	752.21	891.89	757.57	781.38
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

*Note: Significance levels: * 10%, ** 5%, *** 1%. Standard errors are in parentheses.*

Chapter 7 Conclusion

The five papers included in this thesis have assessed the performance of a CA, determined the different factors that can restrict the effectiveness of a competition enforcement regime and the interaction between the different types of anti-competitive cases based on budget allocation decisions in 35 countries for period between 2006 and 2014.

The five papers differ from each other in the specific questions asked, in the theoretical and empirical methodologies. The compilation of the papers in this thesis provides a significant contribution to the existing economics literature, not only in terms of the dataset used, but also in terms of the extension of existing theories and the level of nature of the analysis conducted.

Chapter 2 has provided an overview of the basic features of the data used in the thesis and background information on the CAs found in our database. It has enabled us to better understand the findings of the chapters.

Chapter 3 has studied the different national and institutional features that could impact on the reputation of a CA. We argue that the 'GCR star rating' measure of reputation to be highly correlated with genuine performance. The national governance culture and common law legal systems are found to play a significant role in determining the reputation of a CA. We also observe that 'economies of scale' and (endogenous) budget are important positive factors.

In Chapter 4, a model has been theoretically developed to assess the success of CAs in detection and deterrence of cartelised behaviour. The model is then used in deriving the functional form of the age profile for the number of cartels convicted over time. It is interpreted in terms of both its efficiency in detection and success in deterrence. We find that the age profile of a CA's convicted cartels depends on the magnitude of the detection efficiency of the CA and the deterrence effects of competition law and policy. Detection and deterrence are found to have opposite effects on the age profile of cartels convicted of a CA. The shape of the age profile then depends on the magnitude (outweighing effects) of both detection and deterrence.

Chapter 5 has empirically tested the theory put forward in Chapter 4. I find that age of the cartel law does have an impact on the number of cartels convicted over time and tends to decrease and flatten over time.

This shows evidence of increasing deterrence as a consequence of the increased efficiency of detection and the success of the CAs in deterring cartels. Further empirical findings show that the importance of previous budget allocated is important, leniency, type of law, institution design and fines and imprisonment in the detecting and deterring cartels.

Chapter 6 empirically looked at how the budget allocation decisions impact on the number and types of competition cases that the CA can look into. The empirical analysis is conducted based the above mentioned panel dataset. I apply an IV econometric methodology that deals with the endogeneity of budget allocation problem that may arise. The system models number of cartels detected (cartels), abuse of dominant position cases (abuses) and in-depth merger investigations (mergers) as endogenous. The endogeneity of the budget variables is corrected by using instruments obtained from behaviour of other institutions in similar groups. It consequently enables the better understanding of the behaviour and the strategies by CAs and firms. It is found that while allocation decisions tend to take more time before impacting on cartel and monopoly abuse cases, only budget allocation to cartels seems to have a contemporaneous impact on in-depth merger investigations. I also find evidence of causality between merger investigations and convicted cartels cases as well as a degree of substitutability between cartels and monopoly abuse cases.

Directions for future research

In chapter 3, the model put forward focused mostly on the national characteristics and the institutional design when catering for the endogeneity of budget. However, a full structural equation grounded in the political economy of budget setting may be specified. The study can also be extended by looking at the independence of the CA.

The model developed in chapter 4 assumed that (i) budget is exogenous and is allocated by government, (ii) firms and the CA are risk neutral agents and that (iii) the CA does not make type I and type II errors, so as to keep the model simple. These might be strong assumptions to make in reality and the model could therefore be extended by relaxing such assumptions. For example, the endogeneity of the budget could be looked into such that it is also a function of performance i.e., the optimum probability that a cartel is convicted. It can further be assumed that firms are risk-averse or that there is a possibility that the CA is making errors. Moreover, a more ambitious research will be to incorporate the interaction between mergers investigated and monopoly abuse cases detected into the model. It will be interesting to see how the CA takes cartels, monopoly abuse cases and mergers cases into account when setting up their

threshold. As for chapter 5, extension of the time dimensions might have given more robust results. By lagging budget to cater for the endogeneity of budget, observations were lost.

Chapter 6 has been focusing mostly on the endogeneity of budget and the allocation of budget and the construction of instruments. I looked at a system of equations where cartels, monopoly abuse and merger cases are the endogenous variables. In this chapter, since the lag budget variables and the allocation decisions by a CA are used to study their contemporaneous impact, considerable number of observations are lost. It will therefore be interesting to extend the time period to also obtain more robust results. I also attempted to apply the three-stage least squares. However, this method was dropped due to the difficulty of obtaining a suitable instrument for each equation in our model. It would therefore be challenging to model a system of equations to study the interdependence between the three types of anti-competitive behaviour. As a topic for further research, the analysis could be conducted as a 3-equation VAR model with an accompanying Granger causality test.

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