Cartel Damages and Cost Asymmetries

Berg, Petter

COPENHAGEN BUSINESS SCHOOL
HANDELSHØJSKOLEN
SOLBJERG PLADS 3
DK-2000 FREDERIKSBERG
DANMARK

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"The Doctoral School of Economics and Management is an active national and international research environment at CBS for research degree students who deal with economics and management at business, industry and country level in a theoretical and empirical manner".

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Petter Berg,
Copenhagen, February 2012

Contents

English summary

During the last ten years there has been a rigorous debate on how to improve anti-cartel enforcement in Europe. Introducing private enforcements systems, like in the US, was early in the process regarded as one of the most important steps for significant improvements. In contrast to public enforcement, private enforcement relies on adequate compensation to customers harmed by a cartel. But cartel damages are hard to calculate and the European Commission has therefore presented a draft guideline on how to quantify harm to assist courts and claimants.

The focus in the guidance is on price effects, but cartels are also likely to cause other types of damage, such as efficiency effects. For example, a Swedish committee investigating cartels in the 1950's stated that

"A monopolist or a cartel can charge too high prices in relation to its costs. A cartel determines prices after the least efficient firm in the cartel, and hence protects it" (SOU 1951:27).

This statement reflects an early awareness that pricing and efficiency effects from cartels are deeply related, and jointly determines the harm for consumers. This thesis aims at re-joining the discussion of cartel prices and efficiencies for the purpose of determining cartel damages. It will focus on the issue outlined above, i.e. cartel behaviour and the harm caused by cartels when a cartel consists of members that are not symmetric in costs. Cost asymmetries can be both exogenous and endogenous to cartel formation, but rather than discussing why asymmetries arise, I will in the four chapters focus on the effect the asymmetries have on cartel prices and hence consumer harm.

The first chapter asks if and how the perception of cartel harm changed the cartel legislation. I use the case of Sweden which was first country in Europe to fully incorporate the European Community competition law into national legislation. In the beginning of the 20th century, little was known about cartels and their effects. Economists argued that while they sometimes increased prices, cartels also generated efficiencies. During the 1930's depression, cartels were seen as positive in Europe and were even promoted by governments as a way to cut costs, promote recovery and avoid bankruptcy. The positive view continued during the Second world war when cartels were used as part of the war machinery. After the war attitudes changed in Europe and

Sweden, and after a period of monitoring the extent of cartelisation, the first cartel laws were introduced in the 1950's. Since no evidence of high prices caused by cartels had been found, the legislation focused on improving market efficiency. Cartels themselves were generally not prohibited, but the state had the right to negotiate with cartels that charged too high prices. During most of the later part of the century, cartel legislation was complemented with price control. In the early 1980's it was clear that cartels could increase prices and cartel prohibition was suggested. The proposal caused big controversy in both the legal system and industry, therefore effect-analysis remained the basis of the law. It was not until 1993 when Sweden copied the EC competition law that cartels became prohibited irrespective of their effects. Despite the prohibition, effect-arguments were used in court until the beginning of the 2000's. This chapter illustrates that trying to assess cartel effects is nothing new. If further shows that there are both price and efficiency effects to be expected from a cartel. The rest of the chapters aim at joining these effects.

The second chapter explores the relation between firm efficiency and cartel pricing mechanism. I derive how cartel prices are determined when cartel members are asymmetric in costs and show how cost changes affect both cartel prices and sustainability. Cartel models are often designed as duopolies. This model illustrates that when it comes to understanding cartel behaviour by asymmetric firms, restricting the analysis to a duopoly affects the result. If there are two efficient firms and one inefficient firm in a cartel, the efficient firms can deviate either alone or together. If they deviate together they form a new smaller cartel. When the cost asymmetries are sufficiently large, it is tempting for the efficient firms to deviate together and form their own cartel. This makes the large cartel more unstable. The members are assumed to bargain about the cartel price, where the efficient firms want lower prices than the inefficient one. When the best outside option to being in the large cartel is forming a smaller cartel, prices are set closer to the efficient firms' monopoly price, to induce them to stay. In some cases bargaining does not lead to incentive compatible solutions, but there is still a possibility to form a cartel that would make all members better of than competing. In these cases, price is set at the efficient firms' monopoly price and the division of profits is carried out through market share allocation.

The third chapter departs further from standard cartel models with symmetric firms and homogenous products by assuming that the cartel sells differen-

tiated products. The asymmetry allows the cartel to charge a different price for every product. Using a two-firm model I explore how prices and consumer welfare are affected by cost asymmetries and product differentiation. Prices in the model are determined by the efficient firm giving the inefficient firm a take-it or leave-it offer. Just as in the second chapter, the counterfactual or outside option plays an important role, not only in determining prices, but also damages. While cartel prices are fairly constant over different degrees of product differentiation, the counterfactual varies a considerably. The price difference between the cartel and the competitive situation, i.e. the overcharge, decreases with product differentiation since differentiation allows firms to unilaterally exert market power also in the non-competitive situation. Standard models assume symmetric costs and homogeneous products. This model illustrates that these assumptions lead to an extreme case in which welfare losses are maximal and restitution of damages undercompensates consumers the most. When products are differentiated, damages are lower. The degree of competition if there was no cartel is hence crucial for determining cartel damages.

The fourth chapter centres around the discussion of why cost asymmetries arise and makes the asymmetries endogenous to the model. More importantly it investigates if the differences will prevail. In Europe anticompetitive agreements, such as cartels, can be exempted from prohibition if they generate efficiencies - for example through knowledge sharing. Efficiency arguments are therefore often invoked as a defence for the cartels, a.k.a. efficiency defence. But should we expect cartel members to share information with each other? The section presents two possible explanations as to why they would want to share information; i) to save the cartel when it is unstable, and ii) to align the pricing preferences for the cartel. Using a two-firm model where firms ex ante have the same costs I refute the two above hypothesis - a firm that gains a cost advantage has no incentive to share its knowledge even of the firms form a cartel. The chapter also shows that an efficient firm has larger incentives to invest in cost reducing technology. The difference between the efficient and inefficient firms will therefore increase over time.

Dansk resumé

Gennem de seneste 10 år har der været en omfattende debat om, hvordan man kan forbedre håndhævelsen af anti-kartel foranstaltninger i Europa. Introduktion af private håndhævelsessystemer, blev i processens begyndelse anset som et af de vigtigste skridt mod egentlig forandring. Til forskel fra offentlig retshåndhævelse afhænger privat håndhævelse af tilstrækkelig kompensation til kunder, der bliver skadet af et kartel. Men skadevirkningen er svær at beregne, og Europa-Kommissionen har således fremstillet et udkast til retningslinjer, for hvordan skadesvirkningen kan kvantificeres, for at hjælpe domstolene og den skadelidte.

Vejledningen har fokus på priseffekter, men karteller er også tilbøjelige til skabe andre skadesvirkninger, såsom effektivitetseffekter. For eksempel har en svensk komité til undersøgelse af karteller udtalt følgende:

"En monopolhaver eller et kartel kan kræve for høje priser i forhold til omkostningerne. Et kartel fastsætter prisen efter den mindst effektive virksomhed og beskytter den herigennem." (SOU 1951:27)

Denne udtalelse afspejler en tidlig bevidsthed om, at pris- og effektivitetseffekter fra karteller er tæt forbundne, og at de tilsammen er afgørende for skaden for forbrugerne. Denne afhandling sigter mod at genforene diskussionen af kartelpriser og -effektivitet for at kunne fastslå kartellers skadevirkning. Afhandlingen vil fokusere på de ovenfor nævnte problemstillinger, dvs. kartellers opførsel samt deres skadevirkning, når et kartel består af medlemmer, der ikke har symmetriske omkostninger. Omkostningsasymmetri kan både være exogen og endogen for karteldannelsen, men i stedet for at diskutere hvorfor asymmetrien opstår, vil jeg i de fire kapitler fokusere på, den effekt asymmetri har på kartelpriserne og således også på skadevirkningen for forbrugerne.

Det første kapitel undersøger om, og hvordan opfattelsen af kartellers skadevirkning har ændret lovgivningen om karteller. Jeg anvender Sverige som case, hvilket var det første land i Europa til at indarbejde Det Europæiske Fællesskabs konkurrenceregler i sin nationale lovgivning. I starten af det 20 århundrede vidste man kun lidt om karteller og deres effekter. økonomer hævdede, at selvom de nogle gange hævede priserne, skabte kartellerne også effektivitet. I løbet af depressionen i 1930'erne blev karteller anset som noget positivt i Europa og blev endda støttet af regeringer som en måde at

reducere omkostninger, fremme opsving og undgå konkurs. Denne positive anseelse fortsatte gennem anden verdenskrig, hvor karteller blev brugt som en del af krigsmaskineriet. Efter krigen ændredes holdningen i Europa og Sverige, og efter en periode med kontrol af karteldannelsens udbredelse blev de første love introduceret i 1950'erne. Siden der ikke var fundet bevis for, at højere priser skyldtes kartellerne, fokuserede lovgivningen på at forbedre markedseffektiviteten. Kartellerne selv var generelt ikke forbudte, men staten havde ret til at forhandle med karteller der forlangte for høje priser. Gennem størstedelen af århundredet blev kartellovgivningen suppleret med priskontrol. I starten af 1980'erne stod det klart, at karteller kunne forhøje priser, og forbud mod karteller blev foreslået. Forslaget skabte stor uenighed i både retssystemet og industrien, hvorfor effektanalyse vedblev med at være basis for lovgivningen. Det var ikke før 1993, hvor Sverige kopierede EF's konkurrenceregler, at kartellerne blev forbudt uafhængigt af deres virkninger. På trods af forbuddet blev effekt-argumenterne brugt i retten frem til starten af nullerne. Dette kapitel illustrerer, at forsøget på at vurdere kartellers virkning ikke er noget nyt. Derudover viser det, at der både kan forventes pris- og effiktivitetseffekter af karteller. De følgende kapitler sigter mod at forene disse effekter.

Andet kapitel udforsker relationen mellem virksomheders effektivitet og kartellers prisdannelsesmekanisme. Jeg udreder, hvordan kartelpriser bliver fastsat, når kartelmedlemmerne er asymmetriske med hensyn til omkostninger samt hvordan ændringer påvirker både kartelpriser og bæredygtighed. Kartelmodeller er ofte designet som et duopol. Denne model illustrerer at, når det kommer til at forstå kartelopførsel med asymmetriske firmaer, vil begrænsningen af modellen til et duopol påvirke resultatet. Hvis der er to effektive virksomheder og en ineffektiv virksomhed i et kartel, kan de effektive virksomheder afvige enten alene eller sammen. Hvis de afviger sammen, danner de et nyt mindre kartel. Når omkostningsasymmetrien er tilstrækkelig stor, er det fristende for de effektive virksomheder at afvige sammen og danne deres eget kartel. Dette gør det store kartel mere ustabilt. Medlemmerne formodes at købslå om kartelprisen, hvor de effektive virksomheder ønsker en lavere prise end den ueffektive. Når den bedste valgmulighed alternativt til at være i et stort kartel er at danne et mindre kartel, bliver priserne sat nærmere de effektive virksomheders monopolpris, for at tilskynde dem til at blive. I nogle tilfælde vil forhandling om ikke føre til motivationsfremmende kompatible løsninger, men der er stadig mulighed for at danne et kartel, der

gavner alle medlemmer bedre, end konkurrence ville. I disse tilfælde sættes prisen på denne effektive virksomheds monopolpris og opdelingen af overskud bliver gennemført via fordeling af markedsandele.

Tredje kapitel adskiller sig yderligere fra standard kartelmodeller med symmetriske virksomheder og homogene produkter ved at antage, at kartellet sælger differentierede produkter. Asymmetrien tillader kartellet at opkræve en forskellig pris for hvert produkt. Gennem en model med to virksomheder udforsker jeg, hvordan priser og forbrugervelfærd bliver påvirket af omkostningsasymmetri og produktdifferentiering. Priserne i modellen er bestemt ved, at den effektive virksomhed giver den ineffektive virksomhed et ultimativt tilbud. Lige som i andet kapitel spiller kontrafakta eller den alternative valgmulighed en vigtig rolle, ikke alene for fastsættelse af priser, men også for skadevirkningen. Mens kartelpriser er rimelig konstante over forskellige grader af produktfinansiering varierer kontrafakta betydeligt. Prisforskellen mellem kartellet og konkurrencesituationen, dvs. overprisen, falder med produktdifferentiering, eftersom differentieringen tillader virksomheder til at udøve selvstændig indflydelse på markedet selv i situationen med ikke-konkurrence. Standardmodellerne antager omkostningssymmetri og homogene produkter. Denne model illustrerer, at disse antagelser viser en ekstrem case, hvor velfærdstabene er maksimale, og hvor skadeserstatningen underkompenserer forbrugerne mest. Når produkter er differentierede, er skaderne mindre. Graden af konkurrence, hvis der ikke var noget kartel, er således afgørende for at bestemme kartellers skadevirkning.

Fjerde kapitel er centreret omkring diskussionen af, hvorfor omkostningsasymmetri opstår, og gør asymmetri endogen til modellen. Hvad der er nok så vigtigt, undersøger det om forskellen vil være fremherskende. I Europa kan anti-konkurrencemæssige aftaler, såsom karteller, være undtaget for forbud, hvis det producerer effektivitet - f.eks. via videndeling. Effektivitetsargumenter tages således ofte i brug som forsvar for karteller, med andre ord 'effektivitetsforsvar'. Men bør vi forvente, at kartelmedlemmerne deler information med hinanden? Denne sektion præsenterer to mulige forklaringer på, hvorfor de skulle ønske at dele information; i) for at redde kartellet, hvis det er ustabilt, og ii) for at justere prisen til fordel for kartellet. Gennem en model med to virksomheder, hvor virksomhederne ex ante har de samme omkostninger, modbeviser jeg de to ovenstående hypoteser - et firma, der får en omkostningsfordel, har intet incitament til at dele dets viden selv med andre firmaer i kartellet. Dette kapitel viser ydermere, at en effektiv

virksomhed har større incitament til at investere i omkostningsreducerende teknologi. Forskellen mellem de effektive og de ineffektive virksomheder vil derfor øges med tiden.

Introduction

During the last ten years there has been a rigorous debate on how to improve anti-cartel enforcement in Europe. Introducing private enforcements systems, like in the US, was early in the process regarded as one of the most important steps for significant improvements.[1] Together they are considered to improve cartel deterrence. In contrast to public enforcement, private enforcement relies on adequate compensation to customers harmed by a cartel. But damages are hard to calculate and the legal systems in Europe are not used to these type of processes[2]. This makes private litigation less of an option for customers and a weaker cartel deterrent.

In the US the incentives for private claimants are solved with a trebling of the damages[3] but this route is not envisaged for Europe.[4] To facilitate private litigation the European Commission instead initiated wide-spread discussion on how to estimate damages in a consistent way[5], and published draft guidelines on how to quantify harm.[6] The guidance is non-binding but aims at providing insights into the harm caused by cartels and on the main methods and techniques to quantify such harm.

This move towards a more economic analysis and focus on effects in privately enforced cartel cases stand in stark contrast to the development of the public anti-cartel enforcement. In the publicly enforced cases the transition has instead been in the opposite direction and cartels have from the late 1990's been considered prohibited per se.[7] But, throughout most of the the 20th century cartels in Europe were subject to effect-based legislation where only the harmful cartels were controlled in one way or another. Effect analysis and quantification of harm in cartel legislation is therefore not new in Europe.

The theory of the harm caused by cartels has shifted over time. During the

[1] E.g. Mario Monti, Speach at 8th Annual IBA conference (2004), "Private litigation as a key complement to public enforcement of competition rules and the first conclusions on the implementation of the new Merger Regulation".

[2] The Ashurst (2004) study referred to the European situation as one "of astonishing diversity and total underdevelopment."

[3] American Bar Association (1986)

[4] European Commission (2008) refers to the principle of full compensation.

[5] E.g. Ashurst (2004), CEPS (2007), Oxera (2009) and European Commission (2008)

[6] European Commission (2011)

[7] E.g. Harding and Joshua (2010)

1930's cartels were seen as a good market mechanism for efficiency and to ensure stability. But after the Second World War cartels started to become monitored more closely and several European states introduced formal cartel registers (e.g. in the UK, Germany, the Netherlands, Sweden, Denmark, Norway). Further, in some states cartel prices were subject to control or general price regulation. Contrary to the current discussion where the entire focus is on prices, efficiency arguments were previously raised in relation to cartels. Efficiency arguments were used both to defend the cartels and to illustrate harm not covered by price analysis. A Swedish committee investigating cartels in the 1950's stated that

"A monopolist or a cartel can charge too high prices in relation to its costs. A cartel determines prices after the least efficient firm in the cartel, and hence protects it".[8]

This statement reflects an early awareness that pricing and efficiency effects from cartels are deeply related, and jointly determines the harm for consumers.

This thesis aims at re-joining the discussion of cartel prices and efficiencies for the purpose of determining cartel damages. It will focus on the problem outlined above, when a cartel consists of members that are not symmetric in costs. These asymmetries can be both exogenous and endogenous to cartel formation, but rather than discussing why the asymmetries arise, I will focus on the effect they have on cartel prices and hence consumer harm.

The first chapter describes how changes in the perceived harm by cartels affected the development of the Swedish cartel legislation. The chapter illustrates how an unclear theory of harm and high requirements of measurable effects made the legislation fairly weak. Despite the Swedish law prohibiting restraints of restricting competition (instead of controlling effects) in 1993, effect-arguments were used in court until the beginning of the 2000s.

Aiming at the issues presented in the quote from the Swedish committee, the second chapter investigates how cartel prices are determined when the members are asymmetric and how changes in costs affect prices and cartel stability. In the chapter I show that prices are increased when there are cost differences, but the level of the prices are determined by the best outside option to being in a cartel. If firms with lower costs have better outside options, the cartel price will be lower.

[8](SOU, 1951:27, p. 13).

The third chapter departs further from standard models with symmetric firms and homogenous products. It analyses how cartel prices and consumer welfare are affected when firms have different costs and the products are differentiated. The chapter finds that the standard model, with symmetric costs and homogeneous products is an extreme case in which welfare losses are maximal and restitution of damages undercompensates consumers the most. When products are differentiated, damages are lower. The counterfactual competitive situation is crucial for determining cartel damages.

The fourth chapter discusses why cost asymmetries arise, and more importantly, it analyses if they will they prevail. Anticompetitive agreements such as cartels can be exempted from prohibition if they generate efficiencies - for example through knowledge sharing. This would result in no or reduced cost asymmetries. However it turns out that efficient cartel members have no incentives to share knowledge with inefficient members. Since efficient firms have larger incentives to invest in cost reducing technology, the differences will increase over time.

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Swedish Cartel Legislation and the Theory of Harm - a tale of 1001 committees.

Petter Berg[a]
Copenhagen Business School

February 2012

Abstract

Cartels are today believed to be harmful to society and are therefore prohibited and subject to large fines in most parts of the industrialised world. But the strong stance against cartels only dates back to the 1990s in Europe and in the 1930s cartels were regarded as beneficial and promoted both in Europe and in the US. This paper investigates how the perception of harm influenced cartel legislation. Using the case of Sweden, the paper argues that until the mid 1960s, the weak legislation and enforcement can be explained by economists being uncertain about the theory of harm. From the 1970s to the 1990s, the theory of harm was established but cartel legislation remained inadequate largely due to industry lobbying and reluctance to legal change. As a result cartels were under-enforced.

Keywords: Antitrust, cartels, damage.
JEL-Classification: K21, K42, N24

[a]Copenhagen Business School, Department of Economics, Porcelænshaven 16 A, DK-2000 Frederiksberg, e-mail: pbe.eco@cbs.dk.

1 Introduction

In 1998, during an era where competition enforcement was strong, the OECD concluded that "Hard core cartels are the most egregious violations of competition law. They injure consumers in many countries by raising prices and restricting supply, thus making goods and services completely unavailable to some purchasers and unnecessarily expensive for others"(OECD, 1998). But the insight that cartels are bad for society is old and dates back to at least Adam Smith. In the Wealth of Nations (1776) he discussed the harm cause by cartels and some of the problems designing a suitable legislation[1].

Despite the beliefs that cartels are bad for society, the first important national antitrust legislation was not introduced until 1890 with the passage of the Sherman Act in the US that prohibited contracts and conspiracies that restricted trade. The law was a reaction to exploitative practices by the early capitalists (Peters, 1996, p. 40), but enforcement was relatively weak during the two first decades (Kovacic and Shapiro, 1999). When it was introduced 21 US states already had own antitrust legislations and the Sherman act was something of a codification of the common law (Engerman and Gallman, 2000, p. 537). Antitrust legislation had also been introduced in Canada in 1889, but it was weak and of more symbolic importance since its impact until the mid 1980s was insignificant (Doern, 1996, p. 9). The following year, the Sherman Act was introduced in the US, prohibiting contracts and conspiracies that restricted trade. The law was a reaction to exploitative practices by the early capitalists (Peters, 1996, p. 40), but enforcement was relatively weak during the two first decades (Kovacic and Shapiro, 1999).

The attitude towards cartels in Europe was the opposite. Even though France and Belgium was the starting point for industrial cartels in Europe, Germany became the center for the European cartel development from the 1870s (Schröter, 1996). As a response to the Great Depression the industries started to organise themselves to stabilise the markets and avoid bankruptcies. These structures became even more important in the 1890s when cartel contracts became enforceable in German courts.

Europe did not introduce cartel legislation until half a century later and there

[1] "People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices. It is impossible indeed to prevent such meetings, by any law which either could be executed, or would be consistent with liberty and justice."(Smith, 1776)

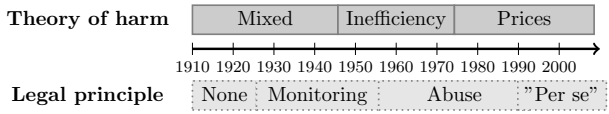
was no cartel prohibition, national or supranational, before the Second World War (Schröter, 1996). In 1951 the first step was taken towards a common cartel policy with the competition provisions in the Treaty of Paris, establishing the European Coal and Steel Community (ECSC)[2]. The competition legislation in the ECSC became the basis for the European Community competition legislation in the Treaty of Rome from 1957, but early enforcement was weak and cartel members were not fined until 1969. Many notified cartels actually received negative clearances, whereas arguably the arrangements would have raised suspicion today (Schinkel, 2007). At a national level, cartel prohibition in Europe was slow, and many European countries didn't introduce strict cartel prohibition until the mid 1990s, i.e. over a century later than in the US.

As described by Harding and Joshua (2003) an important difference in the enforcement between US and Europe was the notion of cartels. In the Sherman Act, cartels are described as planned under-cover conspiracies which in their nature are bad for society. In Europe however, cartels were regarded as an economic institution, with the possibility of inflicting harm. This difference in conception has had large consequences on the cartel enforcement.

This paper traces the development of the theory of harm over time and investigates if and how changing beliefs about cartel effects had an impact on the competition legislation. It focuses on Sweden, a small export dependent nation that was the first country to fully adopt the European Community competition legislation. The paper argues that until the mid 1960s, the weak legislation and enforcement can be explained by an unclear theory of harm. Since harm was not established, the law was largely effects based. From the mid 1970s cartels were understood to be harmful, but they were still underenforced since the law was weak. In the 1990s Sweden switched gear and prohibited cartels. The new legislation, boardering on per se prohibition of cartels, was radically different from the previous case by case economic abuse assessment. But effects arguments were still used in courts. I argue that the economic theory of harm has had an important influence on the cartel legislation, but reluctance to legal changes and industry lobbying slowed down the development. The development in Sweden closely resembles the development in the northern part of Europe.

[2]Treaty of Paris, Chapter VI - Agreements and concentrations, Art. 65.

Figure 1: *Theory of harm and legal changes in Sweden*



This paper consists of three parts where section 2 discusses the development of cartel legislation in the US, in Europe and Sweden from the beginning of the last century until now. The focus is on the theory of harm and how changes in the understanding of cartel effects transformed into legislation. Section 3 concludes the findings.

2 Development of the cartel legislation in Sweden

This section traces the development of US, European and Swedish cartel legislation over time, with a special focus on the economics motivating the laws. The purpose of the Swedish legislation and its pros and cons is mainly derived from a series of committee reports, motivations in legislative proposals and other public documents.

2.1 Before the Second World War: Exploring

In the first two decades of the 20th century there was little information on the extent of cartels and their effects on society. Cartel enforcement had just begun in the US but did not exist in Europe. The first step was to explore the extent of cartels in the industry and to learn about their behaviour. Germany was first among European countries to pass a cartel law, which was intended to gather and disseminate information on cartels. But the law never became operational due to the start of the First World War (Gerber, 2001, p. 109).

A similar step was taken in Sweden when the government in 1911 appointed a commission[3] to analyse the extent of cartels and trusts and their effect on

[3]The Cartel and Trust Commission (Kartell- och trustutredningen).

the Swedish economy.[4] The commission was especially instructed to analyse price formation (SOU, 1951:27). Partly due to the outbreak of the First World War, the findings were few and the main part of the report was made up of a study of the sugar market and the taxation of sugar in Sweden, Denmark and Germany (Wetter, 1961).

The commission however triggered discussions about cartels in Sweden and the report was followed by a book written by an economist, analysing cartels and their effects (Ljunggren, 1912). The introduction to the book declared that limiting cartels reduced efficiency and thereby also welfare. Cartelisation was to be increased, especially in the export industries where cartels were not common (Ljunggren, 1912, p. 11). The book concluded that cartels and trusts were common in the Swedish industry, especially in the food and beverage industries. Despite possible cost reductions from cooperation, it was found that cartels often increased prices above the competitive level. The author however regarded it to be unfeasible to prohibit, and inefficient to nationalise, cartels and therefore proposed publication of the cartel agreements to induce self regulation (Ljunggren, 1912, p. 129). Since cartel registration was not introduced until 1946, the book was ahead of its time but had no contemporary effect on legislation, except for keeping the cartel discussion alive.

Hyper inflation in Europe during the 1920s increased the incentives for firms to join cartels since the cartels could protect the members from inflation by passing the cost increases over to customers (Gerber, 2001). Despite a growing concern in Europe that cartels were a problem, there was little hard evidence to support the claims, both regarding the scope and the magnitude of the problem. Cartels were not seen as inherently negative for society. This was reflected in the European cartel legislation of the 1920s, where cartels were not prohibited, but abusive conduct was regulated or prohibited. Unlike the US Sherman act, the early cartel legislations in Europe were effects based and economists played an important role in drafting the laws.

More like an experiment, the UK introduced the Profiteering Act in 1919 to control excessive prices following the first World War, but the act was discontinued already in 1921 (Prop, 1925:110). Germany introduced a law based on the principle of abuse in 1923 requiring cartel agreements to be in

[4]In a cartel decisions are made by independent firms, whereas a trust has a joint administration that directly or indirectly disposes of the joint assets.

writing and to be registered with an authority (Schwartz, 1957). Norway passed a competition law in 1920 that was aimed at controlling cartels, dominant companies and monopolies, followed by a more comprehensive law in 1926[5] based on the principle of abuse which required cartels to register.

Sweden experienced high inflation during the First World War, peaking at 47 percent in 1918. The hefty price increases renewed the interest in cartels and their effects on prices since it was believed the the inflation was partly caused by the cartels. To assess these claims, the government appointed a committee[6] in 1919, to analyse the extent and effects of monopolistic organisations (SOU, 1924:37). The committee concluded that all important sectors in the Swedish industry were affected by trusts or cartels. Despite considerable variations in the cartel agreements among industries, ranging from a complete trust in the sugar industry to agreements on sales conditions in the clothing industry, cartels were seen to charge high prices. Although foreign competition was found to reduce prices, the committee found examples of prices above the world market price (plus tariffs and transportations costs), caused by agreements between the cartels and firms exporting to Sweden. The committee was however not instructed to propose new legislation.

During the same time the economists were trying to understand the cartel dynamics and Ljunggren (1920) wrote a report discussing the effect of different types of cartels. According to the report, the least organised type of cartel was the condition cartel, where members did not agree on prices, but on auxiliary conditions such as credits, rebates and freight. Since members in such cartels still disposed of many means of competition, this type of cartel was regarded as fairly unproblematic.

Price cartels were seen as the most common type of cartel and were present on all levels of industry. They were however not seen as harmful since these cartels were regarded to be a temporary phenomenon that could only exist in a positive economic climate. In a negative climate it was believed to be too tempting for the firms to deviate from the agreement and produce and sell at full capacity. Production cartels on the other hand were believed to be enduring, since it would be harder to deviate from a pre-determined production level than a pre-determined price. These cartels were therefore potentially harmful, but the study deemed it to be so complicated to assign

[5] Trustloven

[6] The Duty and Treaty Committee (Tull- och traktatkommittén).

production quotas, that there should be few production cartels. Hence there was no need to worry about these cartels neither. Territorial cartels on the other hand were believed to be problematic and easily enforced, especially when transportation costs were high.

The Government appointed a commission[7] in 1920 to propose provisional legislation to investigate and control trusts and other monopolistic associations. Influenced by Ljungrens work it declared in 1921 that the existence of monopolistic associations, and their influences on prices and turnover, was of such importance that the state needed to take action. The commission hence suggested that a permanent authority should be instated to investigate the scope and effects of these associations and if needed, propose legislation. It also suggested that the new authority should inform the government if it found that or associations that used their position in a way that resulted in unreasonable prices (Trustlagstiftningskommittén, 1921).

Despite the concerns of high prices due to cartelisation, the commission also emphasised several positive economic features with cartels such as: efficiency caused by specialisation, diffusion of technology, standardisation and production planning. The overall effects on society were hence unclear and this was a main reason why no stricter legislation was proposed.

The industry opposed the commission's proposal since in their view, it condemned legitimate business practices in favour of an undefined consumer interest. The National Board of Trade was also critical and argued that cartelisation was caused by the industries' drive to improve productivity. As cartels were seen as natural and efficient institutions, the board claimed that fighting the development was inappropriate and futile (Prop, 1925:110). This reflects the belief that cartels were beneficial and that their power were to be used by society.

The law on investigation of monopolistic firms and associations[8] was a watered-down version of the commission's proposal due to uncertainties whether cartels were negative for society. Further, the scope of the cartel problem was unclear. The law only gave the government possibility to, on an ad hoc basis, investigate effects on prices or turnover from monopolistic firms or associations. Thus, the law had no sanctions. If the authority detected harmful

[7]The Trust Legislation Commission (Trustlagstiftningskommittén).

[8]Lag om undersökning angående monopolistiska företag och sammanslutningar (SFS 1925:223)

practices it was to suggest measures to alleviate the encountered problem. These measures included direct contact with the firms, making the report public, suspending or reducing duty rates or proposing new legislation, i.e. measures that were already at the disposal of the government. The general idea with the law was that control should prevent abuse. The legislation was intentionally weak since the positive and negative aspects of a law were still debated. The law was primarily seen as a first step to learn more about cartels (Prop, 1925:110).

The investigation law was no break-through for the fight against cartels in Sweden. It was instead a big failure and almost had negative effects on competition since proposals for new legislation could be countered with the argument that there already existed a law (Bernitz, 1969). In practice the law was only used to make a few industry studies: flour mills, yeast, sugar, porcelain, fuel and lubrication oil (SOU, 1951:27), and the studies did not result in any changes (Wallander, 1952).

With the Great Depression in the late 1920s the tolerance for cartels grew internationally and the World Economic Conference in Geneva 1927 stated that it was not possible to generally state if cartel agreements were good or bad (League of Nations, 1927). As a consequence of the lenient attitude and even state intervention to promote cartelisation, cartels in Europe increased in numbers and spread from raw materials and agricultural products to manufactured goods (Koch, 1945).

Germany introduced a new cartel law in 1933 according to which the government did not only have administrative controls over the cartels, but could also establish compulsory cartels or force outsiders to join already existing ones (Schwartz, 1957). Similar legislations to force outsiders into cartels were also enacted in Norway (1932), Italy (1932), the Netherlands (1935), Belgium (1935) and Denmark (1937).

The pro-cartel attitudes also spread to the US where cartels were made legal with the National Industrial Recovery Act[9], which was established to promote industrial recovery by reducing the fierce competition that was seen as the cause of the depression (Taylor and Klein, 2008). The Supreme Court had however already prior to the law found that joint sales agreements were not illegal.[10] To avoid bankruptcies and unemployment crisis cartels were

[9]Lasting between June 1933 and May 1935.

[10]Appalachian Coals, Inc. v. United States, 288 U.S. 344 (1933).

formed, several of them lasting until the 1940's (Buch-Hansen and Wigger, 2011).

There were no legal changes in Sweden due to the depression, but it was discussed whether the government should take a neutral stand or actively promote cartelisation, for example by legislating that non-cartel members could be forced into an industry cartel (Bernitz, 1969). An official report from 1935 stated that there should be more cartel activity than the firms had taken initiative to themselves, and that the state should assist in achieving this objective (SOU, 1935:65). The purpose was to increase the productive efficiency and reduce costs by concentrating production, promoting specialisation and using wide regulations. Cartels were also seen as a way to control supply and demand. The main arguments for compulsory cartels were hence economic.

In 1939 the Swedish government proposed legislation on compulsory cartels and prohibition of new establishments (Prop, 1939:58) but the parliament and the industry turned against it, and the proposal was rejected.

In order to understand more about the cartels and their effects, a committee[11] was appointed to analyse the extent of organised cooperation between private firms and assess how cooperation affected prices, production and distribution policies. The comprehensive report on organised cooperation in the Swedish industry, published in 1940 (SOU, 1940:35), found that 39 percent of all production for the Swedish market was covered by cartels.

In an attempt to measure the effect of the cartels, the committee analysed specific restrictions of competition and compared profitability in cartelised with profitability in non-cartelised industries[12]. The analysis was based on a sample of eight industries where four were considered to be cartelised and four to be non-cartelised industries[13]. The committee found that cartelised industries (margarine, cement and wallpaper) had significantly higher profitability than non-cartelised industries (shoe and furniture industries)[14]. This was the first quantitative evidence suggesting that cartels had harmful effects. But

[11] Industry organisation experts (1936 års näringsorganisationssakkunniga)

[12] Annex 1 by Sune Carlson

[13] The cartelised industries were: cement, margarine, wallpaper and fine paper. The non-cartelised industries were: cotton fabric, tricot, shoes and furniture.

[14] The profitability was analysed over 10 years to cover all phases in an economic cycle and make the result less dependent on accounting measures.

since the report was completed only after the Second World War had started, the commission did not propose any legislation.

The inter-war interest in cooperative structures was actualised by the hyper-inflation in the 1920s. The cartels were blamed for causing the inflation, and the inflation also spurred new cartels to form. But, the theory of harm was weak, and while it was believed that the cartels had negative price effects, they were also seen to be efficiency inducing. With the mixed messages the Swedish government dismissed the idea of a permanent authority to investigate cartels and decided on assessments in individual cases. During the depression the attitude radically changed and cartels were promoted to stabilise the economy. The benevolent treatment of cartels continued during the Second World War.

2.2 Post World War II: Change of attitude

After the Second World War competition enforcement intensified in the western world. Enforcement had been lenient in the US since the 1930s (Motta, 2004, p. 6) but in a series of decisions the Supreme Court concluded that not only horizontal price-fixing[15] , but also group boycotts[16], tying arrangements[17], divisions of markets[18], minimum[19] and maximum[20] prices, resale price maintenance and territorial exclusivity[21] was to be considered per se illegal.

There was no common competition policy in Europe, but following the allied victory, the US was promoting a tougher stance on cartels also in Europe. This was facilitated by the economic boom in the 1950s-1960s that reduced the need for cartels. Since German cartels had been central in the Nazi war machinery the US wanted to dismantle them, an objective stated already in the Potsdam agreement.[22] A provisional prohibition of cartels was therefore

[15]United States v. Socony-Vacuum Oil Co., 310 U.S. 150 (1940).
[16]Klor's Inc. v. Broadway-Hale Stores, 359 U.S. 207 (1959).
[17]International Salt Co. v. United States, 332 U.S. 392 (1947).
[18]United States v. Topco Assocs., 405 U.S. 596 (1972).
[19]United States v. Parke, Davis & Co., 362 U.S. 29 (1960).
[20]Albrecht v. Herald Co., 390 U.S. 145 (1968).
[21]United States v. Arnold, Schwinn & Co., 388 U.S. 365 (1967)
[22]"At the earliest practicable date, the German economy shall be decentralized for the purpose of eliminating the present excessive concentration of economic power as exem-

in place in 1947. The UK was also influenced by the harder stance on cartels, but prohibition legislation was rejected in favour of a control of abuse system under the Monopolies and Restrictive Practices Act (1948). The reason for the softer approach was that although cartels could exploit their position, it was unclear if they in practice were exploitative (Harding and Joshua, 2003). The focus on economic effects hence suspended tougher legislation.

In Sweden the question of cartel legislation was given to a commission appointed to forecast and develop the post-war economy[23]. Their report was brief and suggested that the first step should be registration of cartels in a public register (SOU, 1945:42) to further understand the scope of the cartel problem. Their suggestion was codified into the law on monitoring of restraints of competition,[24] passed in 1946. Despite previous evidence that cartels were important and potentially had harmful effects there was no call for prohibition. Monitoring seemed like a good option since the effects of cartels was not clear and no other European country had introduced cartel legislation.

The purpose of the register was to map the extent of anticompetitive agreements, but more importantly, to act as a deterrence mechanism by making the cartel agreements public. The general idea was that with a public register firms would enter into fewer new agreements and they would cancel existing agreements. The cartel problem was hence to be solved with self-regulation.

The monitoring law only gave the authorities power to run the register and to perform investigations, hence there was no possibility to ban a specific behaviour or agreement. Anticompetitive agreements were not seen to merit intervention by themselves. But if agreements were abused, general public measures such as forced re-negotiation of agreements, should be taken. As a last resort, the government could increase or decrease duty tariffs, start competing public firms or simply take over one or several firms. The commission did however not expect any form of government intervention to be common (SOU, 1951:27). In fact there are no reports of the measures being used.

The idea of monitoring cartels was not unique to Sweden and several countries had introduced similar registers almost two decades earlier for example

plified in particular by cartels, syndicates, trusts and other monopolistic arrangements." Article II B 12 of the Potsdam agreement.

[23]Kommissionen för ekonomisk efterkrigsplanering.

[24]Lag om övervakning av konkurrensbegränsning inom näringslivet (SFS 1946:448).

Norway (1926) and Denmark (1937), and the UK (1956) and Finland (1957) followed (Berg, 2011). The registers were largely aimed at making the cartel agreements known and publicity remained an important feature of the Western European antitrust legislation for many years (Thorelli, 1959).

According to the Swedish monitoring law, all firms, or associations of firms, were obliged to, upon request by the registry, notify if they had entered into any anticompetitive agreements. Mandatory registration, as was later the case in Finland (Fellman, 2010), was discussed but dismissed since that it was believed that the authority would be buried in notifications and inquiries (SOU, 1945:42). If firms did not notify an agreement, they could be punished with fines, or in considerable aggravating circumstances, by imprisonment up to six months.

The legislation did not define what constituted an anticompetitive agreement and no assessment was made of individual agreements before they were registered. This resulted in a register that soon consisted of agreements with very different effect on competition (Berg, 2011).

The introduction of the register had at least the intended effect that it started a debate on the merits and disadvantages of anticompetitive agreements and cartels. As a response to the critique directed at the industry, the Swedish Industry Association introduced a cartel office to advice cartels to cancel or modify their cooperation (SOU, 1955:45). The office focused on cartels that potentially could have important effects on the market price, such as market sharing and price cartels.

2.3 The 1950s - 1960s: Restricting cartel abuse

During the 1950s and 1960s competition enforcement in the US was very active and private suits for cartel damages increased rapidly (Freyer, 2006). The strict competition enforcement was influenced by the Harvard School's economic thinking. According to the centrepiece of the ideology, the Structure-Conduct-Performance paradigm (Mason, 1939), market performance could be affected by changing the market structure, for example using antitrust policy and regulation.

Inspired by the same ideology, the foundations to competition enforcement were being laid also in Europe, with the purpose of strengthening the industry by eliminating cartels and reducing concentration. The first common

cartel legislation came into force with the Treaty of Rome establishing the European Economic Community, effective in 1958, and its predecessor the Treaty of Paris[25] from 1951. Article 85 of the Treaty of Rome prohibited all cartels and restrictive practices with the object or effect to prevent, restrict or distort competition within the common market. These treaties were a major departure from previous national legislation since they prohibited cartels with the possibility of sanctions where the national legislations in practice only prohibited abuse. Further, the Treaty of Rome transferred legal power to a supranational authority[26] (Harding and Joshua, 2003).

Although legally it was sufficient to show intent, the European Commissions early cartel investigations relied on economic analysis of the effects, even in price fixing agreements.[27] The reason for undertaking complex assessments on effects, rather than relying on the state of mind of the firms, as in the US, was the inherent belief that all cartels were not bad, and that only harmful conduct should be banned.

Despite appearing like a per se prohibition, the European legislation contained exemptions for agreements that contributed towards improving the production or distribution of goods or promoting technical or economic progress and where the consumers would receive a fair share of the benefits (Art. 85.3).[28] Thus a complex balancing process was instituted also for cartels, following a rule of reason approach (Scherer, 1994, p. 35).

Cartel enforcement in Europe was weak in the 1960s and the European Commission investigated a handful of cartel cases in the 1960s without fining any of the members. In fact several of the cartels received negative clearance. The first real hard-core cartels were Quinine and Dyestuffs cases, both from 1969 (Schinkel, 2007).

Contrary to the principle of prohibition and the common European competition legislation (ECSC and EEC)[29], most European national legislations were based on the principle of abuse. For example, the UK introduced the Restricted Trade Practices Act in 1956 that required all restrictive agreements to be registered, irrespective of their effects. Even though restrictive agree-

[25] Article 85 of the Treaty of Rome was modelled after Art. 65 in the Treaty of Paris.

[26] Enforcement was based on Regulation 17/62 which assigned the European Commission as supranational competition authority.

[27] For example se Manufacturers of Glass Containers (IFTRA), 74/292/EEC OJ L 160/1.

[28] Now article 101.3 of the Treaty on the Functioning of the European Union.

[29] European Coal and Steal Community and European Economic Community

ments were not prohibited but subject to a harm analysis, the majority of the agreements were cancelled in the 1960s by the Restrictive Practices Court (Symeonidis, 2002). As such, the national legislations focused on the effect rather than the intent, and this made enforcement hard (Thorelli, 1959). Germany was the exemption and cartels were prohibited in 1957, but could be exempted by the Federal Cartel Agency.

Swedish industry was heavily regulated and especially the governmental price control was seen as an obstacle for competition and price reductions. The industry called for reforms and wanted the price control to be reformed or abolished and proposed that inflation should be fought with competition rather than with price controls (SOU, 1951:27). As a further benefit competition would in the long run also assure that Swedish companies were prepared for international competition (Martenius, 1965).

To promote competition a committee[30] was appointed to analyse restrictions on establishment, specific inappropriate practices (such as boycott, exclusive dealing and price differentiation) and propose new legislation. The commission found that the extent of the private restraints on competition was worrying, based on a number of case studies (SOU, 1951:27)[31]. Despite a reduction in the number of active anticompetitive agreements following the cartel register, it was uncertain if the trend of fewer cartels was going to continue. According to the committee, it was unlikely that even half of the harmful restraints were removed. It concluded that the government was obliged to protect the society against harmful practices.

There was a debate on the need for cartel legislation as all industries were subject to price regulation. The committee stated not only that price regulations were ineffective, but also that cartels caused costs to inflate - a problem not caught with price regulation (SOU, 1951:27). Since it had not been proven that cartels generally increased prices, the focus on costs and inefficiencies became the main theory of harm.

The committee's proposal was radical and rested on two innovations. First, there should be a presumption of harm from cartel agreements regarding prices, bids or market shares. The assumption rested heavily on inefficient production. The presumption was to be able to be refuted (hence it shifted the burden of proof) or revoked if the cartel generated savings that came to

[30] New establishments experts (Nyetableringssakkunniga).
[31] SOU 1951:28 contained many of the cases.

the benefit of consumers (SOU, 1951:27, p. 547). Second, an independent authority that could impose binding measures was proposed. Violations of the measures should be settled in civil court.

The committee was heavily criticised on almost all grounds and the critique came from business organisations as well as public authorities and the justice system. The National Board of Trade[32] and the Board of Price Controls[33] were in favour of a stricter cartel legislation, but preferred individual assessment (Prop, 1953:103, p. 80). The court of appeal[34] was very critical, both to the structure and the content of the proposal. It stated that the freedom of contract was normally given priority over freedom of trade, implying that all agreements should be respected by the courts. It also claimed that the effects of free competition, where firms face cut-throat competition, would be unfavourable for the industry (Prop, 1953:103, p. 84).

Also economists were critical to the proposal and six of them wrote a report focusing on the cost side. They argued that most cartel agreements, including price agreements, were positive for society since they resulted in cost reductions and hence lower prices. If the cartels increased prices, the members would be able to undertake technical or economical development to reduce costs, that they otherwise would not have been able to do (Brems and Wallander, 1951, p. 44). Market sharing and territorial allocation were, at least in the short run, seen as positive since it reduced sales and transportation costs. In the long run, production restrictions were however believed to hinder the expansion of efficient firms, and to keep inefficient firms alive (Brems and Wallander, 1951, p. 92). The authors were therefore more sympathetic to strict regulation on this type of agreements. But they concluded that, rather than relying on general prohibition, there should be an individual assessment of the effects of an agreement. The authors did however not touch upon the issues raised by the committee, that cartel members became inefficient.

The legislators were in a difficult position with on the one hand, more than 1,100 registered cartel agreements in 1953, of which more than half were operational (Modin and Sandberg, 1958) and a commission proposing cartel prohibition. On the other hand, industry, public authorities, economists and the legal system claiming that the proposal was too far-reaching. New

[32]Kommerskollegium
[33]Statens Priskontrollnämnd
[34]Svea Hovrätt

legislation was needed and in 1953 the law against restraints on competition[35] was passed.

The general prohibition principle was rejected with reference to the fact that there were no examples of well functioning cartel prohibition in Europe (Prop, 1953:103, p. 97). As most national cartel legislations in Europe, the law was based on an abuse principle where enforcers should intervene first when restrictive practises were abusive, i.e. a weak form of rule of reason. The law defined two distinct cases in which an authority should intervene;

- cartel cases: agreements between independent firms on a specific conduct, and
- monopoly cases: behaviour by a firm that had a large share of the market.

The two most important concepts in the law were "restriction of competition" and "harmful to society". The law did not define what constituted a restriction of competition as it was deemed impossible to give a fully covering definition. Any definition would therefore be so weak that it would not provide any guidance (Bernitz, 1969, p. 156).

According to the new law, increased concentration or restriction of competition was by itself not regarded as negative since there were examples where concentration or strong restraints had led to rationalization to the benefit of consumers. This was a result of the economists being influential in the drafting. This had the result that the legal status of agreements therefore depended solely on their effects (Gerber, 2001) and little regard was given to purpose or intent.

Due to the focus on economic effects, the concept of harmful to society was central. It referred to a restriction of competition that: 1) affected pricing in an abusive manner, 2) restricted operations within the industry, for example by hindering technical of economic development or, 3) hindered or discouraged other firms' operations.

Since the new law was heavily influenced by economics, all three criteria for harm had an economic foundation. Whereas the first criteria focused on the

[35]Lagen om motverkande i vissa fall av konkurrensbegränsning inom näringslivet (SFS 1953:603)

lack of static competition (the price argument), the purpose of the two following ones was to improve dynamic competition, i.e. to improve the competitive environment. The second criteria aimed at improving market efficiency by encouraging improved production and distribution methods (Gerber, 2001). With more innovation, competition would increase. The third criterion was intended to facilitate market entry, i.e. the competitive process. By allowing more efficient firms to enter on equal terms competition would increase. The main targets were practices such as group boycotts, exclusive dealing and discrimination, primarily by a dominant firm (Prop, 1953:103, p. 119). Long-run effects were hence given a lot of weight in the enforcement (Gerber, 2001, p. 81). This suggests that the theory of harm shifted from the belief that cartels made large profits due to high prices, which had not been empirically verified, to their negative effects on the cost side. It was believed that neglect of rationalisations and keeping inefficient plants alive were causing the most severe harm to society (Wallander, 1952).

In the preparations of the law there was an intense debate on how to measure harm, or even more difficult, a risk of harm, on prices and efficiency. Due to the complexities in assessing costs the discussion still focused on prices. Several of the consulted institutions maintained that it was practically impossible to assess what the prices would have been without a cartel. But the government proposal declared that effects should be measured by comparing if prices, from an accounting perspective, were high compared to the costs in an efficient operation. If there were both efficient and inefficient members of a cartel, comparisons should be made with the efficient firms. It was however also important to incorporate the business risk in the analysis and allow a profit margin for mergers, rationalizations and research and development in the calculations (Prop, 1953:103). In practice price/cost comparisons became the tool to asses harm (SOU, 1978:9, p. 96) and the enforcement relied on a highly pragmatic use of the Harvard school theory. If the authority found restrictive practices where the harm outweighed the benefits, it was to eliminate the negative effects by negotiation .

Two new authorities were created to handle the abuse cases; the Competition Ombudsman[36] and the Free Trade Council[37] (that later became the Market Council and finally the Market Court). The Ombudsman was the investigative authority that competition called for negotiations after finding harmful

[36]Näringsfrihetsombudsmannen
[37]Näringsfrihetsrådet, later Marknadsrådet and Marknadsdomstolen

restrictions of competition. The role of the Free Trade Council was to decide if the restriction of competition was actually harmful to society. Since the Council consisted of lawyers, economists and representatives for consumers and the industry, its assessments were respected in the industry and half of all cases were settled with negotiations (Trolle, 1963). If a restriction was found to be harmful it was the Ombudsman's task to try to eliminate the harm through negotiation (the negotiation principle).

The ombudsman had no enforcement power but if negotiation failed in an important case, this was to be reported to the government. However the government had no authority to intervene in individual cases and could therefore only use its general powers, i.e. to change customs duties, start public enterprises or legislate.

The law did however also contain two prohibitions. Resale price maintenance and tender cartels were outright banned since these practices were seen (in general) to have a harmful effect on competition. For resale price maintenance the logic was that competition between retailers would soften if suppliers were free to set retail prices and tendering cartels were presumed to increase prices. The prohibition against tendering cartels was geared towards bidding rings that were common mainly in the construction industry. The rings were known to secretly negotiate bids prior to the tender and the prohibition principle was hence derived from a strong presumption of harm. Those who violated the prohibitions against resale price maintenance or tender cartels could be punished with fines, or if the crime was serious, with incarceration up to a year.

Firms could however apply for exemption from the prohibitions. Exemptions could be approved if the restriction of competition was presumed to reduce costs, and the consumers could be expected to receive a fair share of the resulting benefits or the agreement contributed to the good of the society, or if there were other specific reasons to allow an exemption. The purpose of the exemption procedure was to verify that the presumption was holding in individual cases. In most occasions the assumption was found valid, and only in a few cases was exemption granted (Prop, 1981/82:165). Most of the exemptions during the first 10-years regarded resale price maintenance (most of them denied) and in two cases the prohibition of tendering cartels which were both approved (Näringsfrihetsrådet, 1965).

Since the industry was both subject to price control and competition legis-

lation prohibiting abusive behaviour, a commission was appointed to assess whether public price control was still necessary.[38] It found that competition was a more efficient price regulator than any form of public price control. The economy was considered to be too complex for an authority to fully understand and while the government should not totally refrain from price regulation, it should under normal circumstances rely on competition (SOU, 1955:45).

The commissions work resulted in set of new laws[39] extending the law against restriction of competition so that negotiation for contract changes could be initiated for all forms of restrictive practices, not only cartel and monopolist cases. At the same time a new provision was introduced that allowed the government to temporarily determine a maximum price on a good. This provision could be used when a restrictive practice had been found to lead to too high prices.[40]

The purpose of the reforms was to eliminate the price control by 1) monitoring the prices to evaluate if competition was a sufficiently strong price regulator, 2) acquire information on prices to increase consumers price awareness and 3) get more power to intervene against anticompetitive agreements.

With the legislation in place, the government was overall pleased with the competition in the private sector despite the cartel register containing more than 1 700 agreements in 1957 (Modin and Sandberg, 1958), and no new laws were proposed during the 1960s (SOU, 1961:3).

During the 1950's and 1960's cartels were common in the industry. Since large price increases had not been found, the theory of harm shifted over to the cost side. Economists favouring individual assessment of harm were influential and the law was effect based. There was a strong belief in the precision of economic analysis and the comparisons needed to measure harm required an advanced methodology. But in practice it proved difficult to measure effects.

[38] Price control investigation (Priskontrollutredningen).

[39] SFS 1956:244-246

[40] The monitoring law was replaced with the reporting law (lag om uppgiftsskyldighet rörande pris- och konkurrensförhållande, SFS 1956:245) and the price regulation law was changed to the general price regulation law (Allmänna prisregleringslagen, SFS 1956:236).

2.4 The 1970s - 1980s: Transition period

As a reaction to the interventionist Harvard School, the US competition enforcement in the late 1970s and 1980s was influenced by the Chicago School (van Cayseele and van den Bergh, 2000). The Chicago school focused on efficiency and the market structure itself was irrelevant. Even a monopoly was regarded as efficient since it must be more efficient than other firms to keep the position (Voigt and Schmidt, 2005). If a firm could increase prices, the Chicago School argued, the effect would usually only be temporary since high profits would attract new entrants and the competitive response would restrain market power faster than would antitrust intervention. The Chicago School did however not want to abolish competition policy altogether but argued that horizontal agreements should be prohibited (Voigt and Schmidt, 2005). The Chicago School questioned the many rules of per se illegality and argued that many of them were harmless or even pro-competitive. Despite the Chicago School the number of cartels prosecuted in the US increased during the 1980s. By the end of the decade a leniency program was introduced in the US with the purpose of destabilising cartels by providing an incentive to leave the cartel.

In Europe, inflation and unemployment was rising in the 1970s and competition policy was given less priority at a national level. As a result the cartel legislation was not strictly enforced in for example France and Germany (Buch-Hansen and Wigger, 2011). At the Community level the development was two-fold. From the mid 1970s the European Commission increased the number of cartel decisions to roughly four cases a year (Schinkel, 2007). But, at the same time it allowed for more lenient treatment of cartels, especially in the case of crisis cartels. These were cartels to reduce competition by restricting overcapacity in crisis industries. Despite these cartels being relatively few, the Commission developed conditions for when the exemption should apply (European Commission, 1982). Economic arguments were hence used to define when cartels were legal. The lenient stance against cartels was overturned in the mid 1980s and the cartel prosecution became more stringent (Buch-Hansen and Wigger, 2011).

In the 1970s litigation in the European cartel cases was limited, but this was to change. With a growing number of cartels prosecuted by the European Commission in the 1980s, the cartels started to appeal the Commissions' decisions. In many of the appealed cases there was no doubt to the question of

collusion - the appeals were based on procedural issues (Harding and Joshua, 2010). These appeals led to major reversals for the Commission during the late 1980s and beginning of the 1990s. As a result the European Commission changed enforcement strategy (see next section).

In the 1970s Sweden, both inflation and industry concentration were raising rapidly. This motivated the government to establish several commissions to study the effects of concentration (Holmberg, 1981, p. 46). Contrary to the approach in the 1920s and the motivation in the competition law from 1956, Sweden decided to counter inflation using extensive price regulation instead of competition. Hence the Price and Cartel Board[41] was instructed to intensify the monitoring of prices and margins. By resorting to price regulation, there was less need for active cartel enforcement and price controls remained an important tool to fight inflation until the 1990s (OECD, 2006).

In 1978 a commission[42] directed to review the effectiveness of the competition statutes proposed a new law (SOU, 1978:9). Although the structure of the proposal was similar to the law against restraints on competition, with few defined prohibited practices and an abuse principle for all other practices, the proposal included strong reinforcements of the law.

The commission proposed to prohibit price and market sharing cartels (besides the already prohibited tender cartels) and to increase the definition of tender cartels[43]. Strong revisions were also proposed for the abuse cases where the commission suggested that the negotiation principle be replaced with prohibition and a system of fines and injunctions to improve speed and efficiency of the enforcement.

The main motivation to the proposed changes was to prevent the harmful effects of cartels. Despite the strong price control cartels were believed to increase prices. In fact, several cartels were set up with the purpose of influencing the price control board (Berg, 2011). The theory of harm was a combination of price and inefficiency effects. Cartels were seen to protect inefficient firms by establishing high prices, and as giving rise to large profits for efficient firms. Reduced competition was also seen to hinder much needed structural reforms.

The report created substantial controversy in both government and industry.

[41] Statens pris- och Kartellnämnd
[42] Competition investigation (Konkurrensutredningen).
[43] Non-binding consultations between the firms was proposed to be illegal.

The Swedish bar association claimed that prohibiting price cartels would not guarantee sufficient legal certainty and the industry argued that the law would be unpredictable and that exchange of price information was in fact pro-competitive. The industry also asserted that prohibiting market sharing could reduce efficiency-inducing cooperation that enabled the members to rationalise production, avoid over-investment and reduce distribution and marketing costs (Prop, 1981/82:165).

Due to the objections, many of the novelties were rejected in the legislative proposal with the motivation that it would be impossible for firms to know if a specific practice was illegal or not. The scope of the proposed prohibitions and exemptions were not precise enough to fulfil adequate requirements on legal certainty (Prop, 1981/82:165). The legislators feared that firms would either apply for exemption for many agreements or refrain from a practice that could have positive effects on competition. The exemption applications would burden the administrative system and reduce the possibilities of fast and efficient intervention against restrictive practices that generated real harm. Instead of discussions on the scope of cartels and their harm, focus was hence shifted to legal certainty, administrative burdens and problems with identification or restrictive agreements.

The first competition law[44] was therefore, just like its predecessor, based on the principle of abuse. The previous definitions of harm were transferred into the new law, and economic analysis was still an important part of the enforcement. Harmful restrictive practices were to be eliminated by negotiation but an important change was that the Market Court was given authority to ban practices, and order injunctions if negotiations failed (SOU, 1991:59). The new law made negligence criminal under certain conditions and increased the punishment for tender cartels to up to two years incarceration since the purchaser would not realise that competition was eliminated. In practice, no one was ever convicted to jail, but there were in total as around ten cases where fines were imposed (SOU, 2004:131).

At the end of the 1980s inflation was increasing again. But, instead of resorting to price control as had been the case a decade earlier, the focus was on increasing competition especially in protected sectors. Competition was to be improved by lowering lowering entry barriers and deregulation therefore

[44]SFS 1982:729

became one of the top priorities[45].

In the beginning of the 1970s the industry was price controlled, and the effects of cartels were therefore believed to be small. But by the end of the century cartels were found to increase prices and the theory of harm was based both on price and efficiency effects. A legal proposal prohibiting cartels was rejected and the effects-based legislation continued into the 1990s. It was no longer questions of the effects of cartels that halted the legislative development, but legal doubts.

2.5 1990-2010: 'Per se' prohibition of cartels

The 1990s and the beginning of the century marks an active era in competition enforcement. From the 1990s to the turn of the century the US led the fight against cartels but radical changes were going on in Europe. The European Commission increased fines for cartels who as a result started challenging the Commissions decisions (Rodger and MacCulloch, 2009). As a response, the Commission started to rely more heavily on the intent of a cartel agreement, rather than performing complex and refutable economic assessments of the effects.[46] In doing so it approached the US enforcement practice of per se prohibition.[47] The Commission declared that for example price fixing[48] and market sharing[49] cartels had anticompetitive objects, so it was not necessary to demonstrate effects on competition. The change in enforcement, from effect to object based, rendered economic arguments that could justify cartel behaviour invalid. As a result, economic testimony on effects lost relevance (Harding and Joshua, 2010). The Commission also introduced a US style leniency program in 1996 to improve the anti-cartel enforcement.[50]

The changes on EU level were transferred to the national legislations since most European countries replaced the national competition legislation based

[45] From the directive to the committee on stronger competition policy

[46] E.g. Polypropylene, Commission decision 86/398/EEC (1988) OJ L 230/1

[47] In 2001 the European Commission declared that it can be presumed that price fixing and output limitation have negative market effects and are therefore almost always prohibited

[48] Vitamins, Commission decision 2003/2/EC (2003) OJ L 6/1

[49] Seamless steel tubes, Commission decision 3003/383/EC (2003) OJ L 140/1

[50] Revised in 2002 and 2006

on the abuse principle with cartel prohibition by resembling Art. 85 in the Treaty of Rome, during the mid 1990s.

Sweden applied for membership in the European Union in 1991 and in the accession procedure OECD and the European Commission commented on the lack of competition and the need for stronger competition legislation. Such changes were however already on the way. In 1989 a committee was appointed to assess how the competition had changed during the last decade and the importance of competition on general economical and political objectives (SOU, 1991:59).

The committee stated, just like a contemporaneous committee focusing on productivity,[51] that lack of competition was an important factor explaining the low productivity growth in Sweden during the preceding two decades. On behalf of the committee, the Price and Competition Authority analysed 61 industries and found that competition was weak in most of them (SOU, 1991:28). While the committee declared that the competition law had not been able to stop anticompetitive agreements, it still proposed legislation based on the principle of abuse but added prohibition of price and market sharing cartels. Legislations with this structure were at the time introduced in Finland, Denmark and Norway.

Due to the critique of the proposal and Sweden's coming accession to the EU, the department of industry rejected the proposal and presented a new proposal, based on the European competition rules (DS, 1992:18).[52] By fully incorporating the European competition law, Sweden went further than any other European country in the process of integrating competition legislations across Europe (Gerber, 2001).

In the new competition law[53] all anticompetitive agreements were prohibited.[54] This was a shift towards legalistic treatment of cartels from the economic assessments that had been in place from the 1950s. Since the fines in the previous legislation had been small and were found to have a negligible effect on cartel behaviour, breaches against the new law were going to result in higher fines to increase deterrence. At the same time imprisonment was removed since it was not seen as appropriate (Prop, 1992/93:56). Despite

[51] Produktivitetsdelegationen (SOU, 1991:82).

[52] There was however no requirement on harmonised legislation.

[53] SFS 1993:20

[54] There were however possibilities for exemption from the prohibition, just like under the EC legislation.

the important change from abuse to prohibition principle, the Market Court stated that the application of the law, would to a large extent, remain the same (Prop, 1992/93:56). With the new competition law, the cartel register was closed down in 1993, containing 1,250 active agreements.[55] Almost half of these cartels were active in the industrial sector and most of them were located in the food and drinks, metal and chemical industries (Berg, 2011).

The transition to prohibition was not easy and critics claimed that it was inappropriate to import EU legislation, that the law was unpredictable and that the legal development would be in the hand of the competition authority (SOU, 1997:20). The competition authority was also criticised for being over-ambitious. A committee[56] was therefore instated to assess the effect of the law, already after two years. It concluded that there were no good economic instruments to evaluate the competition law and that any evaluation had to be done in the long-term perspective (SOU, 1997:20). While questioning whether it had been a wise move to implement the European competition rules, the committee only proposed some administrative changes to improve enforcement.

This was however not the end of the scepticism, and in the beginning of the 2000s another committee was appointed to assess the efficiency of the competition legislation in Sweden[57]. They found that the Competition Authority had only filed for fines in 13 cases and the majority of these were not cartels. The outcome was a result of the deliberate choice by the Competition Authority to focus on the cases of clearance and exemption filed at the Authority with the introduction of the law (SOU, 2001:74).[58] By the end of 1993 the competition authority had received 900 applications for negative clearance or exemption and the authority was using these to set precedence.

Most of the exemption cases from 1993 had been handled by 1995 (SOU, 1997:20, p. 430) but enforcement was limited throughout the 1990s. The competition authority suddenly intensified the cartel enforcement and produced six cartel decisions between 2000 and 2004 . However, an OECD report

[55]Most of these were however not cartel agreement but other types of agreements restricting competition, such as exclusivity contracts and non-competition clauses ancillary to mergers.

[56]The Competition law investigation (Konkurrenslagsutredningen).

[57]Kartellbekämpningsutredningen

[58]By the end of 1993, 900 cases of negative clearance/exemption, was filed at the competition authority SOU 1997:20).

in 2004 still concluded that the cartel enforcement in Sweden was ineffective. To deter cartels, the competition authority and the courts needed to improve cartel detection and prosecution and fines needed to be higher (OECD, 2004). The authority's litigation was regarded a major source of inefficiency and an external evaluation stated that the authority's full or partial success rate of 54 percent, compared to the European Commission's rate of 75-85 percent, was insufficient to ensure an efficient anti-cartel enforcement. In more than 50 percent of the lost cases, the court did not agree with the authority's interpretation of the law and in 30 percent the facts and market conditions were insufficiently investigated (Simonsson, 2005).

While the new law prohibited cartels per se, the competition authority partly still operated under an abuse principle where it sought to illustrate the effects of the cartels it prosecuted. This had been the main legal approach since 1953. In its first large hard-core cartel case (petroleum), the competition authority therefore partly relied on the effect of the cartel, instead of on intent. The strategy was unsuccessful due to the difficulties of prove actual effects from a cartel. In the appeal to the Market Court, the Competition Authority dropped the claims of actual price effects and relied on the intent to fix price.

Effects analysis continued to be an important issue in the Asphalt and Volvo retailer cartel cases where defendants presented economic and econometric evidence that prices had not increased due to the cartel. In the Volvo case Stockholm City Court concluded that the scope for competition between the accused firms was so small that the practice was seen not to have a significant effect on competition and the case was dismissed. The economic arguments were however refuted by the Market Court upon appeal by the competition authority. The Market Court concluded that the case was based on an anticompetitive purpose, not effect and findings that the behaviour had no effect on prices should not reduce fines.[59] The same conclusion was reached in the Asphalt case where the Market Court rejected arguments that fines should be reduced if no harm had occurred.[60] These decisions marked a new era in Swedish antitrust enforcement. From focusing on the effects for 50 years, the enforcement had become legalistic and effects arguments were dismissed. The role of economics in the legal process has therefore decreased. Economic arguments are however still important and the courts

[59]Marknadsdomstolen, Dnr 2008:12
[60]Marknadsdomstolen, Dnr 2009:11

employ economists to work on the cartel cases.

During the 2000s, there were continuous legal reforms to ensure that Swedish competition law was in line with EU development. In 2001 the competition authority was authorised, and in 2004 obliged, to apply the competition articles in the European Treat. A national leniency program was instated in 2002 to improve the effectiveness of the enforcement.

In 2004 a committee was appointed to analyse the efficiency of the enforcement of the Swedish competition legislation and to focus especially on cartels (SOU, 2006:99). The report concluded that overall the enforcement system was well functioning and therefore only proposed minor amendments. Interestingly the 744 page long report does not mention the negative cartel effects that the legislation is aiming to stop. The theory of harm hence seems to be lost.

The new competition law was introduced in 2008[61] and contained two novelties regarding cartel enforcement. First, the Competition Authority can issue fine orders. If cartel members consent to the order, no further formal proceedings are undertaken. Second, the Authority can issue trading prohibitions against individuals in a cartel firm, prohibiting them from for example founding a firm or acting as a chief executive officer.[62]

The 1990s were a transitional period for Swedish cartel enforcement. The abuse principle that had been used for 40 years was replaced with prohibition. During the first years of the 21th century the Market Court concluded that economic analysis that had traditionally been a crucial aspect of the evaluation of harm under the old legislation, had little or no place under the object based prohibition legislation.

3 Discussion

In the period leading up to the Second World War, the theory of cartel harm was weak. Cartels were believed to increase prices but also to generate cost reducing efficiencies, the net effect was therefore unknown. During the depression cartels were seen as positive stabilising factors. During the interwar period, the extent of cartelisation in the industry was unknown and

[61] Konkurrenslag (2008:579).
[62] Lag (1986:436) om näringsförbud

active legislation was not introduced. After the war, cartel legislations that banned abusive behaviour started to appear in Europe. In Sweden the laws were based on economic foundations and required advanced assessment of cartel harm using counterfactual analysis. The law was therefore difficult to apply. Since cartels had not proven to lead to higher prices, the theory of harm was shifted over to losses in efficiency. This influenced the legislation introduced in the 1950s that focused on achieving efficiency, both static and dynamic.

In the mid 1970s cartels were again accused of causing inflation. The theory of harm was again that cartels increased prices. Despite proposals to prohibit cartels, the main provisions of the law were kept unchanged. The main argument against prohibition was that the law would not ensure legal certainty. The doctrinal change came with cartel prohibition in 1993. Sweden copied the provisions in the Treaty of Rome and hence got a legislation where cartels were prohibited by objective, not by effect. However, still ten years into the new law, both the competition authority and firms argued according to effects of the cartel. The Market Court, which is the court of last instance, finally declared that effects analysis was irrelevant in cases where the behaviour is prohibited by object.

From having shaped the cartel legislation during half a decade, effects analysis was largely excluded in the cartel enforcement. The reason for this change was that economists identified large price effects from collusion and cartels can therefore be presumed to have adverse effects on competition, without requiring a case by case analysis. The harm cartels cause are therefore no longer part of legislative proposals. The fact that the presumption cannot be lifted if proven invalid, suggests that the basis for the Swedish cartel legislation has changed fundamentally. The view of cartels is now much more related to the US treatment, where cartels by nature are bad for society. This is a visible contrast to the previous legislations when cartels were viewed as economic institutions, possible of causing harm.

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Cartel damages when costs are asymmetric

Petter Berg[a]
Copenhagen Business School

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Abstract

An important standard assumption in traditional collusion models is that firms have symmetric costs. Harrington (1991), using a two-firm model, relaxed this assumption and investigated how cartel stability and prices are affected by cost asymmetry. With more than two members the strategies become more complex since in addition to standard unilateral deviation, the asymmetries allow efficient firms to deviate jointly into subcartels. Any cartel needs to be stable to both kinds of deviation. For large cost differences, it is tempting for efficient firms to form a subcartel, which makes a larger cartel harder to sustain. Cartel prices are lower when the most profitable alternative to the grand cartel is to deviate to a subcartel, rather than to the Bertrand equilibrium.

Keywords: Collusion, cost-asymmetries, damages.
JEL-Classification: L13, L41, D74

[a]I thank the participants at the 3rd Swedish Workshop on Competition Research for comments and questions. The usual disclaimer applies. Copenhagen Business School, Department of Economics, Porcelænshaven 16 A, DK-2000 Frederiksberg, e-mail: pbe.eco@cbs.dk.

1 Introduction

The effect of cartels has since long been an important research topic, but even more so the last 10 years with the increased importance of private litigation. This model brings new insights to pricing strategies implemented by cartels and hence the damage they cause. The cartel price does not only depend on demand, but also on the relative strength of the cartel members, and on the members' best alternatives to being in the cartel. This helps to explain why overcharges differ significantly between different cartels[1].

The damage is normally estimated by litigators as the difference between the cartel price and the counterfactual. This model illustrates that the counterfactual plays an important role also within cartels since it will determine price and sustainability, as long as there are cost asymmetries between the members.

Traditional models of collusion[2] assume that all firms in an industry have the same production costs. One reason for this assumption is that without common costs, no one focal price is optimal for all firms. Instead, firms with higher costs prefer higher prices than firms with lower costs. Bain (1948) noted that solving the cartel pricing problem with standard joint profit maximization when firms have different costs, may require the inefficient cartel members to refrain from producing or to quit the cartel. The problems for inefficient firms to remain in cartels may indeed explain why efficient cartels acquire fringe firms (Martin, 2010, p. 189). Without sidepayments, there are no incentives for inefficient firms to join the cartel, and the market remains competitive (Scherer and Ross, 1980).

Since firms do not always have symmetric costs[3] this paper investigates how cartel stability and prices are affected by the asymmetry. Contrary to previous models I investigate how the introduction of additional members affect

[1]OECD (2003) investigated 16 large cartels and found that the price effects varied between 3% to 65%.

[2]Without binding agreements, firms are said to be colluding tacitly whereas if they enter into agreements they form a cartel. Both in the US and the EU, tacit collusion is regarded as normal business practice, while cartels are illegal and can give rise to high fines, damages and even imprisonment (e.g. US Supreme Court in Brooke Group v Brown & Williamson Tobacco (1993) and Motta (2004).) Despite the sharp legal distinction between tacit collusion and cartels, the economic rationale for the behaviour is the same.

[3]For example in the pre-insulated pipe cartel (European Commission, 1998), the cost differences between the members were 15-20 %.

the cartel.

In a competitive market inefficient firms producing homogenous products would be forced to shut down. Hence, cost asymmetries are more likely to be found in collusive markets where the firms are protected from competition. In fact, even symmetric firms joining a cartel may end up with asymmetric costs due to different managerial preferences. Managerial slack (X-inefficiency) can arise since there are no outside firms that can discipline managers in the cartel firms (Hart, 1983)[4] or because the owners have bad benchmarks for designing incentive schemes (Nalebuff and Stiglitz, 1983). Both Scherer (1975) and more recently Symeonidis (2008) provide empirical evidence that labour productivity is indeed lower in industries with many cartels, compared to those without. Cost differences among cartel members can therefore either be endogenous or exogenous to cartel formation. Rather than modelling the process leading up to cost asymmetries, this paper assumes that some firms in a cartel are efficient and some are not.

This paper is based on a setting with one inefficient and two efficient firms. They determine prices using Nash bargaining and the cartel is supported by grim trigger strategies. I find that cost asymmetries increase collusive prices and make collusion harder to sustain. But, by introducing a second efficient firm, the efficient firms can threaten to form a subcartel which makes comprehensive collusion more unstable when cost differences are large. Such a threat also reduces the collusive prices. The collusive price therefore depends both on the cost asymmetry but also on the deviation strategy.

A small but growing literature exists on collusion among firms with cost asymmetries. The current framework of Bertrand models with homogenous products was first introduced by Bae (1987) who finds that asymmetries make a cartel unstable and that a cartel price is non-monotonically increasing in the asymmetries. Harrington (1991) refined the model by identifying the collusive solution through a bargaining process instead of by joint profit maximization and found similar results, but higher cartel prices. Miklos-Thal (2011) uses a model similar to that of Harrington but rather than discussing how firms select a specific equilibrium, she focuses on the sustainability of collusion. As in the models by Bae and Harrington, she finds that cost asymmetry makes collusion harder to sustain, but when sidepayments are

[4]Scharfstein (1988) criticises Harts' results since they crucially depend on the assumptions on managerial preferences.

possible, cost asymmetry actually facilitates collusion.

Rothschild (1999), Collie (2006) and Vasconcelos (2005) look at homogenous and differentiated Cournot models in which price is set by joint profit maximization. They find that even when the inefficient firm is active, it will receive a lower market share than the efficient firm and therefore have larger incentives for deviating. Furthermore, if a cartel is formed and one firm deviates, the efficient firm will be penalized proportionately more and therefore will want to deviate from the punishment strategy. Schmalensee (1987) also investigates Cournot models and states that joint profit maximization is not a plausible mechanism for determining the collusive price when costs are asymmetric, unless the firms use sidepayment schemes. Using four different bargaining solutions, he finds that low cost firms may have little to gain from collusion. Thus, the standard finding is that without side payments, cost asymmetries make collusion less sustainable. In contrast to this, Ganslandt et al. (2008) find that when collusion carries indivisible costs, some asymmetry will make cartels more stable, since it enables the leader to recoup its costs. (Roberts, 1985) finds that not only is tacit collusion harder when there are cost asymmetries, but this is also the case when the firms have access to binding agreements.

Most of the literature is based on a duopoly setting, with one efficient and one inefficient firm.[5] I argue that the restriction to two players has a significant impact on the outcome and that allowing for one additional efficient player will change the results.[6] This paper thus relaxes two standard assumptions in collusion models by allowing for asymmetric costs and for more than two firms on the market.

Section 2 in this paper introduces the basic framework and general definitions. It also solves the non-collusive Bertrand equilibrium. Section 3 defines the conditions under which collusion is rational for individual firms, i.e., the combinations of market share and price for which a cartel is sustainable. When there are three firms the members can form subcartels and the conditions for a stable cartel is different depending on whether firms prefer to deviate alone (unilateral deviation) or deviate by forming a subcartel (coor-

[5]Miklos-Thal (2011) introduces notation for a n-player game, but the model is solved for two players. Schmalensee (1987) models one efficient and n inefficient firms.

[6]If additional inefficient firms are introduced, the efficient firm will still as only firm make profits in a non-cooperative situation. This results in bargaining leverage that does not exist when there are two efficient firms.

dinated deviation). The section derives the sustainability conditions for both cases and defines which of these two deviation strategies that most easily can sustain collusion. The cartel members are assumed to decide on the outcome using Nash bargaining. Section 4 defines the Nash bargaining problem and performs some comparative statistics. It further compares the findings to those made by Harrington (1991). Section 5 is an extension of the model to a n-firm setting. The results are discussed in section 6. All proofs are provided in the appendix.

2 Model

I expand the model developed by Harrington (1991) by extending it to a three-firm game, where two firms are equally efficient and one firm is inefficient. The firms interact repeatedly in a homogeneous products industry and decide whether to compete in prices or collude. The model is assumed to satisfy the following five conditions:

A1: There exists a $\bar{P} > \max\{c_{E1}, c_{E2}, c_I\}$ such that market demand, $D(P) = 0$ if $P \geq \bar{P}$ where c_{Ei} is the marginal cost of an efficient firm $i \in \{1, 2\}$ and c_I is the marginal cost of the inefficient firm.

A2: $D(P)$ is continuous and twice differentiable.

A3: $\pi_i(P) = (p - c_i) D(P)$ is strictly concave in P for all $P \in \left(0, \bar{P}\right)$, i.e. there exists a unique monopoly price for each firm.

A4: $D'(P) < 0$ for all $P \in \left(0, \bar{P}\right)$.

A5: $c_{E_1} = c_{E_2} = c_E < c_I < P_E^m$ where $P_E^m = \arg\max \pi_E(P)$, i.e. the efficient firms' monopoly price. This assumption implies that one firm is inefficient but the cost difference is not drastic and hence the inefficient firm can be active when the efficient firms set monopoly price. From this assumption also follows that $P_E^m < P_I^m$.

Firms simultaneously set prices and I assume that no firm will set prices outside $\left[0, \bar{P}\right]$. Market demand is allocated to the firm offering the lowest price. If several firms offer the same price, the firms decide how to allocate

demand between them. In equilibrium no firm wants to deviate from the agreed market shares since they are all incentive compatible. This gives the demand function

$$D_i(P_i) = \begin{cases} 0 & \text{if} \quad P_i > min\{P_j, P_k\} \\ s_i D(P_i) & \text{if} \quad P_i = P_j < P_k \\ D(P_i) & \text{if} \quad P_i < min\{P_j, P_k\} \end{cases} \tag{1}$$

where $s_i \in [0,1]$ is the market share of firm i. I further assume that all firms have a common discount factor $\delta \in (0,1)$. Since the two efficient firms are totally symmetric, they are assumed to have equal market share when their prices are the same.

According to this simple set-up, the only non-cooperative Nash equilibrium in the one-period game is that the efficient firms charge price $P = c_E$, while the inefficient firm does not produce anything. Hence, contrary to the models by Bae (1987) and Harrington (1991), the efficient firms in our non-cooperative Nash equilibrium earn zero profit. The non-cooperative infinite horizon game is a repetition of the one-stage game and total profits are therefore zero for all firms.

Turning to the collusive equilibria, the cartel faces two problems; to decide on a collusive price and to allocate market shares (or production quotas) among the members. The collusive outcome is thus defined by a collusive price and market shares (P, s_E, s_I). Since we do not allow for sidepayments and the products are homogenous, the firms set one joint collusive price.

Another modelling approach could have been to use the firms' output decisions rather than their share of the market as choice variable. This would require a two-stage setting. If the firms first decide on the cartel price, then on quantities, the result is identical to the current set-up. If the firms instead first decide on quantity and then on price, the pricing decision is effected by the agreed production constraints. In such a situation the firms can charge different prices, but the exact pricing crucially depends on the choice of rationing rule. Since I do not want to make any assumptions regarding the rationing rule, and to facilitate comparison with previous findings, the firms are assumed to make a simultaneous price and market share decision.

For all firms to be active, the cartel price must fall in the interval $P \in [c_I, p_I^m]$. If the collusive price falls below c_I the inefficient firm will no longer be active on the market. Prices above the inefficient firm's monopoly price, p_I^m, will

not be profit maximizing for any member of the cartel (from A.5) and hence neither for the cartel.

Per period profits under collusion are $s_i (P - c_i) D(P)$ which in this paper also is denoted $s_i \pi_i^c$. The individual firms' share of the market s_i, must satisfy $\sum_1^3 s_i = 1$. Since the efficient firms are symmetric, I will in the following refer to the market share of an efficient firm as s and therefore to the market share of the inefficient firm as $(1 - 2s)$.

3 Sustainability

Collusion is inherently unstable since there will always be an incentive for members to cheat on the agreement and undercut the collusive price to serve the entire market alone. To assure that collusion is sustainable there has to be some kind of punishment mechanism and the possibility for collusion therefore increases if the punishments for deviation becomes harder. In this paper I assume, just like Bae (1987) and Harrington (1991), that collusion is supported by standard grim trigger strategies (Friedman, 1971)[7]. Hence firms set collusive prices until they detect that someone has deviated, and if deviation is detected, firms play non-cooperative Nash forever after. The punishment implies that after deviation is detected, only the two efficient firms are active and that all firms make zero profits.

For a cartel to be sustainable, the discounted collusive profits have to be higher than discounted profits from deviating and the ensuing Nash profits. The incentive constraint for a cartel to be sustainable is

$$\frac{1}{1-\delta}\pi_i^c s_i \geq \pi_i^d (P, c_i) + \frac{\delta}{1-\delta}\pi_i^n (c_i), \; i \in \{E_1, E_2, I\} \tag{2}$$

where $s_i \pi_i^c$, π_i^d and π_i^n are collusive, deviation and non-cooperative Nash profits respectively. This constraint is often re-arranged in terms of minimum required discount factor, $\tilde{\delta}_i \geq \frac{\pi_i^d - \pi_i^c s_i}{\pi_i^d - \pi_i^n}$.

[7]There are other punishment schemes that may entail lower prices in the punishment period, such as optimal punishments, (Abreu, 1986) and (Abreu, 1988), or minmax punishments (Miklos-Thal, 2011). These schemes however, rely on below cost pricing in the punishment phase and are hence weakly dominated by pricing at cost.

In standard two-firm collusion models, deviation is a unilateral decision. However, in a model with more firms, the best strategy may not be to deviate unilaterally but to coordinate deviation with another firm, so called partial cartels. We therefore need to assess the sustainability based on different assumptions regarding coordination between the cartel members. The idea is inspired by the Shapley value (Shapley, 1953) allowing firms to form new coalitions if it can make them better off. For the grand coalition to be sustainable, the profits to all firms must be higher than profits from unilateral deviation or deviation to a new smaller coalition. With three firms on the market, there are five possible coalitional structures.

Table 1: *Possible coalitions*

Coalition	Members
A	$\{E_1\}, \{E_2\}, \{I\}$
B	$\{E_1, E_2\}, \{I\}$
C_1	$\{E_1, I\}, \{E_2\}$
C_2	$\{E_2, I\}, \{E_1\}$
D	$\{E_1, E_2, I\}$

Structure A is the normal non-cooperative solution where all firms are independent and play Bertrand. In B, the two efficient firms form a coalition and the inefficient firm is fringe. In the two C coalitions the inefficient firm forms a coalition with one of the efficient firms. Situation D is the grand cartel with all firms included.

Proposition 1. *Coordinated deviation is only a profitable strategy for efficient firms.*

If one efficient and one inefficient firm jointly decide to deviate, they will make one period of deviation profits (that they split). This will trigger reversion to non-cooperative Nash prices and since the fringe firm is efficient, retaliation will lead to marginal cost pricing for the efficient firms, and exclusion of the inefficient firm. As the two deviating firms will split the deviation profits, coordinated deviation by one efficient and one inefficient firm is weakly dominated by unilateral deviation where the deviating firm gets the entire deviation profit.

If the two efficient firms decide to deviate jointly, coalition B, they will also split the deviation profits. But since their costs are lower than the fringe

firms' costs, they can still make profit in the punishment phase by lowering the collusive price to (just below) c_I. Since I have assumed non-drastic cost differences ($P_E^m > c_I$) this will be the only equilibrium. For sufficiently high discount factors, it is hence more profitable for the efficient firms to coordinate deviation and split deviation and punishment profits than to deviate unilaterally.

As stated in proposition 1 the C coalitions are not subgame perfect since the efficient firm is weakly better off by deviating unilaterally. Coalition B can however be more profitable than unilateral deviation and it is hence the only possible sub-cartel. We will in section 3.1 assess the conditions for when the grand cartel is sustainable to standard unilateral deviation, i.e. when the profits from coalition D is larger than the profits from coalition A. These conditions ensure that the cartel is stable also to partial collusion. In section 3.2 we will investigate the case of coordinated deviation, i.e. under what conditions the profits from coalition D is larger than the profits from coalition B. The three-firm cartel has to be sustainable to both kinds of deviation, and in section 3.3 we elicit which deviation strategy that is most profitable, i.e. which one that binds the cartel.

3.1 Unilateral deviation

I here compare the profits from the grand coalition D to the non-cooperative Nash (Bertrand) outcome A and thereby rely on the one-stage deviation principle (Fudenberg and Tirole, 1991). If cartel prices are high, $P \in (p_E^m, p_I^m]$, the best deviation strategy for an efficient firm is to lower price to its monopoly price and charge p_E^m. The inefficient firm on the other hand, will deviate by setting a price just below the cartel price. If the cartel instead sets a low price, $P \in [c_I, p_E^m]$, any deviator will just slightly undercut the cartel. Due to the use of grim trigger strategies, prices in all periods following the deviation will be determined by the Bertrand equilibrium and all firms will make zero profits. This simplifies expression (2) to

$$\frac{1}{1-\delta}\pi_i^c s_i \geq \pi_i^d(P) \tag{3}$$

Proposition 2. *With unilateral deviation, cost differences don't affect the minimum required market share.*

By inserting the efficient firms' equilibrium profits in equation (3) and re-arranging, we express the incentive constraints in terms of the minimum required market share, $\underline{s}$. For the efficient firms it holds that

$$\begin{array}{lll} s \geq \underline{s}^{uni} = (1-\delta) & \text{if} & P \in [c_I, p_E^m] \\ s \geq \underline{s}^{uni} = (1-\delta)\frac{\pi_E^m}{(P-c_E)D(P)} & \text{if} & P \in (p_E^m, p_I^m] \end{array} \tag{4}$$

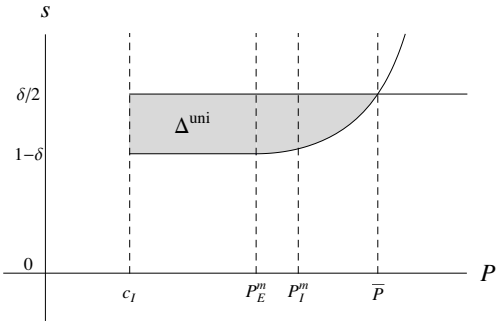
The minimum required market share is the minimum share that an efficient firms must receive to find collusion to be the most profitable option. When the cartel sets a price above the efficient firm's monopoly price, an efficient firm can deviate and charge the monopoly price. For this not to be profitable, the efficient firms needs to be compensated by a higher market share in the cartel. The market share required therefore increases with the distance from the efficient firm's monopoly price. The incentive constraints for the inefficient firm can in the same way be expressed as the minimum share the inefficient firm requires, or the maximum that it will allow the efficient firms to have. It solves for

$$s \leq \overline{s} = \frac{\delta}{2} \tag{5}$$

where $\overline{s}$ caps the market share of the efficient firms. For any larger share, the inefficient would be better off deviating instead of participating in the cartel. When the discount factor increases, so does the market share that the inefficient firm is willing to give up to the efficient firms. Since the inefficient firm cannot deviate to its monopoly price, $\overline{s}$ does not depend on the collusive price.

The incentive constraints (4) and (5) together determine the set of allocations of P and s that assure that the cartel is sustainable, i.e. where $\overline{s} > \underline{s}$. Since the efficient firms needs to be compensated with extra market shares for not deviating when $P > p_E^m$, the maximum collusive price is determined by the intersection of the incentive constraints for the efficient and inefficient firms. The minimum price on the other hand is given by c_I which is the lowest price were all firms are active. Plotting the constraints gives the following figure where the area $\Delta^{uni}(\delta)$ is the set containing all incentive compatible combinations of P and s.

Figure 1: *Unilateral deviation*



From the incentive constraints it is clear that the discount factor affects the set of sustainable cartels. I find that $\frac{\partial \underline{s}}{\partial \delta} < 0$ and $\frac{\partial \overline{s}}{\partial \delta} > 0$ for any P since future cartel gains becomes more valuable. Thus the set expands with the discount factor. Cost asymmetries do not affect the minimum required share, but the cost levels still affect the size of the set since they define the boundary between high and low cartel prices. These effects will be more thoroughly analysed in section 4.2.

The set of outcomes (P, s) that are subgame perfect to unilateral deviation, $\Delta^{uni}(\delta)$ is defined by

$$\Delta^{uni}(\delta) \equiv \left\{ (P,s) \mid \begin{array}{c} P \in \left[c_I, \overline{P}(s)\right] \\ s \in \left[1-\delta, \frac{\delta}{2}\right] \end{array} \right\} \tag{6}$$

Re-writing the requirement on market share shows that collusion is only possible when $\delta \geq \frac{2}{3}$, i.e. the standard Bertrand result,[8] irrespective of the level of cost asymmetry. If there is only one efficient firm, as in the two-firm models by Bae (1987) and Harrington (1991), collusion can be supported with $\delta \geq \frac{1}{2}$ if there are no cost asymmetries, but the requirement on discount factor increases with the degree of cost asymmetry. Hence, by introducing a

[8] In a n-firm Bertrand model the required discount factor is $\delta \geq \frac{n-1}{n}$ (Motta, 2004, p. 162).

second efficient firm the scope for collusion is decreased, in line with standard Bertrand results.

3.2 Coordinated deviation

The cartel doesn't only need to be stable to unilateral deviation, but also to coordinated deviation when the efficient firms deviate into a sub-cartel. In this section I assess the requirements for the grand coalition (D) to be sustainable to deviation to a sub-cartel between the efficient firms (B). When efficient firms coordinate deviation, they will make a positive profit also in the punishment phase where they will charge price c_I. Since the efficient firms are symmetric we assume that they will split the profit equally so profits in the punishment phase will be $\frac{(c_I - c_E)D(c_I)}{2}$.

The incentive constraints are solved for the minimum market share that the efficient firms require to stay in the cartel. Since coordinated deviation is never the best deviation strategy for the inefficient firm, the maximum market share for an efficient firm remains $\overline{s} = \frac{\delta}{2}$.

Proposition 3. *With coordinated deviation, cost differences increase the minimum required market share.*

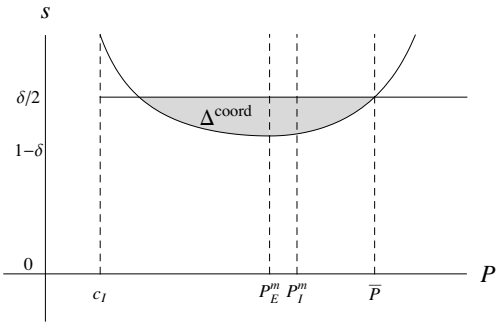
Just as in the case of unilateral deviation, the efficient firms' requirement on market share is found by inserting equilibrium profits in the incentive constraints (2) and solving for the minimum required market share.

$$\begin{aligned} s \geq \underline{s}^{coord} &= \tfrac{(1-\delta)}{2} + \tfrac{\delta(c_I - c_E)D(c_I)}{2(P-c_E)D(P)} && \text{if} \quad P \in \left[c_I, p_E^M\right] \\ s \geq \underline{s}^{coord} &= \tfrac{(1-\delta)}{2}\tfrac{\pi_E^M}{(P-c_E)D(P)} + \tfrac{\delta(c_I - c_E)D(c_I)}{2(P-c_E)D(P)} && \text{if} \quad P \in (p_E^M, p_I^M] \end{aligned} \tag{7}$$

Like the unilateral case, it follows that $\frac{\partial \underline{s}}{\partial \delta} < 0$ and $\frac{\partial \overline{s}}{\partial \delta} > 0$, i.e. increasing the discount factor expands the set of subgame perfect outcomes. The requirements on minimum market share for the efficient firms under coordinated deviation are different from the unilateral case as they depend on the level of cost asymmetry. In the unilateral case, costs only determine the pricing regions, but when deviation is coordinated, cost differences affect the market share requirement directly. The effect of the costs are more thoroughly analysed in section 4.2. Figure 2 depicts the two incentive constraints and

the area $\Delta^{coord}(\delta)$ is all the outcomes (P, s) that can support collusion when coordinated deviation is possible.

Figure 2: *Coordinated deviation*



Unlike the case of unilateral deviation, the combinations of price and market share that can sustain coordinated deviation is U-shaped, with the incentive constraint of the inefficient firm again being the upper limit. The efficient firms require the least market share when prices are set at their monopoly price and the further away from this the cartel sets its price, the larger market share will they require as compensation. The reason for the U-shape is that the efficient firms can make profit also in the punishment phase, and when there are cost differences and prices are far from their optimum, it is tempting to deviate and rely on punishment profits instead.

I denote the set of subgame perfect equilibrium outcomes supported by coordinated deviation by $\Delta^{c}(s)$, it is defined by

$$\Delta^{coord}(\delta) \equiv \left\{ (P,s) \mid \begin{array}{c} P \in \left[\underline{P}(s), \overline{P}(s)\right] \\ s \in \left[\frac{(1-\delta)}{2} + \frac{\delta(c_I - c_E)D(c_I)}{2(P-c_E)D(P)}, \frac{\delta}{2}\right] \end{array} \right\} \tag{8}$$

When the firms can coordinate their deviations, collusion is only a subgame

equilibrium when

$$\delta \geq \frac{(P - c_E) D(P)}{2(P - c_E) D(P) - (c_I - c_E) D(c_I)} \tag{9}$$

Hence, when deviation is coordinated and there are no cost differences, the grand cartel is profitable if $\delta \geq \frac{1}{2}$. This is lower than in the standard model where a three-firm cartel needs $\delta \geq \frac{2}{3}$ to be sustainable (Motta, 2004, p. 162) and essentially reflects the fact that two firms act as one. The required discount factor increases with the degree of cost asymmetry since $\frac{\partial \delta}{\partial (c_I - c_E)} > 0$.[9]

3.3 Deviation for most sustainable collusion

Above it was shown that a cartel with more than two efficient firms is vulnerable to both unilateral and coordinated deviation. For the cartel to be sustainable, the firms' discount factor needs to be larger than both the discount factor needed to sustain unilateral deviation and coordinated deviation. This section determines which of the two deviation possibilities that will bind the grand cartel. For the inefficient firm we know that unilateral deviation weakly dominates coordinated deviation, hence there is no need for further analysis. Thus the following section only concerns efficient firms.

The incentive constraints inform us that the grand cartel will not be sustainable with any deviation mechanism if $\delta < \frac{1}{2}$. For discount factors larger than this, collusion may be stable depending on the deviation possibility and the level of cost asymmetry. With unilateral deviation the minimum discount factor is constant at $\delta < \frac{2}{3}$. The requirements for the grand cartel to be stable are given by

$$\begin{array}{lll} \text{Three-firm collusion not possible} & \text{if} & \delta < \min[\frac{2}{3}, \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}}] \\ \text{Possible w. coordinated dev.} & \text{if} & \delta \geq \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}} \\ \text{Possible w. unilateral dev.} & \text{if} & \delta \geq \frac{2}{3} \end{array} \tag{10}$$

where $\overline{\pi} = (c_I - c_E) D(c_I)$. The maximum of these three constraints defines the minimum discount factor for cartel sustainability.

[9] This as $\frac{\partial \delta}{\partial c_E} < 0$ and $\frac{\partial \delta}{\partial c_I} > 0$.

Proposition 4. *For sufficiently large cost asymmetries, the minimum required discount factor increases with cost asymmetries.*

From the incentive constraints it is clear that unilateral deviation binds the collusion if

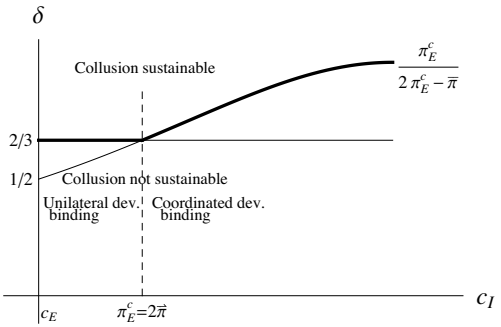
$$\frac{(P - c_E) D(P)}{2(P - c_E) D(P) - (c_I - c_E) D(c_I)} \leq \frac{2}{3}. \tag{11}$$

which simplifies to

$$\pi_E^c \geq 2\overline{\pi} \tag{12}$$

The inequality in equation (12) only holds for small cost asymmetries. In these cases unilateral deviation binds the cartel and the required discount factor is independent of the cost asymmetries (see Figure 3). If instead $\pi_E^c < 2\overline{\pi}$, i.e. for sufficiently large cost asymmetries, coordinated deviation binds the cartel. In these cases the minimum discount factor increases with the level of cost asymmetry. The minimum discount factor is hence weakly increasing in the level of cost asymmetry.

Figure 3: *Minimum δ for sustainable collusion*



When coordinated deviation is binding the cartel, the members could make collusion more sustainable if they could contract on not coordinating deviation. But as will be illustrated in the coming section, this would require the efficient firms to forgo cartel profits.

In the models of unilateral and coordinated deviation I defined two sets of subgame perfect equilibrium. For the grand cartel to be sustainable the solution must be in both sets. The set of subgame perfect equilibria to the grand cartel is therefore $\Delta(\delta) = \Delta^{uni}(\delta) \cap \Delta^{coord}(\delta)$ and no firm has an incentives to deviate from any price-market share combination in this set.

By taking the intersect of the equilibrium sets I define the set of subgame perfect equilibrium outcomes as

$$\Delta(\delta) \equiv \left\{ (P,s) \mid P \in \left[\underline{P}(s), \overline{P}(s)\right], \begin{array}{lll} s \in \left[1-\delta, \frac{\delta}{2}\right] & \text{if} & \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}} \geq \delta \geq \frac{2}{3} \\ s \in \left[\frac{(1-\delta)}{2} + \frac{\delta\overline{\pi}}{2\pi_E^c}, \frac{\delta}{2}\right] & \text{if} & \delta \geq \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}} \end{array} \right\}$$

Figure 3 illustrates that findings concluding that cost asymmetries make collusion harder to sustain (e.g. Bae (1987), Harrington (1991) and Miklos-Thal (2011)), rest on the existence of non-cooperative profits for the efficient firm. This assumption is inherent to two-firm models but e.g. with two efficient firms deviating unilaterally, the assumption does not hold and cost asymmetries have no effect on cartel stability.

4 Collusive bargaining

In the previous sections we categorized the outcomes $\Delta(\delta)$ that support collusion. A central question is which combination of price and market share allocation the cartel will choose. To answer this I must define the mechanism firms use to reach their decision.

Even though sidepayments sometimes are part of a cartel's contractual agreement, most modern theories of collusion do not recognize these contracts[10] as they; i) are illegal and cannot by enforced in court (Kihlstrom and Vives, 1989), ii) increase both the risk of detection and conviction (Pesendorfer, 2000), and iii) over time reduce the non-producing firms' ability to act competitively in the market (Friedman, 1977). This is also supported empirically. In a study of 81 international cartels convicted of colluding in either the United States or the European Union (or both) since 1990 Levenstein and

[10]For exceptions see Miklos-Thal (2011).

Suslow (2010) find that *"direct compensation raises the risk of detection by competition authorities and is not observed in the current legal environment."*

If sidepayments are allowed and products are homogenous, a cartel would commission the firm with the lowest costs to produce market demand at the monopoly price and allocate the profits among the members. But this was not the case in the Norwegian cement cartel (1955-1968) which, first after a merger among the members, reduced capacity and lowered costs to the extent that creating a monopoly was actually welfare enhancing (Röller and Steen, 2006).

When sidepayments are not allowed, all firms need to be active to receive a share of the collusive profits. When firms are symmetric, there is no coordination problem and all firms will make the same profit. But when firms are asymmetric, the cartel needs to set prices so that all members make a profit and also allocate market share among the members to compensate firms for a price that is not their optimal price to prevent them from leaving the cartel. This paper, instead of relying on sidepayment contracts, defines collision to be stable if the profit from membership without explicit agreements on transfers is higher than that from deviation. This is in essence the economic meaning of collusion.[11]

In standard models of collusion, the cartel is assumed to set prices by joint profit maximization. When firms are symmetric this is a reasonable assumption since they all prefer the same price (the monopoly price). But with cost asymmetries, joint profit maximization will propose that the inefficient firm should exit the market (Bain, 1948). Hence, by not allowing for sidepayments, only efficient firms will make positive cartel profits which is not an equilibrium. When firms are asymmetric, joint profit maximization is therefore not a reasonable mechanism for deciding allocation of price and market share (Schmalensee, 1987). With cost asymmetries the cartel members have to solve a non-trivial pricing problem, and the larger asymmetries, the more trouble the firms will have deciding on a common price since the preferred prices differ (Vasconcelos, 2005).

[11]Not allowing for sidepayments also facilitates comparisons with related literature since the same restriction on collusive strategies is also imposed by Bae (1987) and Harrington (1991). Within the model collusion with sidepayments is however the parteto efficient outcome for the members.

Proposition 5. *Without sidepayments, joint profit maximization is not a subgame perfect equilibrium when costs are asymmetric.*

The most profitable conduct for a cartel with asymmetric members producing homogenous products is to only let the efficient firms produce, i.e. produce at minimum cost, sell at monopoly prices and distribute total profits among all members.

This is verified by the fact that the first order condition of the joint maximization problem with respect to s is $\pi_E - \pi_I > 0$. The result is hence a corner solution and the efficient firm's market share should be at its maximum, i.e. $\widehat{s} = \frac{1}{2}$. Consequently, the inefficient firm does not produce anything in the joint profit maximization solution. Since only efficient firms produce, price is set at P_E^m. Distributing cartel profits requires side-payments that we do not allow for and without re-distribution the inefficient firm will deviate and the game therefore ends in the Bertrand solution. Hence, any solution to the pricing problem relying on joint profit maximization needs some specific assumptions about the market share of the inefficient firm, since it otherwise would be zero.

Bae (1987) proposed that when firms had different costs, price and market share should be allocated using the balanced temptation equilibrium (Friedman (1971). This implies that the set of sustainable outcomes is constrained so that all firms in equilibrium are equally tempted to deviate from the cartel. This is achieved by assuming that the ratio cartel profits/deviation profits is restricted to be the same for all members, hence the term balanced temptation. This assumption forces the inefficient firm's market share to be positive and prices can be determined using joint profit maximization. Restricting the equilibrium set however implies that there can be situations where there is no solution in the balanced temptation equilibria, even though the combination of price and market share fulfils the incentive constraints.

Harrington (1991) points out that it is unclear why the firms should settle on the balanced temptation equilibrium and why all firms would agree to use joint profit maximization to find the outcome. He further concludes that the allocation mechanism does not specify both a price and market sharing rule, nor does it always exist. Finally he also criticizes Bae's model for containing an ad hoc assumption.[12] In the light of this criticism Harrington

[12]When δ is low, the joint profit maximizing solution is not part of the collusive set.

instead treats the allocation question as a bargaining problem. The solution is defined by Nash bargaining where the utility vector is the collusive profits and the threat is reversion to the single-period Nash equilibrium.

I find Harrington's approach natural and want to continue in this path. However, Nash bargaining games are normally not used when there are $n > 2$ players since such games ignore the possibilities for collusion among subgroups of the grand coalition. From our previous analysis we know that the efficient firms may find it profitable to deviate from the grand coalition and form a smaller cartel. Hence the n-firm Nash bargaining can only be a relevant solution if we assume that the firms only can negotiate effectively in the grand coalition (Myerson, 1997). This could be the case if there is a high risk that the fringe firm receives indications about collusion behind its back and contacts the competition authorities. Any deviation will then result in Bertrand competition. But, I introduce the possibility of effective negotiation also between a subset of the members. This allows for the creation of subcartels.

The solution concept in this paper is based on a modified Nash bargaining approach, that allows us to take into account the possibility for coordinated deviation, further it simplifies comparisons with Harrington's original model. Nash's bargaining problem consists of a point in the utility set, here defined by the subgame perfect outcomes, and a threat point which comes to play if the parties fail to come to an agreement or if the agreement exogenously breaks down. It is therefore natural to think of the threat point as the outcome of the punishment phase, i.e. the best outside option to being in the cartel. There are of course several other possible solutions such as the Kalai and Smorodinsky (1975) solution where the gains from collusion is the same fraction of maximum gains for all members or Roth's equal gains solution (Roth, 1979) where absolute gains are equal for the members. Despite these solutions being subgame perfect equilibria, it is unclear why efficient firms would want to settle on these solutions. Another approach is Rubinstein (1982) bargaining with alternating offers, but those results will equal the Nash bargaining solution as the time between offers approaches zero.

Recall from equation (10) that if $\frac{2}{3} \leq \delta \leq \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}}$, the grand coalition is threatened by unilateral deviation that would result in deviation to the Bertrand

Bae then assumes that the collusive outcome is the one that maximizes the efficient firm's market share.

equilibrium and hence zero profits. When on the other hand $\frac{2}{3} \geq \delta \geq \frac{\pi_E^c}{2\pi_E^c - \overline{\pi}}$, the coalition faces the threat of coordinated deviation where the two efficient firms form a sub-cartel. The threat point in this case is positive as the efficient firms can make profits in the punishment phase. To solve the optimal price and market share allocation for the cartel we therefore only need to consider the two possible deviation cases. Which solution is applicable in the individual case depends on the discount factor and level of cost asymmetry.

Since the two efficient firms are symmetric and the inefficient firm has no profitable outside option, the cartel faces following the bargaining problem

$$\max_{(P,s)\in\Delta(\delta)} \left(s\pi_E - O_E\right)^2 \pi_I \left(1-2s\right) \text{ s.t. } s\pi_E^c \geq O_E \tag{13}$$

where O_E is the threat point or outside option for the efficient firms. It is typically assumed that δ is sufficiently large so that the solution to equation (13) is in the collusive set. This is however not always the case and in section 4.1 I investigate the some properties of the solution when the bargaining solution is not in the collusive set. The important comparative statics on price in sections 4.2 and 4.3 will be performed both when $\delta \geq \widehat{\delta}_E$ and when $\delta \in (\underline{\delta}, \widehat{\delta}_E)$, i.e when price is set by unconstrained and constrained bargaining.

The only factor that separates the bargaining problem for unilateral deviation from coordinated deviation is the size of the outside option for the efficient firms. With unilateral deviation the outside option is the Bertrand equilibrium whereas it with coordinated deviation is a subcartel. Regarding the profits in these two cases we know that

$$O_E = \left\{ \begin{array}{ll} 0 & \text{if Bertrand eq.} \\ \frac{(c_I - c_E)D(c_I)}{2} & \text{if Subcartel} \end{array} \right\} \tag{14}$$

I denote the solution to the unconstrained bargaining problem by $\widehat{P}$ and $\widehat{s}$. Harrington (2001) shows that since the utility set $U(\delta)$ [13] is compact, the solution to (13) is the only solution that satisfies Nash's axioms. But since it is not generally convex when firms have different unit costs we are not assured that the solution is unique.

[13] $U(\delta) \equiv \left(2s\left(P - c_E\right)D(P), \left(P - c_I\right)\left(1-2s\right)D(P)\right) \shortmid (P,s) \in \triangle(\delta)$

From the bargaining problem in equation (13) it can be seen that costs have two distinct effects on the bargaining surplus. First they determine optimal prices for the inefficient and efficient firms where higher costs call for higher prices. Second, with coordinated deviation, it determines the value of the outside option for the efficient firms. When the cost difference is large the bargaining surplus for the efficient firms is smaller.

Solving the bargaining problem for optimal market share gives

$$\widehat{s} = \left\{ \begin{array}{ll} \frac{1}{3} & \text{if Bertrand eq.} \\ \frac{1}{3} + \frac{\overline{\pi}}{6\pi_E} & \text{if Subcartel} \end{array} \right\} \tag{15}$$

When the outside option is the Bertrand equilibrium no firm has bargaining leverage and it is hence optimal that the firms share the market equally, independent of their level of efficiency. When the outside option is a subcartel the efficient firms have a bargaining advantage which translates into higher market shares. The shares increase with the degree of inefficiency.

Substituting the optimal market share into the bargaining problem in equation (13) enables us to solve for the optimal cartel prices.

4.1 Constrained Nash bargaining

The optimal market shares in equation (15) were derived without constraints on the collusive outcome. But, the unconstrained Nash Bargaining solution is not always in the set and in these cases the members need to adjust price and market share to reach a sustainable solution.

For $\delta \in [\underline{\delta}, \widehat{\delta}_E)$, where $\underline{\delta}$ is the minimum discount factor for collusion to be sustainable[14] and $\widehat{\delta}_E$ is the minimum required discount factor for the efficient firms[15] when price and market shares are determined by Nash bargaining, collusion is possible but the unconstrained Nash bargaining solution is not part of the collusive set. In these cases the members have to adjust the bargaining solution (price and market share) to make collusion sustainable, i.e. choose a solution in the collusive set.

Proposition 6. *When $\delta \in (\underline{\delta}, \widehat{\delta}_E)$, the firms will decide on the lowest market share possible and set the cartel price at P_E^m.*

[14] From equations (6) and (9).

[15] The requirement on discount factor is higher for the efficient firms.

The lowest discount factor sustainable for the efficient firms is $\tilde{\delta}_E$. When this is binding, the solution to the bargaining problem in equation (13) is subject to $\delta = \tilde{\delta}_E$.[16] By substituting the constraint into the objective function and taking the first-order condition with respect to s, I find that the optimum market share is a corner solution where the share is set as low as possible. The minimum market share is given by setting prices at P_E^m. The results thus generalise Harrington's (1991) finding that the collusive solution is $(P_E^m, \overline{s})$ when $\delta \approx max(\underline{\delta}_i)$. However it is contrary to Bae's (1987) assumption that the cartel would chose the outcome that maximized the low-cost firm's market share. In fact I find the opposite. Thus in this model only market shares will be affected from changes in δ when $\delta < \widehat{\delta}_E$.

Cartel prices are constant at P_E^m. Therefore they only vary with the marginal costs of the efficient firm. Since $\frac{\partial P_E^m}{\partial c_E} > 0$ lower costs leads to lower prices. As $\frac{\partial \overline{s}}{\partial \delta} < 0$ in both the unilateral and coordinated case, lower discount factor results in a higher market share for the efficient firm. Otherwise the efficient firm would be tempted to deviate.

4.2 Collusive price

In the following we investigate the property of the collusive prices and the solutions to the bargaining problem. We also compare the findings to Harrington's two-firm model.

Proposition 7. *The grand cartel will set prices in the interval* $\widehat{P} \in (p_E^m, p_I^m)$

The cartel will always set a price somewhere in between the monopoly prices of the efficient and inefficient firms. From assumption A.5 the monopoly price is higher for the inefficient firm. Thus, starting at the monopoly price for the efficient firms, a small increase in price will not change the profitability for the efficient firms, but it will increase for the inefficient firm. Starting from the monopoly price of the inefficient firm, a small reduction of the price will increase the efficient firms' profits but leave the inefficient firm's profit unchanged. Setting price between the monopoly profits therefore maximizes the total bargaining surplus.

[16] Since $\tilde{\delta}_E > \tilde{\delta}_I$.

From the cartel's incentive constraints it is obvious that a cartel can allow inefficient firms to survive even though they could not be active on a competitive market. By including inefficient firms in the cartel, prices are higher than they would have been if only efficient firms were included. Therefore, both overcharges and the welfare loss caused by the cartel are higher when inefficient firms are included. The total effect of including an inefficient firms in a cartel is determined by its effect on collusive prices and on its market share.

Proposition 8. *The cartel price is lower when the outside option is a sub-cartel than if it is the Bertrand equilibrium.*

The difference in cartel price between the two regimes, $\widehat{P}^{sub} < \widehat{P}^{bert}$ arises from the existence of bargaining leverage. The inefficient firm has no valuable outside option in any of the regimes and hence limited leverage. The efficient firms on the other hand have a good outside option if they can coordinate their behaviour, since that will ensure them positive profits in a punishment period. The leverage is used to negotiate prices closer so their monopoly price, i.e. lower price. The difference in prices between the two regimes increases monotonically with the cost difference since the efficient firm's leverage increases with the cost difference. Thus, when it comes to the effect of cartels, prices are lower when the efficient members can coordinate their out of equilibrium behaviour.

When pricing is constrained, the constraint affects the two bargaining functions in the same way. Hence the relation between the prices is the same as when the bargaining is unconstrained.

In a duopoly setting Harrington (1991) found that cartel prices are higher when set by Nash bargaining than when determined by joint profit maximization[17]. He stated that these results also should hold for n-firm games. I compare the results from my three-firm model to his findings to see the effect of introducing an additional efficient firms in the model.

In the following two propositions I show that when the threat of unilateral deviation binds the cartel, i.e. equation (12) is satisfied, the cartel price in

[17]To compare the two models Harrington assumed that the optimal market share in joint profit maximization is the same as when determined by Nash Bargaining. As discussed in proposition 6, this is however not the case in equilibrium.

my three-firm model is higher than the price determined by Harrington's two-firm model (Proposition 10). When equation (12) does not hold and the threat of coordinated deviation binds the cartel, cartel prices are lower than those calculated by Harrington (Proposition 9). These findings nuances Harrington's results and illustrate the important role of the outside option in determining the effect of a cartel.

Proposition 9. *The price set by a three-firm cartel when the outside option is a subcartel, is lower than the price set by a two-firm cartel with cost asymmetries.*

Proposition 8 stated that $\widehat{P}^{sub} < \widehat{P}^{bert}$. I find that $\widehat{P}^{sub} < \widehat{P}^{two-firm}$, hence the introduction of a second efficient firm leads to lower cartel prices and a less harmful cartel when the outside option is a subcartel. Increasing the number of efficient firms hence decreases prices.

In the two compared equilibria, the efficient firms make profits in the punishment phase. These profits will be higher when there is only one efficient firm since they are then not shared. Proposition 9 implies that increased profits in the punishment phase reduces prices as the efficient firms' bargaining leverage increases. According to this logic the two-firm model should give the lowest prices since the punishment profits is higher. There are however two factors that pull in the opposite direction.

First, an obvious effect is the weighing in the bargaining problem. In the three-firm bargaining model the three firms have equal weights and the bargaining surplus of the efficient firms is thus squared which brings down the cartel price.

Second, cartel prices are also a function of optimal market share. The equilibrium market share for the efficient firms are

$$\widehat{s} = \left\{ \begin{array}{ll} \frac{1}{3} + \frac{\overline{\pi}}{6\pi_E} & \text{if three-firms (subcartel)} \\ \frac{1}{2} + \frac{\overline{\pi}}{2\pi_E} & \text{if two-firms} \end{array} \right\}$$

Thus an efficient firm gets a higher equilibrium market share in the two-firm model. This is natural since we expect market shares to fall with the number of firms in the cartel. In both models the effect from an increase in market share on price is positive, i.e. $\frac{\partial}{\partial s}\left(\frac{\partial \pi_E}{\partial P}\right) > 0$[18]. This is in line with the

[18]It also holds that $\frac{\partial \widehat{s}}{\partial P} > 0$ since $P > P^m$.

finding that market share is used as a compensation to the efficient firm for accepting a price above its monopoly price. Since the market share is larger in the two-firm model, it can accept higher prices than when there are three firms.

Proposition 10. *The price set by a three-firm cartel where the outside option is the Bertrand equilibrium, is higher than the price set by a two-firm cartel with asymmetric costs.*

Since $\widehat{P}^{sub} < \widehat{P}^{bert}$ and $\widehat{P}^{sub} < \widehat{P}^{two-firm}$ I investigate if $\widehat{P}^{two-firm} < \widehat{P}^{bert}$. If not, introducing a second efficient firm always reduces cartel prices, irrespective of the deviation strategy. When the outside option is the Bertrand equilibrium, prices set by a three-firm cartel, $\widehat{P}^{bert}$ are higher than if there are only two firms on the market, $\widehat{P}^{two-firm}$. The intuition for this is fairly straight forward. The efficient firms in the three-firm model have no outside option when they deviate unilaterally since this results in the Bertrand equilibrium. Hence they have no bargaining leverage to demand lower prices, closer to their monopoly price. On the other hand, if there are only two firms, the efficient firm will be able to make profits in the punishment period as long as there are cost differences. This translates into bargaining leverage and allows the efficient firm to require lower prices. Therefore, increasing the number of efficient members in the cartel from one to two reduces their bargaining power and increases cartel prices.

4.3 Effect of changes in efficiency

To understand how cost asymmetries affect the cartel's pricing I perform some comparative statics. When the outside option is the Bertrand equilibrium the results coincide with those by Harrington (1991).

Proposition 11. *Cost reductions for the efficient firm leads to lower cartel prices.*

When it is most profitable to deviate to the Bertrand equilibrium there is no valuable outside option. The effect on price from a change in costs is therefore only determined by how the cost change affects the firms' optimal

prices. A reduction of the efficient firms' costs lowers the efficient firms' monopoly prices, but does not affect the inefficient firm's monopoly price. A cost reduction therefore reduces the cartel price.

When the most most profitable option is to deviate to a subcartel there are also profits in the punishment phase. Lower costs increase the value of the outside option and from proposition 9 we know that a more valuable outside option reduces price. Both effects hence pull in the same direction and prices fall faster as a result of cost reductions by the efficient firms when they would deviate to a subcartel. Thus, irrespective of the deviation strategy, $\frac{\partial P}{\partial c_E} > 0$ holds.

When $\delta \in (\underline{\delta}, \widehat{\delta}_E)$ the cartel cannot agree on the Nash bargaining outcome and therefore agrees on P_E^m. A reduction of c_E reduces P_E^m. Hence the effect of cost changes is the same as above.

Proposition 12. *Cost reductions for the inefficient firm can either reduce or increase the cartel price.*

When the best outside option is to deviate to the Bertrand equilibrium, reducing c_I has the same effect on price as a reduction in c_E, i.e. a reduction in costs reduces the monopoly price - in this case for the inefficient firm. Lower costs therefore reduces the cartel price. When the best option is to deviate to a subcartel the relationship is more complicated since changes in costs, besides changing the optimal price, also influences the value of the outside option. The outside option for the efficient firms is $\frac{(c_I - c_E)D(c_I)}{2}$ and reducing c_I reduces the value of the outside option which gives the efficient firms less leverage and pushes the cartel price upwards. The two effects work in opposite directions. The effect of the cost reduction on prices hence depends on which of these two effects are strongest.

When the cost differences are small the price increasing effect of the outside option is small and prices fall with cost reductions from the inefficient firm $\frac{\partial P}{\partial c_I} > 0$. But for sufficiently large cost differentials, the price will increase as the inefficient firm becomes more efficient because the efficient firm looses bargaining leverage, i.e. $\frac{\partial P}{\partial c_I} < 0$. Berg (2011) defines the critical cost difference that turns the relation negative in a two player game using a linear demand function. Without further assumptions on the concavity of demand, it is not possible to determine the effect when the best outside option is to deviate to a subcartel.

In the constrained bargaining situation, when the firms cannot agree on the Nash bargaining outcome, the cartel price is set at P_E^m. In this case changes in the efficient firm's costs do not affect the cartel price.

Proposition 13. *Cost reductions only affect the optimal market share when the most profitable deviation strategy is a subcartel.*

When it is most profitable to deviate to the Bertrand equilibrium, the optimal market share is given by

$$\widehat{s}^{bert} = \frac{1}{3} \tag{16}$$

Hence all firms will receive the same market share in the cartel, independent of the firm level of efficiency since there are no profits for the efficient firms in the punishment phase. Consequently there is no valuable outside option that confers bargaining leverage that enables the efficient firms to require a higher market share despite being more efficient.

When it is most profitable to deviate to a subcartel the optimal market share is given by

$$\widehat{s}^{sub} = \frac{1}{3} + \frac{(c_I - c_E)\, D\,(c_I)}{6\,(P - c_E)\, D\,(P)} \tag{17}$$

When the members are symmetric all firms get the same market share. But, this is not the case when there are cost asymmetries. In similarity to Harrington (1991) I conjecture that $\frac{d\widehat{s}^{sub}}{dc_E} < 0$ and $\frac{d\widehat{s}^{sub}}{dc_I} > 0$ because an efficient firm should get a higher market when its outside option improves.[19]

The direct effect of c_E on $\widehat{s}$, holding P constant, is indeed negative. But as seen in Proposition 11, the cartel price is affected by c_E where $\frac{\partial P}{\partial c_E} > 0$ and from footnote (18) $\frac{\partial s}{\partial P} > 0$. There is hence a countervailing effect through the prices where $\frac{\partial \widehat{s}^{sub}}{\partial c_E} > 0$. Although I cannot generally determine the total effect, numerical simulations using linear demand function[20] confirms that the overall effect is negative in that case.

Holding P fixed the partial effect $\frac{\partial \widehat{s}^{sub}}{\partial c_I} > 0$.[21] But from proposition 12 c_I also affects P and the effect depends on the size of the cost difference. Total

[19] I have only been able to verify this numerically for a linear demand function.

[20] Demand function: $D\,(P) = a - P$.

[21] $\frac{\partial s}{\partial c_I} = \frac{(c_I - c_E)D'(c_I) + D(c_I)}{6(P - c_E)D(P)} > 0$ since $c_I < p_E^m$.

differentiation gives $\frac{d\widehat{s}^{sub}}{dc_I} > 0$ if $\frac{\partial P}{\partial c_I} > 0$ and this is the case for small cost differences. The logic is that increased costs for the inefficient firm gives a higher price. Due to higher prices the efficient firms needs more compensation with market share to stay in the cartel. The finding which is consistent with that of Bae (1987), is confirmed by numerical simulation in the case of linear demand.

5 Extending the model to N-firms

So far the model only allowed for three firms in the market. In this section I illustrate that the findings from this model are valid also for settings with more firms. The effect on prices from an additional firm depends on its efficiency. A new firm can be

1. More efficient than most efficient firms
2. Just as efficient as most efficient firms
3. More efficient than inefficient firm
4. Just as efficient as inefficient firm
5. More inefficient than inefficient firm

For tractability we only investigate the effects by adding n efficient firms, i.e. all firms fall into category 2 above, rather than inclusion of firms with different levels of efficiency. But the general framework can be applied to any degree of efficiency.

Increasing the number of efficient firms to n gives us the following bargaining problem.

$$\max_{p,s} \left(s\pi_E - O_E\right)^n \pi_I \left(1 - ns\right) \text{ s.t. } s\pi_E^c \geq O_E$$

where the outside option is given by.

$$O_E = \left\{ \begin{array}{ccc} 0 & \text{if} & \text{Bertrand eq.} \\ \frac{\overline{\pi}}{n} & \text{if} & \text{Subcartel} \end{array} \right\} \tag{18}$$

When it is most profitable to deviate unilaterally and end up in the Bertrand equilibrium the price effect of introducing n efficient firms comes from two sources. First, as the number of efficient firms increase so does their relative weight in the bargaining problem. Prices are therefore lowered towards their monopoly price as n increases. Second, the optimal market share is affected by the number of firms. The optimal market share for an efficient firm is

$$\widetilde{s} = \frac{n}{2\left(1+n\right)}$$

and with $n = 2$ we have $s = \frac{1}{3}$ just as before. Naturally, the optimal market share decrease when the number of firms increase. The incentive constraints in equation (4) show that the cartel is sustained by the allocation of market shares, where the efficient firms are being compensated with higher market shares for accepting $\widehat{P} > p_E^M$. Increasing the number of firms reduces the possibility of market share compensation and the set of sustainable outcomes is reduced when n increases. Since there can be less compensation, prices are reduced. These two effects result in price reductions when more efficient firms are introduced, i.e. $\frac{dP}{dn} < 0$. This finding is natural since the number of firms with a preference for a lower price increases and the maximum compensation to the efficient firms for accepting $\widehat{P} > p_E^M$ is smaller.

In the case of deviation to a subcartel the optimal market share is

$$\widehat{s} = \frac{\pi_E n^2 + 2\overline{\pi}}{2\pi_E\left(n+n^2\right)}$$

Hence, without any cost asymmetries and $n = 2$ the result is $s = \frac{1}{2}$ just as before. Keeping prices fixed, introducing cost asymmetries increases the market share for the efficient firms. The effects are hence similar to in the above case. But, a third countervailing effect enters the model when firms can deviate to a subcartel. With more efficient firms the outside option is reduced, making it less profitable to deviate jointly as n increases. Since the value of the outside option is reduced with n, so is their bargaining leverage and prices are pushed up.

The total effect from increasing n is $\frac{dP}{dn} < 0$. Thus the two negative effects are larger than the loss in bargaining leverage. Irrespective of the size of the cost asymmetries, increasing the number of efficient firms reduces the cartel price. As the number of firms increases, the prices from the subcartel model will

converge to the prices in the model where the Bertrand equilibrium model is the best outside option since the outside option becomes smaller.

6 Discussion

This paper uses a infinitely repeated games framework to analyse the effect of cost asymmetries on cartel sustainability and prices. With cost asymmetries and more than two-players, collusion is not only threatened by unilateral deviation, firms may also deviate to smaller cartels. Collusion is therefore more difficult to sustain when the cost differences are large as the temptation to deviate to the sub-cartel becomes strong. This provides an explanation as to why large cartels are not common in industries with heterogeneous firms.

The main difference between the models where the efficient firms deviate unilaterally (to the Bertrand equilibrium) and coordinatedly (to a subcartel), is the outside option. In two-firm models the restriction of players convey a profitable deviation for the efficient firm. But, unilateral deviation in a market with $n \geq 2$ efficient firms leads to the zero profit Bertrand equilibrium in the punishment phase. Hence only if the efficient firms can coordinate their deviation and form a subcartel, is there a valuable outside option. The outside option enables the efficient firm to require lower prices than in the case of unilateral deviation. Thus, to understand a cartel's pricing scheme one must not only know the cost levels of the individual firms, but also find out which is the best deviation strategy. The findings can explain some of the diversity in cartel overcharges. In markets with many efficient firms, and with possibilities to make partial cartels prices are expected to be close to the lower. Whereas in markets with many inefficient firms and where it is not possible to form partial cartels, prices are higher. Hence, if the competition enforcement is active such that it hinders the negotiation of partial cartels, it actually leads to higher cartel prices for the cartels that are formed.

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A Appendix

The detailed appendix is to the benefit of the referees and should be excluded in the final version of the paper.

A.1 Nash bargaining solutions

Outside option is Bertrand competition

When Bertrand competition is the outside option $O_i = 0$,for all i. This simplifies the bargaining problem in equation 13 to $V(P,s) = \max_{P,s}(s(P-c_E)D(P))^2(P-c_I)D(P)(1-2s)$. This gives the first order conditions $V_P(P,s) : (P-c_E)(s-1)s(D(P)(3P-2c_I-c_E)+3(P-c_I)(P-c_E)D'(P)) = 0$ and $V_s(P,s) : 2(1-2s)sD(P)^3(P-c_I)(P-c_E)^2 - 2s^2D(P)^3(P-c_I)(P-c_E)^2 = 0$. The $V_s(P,s)$ can be re-arranged to $\widehat{s} = \frac{1}{3}$. Substituting the optimal market share in $V_P(P,s)$ gives

$$(P-c_E)\,D(P)\,((3P-c_E-2c_I)\,D[P]+3\,(P-c_E)\,(P-c_I)\,D'(P)) = 0. \qquad (19)$$

Outside option is a subcartel

When the efficient firms can form a subcartel they have a positive outside option. The bargaining function is then given by $V(P,s) = \max_{p,s} \left(s\left(P-c_E\right)D\left(P\right) - \frac{\left(c_I-c_E\right)D(c_I)}{2}\right)^2 \left(\left(P-c_I\right)D\left(P\right)\right)\left(1-2s\right)$.

The first order conditions are $V_P(P,s) : \frac{2(P-c_E)+(c_I-c_E)D(c_I)}{(P-c_i)D(P)}$ $\left(\left(P-c_E\right)D(P) - \left(c_I-c_E\right)D(c_I)\right)\left(\left(3P-c_E-2c_I\right)D(P) + 3\left(P-c_E\right)\left(P-c_I\right)D'(P)\right) =$ 0 and $V_s(P,s) : \left(P-c_I\right)D(P)\left(2\left(P-c_E\right)D(P)s - \left(c_I-c_E\right)D(c_I)\right)$ $\left(2\left(P-c_E\right)\left(3s-1\right)D(P) - \left(c_I-c_E\right)D(c_I)\right) = 0$. The $V_s(P,s)$ can be solved for $\widehat{s} = \frac{2(P-c_E)D(P)+(c_I-c_E)D(c_I)}{6(P-c_E)D(P)}$. Substituting the optimal market share in $V_P(P,s)$ gives

$$\left(P-c_E\right)D(P)\left(\left(3P-c_E-2c_I\right)D(P) + 3\left(P-c_E\right)\left(P-c_I\right)D'(P)\right) = 0. \tag{20}$$

Two-firm model

If there is only one efficient and one inefficient firm the bargaining problem is $V(P,s) = \max_{P,s}\left(s\left(P-c_E\right)D\left(P\right) - \left(c_I-c_E\right)D\left(c_I\right)\right)\left(P-c_I\right)D\left(P\right)\left(1-s\right)$ which gives the following first order conditions. $V_P(P,s) : \left(s\left(P-c_E\right)D'\left(P\right) + D\left(P\right)\right)$ $\left(P-c_I\right)D\left(P\right)\left(1-s\right) + \left(\left(P-c_I\right)D'\left(P\right)\left(1-s\right) + D\left(P\right)\left(1-s\right)\right)$ $\left(s\left(P-c_E\right)D\left(P\right) - \left(c_I-c_E\right)D\left(c_I\right)\right) = 0$ and $V_s(P,s) : \left(P-c_E\right)D\left(P\right)\left(P-c_I\right)D\left(P\right)$ $\left(1-s\right) - \left(P-c_I\right)D\left(P\right)\left(s\left(P-c_E\right)D\left(P\right) - \left(c_I-c_E\right)D\left(c_I\right)\right) = 0$. The $V_s(P,s)$ can be simplified to $s = \frac{1}{2} + \frac{\left(c_I-c_E\right)D(c_I)}{2\left(P-c_E\right)D(P)}$. Substituting s in $V_P(P,s)$ gives

$$\begin{aligned}&\left(P-c_E\right)D\left(P\right) - \left(c_I-c_E\right)D\left(c_I\right)\\ &\left(\left(2P-c_E-c_I\right)D\left(P\right) - \frac{\left(c_I-c_E\right)^2}{P-c_E}D\left(c_I\right) + 2\left(P-c_E\right)\left(P-c_I\right)D'\left(P\right)\right) = 0\end{aligned} \tag{21}$$

A.2 Proofs

Proof of Proposition 5. The objective function for joint profit maximization is $\Pi\left(P,s\right) = 2s\pi_E + \left(1-2s\right)\pi_I$. $V_s(P,s) : 2\left(\left(P-c_E\right)D\left(P\right) - \left(P-c_I\right)D\left(P\right)\right) = 0$ and $2\left(\pi_E-\pi_I\right) > 0$. The solution is therefore a corner solution where the efficient firms produce market demand. □

Proof of Proposition 6. Re-arranging the constraint $\delta = \widehat{\delta}$ gives $\pi_E^c s = \left(1-\delta\right)\pi_E^d + \delta\pi_E^n$. Substituted into the objective function the bargaining problem becomes

$$max_{P,s}(1-\delta)(O_E - \pi_E^n)^2(1-2s)\pi_I \text{ s.t. } O_E > \pi_E^n$$

Since s only enters in the second part of the problem it is easy to see that $V_s(P,s) < 0$. The optimal market share is hence a corner solution where the share should be set as low as possible. By $\underline{s}$ this is achieved when the cartel price is set as P_E^m. □

Proof of Proposition 7. By assumption $c_I > c_E$ and therefore $p_I^m > p_E^m$.
At $P < P_E^m$, $\pi'_E(P) > 0$ and $\pi'_I(P) > 0$, hence the bargaining surplus increases with P.

At $P = p_E^m$, $\pi'_E(P) = 0$ and $\pi'_I(P) > 0$. Thus for a small enough increase in P, the bargaining surplus is increased.

At $P > p_I^m$, $\pi'_E(P) < 0$ and $\pi'_I[P] < 0$, hence both firms would profit from reduced price.

At $P = p_I^m$, $\pi'_E(P) < 0$ and $\pi'_I[P] = 0$. Thus for a small enough decrease in P, the bargaining surplus is increased. □

Proof of Proposition 8. Maximizing the bargaining function gives $V_P(P,s) = (2s-1)$ $((P-c_E)\,sD(P) - O_E)\,(D(P)\,(s\,(2\pi_I + \pi_E) - O_E) + (P-c_I)\,(3\pi_E s - O_E)\,D'(P)) = 0$. The difference between the two models is the outside option, O_E. The effect of O_E on $V_P(P,s)$ is $(2s-1)\,(-O_E)\,(-O_E D(P) - (P-c_I)\,O_E D'(P))$. The last parenthesis can be re-written as $-O_E\,(\pi'_I)$ and π'_I is known to be positive. Therefore all three parenthesis are negative so increases in O_E decreases $V_P(P,s)$ and thus P. □

Proof of Proposition 9. Both $V_P(P,s)$'s in equations 20 and 21 are equal zero in optimum. For any price higher than the optimal price $V_P(P,s) < 0$. Thus if $P^{sub} < P^{two-firm}$ then it should be that $V_P(P,s)^{sub} < 0$ and $V_P(P,s)^{two-firm} = 0$ at $P^{two-firm}$, i.e. $V_P(P,s)^{sub} < V_P(P,s)^{two-firm} = 0$. Re-arranging the terms, the expression can be stated as $(P-c_I)\,((P-c_E)\,D(P) - (c_I-c_E)\,D(c_I))\,(D(P) + (P-c_E)\,D'(P)) < 0$, which simplifies as $(P-c_I)\,(\pi_E - \overline{\pi})\,\pi'_E < 0$. Since $\pi_E > \overline{\pi}$ and as the proof to proposition 7 states that $\pi'_I > 0$, the relation holds. □

Proof of Proposition 10. Following the same reasoning as in the proof of Proposition 9, it should be that $V_P(P,s)^{Two-firm} < V_P(P,s)^{uni} = 0$, where $V_P(P,s)^{Two-firm}$ and $V_P(P,s)^{uni}$ are given by equations 19 and 21, if $P^{Two-firm} < P^{uni}$. By simplifying the notation the relation can be re-arranged to $-\pi_E\pi_I - \pi_E\,(2\overline{\pi} + (P-c_E)\,(P-c_I)\,D'(P))$ $+\overline{\pi}\left(\frac{c_I-c_E}{P-c_E}\overline{\pi} - 2\,(P-c_E)\,(P-c_I)\,D'(P)\right) < 0$. Since $\pi_E > \overline{\pi}$,the expression is true if the first parenthesis is larger than second one. As $c_I - c_E < P - c_E$ it follows that $0 < \frac{c_I-c_E}{P-c_E} < 1$ and therefore $2\overline{\pi} > \frac{c_I-c_E}{P-c_E}\overline{\pi}$. Evaluating at the largest degree of asymmetry possible, $\frac{c_I-c_E}{P-c_E} = 1$ and dividing the expression by $\overline{\pi}\,(P-c_E)$ gives, $-\frac{(P-c_I)D(P)^2}{(c_I-c_E)D(c_I)} - D(P) - (P-c_I)\,D'(P) < 0$. The proof to proposition 7 states that $\pi'_I > 0$, thus the relation is true. It is also true for any $c_I \leq P$. □

Proof of Proposition 11. The $V_P(P)$ from the bargaining function can be stated as $V_{P(c_E),c_E} = 0$. Applying the chain rule $\frac{dV(P(c_E),c_E)}{dc_E}$ can be re-formulated as $\frac{\partial V_P}{\partial P}\frac{\partial P}{\partial c_E} + \frac{\partial V_P}{\partial c_E} = 0$. Re-arranging gives $\frac{\partial P}{\partial c_E} = -\frac{\frac{\partial V_P}{\partial c_E}}{\frac{\partial V_P}{\partial P}}$. Since the collusive price is set at the bargaining

optimum, $V_P = 0$ and thus $\frac{\partial V_P}{\partial P} < 0$. Therefore $\frac{\partial P}{\partial c_E}$ is positive if $\frac{\partial V_P}{\partial c_E}$ is positive. When the outside option is the Bertrand equilibrium, dividing equation (19) by $(P - c_E)^2 D(P)$ gives $1 + \frac{2(P-c_I)}{(P-c_E)} + \frac{3(P-c_I)D'[P]}{D(P)}$ and $\frac{\partial V_P^{uni}}{\partial c_E} = \frac{2P-2c_I}{(P-c_E)^2} > 0$. Therefore, decreased c_E reduces P. When the outside option is a subcartel I note that reducing c_E increases O_E. From Proposition 7, increases in O_E reduces P. Thus the effect is the same also in this case. □

Proof of Proposition 12. By analogy with the proof to Proposition 11 it is clear that $\frac{\partial P}{\partial c_I}$ is positive if $\frac{\partial V_P}{\partial c_I}$ is positive. Using the simplified V_P^{uni} from the Proof of Proposition 11 $\frac{\partial V_P^{uni}}{\partial c_I} = (P - c_E)(-2D(P) - 3(P - c_E)D'[P]) > 0$. This can be re-stated as $(P - c_E)(-2\pi'_E - (P - c_E)D'(P))$ and as $\pi'_E < 0$ and $(P - c_E)D'(P) < 0$ it follows that $\frac{\partial V_P}{\partial c_I} > 0$ and hence that $\frac{\partial P}{\partial c_I} > 0$ When c_I is reduced so is P. It is not possible to determine $\frac{\partial P}{\partial c_I}$ when collusion is supported by coordinated deviation, without further assumptions on the concavity of demand. □

The effects of asymmetric costs on cartel damages: The importance of the counterfactual

Petter Berg[a] and Peter Møllgaard
Copenhagen Business School

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Abstract

Cartel overcharges and the resultant damages and welfare losses are typically calculated by subtracting counterfactual prices from cartel prices. We determine both prices in a repeated game with cost asymmetries and product differentiation. Cost asymmetries and product differentiation significantly affect counterfactual prices, but only have small effects on collusive prices. We find that overcharges and losses in consumer welfare increase with the degree of cost symmetry and substitutability of products. The case of symmetric costs and homogeneous products makes for the extreme case in which welfare losses are maximal and restitution of damages undercompensates consumers the most.

Keywords: Collusion, oligopoly, damages, antitrust
JEL-Classification: D43, L13, D41

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1 Introduction

The fight against cartels is to a large extent driven by private litigation. This is especially true in the US where 90 percent of the cartel cases are litigated through private enforcement (Wils, 2003). Improved private enforcement is a top priority also in Europe (European Commission, 2008) and in order to facilitate and promote private enforcement, the European Commission published an economic report on how to assess cartel damages (Oxera, 2009) and draft guidelines on how to quantify harm (European Commission, 2011). As is evident from the economic report, game theoretic collusion models play an important role in determining the negative effects from cartels and are considered one of three main methodological approaches to quantifying cartel damages.[1] In this tradition and within a coherent model of collusion, this paper illustrates how sensitive cartel damages are to product differentiation and cost asymmetries. It also investigates how these features affect consumer welfare.

The overcharge damages caused by cartels is largest when products are homogeneous and the member firms are symmetric. Under these conditions cartels result in the largest losses of consumer welfare. Competition authorities that want to focus on the most detrimental cartels should therefore give priority to cartels in this type of environments. This is true even with active private enforcement since consumers are most under-compensated in these types of cartels, even when they are awarded full compensation for the overcharges.

The effect of horizontal differentiation on collusion has been widely investigated for many years. There are two strands of models that give somewhat different results depending on their assumptions; non-spatial and spatial (Hotelling) models. In the non-spatial framework that we will apply, it is standard to determine cartel prices through maximization of joint profits. While not generally applicable, this approach, an artifact from Patinkin (1947), is reasonable when firms are symmetric. With this approach, cartel prices are not affected by product differentiation and the cartel will always strive to set the monopoly price. Product differentiation only affects the ability to sustain collusion, not the collusive outcome itself. Product differentiation lowers deviation profits and increases Nash profits. To a large extent, this literature focuses on the sustainability of collusion as measured

[1] The other main methods envisaged are comparator based and financial analysis based approaches.

by the minimum discount rate that is necessary to sustain collusion by some punishment strategy.

Deneckere (1983) pioneered a two-firm differentiation model with non-spatial product differentiation. Collusive prices are set at the monopoly level, grim trigger strategies are used to sustain collusion, and the minimum discount factor that can sustain collusion is found for both Bertrand and Cournot cases. In subgame-perfect equilibrium, collusive prices are unaffected by product differentiation. Deneckere finds a U-shaped relationship between the degree of differentiation and the discount rate that is required to sustain collusion when firms compete in prices. For quantity competition the relationship is monotonically positive. For highly differentiated products, collusion is more stable under quantity than under price competition. However as products become close substitutes, collusion is more stable under price competition. These results also hold for different demand structures (Albaek and Lambertini, 1998). Wernerfelt (1989) extends Deneckeres Cournot model to allow for n-firms and collusion supported by optimal punishment (Abreu, 1986). Contrary to the standard intuition, he finds that product differentiation increases the rewards from cheating and makes punishments harder. The net effect depends on the parameters. For example, differentiation increases the scope for collusion when there are few firms on the market. Cartel prices however, are unaffected by product differentiation.

The other strand of models employs spatial differentiation with heterogenous consumers. In these models, the collusive prices change with the degree of differentiation. In a duopoly setting where firms compete in prices, collusive prices are set by joint profit maximization, and grim strategies are used to sustain collusion. Chang (1991) shows that the effect from differentiation on the collusive price is non-monotonic: the price increases with product differentiation when the products are sufficiently differentiated, but reduces with differentiation when the products are closer substitutes. Also in contrast to Deneckeres findings, there is a monotonic relationship between the sustainability of collusion and product differentiation where collusion is always harder to sustain for products that are closer substitutes. Chang (1991) shows how the difference between the models arises from the way in which differentiation is modeled. Häckner (2000) confirms Chang's results with optimal punishments. Jehiel (1992) studies whether cartels will produce differentiated or homogeneous products in a setting similar to that of Chang but determines the collusive price by Nash bargaining and allows for sidepay-

ments. When sidepayments are not possible, there will be no differentiation while when sidepayments are allowed, there may be some differentiation since own location becomes unimportant for market shares.

The literature on collusion with asymmetric costs is much less developed for both strategic and computational reasons. Asymmetric firms no longer agree on the optimal cartel price and so deciding on cartel prices becomes more complicated. Extending the price-setting duopoly of Bae (1987), Harrington (1991) employs Nash bargaining to determine cartel prices. He finds that cost asymmetries make the cartel less sustainable and that the cartel price is increasing in the cost of the efficient firm but decreasing in the cost of the inefficient firm, provided the cost difference is sufficiently large. Rothschild (1999), Collie (2006) and Vasconcelos (2005) look at homogenous and differentiated Cournot models in which the cartel price is determined by joint profit maximization. They find that when the inefficient firm is active, it will receive a lower market share than the efficient firm and therefore have larger incentives to deviate. Further, if a cartel is formed, and one firm deviates, the efficient firm will be disproportionately harmed and therefore wants to deviate from the punishment strategy.

Contrary to the literatures on collusion with product differentiation and with asymmetric costs, we focus mainly on the price effects caused by differentiation and cost asymmetries and are less concerned with sustainability of collusion. We find that product differentiation interacts with cost asymmetries in surprising ways. In our set-up, the cartel price is determined by take-it or leave-it bargaining - a version of Nash bargaining that gives all bargaining power to one of the firms. In most of the exposition we assume that it is the efficient firm that has all the bargaining power, in effect being the "ring leader". However, for robustness we also check what happens if the inefficient firm has all the bargaining power. In this way we essentially span the set of outcomes that would arise with generalized Nash bargaining, see Binmore et al. (1986).

We find that cartel prices are relatively unaffected by cost asymmetries and product differentiation but that the counterfactual Nash price is strongly affected by both. Product differentiation and cost differences increase the counterfactual price and leaves less room for the cartel to increase prices. This in turn means that the overcharge (cartel price minus counterfactual price) as well as the damages and the welfare loss caused by the cartel are seriously affected by cost asymmetries and product differentiation. The ex-

treme case is the standard textbook case of collusion with homogeneous goods and symmetric firms. This is the worst case in the sense that the damages and the welfare losses to consumers are higher in this case than in any other case we analyse. It is also the worst case in the sense of the degree to which the restitution of damages compensate consumers for this loss.

We set up our basic model of cost asymmetries and product differentiation in section 2 and find the non-cooperative (counterfactual) equilibria in section 3. We then assume that firms form a cartel where the efficient firm offers a take-it or leave-it offer to the inefficient firm and solve the collusive model numerically in section 4. In section 5 we investigate the effects of the cartel on damages and consumer surplus. Section 6 concludes. All proofs and derivations are found in the appendix.

2 Model

We base our model on the Singh and Vives (1984) duopoly model for differentiated products[2]. Consumers maximize their net utility and face the problem

$$\max_{q_1,q_2} q_1 + q_2 - \frac{(q_1^2 + 2\gamma q_1 q_2 + q_2^2)}{2} - \sum_{i=1}^{2} p_i q_i \tag{1}$$

This gives the following inverse demand function

$$p_i = 1 - q_i - \gamma q_j \quad \{\, i, j = 1, 2, i \neq j\} \tag{2}$$

where q_i is the quantity supplied and γ is a measure of the degree of horizontal product differentiation. We are only interested in the case of competing products and therefore restrict γ to $\gamma \in (0, 1)$. When $\gamma = 0$ the products are independent in demand and hence, firms are monopolists on their own product. When $\gamma = 1$, the products are homogenous, i.e. perfect substitutes. Invert (2) to obtain the following direct demand functions[3].

[2]This differs from Singh and Vives (1984) original paper since we have normalised the own-quantity slope of the inverse demand function by setting their $\alpha = 1$ and $\beta = 1$.

[3]The demand function is not well defined when $\gamma = 1$, see Singh and Vives (1984)

$$q_i = \frac{1 - p_i - \gamma\,(1 - p_j)}{1 - \gamma^2} \text{ where } \{i, j = 1, 2;\ i \neq j\} \tag{3}$$

The effect on demand from reducing product differentiation (increasing γ) comes from two sources. First there is a business stealing effect that gives more demand to the firm with lowest price. Second, there is an effect from reduced variety. As the preferences exhibit love of variety (utility is decreasing in γ), reducing product differentiation lowers total demand. If the price difference is very large, the stealing effect is dominant and the quantity of the firm with the lowest price will increase monotonically as the products become less differentiated. When the price difference is smaller, the loss of variety is initially the dominant effect, causing less quantity sold. But, for less differentiated products the stealing effect dominates and quantity increases as the products become more alike.

Firms face linear cost functions where c_i denotes the marginal cost for firm i. Although Singh and Vives' (1984) model allows for cost asymmetry, they restrict the space of the model by assuming that both firms produce positive outputs, i.e. that both firms face positive demand when prices are set at marginal cost. This implies that the model is restricted to firms with symmetric costs, as any other situation would force the inefficient firm to produce zero. We relax this assumption: when $q_i = 0$, demand for product j is given by $q_j = 1 - p_j$.

We assume that firm 1 is fully efficient and that $c_1 = 0$. Firm 2 is less efficient, i.e. $c_2 \geq 0$ and c_2 can therefore be interpreted as the cost difference between the firms.

Our model is based on a collusive and one non-collusive state. In the non-collusive state, we assume Bertrand competition, i.e. firms compete by setting prices simultaneously. In the collusive state firms we assume that the efficient firm makes a take-it or leave-it offer to the inefficient firm. Collusion is sustained as a subgame perfect equilibrium where deviation is deterred by a grim trigger strategy that brings the market to the non-competitive equilibrium if deviation is detected. The Folk Theorem implies that any set of individually rational collusive payoffs can be sustained as the outcome of a subgame perfect quilibrium of an infinitely repeated game as long as the discount factor is sufficiently high (Fudenberg and Maskin, 1986). In this paper, our prime focus is however not primarily to analyse the minimum

discount factor that can sustain collusion, but rather to focus on the damage caused by the cartel.

3 Non-cooperative equilibrium - counterfactual

We first characterize the non-collusive Bertrand equilibria in a standard non-constrained duopoly model in which both firms are active. However, as the inefficient firm will not be able to survive in the highly competitive market that results when products are fairly homogenous, we also investigate two sets of non-cooperative equilibria in which the inefficient firm is not active on the market; one in which the inefficient firm acts as a constraint on the pricing of the inefficient firm, and one in which the efficient firm may charge monopoly prices. The analysis follows Zanchettin (2006) and is for this reason brief.

The firms face the following profit function

$$\pi_i = (p_i - c_i)\left(\frac{1 - p_i - \gamma\,(1 - p_j)}{1 - \gamma^2}\right) \tag{4}$$

Due to the cost asymmetry between the firms, a standard Bertrand equilibrium will not always exist. When the cost difference between the firms is sufficiently high and the products are sufficiently close substitutes, the inefficient firm will not be active on the market. The combination of inefficiency and product differentiation for which the inefficient firm will have zero production is given by

$$\widehat{c}_2 \equiv 1 - \frac{\gamma}{2 - \gamma^2} \tag{5}$$

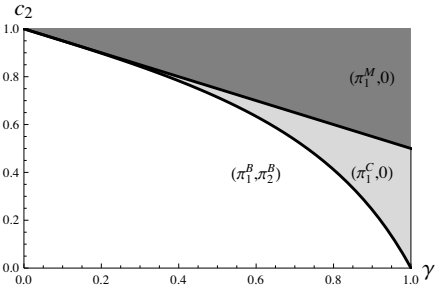
When $c_2 > \widehat{c}_2$, only the efficient firm is active. There is a trade off between product differentiation and cost asymmetry that enables the inefficient firm to remain active if the products are sufficiently differentiated. When $c_2 > \widehat{c}_2$, the inefficient firm still restricts the pricing behaviour of the efficient firm until the cost difference becomes so large that the efficient firm can set monopoly prices without incurring entry. The critical cost difference beyond which the

efficient firm is unconstrained in its pricing is given by

$$\widetilde{c}_2 \equiv 1 - \frac{\gamma}{2}$$

The degree of product differentiation and cost asymmetry define three regions of competition. These regions in the space $\{c_2, \gamma\}$, are illustrated in Figure 1 below.

Figure 1: *Forms of competition*

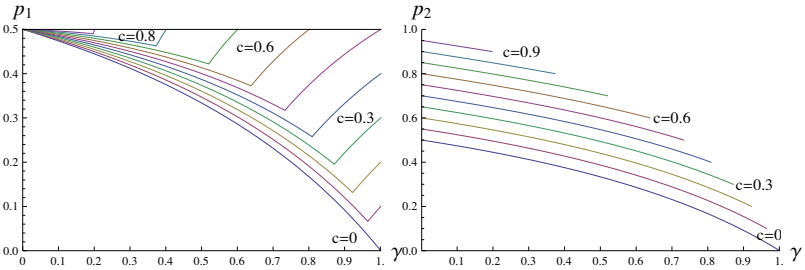


The white area in the bottom left in Figure 1 is the standard Bertrand region where both firms are active. The top right dark grey area is the monopoly region for firm 1. In the region between the monopoly and Bertrand areas, pricing is constrained: only the efficient firm produces, but at a price below the monopoly level. The range of non-cooperative outcomes is summarized in Table 1 of the Appendix.

Figure 2 illustrates how counterfactual prices depend on product differentiation and cost asymmetries.

Figure 2: *Non-cooperative prices*

(a) *Efficient firm* **(b)** *Inefficient firm*



The lower lines in the two figures are the Bertrand prices when there are no cost asymmetries. Hence they are the same for the efficient and inefficient firms. In the curves above, cost asymmetry is introduced with increments of 0.1. The curves for the prices of the inefficient firms become shorter for higher levels of cost asymmetry since the inefficient firm is forced to exit the market when $c_2 \geq \widehat{c}_2$. The reduction in prices for higher levels of γ is not only attributed to increased competition as products become more homogenous. The effect is reinforced by the love of variety property of the utility function that affects total market demand. Demand with homogenous products is only half compared to the case of independent products and the demand reduction is monotonic in product substitutability. Since demand is lower, so is price. When $c_2 > \tilde{c}_2$ firm 1 sets its monopoly price.

From the three possible pure strategy non-cooperative equilibria, defined by γ and c_2, it is trivial to show that $\pi_1^M > \pi_1^{Constr} > \pi_1^{Bert}$. In the following we refer to the relevant pay-off from the non-cooperative equilibria in Table 1 of the Appendix as π^n.

4 Collusive equilibrium

In this section we analyse the cooperative equilibrium. We focus on subgame perfect collusion and will therefore, in line with most of the literature (see Miklos-Thal (2011) for a brief discussion), not allow for side-payments be-

tween firms.[4] In this model, collusion is only sustainable if the private gains from being in the cartel is larger than those obtained by chiselling. We first briefly describe the requirement for cartel stability to then turn the attention to the selection of collusive prices by members of the cartel.

4.1 Sustainability of collusion

Cartels are inherently instable as there is always a temptation to deviate from the agreement to make short-run profits. The cartel is therefore only sustainable as long as all members find that the discounted value from staying in the cartel is higher than the value from deviating. Thus, high cartel profits and tough punishment of deviation will improve the sustainability of a cartel. We assume that deviation from the collusive price triggers a grim response, leading to the non-cooperative equilibrium ever after. It is therefore profitable for a firm to stay in the collusion if

$$\frac{1}{1-\delta}\pi_i^{Cart}\left(c_i,c_j,\gamma\right) \geq \pi_i^{Dev}\left(p,c_i,\gamma\right) + \frac{\delta}{1-\delta}\pi_i^{n}\left(c_i,c_j,\gamma\right), i \in \{1,2\} \qquad (6)$$

Thus the lowest discount factor for collusion to be sustainable is defined by

$$\widehat{\delta}_i \equiv \frac{\pi_i^{Dev}\left(p,c_i,\gamma\right) - \pi_i^{Cart}\left(c_i,c_j,\gamma\right)}{\pi_i^{Dev}\left(p,c_i,\gamma\right) - \pi_i^{n}\left(c_i,c_j,\gamma\right)} \qquad (7)$$

Our starting point is the situation in which an antitrust authority or a court has already established the existence of the cartel. At that point, the question is not if the cartel was sustainable or not, but rather what damages are inflicted upon customers and on society. For this reason, we de-emphasize sustainability in our analysis.

As shown by Bae (1987), Harrington (1991) and Berg (2011), asymmetric producers of homogenous products have to agree on a single price to ensure that they are all active in equilibrium. However, when products are differentiated, firms may charge different collusive prices. Before deciding on a

[4] Side-payments exist in reality, in fact several cartels have been known to have elaborate transfer schemes (Levenstein and Suslow (2006), but as transfers cannot be contracted they represent a challenge to the sustainability of collusion. See Berg (2011) for further reasons. The inability to contract side-payments may be an explanation for price wars.

price setting mechanism, we note that due to cost asymmetries and product differentiation, cartel members prefer to set individual prices rather than a common price.[5] By setting a higher price for the inefficient firm and a lower price for the efficient firm, collusive profits will increase and deviation profits will decrease (non-cooperative profits are unaffected), hence it will also lead to a lower required discount factor than when the cartel is forced to charge one price. The remaining question is which mechanism the firms should use to select their cartel prices.

4.2 Determination of cartel prices

When products are homogenous, a cartel needs to decide both on a price and on market shares for the individual firms (Tirole (1988), Cabral (2000)). With differentiated products each firm has a unique demand function and there is therefore no need to decide on a market sharing rule. In fact, allocation of market shares between the firms is redundant once prices are determined. To some extent this makes the cartel's problem easier to solve as the firms only have to coordinate along one dimension, prices.

When firms are symmetric, all members have the same reaction functions and the cartel therefore sets a joint price for all members. It is often assumed that the price is set to give the Pareto optimal profit for the members, i.e. set at the monopoly price which is the same for all firms (irrespective of products being homogenous or differentiated). As a consequence, joint profit maximization is the most commonly used mechanism to select the cartel price. But, when there are cost asymmetries there is no one focal price on which the members coordinate (Scherer, 1980): firms with lower costs prefer lower prices than those with high costs. In fact, joint profit maximization will not provide a stable equilibrium: for some combinations of c_2 and γ, the inefficient firm will need to leave the market and let the efficient firm produce everything. Without sidepayments this cannot be an equilibrium.[6]

[5] See appendix for proof.

[6] Bae (1987) combines joint profit maximization with Friedman's (1971) balanced temptation requirement but this is problematic, see Harrington (1991). Davis and Sabbatini (2011) analyse the sustainability of collusion where prices are determined either by joint profit maximization or by Nash bargaining. In both cases they introduce Incentive Compatibility Constraints (ICCs). They focus on the minimum discount factor necessary to sustain collusion: if the ICCs bind, the scope for collusion is reduced until the point where

To see this in our framework, note that if prices were set by joint profit maximization, the inefficient firm would be forced to exit the market when $c_2 \geq \overline{c}_2$ where

$$\overline{c}_2 \equiv 1 - \gamma$$

Since $\overline{c}_2 > \widehat{c}_2$, the restriction on efficiency is stricter when prices are set by joint profit maximization than with Bertrand competition. This implies that for $c_2 \geq \overline{c}_2$, firm 2 would be too inefficient to be part of a cartel, while it could make positive profits in a non-cooperative setting. This makes no sense and cannot be the equilibrium for a stable cartel without side payments. Accordingly, joint profit maximization is not a good mechanism for determining cartel prices when there are cost asymmetries between the firms, but no side payments allowed. The reason for this is that without the possibility to distribute profits among the members, firms are interested in maximizing own, not total profits. Hence we need to turn to another mechanism for determining the cartel price; which one to use in this setting is not obvious.[7]

One way to handle the problem of setting prices is to follow Harrington (1991) and let the firms bargain over prices using Nash bargaining. For any combination of c_2 and γ, the bargaining surplus for each firm is given by the difference of the profits from collusion minus the profits from the best outside non-cooperative option, in this case the Bertrand equilibrium. Since the efficient firm has a better outside option than the inefficient firm, prices will be closer to the monopoly price of the efficient firm. However they will not be set so low that the inefficient firm is forced inactive. Unfortunately the problem cannot be solved for a simple algebraic form when products are differentiated and costs are different.

4.3 Take-it or leave-it offer (TIOLI)

In most of this paper, we employ an extreme version of Nash Bargaining where the firm with the best bargaining position, the efficient firm, makes a

the ICC just binds. They show that when the ICCs bind and in the absence of side payments, the models associated with joint profit maximization and Nash bargaining are not observationally equivalent.

[7] We note that when $c_2 < \overline{c}_2$ joint profit maximization is indeed a valid solution. This paper focuses on the cases when it is not.

take-it or leave-it offer to the inefficient firm and maximizes its own profits.[8] The lowest possible offer that the inefficient firm will accept, is an offer that makes it indifferent between collusion and the non-cooperative Bertrand equilibrium. The collusive solution is therefore a menu of prices (one for each firm) proposed by the efficient firm.

The efficient firm's pricing problem can be formulated as

$$Max_{p_1,p_2}\ \pi_1\ s.t.\ \pi_2^{Tioli} \ \geq \ \pi_2^n + \overline{\pi}_2 \tag{8}$$

where π_2^{Tioli} is defined by the general profit function in equation (2) and π_2^n is the relevant non-cooperative profit for the inefficient firm (see Table 1 in the Appendix). $\overline{\pi}_2$ is the extra profit that firm 1 needs to leave on the table in order that the inefficient firm prefers to stay with the cartel. In this case, firm 1 ensures that firm 2 just wishes to follow the trigger strategy, i.e. $\overline{\pi}_2$ should be such that $\delta_2 = \widehat{\delta}_2$ when $\pi_i^{Cart}(c_i, c_j, \gamma) = \pi_2^{Tioli} = \pi_2^n + \overline{\pi}_2$. Solving the constraint with equality, we get

$$\pi_2^{Tioli} = \delta_2 \pi_2^n + (1 - \delta_2)\pi_2^{Dev}$$

so the cartel payoff to firm 2 that makes it just willing to participate in the cartel is a convex combination of the single-stage Nash payoff and the deviation payoff. For ease of exposition, in the following we first assume that $\delta_2 = 1$, implying that firm 2's cartel payoff is $\pi_2^{Tioli} = \pi_2^n$.[9] The constraint $\delta_2 = \widehat{\delta}_2$ can then be solved to obtain the price, $\widetilde{p}_2$, that assures Bertrand profits to the inefficient firm. It can be shown that $\frac{\partial \widetilde{p}_2}{\partial p_1} > 0$, which implies that prices are strategic complements as in the non-cooperative equilibrium.

The maximization problem for the efficient firm now boils down to

[8] Since all bargaining power is given to the firm that prefers low prices, the general Nash bargaining solution will give higher collusive prices. Below we show what would happen if all bargaining power was transferred to the high-cost firm, thus indicating the range of outcomes that may occur under generalized Nash bargaining.

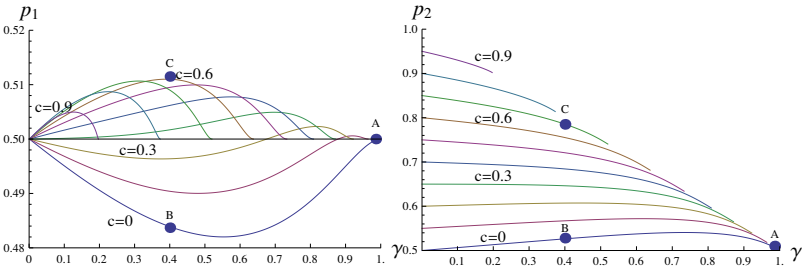
[9] This means that $\widehat{\delta}_2 = 1$, see (7). In the more general case when $\delta_2 < 1$, firm 1 will have to leave more "money on the table" for firm 2. This would not change the results in the following qualitatively but does make the exposition a lot more complicated, so in most of the paper, we assume that $\delta_2 = 1$ and $\overline{\pi}_2 = 0$. But, int the end of this section we illustrate what happens when $\delta_2 < 1$.

$$\max_{p_1} p_1 \left(\frac{1 - p_1 - \gamma \left(1 - \widetilde{p}_2\right)}{1 - \gamma^2} \right) \tag{9}$$

Despite a relatively simple functional form, the algebraic solution to the take-it-or-leave-it problem is too complex to show, thus we proceed numerically. By definition, the efficient firm's collusive price is always larger than the non-cooperative price at any level of product differentiation and cost asymmetry. But we also find that its collusive price is higher than the efficient firm's monopoly price for most combinations of γ and c_2.

Figure 3: *Cartel prices*

(a) *Efficient firm* **(b)** *Inefficient firm*



As a reference point we assume a extreme model with homogenous products and no cost asymmetries, point A in the two figures above. Introducing product differentiation (but assuming symmetric costs) reduces the price for the efficient firm's product and increases the price for the inefficient firm's product (point B in the figures above). By setting a price below its monopoly price the efficient firm steals demand from the inefficient firm (business stealing effect) and to assure that the inefficient firm receives non-cooperative profits despite a lower market share, the inefficient firm's price is increased above its monopoly level. The difference in price for different degrees of product differentiation is however relatively small. But the differences in demand are important when it comes to assessing the damages caused by respective firm.

When costs are asymmetric, the inefficient firm will only make positive non-cooperative profits if $c_2 < \widehat{c}_2$ so for large cost differentials and sufficiently

substitutable products, there will be no cartel and the efficient firm will serve the market by itself charging constrained or monopoly prices. This is consistent with previous findings that cost asymmetry makes collusion less stable.[10] Higher costs for the inefficient firm leads to a higher collusive price and a lower non-cooperative profit. For small cost differences the efficient firm will steal market share by reducing price below the monopoly level, but the reduction is less than in the symmetric case, hence price is higher.

For sufficiently large cost asymmetry, the efficient firm needs to increase price above the monopoly level to assure that the inefficient firm's incentive constraint is satisfied (point C in Figure 3 (a)). Non-cooperative profits fall with product substitutability, hence when the inefficient firm approaches the maximum degree of inefficiency $c_2 = \widehat{c}_2$, the constraint becomes less binding and the efficient firm charges a price closer to its monopoly price. The inefficient firm's price increases monotonically with the level of cost asymmetry. The cost asymmetry also determines the effect of product differentiation on prices. For large cost differences the inefficient firm's price is monotonically decreasing in product substitutability.

As can be seen in Figure 3, the efficient firm's collusive price is close to the monopoly price in all cases. To the extent that it varies, it is a non-monotonic function of product differentiation and of the cost asymmetry. The degree of cost asymmetry determines whether the relation between product differentiation and collusive price is convex or concave. Without cost asymmetries the relation is convex as the efficient firm undercuts for highly differentiated products but increases prices towards the monopoly level as products become more similar. This contradicts the earlier findings by Deneckere (1983) that product differentiation has no effect on collusive prices and by Chang (1991) that $\frac{\partial p}{\partial \gamma} > 0$ and $\frac{\partial p}{\partial \gamma} < 0$ for low and high γ respectively. In fact we find the opposite. When there are sufficiently large cost differences and products are differentiated, the efficient firm sets a price above the monopoly level to assure that the inefficient firm receives non-cooperative profits. As the non-cooperative profits fall with product differentiation, the constraint becomes less binding and the efficient firm lowers its price towards the monopoly level.

If we transfer all bargaining power from the efficient firm to the inefficient firm (the inefficient firm makes the take-it-or-leave-it offer), these results change relatively little. In this case, the inefficient firm's cartel price will be

[10] Bae (1987), Harrington (1991), Collie (2006) and Vasconcelos (2005).

lower and the efficient firm's cartel price higher than when the bargaining positions were reversed. In this way, the inefficient firm steals business from the efficient firm. When $\gamma = 0.65$, the efficient firm's cartel price is around 12 per cent higher and the inefficient firm's cartel price up to 11 per cent lower than those illustrated in Figure 3.[11]

In the above analysis it was assumed that $\delta_2 = 1$, a rather extreme assumption used for tractability. Here we relax this assumption and illustrate the our findings also hold when $\delta_2 < 1$, the results are just scaled.

In the take-it-or-leave-it offer, the efficient firm makes the inefficient firm indifferent between accepting the offer and deviating to a non-cooperative situation. Firm 2 is indifferent between staying in the cartel and deviating when $\pi_2^{Tioli} = \pi_2^n + \overline{\pi}$. To maximize own profits the efficient firm will set prices so that $\delta_2 = \widehat{\delta}_2$. This relation can be solved for $\overline{\pi}$ which expresses how much more than the non-cooperative profits that the inefficient firm requires to be indifferent for any level of δ_2. The two constraints can jointly be solved for $\overline{p}_2(p_1, \delta_2)$ which is the price that ensures that firm 2 is indifferent. Since $\frac{\partial \overline{p}_2}{\partial \delta_2} < 0$, the inefficient firm requires higher prices when $\delta_2 < 1$. p_1 on the other hand increases with δ_2, see Figure 11 in the Appendix.

The efficient firm determines both p_1 and p_2 by substituting the constraint $\overline{p}_2$ into the maximization problem in equation (9).[12] By leaving more profits for the inefficient firm (i.e. $\overline{\pi}$) when $\delta_2 < 1$, $\widehat{\delta}_2$ is reduced as π_I^{Cart} increases. But at the same time $\widehat{\delta}_1$ is increased since deviation becomes more tempting for the efficient firm. The minimum sustainable discount factor is hence $\widehat{\delta}_1 = \widehat{\delta}_2$ as long as $\delta_i > \widehat{\delta}_i$. The above illustrates that allowing for $\delta < 1$ only scales the previous results. The analysis for $\delta = 1$ thus holds qualitatively.

Product differentiation and cost asymmetries can affect cartel prices in both an upward and a downward direction but overall cartel prices do not change significantly with the degree of product differentiation or cost asymmetry. However, product differentiation does have a significant impact on the counterfactual, non-cooperative prices as seen in Figure 2 so overcharges will depend significantly on product differentiation and cost asymmetries. We now turn to the calculation of damages and relate this to consumer welfare.

[11] See Figure 9 for a comparison of the two cases.

[12] The maximization implicitly also determines deviation profits and the constraint assures that $\delta = \widehat{\delta}_2$.

5 Damages and consumer welfare

The ability to claim damages for cartel overcharges is the main driver for private litigation. In this section, we determine how damages and consumer surplus vary with cost asymmetries and product differentiation. We show that the extreme case of homogeneous products and symmetric costs is the worst for consumers, both in terms of how much damage is done and in terms of the extent to which they are compensated for their loss of welfare.

5.1 Overcharges and damages to customers

Since actual cartel prices are (more or less) observable, the most central element in overcharge estimations is determining the counterfactual price, i.e. what the price would have been "but for" the cartel.[13] The counterfactual is in most cases not a perfectly competitive market with marginal cost pricing, but an imperfect market where firms are likely to make profits in equilibrium.[14]

Overcharges are therefore simply defined as the difference between the cartel price and the counterfactual price $\left(p_i^{Cart} - p_i^n\right)$ and the damages suffered by those who purchased the good are found by multiplying the overcharge by the quantity sold by the cartel member, q_i^{Cart}:

$$\text{Damage of firm } i = \left(p_i^{Cart} - p_i^n\right) q_i^{Cart}$$

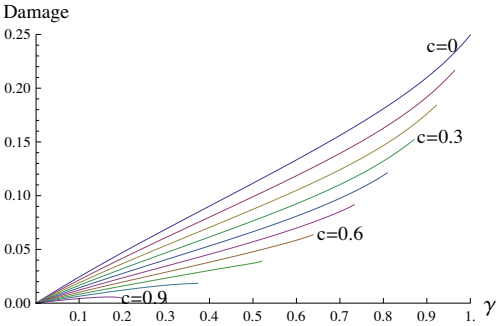
In this section, we calculate total damages for different degrees of product differentiation and cost asymmetry. The previous section showed that product differentiation and cost asymmetry affect the efficient firm's collusive price relatively little while the inefficient firm's collusive price always exceeds the monopoly price of the efficient firm (which would be the benchmark of an efficient cartel). The damages caused by the cartel are nevertheless significant. Figure 4 depicts total damages by the cartel and we find that damages

[13]The importance of using counterfactuals when asessing effects of cartels was noted already in 1966 in Europe, when the Court of Justice declared that "The competition in question must be understood within the actual context in which it would occur in the absense of the agreement in dispute."Société Technique Minière, Case 56/65 1966.

[14]Most cartels are found in concentrated markets, see for example Levenstein and Suslow (2006). This may be attributed to the fact that it is easier to coordinate with fewer agents.

are larger for lower levels of cost asymmetry and decrease with product differentiation (increase with γ).[15]

Figure 4: *Total damages*



The upper curve in Figure 4 illustrates the damages caused by a cartel consisting of symmetric firms and the lower ones indicate higher degrees of cost asymmetry. The largest damages are thus caused by symmetric firms selling homogeneous products. When there is product differentiation, this lowers the damage of the cartel, mainly because the counterfactual price also entails market power. For example, if $\gamma = 0.57$ and $c_2 = 0$, damages are only half of what they would be, if goods were homogeneous. This is mainly because of an increase in the counterfactual from $p_i^n(c_1 = c_2 = 0, \gamma = 0) = 0$ to $p_i^n(c_1 = c_2 = 0, \gamma = 0.57) \simeq 0.3$ (see Figures 2 and 3). Similarly, a larger cost difference leads to lower damages and again through the counterfactual: If, for example, $\gamma = 0.57$ and $c_2 = 0.5$, damages are roughly half of those that obtain in the situation where $\gamma = 0.57$ and $c_2 = 0$.[16] Again, this is mostly due to an increase of the counterfactual prices from 0.3 to

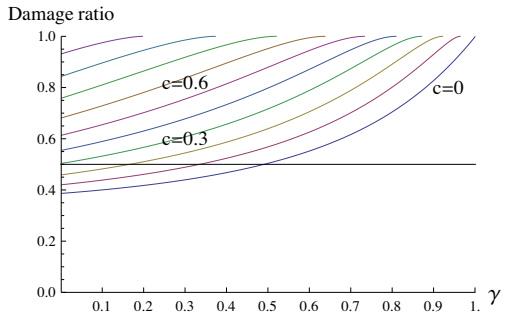
[15]When conducting such a horizontal comparison, one should however remember that the total overcharges are mitigated by the love of variety effect embedded in the utility function. Since demand increases with product differentiation, horizontal comparison does not distinguish between love of variety and the pure price effect. The high overcharges from homogenous products are generated by a demand that is only half the size compared to fully differentiated, or independent products. For constant demand, the slopes in Fig. 6 are even steeper.

[16]And in turn damages w. $\gamma = 0.57$ and $c_2 = 0.5$ are one quarter of those that would

$p_1^n(c_1 = 0, c_2 = 0.5, \gamma = 0.57) \simeq 0.38$ and $p_2^n(c_1 = 0, c_2 = 0.5, \gamma = 0.57) \simeq 0.6$, for the efficient and the inefficient firm, respectively.

These results indicate that the two firms' share of total damages are also asymmetric. Figure 5 corroborates this impression: when the cost difference is larger than $c_2 = 0.3$, the efficient firm cause the larger part of the damage. Similarly, when the degree of product differentiation is low ($\gamma \geq 0.5$), the efficient firm is also responsible for the lion's share of damages. This is because the efficient firm sells a larger quantity and has a higher overcharge, which in turn is predominantly due to its lower counterfactual price. The inefficient firm is responsible for the larger part of the damages only when the degree of product differentiation is very high and the cost difference small.

Figure 5: *Damage efficient / Total damage*



As a robustness check, we have analysed what happens if all bargaining power is transferred from the efficient firm to the inefficient firm (so the inefficient firm makes the take-it or leave-it offer). In this case total damages are higher because the inefficient firm dictates that the efficient firm sets higher prices. In percentage terms the ratio of total damages under the two bargaining models is relatively unaffected by the degree of product differentiation, unless products are relatively homogeneous. In this case the threat point of the efficient firm is so dominant, that it constrains the inefficient firm's ability

occur if $\gamma = 1$ and $c_2 = 0$, i.e. the reference case of product homogeneity and cost symmetry.

to increase the efficient firm's price. Very clearly, the higher the cost disadvantage of the inefficient firm, the more damaging is it that it has all the bargaining power. This is illustrated in Figure 10 (a) in the Appendix.

5.2 Consumer welfare (Consumer dead weight loss)

Economists have traditionally been more preoccupied with consumer welfare than with damages since the latter just reflects a re-allocation between producers and consumers without any effects on total welfare. The welfare loss from high cartel prices, the deadweight loss, is incurred by consumers that do not buy the good because the cartel prices are too high. However, antitrust damages are currently only awarded to those who suffered from overcharges, and the real damage to society, the welfare loss is left uncompensated. In fact, in the US, damages to non-buyers have been found to be too speculative to give rise to compensation, since it is impossible to know from whom the claimants would have purchased, the quantity purchased and at what price.[17] In the EU there are references to the legal and economic difficulties for non-buyers to prove injury (European Commission, 2007). Below we illustrate how product differentiation and cost asymmetry combine to determine the effects of the cartel on consumer welfare, i.e. the difference between the consumer surplus with the cartel and the consumer surplus in the counterfactual situation without the cartel.[18] Consumer surplus is calculated as the net utility in equation (1).

From equation (1) we know that $\frac{\partial U}{\partial p_i} < 0$ since higher prices reduce the number of products a consumer would want to purchase. As costs increase prices, net utility decreases with c_2 for the same reason. Utility increases with product differentiation since the utility function exhibits love of variety. However, in the counterfactual, non-cooperative equilibrium, the partial effect of product differentiation on net utility is negative, i.e. $\frac{\partial U}{\partial \gamma} > 0$. This is explained by the finding in Table 1 in the Appendix that prices increase with product differentiation, i.e. $\frac{\partial p_i}{\partial \gamma} < 0$. In the collusive equilibrium net utility increases

[17] Montreal Trading Ltd v. Amax Inc, §§ 15-16.

[18] In the US a consumer welfare standard is applied, but it is still debated wether it in reality is a consumer or total welfare standard (Orbach, 2011). In Europe the Court of First Instances confirmed in the case GlaxoSmithKline (T-168/01 2006, para 118) that consumer welfare is the relevant standard.

with product differentiation (i.e. decreases with γ) since the average price does not change significantly.

The effect of collusion on welfare is calculated as the difference in utility between the non-cooperative and the collusive states. Figure 6 shows the total loss of consumer welfare that is caused by the cartel and how this depends on the degree of product differentiation and on the cost asymmetry. The negative welfare effects from collusion are largest when the cartel is operating on a market with homogenous products and symmetric firms. Since cost asymmetries increase counterfactual prices more than cartel prices, the difference in net utility between the non-cooperative and collusive states falls as cost asymmetries increase. The difference in net utility also decreases when products are differentiated, again because the counterfactual price is higher with more product differentiation than with less.

Figure 6: *Change of consumer welfare due to cartel*

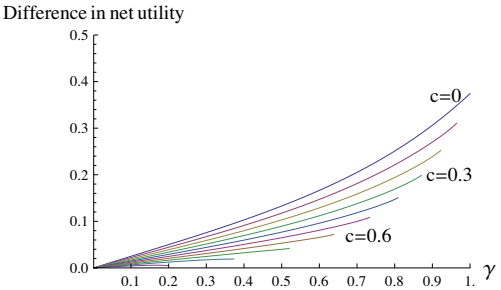
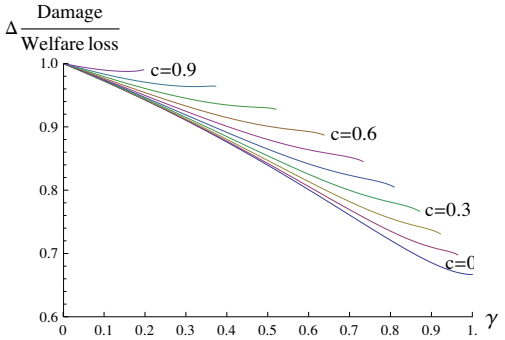


Figure 6 is very similar to Figure 4 that illustrates total damages. It is interesting to compare the two graphs to investigate which fraction of total welfare consumers would be compensated for if they were awarded damages. To this end, Figure 7 shows the fraction of the total loss of consumer surplus, consumers will get as compensation for damages. The relation between the damages and the loss of consumer surplus caused by the cartel depends on the degree of product differentiation and cost asymmetry. For highly differentiated products and high cost differences, damages awarded according to the model would compensate consumers fully because the counterfactual prices are high; but for less differentiated products and smaller cost asym-

metry, damages awarded according to the model would undercompensate consumers. The reason is that when goods are independent, the two firms are monopolists and a cartel between them does not make the situation worse for the consumers. On the other hand, when products would have competed in the counterfactual, then the cartel prices result in lower quantities and large overcharges: Consumers are most undercompensated when products are homogeneous and firms are symmetric.[19] Consumers then only recover 2/3 of the welfare losses if they get correct damage payments.

Figure 7: *Degree of compensation of loss of consumer welfare*



In the US private damages are automatically trebled[20] to encourage private actions (American Bar Association, 1986). Treble damages (given that correctly calculated) will hence always exceed the welfare loss caused by a cartel and the damages and will therefore always over-reward claimants. The proposed European system with single damages will on the other hand leave consumers uncompensated for the loss in consumer surplus that results from their decision not to buy due to high cartel prices.

[19] If as a robustness check we transfer all bargaining power to the inefficient firm (so it makes the take-it-or-leave-it offer to the efficient firm) we find that consumer surplus falls compared to the bargaining situation when roles are reversed. The argument follows the discussion of how bargaining roles affect total damages, see the end of the previous subsection. This is illustrated in Figure 10 (b).

[20] 15 U.S.C. § 15(a)

6 Conclusions

Collusion models are important tools to estimate the negative effect of cartels, but they need to be calibrated after the specific market at hand to give correct results. We incorporate two common market features, product differentiation and cost asymmetry, in a standard model and find that overcharges are very sensitive to this change of specification. The main driver of this result is not that collusive prices vary a lot with product differentiation and cost asymmetry - they do not - but rather that the counterfactual, non-cooperative prices do.

We find that the standard case of homogeneous products and symmetric costs is the worst situation for consumers both in terms of their welfare loss and the degree to which the restitution of damages compensate them for this loss. This is because in this case the overcharge is large because the counterfactual price is low and also because of the resultant large drop in quantity. Product differentiation serves to mitigate these effects both by increasing counterfactual prices and by making quantities less sensitive to price changes. Cost asymmetries also assuage the problem, mainly by increasing the counterfactual price.

Competition authorities aiming at hindering the anticompetitive practices that are worst for consumers should therefore focus on cartels in which symmetric firms produce homogeneous products. This is also true with active private enforcement since consumers in this type of markets, always will be under-compensated - even when awarded full overcharge damages.

The analysis is based on a two-firm model. Extending it to $n > 2$ firms is a complicated task since, depending on the level of product differentiation and cost asymmetry, firms may prefer to form smaller cartels instead of one large. Berg (2011) deals with the the situation of three firms, two of which are efficient and extends this to a larger number of efficient firms.

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A Appendix

The detailed appendix is to the benefit of the referees and should be excluded in the final version of the paper.

A.1 Non-cooperative equilibrium

Table 1: *Non-cooperative equilibrium*

	Bertrand $c_2 < \hat{c}_2$	Constrained $c_2 \in [\hat{c}_2, \tilde{c}_2]$	Unconstrained $c_2 > \tilde{c}_2$
$p_1 - c_1$	$\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}$	$\frac{c_2+\gamma-1}{\gamma}$	$\frac{1}{2}$
q_1	$\frac{p_1-c_1}{1-\gamma^2}$	$\frac{1-c_2}{\gamma}$	$\frac{1}{2}$
π_1	$\frac{1}{1-\gamma}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2)}{4-\gamma^2}\right)^2$	$\frac{(1-c_2)(c_2-1+\gamma)}{\gamma^2}$	$\frac{1}{4}$
$p_2 - c_2$	$\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}$	0	0
q_2	$\frac{p_2-c_2}{1-\gamma^2}$	0	0
π_2	$\frac{1}{1-\gamma}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2(2-\gamma^2)}{4-\gamma^2}\right)^2$	0	0
$Q \equiv q_1 + q_2$	$\frac{p_1+p_2-c_1-c_2}{1-\gamma^2}$	$\frac{1-c_2}{\gamma}$	$\frac{1}{2}$

The first term of the Bertrand equilibrium markup, $p_i - c_i$, illustrates the effect of product differentiation. At full differentiation ($\gamma = 0$) prices equal monopoly prices[21]. This effect increases monotonically with product differentiation, as in the literature Deneckere (1983).If $c_2 = 0$ and $\gamma = 1$ we get the standard Bertrand result, zero markup.

The second term of the Bertrand equilibrium markup determines the effect of cost differences. When the inefficiency (c_2) increases, the price margin increases for the efficient firm both in the constrained and in the Bertrand equilibria, but the price margin decreases for the inefficient firm in the Bertrand equilibrium and remains zero in the other two cases. For all $c_2 > 0$, profits are higher for the efficient firm than for the inefficient firm. The cross-partial $\frac{d^2(p_i - c_i)}{d\gamma dc_2}$ from the Bertrand equilibrium reveals that the margin exhibits increasing and decreasing differences for the efficient and inefficient firm respectively. Thus, the positive effect from cost asymmetries on the price margin of the efficient firm is stronger for more substitutable products.

The derivations below are to the benefit of the referees only. They are not intended to remain in the final version.

Static Nash

$\pi_1 = p_1 \left[\frac{1-p_1-\gamma(1-p_2)}{1-\gamma^2}\right]$

$\pi_2 = (p_2 - c_2) \left[\frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2}\right]$

Hence the firms best response functions are $R_1(p_2) = \frac{1-\gamma(1-p_2)}{2}$

$R_2(p_1) = \frac{1+c_2-\gamma(1-p_1)}{2}$

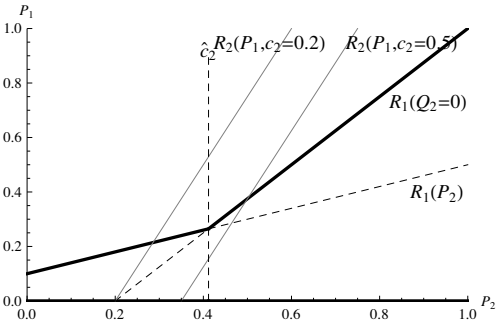
According to the best response functions, a firm should increase markup if it becomes more efficient or if the competing firm increases it's price. Further, increased product differentiation will as expected lead to higher markups.

Solving these reaction functions give the equilibrium prices $p_1 = \frac{2-\gamma(1+\gamma-c_2)}{4-\gamma^2}$

$p_2 = \frac{2(1+c_2)-\gamma(1+\gamma)}{4-\gamma^2}$

These can be plotted as

[21] The monopolist's profit is $\pi_i = (p_i - c_i)(1 - p_i)$. So the monopoly price is $p_i = \frac{1+c_i}{2}$. For the efficient firm $p_1^M = \frac{1}{2}$ and for the inefficient firm $p_2^M = \frac{1+c_2}{2}$ and so $p_2^M - c_2 = \frac{1-c_2}{2}$ when $\gamma = 0$.



If both firms are active, the equilibrium margins are

$$p_1 - c_1 = \frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}$$

$$p_2 - c_2 = \frac{1-\gamma}{2-\gamma} - \frac{c_2\left(2-\gamma^2\right)}{4-\gamma^2}$$

Inserting the prices in the demand function yields

$$q_1 = \frac{2-\gamma+\gamma c_2-\gamma^2}{\left(4-\gamma^2\right)\left(1-\gamma^2\right)}$$

$$q_2 = \frac{2-2c_2-\gamma-\gamma^2+\gamma^2 c_2}{\left(4-\gamma^2\right)\left(1-\gamma^2\right)}$$

We see that the equilibrium margins $(p-c)$ and quantities have similar expressions. We can therefore re-write equilibrium demand as a function of prices.

$q_1 = \frac{p_1-c_1}{(1-\gamma^2)} = \frac{2-\gamma+\gamma c_2-\gamma^2}{(4-\gamma^2)(1-\gamma^2)}$

$q_2 = \frac{p_2-c_2}{(1-\gamma^2)} = \frac{2-2c_2-\gamma-\gamma^2+\gamma^2 c_2}{(4-\gamma^2)(1-\gamma^2)}$

Consequently the profits can be expressed as

$$\pi_1 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right)^2$$

$$\pi_2 = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2\left(2-\gamma^2\right)}{4-\gamma^2}\right)^2$$

Constrained Bertrand

The efficient firm however knows that the inefficient firm will be out of the market when $q_2 = \frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2} = 0$ hence at $p_1 = \frac{p_2-1+\gamma}{\gamma}$ which is the best response function of the efficient firm when the inefficient firm is not active. The inefficient firm has no option but to play the same best response as before.

Thus in the limit case we have the best response functions are

$p_1 = \frac{p_2-1+\gamma}{\gamma}$

$p_2 = \frac{1+c_2-\gamma(1-p_1)}{2}$

These two best response functions solve for equilibrium prices

$$p_1 = \frac{1}{\gamma}(c_2 + \gamma - 1)$$

$$p_2 = c_2$$

This gives the following margins

$$p_1 - c_1 = \frac{1}{\gamma}(c_2 + \gamma - 1)$$

$$p_2 - c_2 = 0$$

The equilibrium prices solve for the following quantities

$$q_1 = \frac{1}{\gamma}(1 - c_2)$$

$$q_2 = 0$$

The constrained equilibrium therefore gives the following profits

$$\pi_1 = \frac{(1-c_2)(c_2 - 1 + \gamma)}{\gamma^2}$$

$$\pi_2 = 0$$

Unconstrained Monopoly

When $q_2 = \frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2} \leq 0$ the demand for product 1 becomes $q_1 = 1 - p_1$

The profit function becomes $p_1(1-p_1)$ which gives $p_1 = \frac{1}{2} = q_1$

So $\pi_1 = \frac{1}{4}$ which is the standard monopoly result

A.2 Exit conditions

The inefficient firm is active in the Bertrand equilibrium given that $c_2 \leq \widehat{c}_2$

In this model any firm that is forced out can re-enter the game at a later stage without incurring any costs, i.e. there are no entry or exit costs. The inefficient firm exits the market when the sales in the non-cooperative equilibrium turns negative. The inefficient firm drops out from the market when $q_2 = 0$. The inefficient firms equilibrium quantities solves for

$$\widehat{c}_2 \equiv 1 - \frac{\gamma}{2-\gamma^2}$$

The efficient firm is unconstrained in its pricing when $c_2 > \widetilde{c}_2$

Despite the inefficient firm not being active when $c_2 \geq \widehat{c}_2$ it still restricts the pricing behaviour of the efficient firm, as the inefficient firm would enter should the efficient firm charge monopoly prices. Therefore the efficient firms prices are constrained until $q_2 \leq 0$ given $p_2 = c_2$ and $p_1 = p_1^M$. Solving for c_2 gives

$$\widetilde{c}_2 \equiv 1 - \frac{\gamma}{2}$$

The inefficient firm will be forced to exit when the cartel sets prices by joint profit maximization when $c_2 \geq \overline{c}_2$. The inefficient firm will have $q_2 = 0$ in the cartel equilibrium given by joint profit maximization if

$q_2 = \frac{1-P_2^M-\gamma}{1-\gamma^2} = 0$

$$\overline{c}_2 \equiv 1 - \gamma$$

A.3 Effect on discount factor of having several prices

Using different prices will increase collusive profits and decrease the deviation profits, hence it will also lead to a lower required discount factor than when the cartel is forced to charge one price $\left(\widehat{\delta}_{one-price} - \widehat{\delta}_{two-price} > 0\right)$. Just as in the Bertrand equilibrium, product differentiation will protect inefficient firms and thereby also the cartel.

The Bertrand profits are not affected by the choice of pricing, hence the difference between the critical discounts for a one versus a two-price regime is given by

$$\frac{\Delta\pi_i^{Dev}(p, c_i, \gamma) - \Delta\pi_i^{Co}(c_i, c_j, \gamma)}{\Delta\pi_i^{Dev}(p, c_i, \gamma)}$$

Harrington (1991) shows that if firms set one joint price, the cartel price $p^* \in \left(p_1^M, p_2^M\right)$. But $\pi_1'(p^*) < 0$ when $p^* > p_1^M$, hence the efficient firm could make higher profits by reducing price. The efficient firm on the other hand could make higher profits by increasing price as $\pi_2'(p^*) > 0$. Both firms would thus increase profits by charging individual prices.

For $p^* > p_1^M$ the efficient firm would increase profits by deviating to p_1^M. But with an individual cartel price $\widehat{p}_1 \in [p_1^M, p^*)$, the gains from deviation would be lower. As a result of the lower price, the inefficient firm needs to charge a deviation price that is lower than if there was one common price, and would deviate from a higher price level since $\widehat{p}_2 \in (p^*, p_1^M]$. Both these effects make deviation more costly for the inefficient firm. For both firms we then have, $\Delta\pi_i^{Dev}(p, c_i, \gamma) < 0$ and $\Delta\pi_i^{Co}(c_i, c_j, \gamma) > 0$ which makes the equation above positive. The one price regime therefore makes collusion more sustainable.

A.4 Take-it or leave-it offer 1: The efficient firm makes the offer

We here assume that the efficient firm makes the offer. The maximization problem is $max_{p_1,p_2}\ \pi_1$ s.t. $\pi_2^c \geq \pi_2^N$ where $\pi_1 = p_1\left(\frac{1-p_1-\gamma(1-p_2)}{1-\gamma^2}\right)$ and the constraint is $\pi_2^c = \pi_2^N$

$\pi_2^c = (p_2 - c_2)\left[\frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2}\right]$

$\pi_2^N = \frac{1}{(1-\gamma^2)}\left(\frac{2-2c_2-\gamma-\gamma^2+\gamma^2 c_2}{(4-\gamma^2)}\right)^2$

That is $(p_2 - c_2)\left[\frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2}\right] - \frac{1}{(1-\gamma^2)}\left(\frac{2-2c_2-\gamma-\gamma^2+\gamma^2 c_2}{(4-\gamma^2)}\right)^2 = 0$

At what p_2 is $\pi_2^c = \pi_2^N$

Solve $(p_2 - c_2)\left[\frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2}\right] = \pi_2^N$ for p_2

The result is $\widetilde{p}_2 \equiv \frac{1}{2}\left(1 + c_2 + (p_1 - 1)\gamma + \sqrt{(c_2 + \gamma - 1 - p_1\gamma)^2 + 4\pi_2^{Nash}\left(-1 + \gamma^2\right)}\right)$

Hence there is only a solution when the term under the root are positive. This is the case if $(c_2 + \gamma - 1 - p_1\gamma)^2 + 4\pi_2^{Nash}\left(-1 + \gamma^2\right) \geq 0$. Inserting Nash profits gives

$(c_2 + \gamma - 1 - p_1\gamma)^2 + 4\left(\frac{1}{(1-\gamma^2)}\left(\frac{2-2c_2-\gamma-\gamma^2+\gamma^2 c_2}{(4-\gamma^2)}\right)^2\right)\left(-1 + \gamma^2\right) \geq 0$

Solve for p_1, gives: $p_1 \geq \frac{2-\gamma(1+\gamma-c_2)}{4-\gamma^2}$ which is the same as p_1^{Nash}

Comparative statics $\frac{\partial\widetilde{p}_2}{\partial p_1} > 0$.

$\frac{d}{dp_1} = \frac{1}{2}\gamma\frac{\gamma p_1 - c_2 - \gamma + \sqrt{\gamma^2 - 2c_2 - 2\gamma + c_2^2 + \gamma^2 p_1^2 + 2\gamma c_2 + 2\gamma p_1 - 4\pi_2^{Nahs} + 4\gamma^2\pi_2^{Nahs} - 2\gamma^2 p_1 - 2\gamma c_2 p_1 + 1} + 1}{\sqrt{\gamma^2 - 2c_2 - 2\gamma + c_2^2 + \gamma^2 p_1^2 + 2\gamma c_2 + 2\gamma p_1 - 4\pi_2^{Nahs} + 4\gamma^2\pi_2^{Nahs} - 2\gamma^2 p_1 - 2\gamma c_2 p_1 + 1}}$

Since the roots are positive, the derivative is positive iff $p_1 > 1 + \frac{c_2 - 1}{\gamma}$. Numerically one can show that collusive prices, $p_1^{cart} > 1 + \frac{c_2-1}{\gamma}$.

A.5 Take-it or leave-it offer 2: The inefficient firm makes the offer

We here assume that the inefficient firm makes the offer. The maximization problem is $Max_{p_1,p_2}\ \pi_2$ s.t. $\pi_1^c \geq \pi_1^N$

The efficient firm should be made indifferent $\pi_1^{cartel} = \pi_1^{Nash}$ where $\pi_1^{cartel} = p_1\left(\frac{1-p_1-\gamma(1-p_2)}{1-\gamma^2}\right)$

$\pi_1^{Nash} = \frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right)^2$

Solve for p_1. $\widetilde{p}_1 = \frac{1}{2}\left(1+(p_2-1)\gamma - \sqrt{(1+(p_2-1)\gamma)^2 + 4\pi_1^{Nash}(\gamma^2-1)}\right)$. This is only a solution if the root is positive and this is the case if $(1+(p_2-1)\gamma)^2 + 4\pi_1^{Nash}(\gamma^2-1) \geq 0$. Inserting π_1^{Nash} and solving for p_2 gives $p_2 \geq \frac{2(1+c)-\gamma(1+\gamma)}{4-\gamma^2}$ which is the same as p_2^{Nash}

So again we only need the restriction that the firm giving the TIOLI-offer needs to set $p_i > p_i^{Nash}$. The inefficient firm maximizes π_2 w.r.t. p_2 given $p_1 = \widetilde{p}_1$.

A.6 Joint profit maximization

$Max_{p_1,p_2}\pi_1 + \pi_2$

$\frac{d}{dp_1}\left((p_1)\left[\frac{1-p_1-\gamma(1-p_2)}{1-\gamma^2}\right] + (p_2-c_2)\left[\frac{1-p_2-\gamma(1-p_1)}{1-\gamma^2}\right]\right) = 0$

The above equation gives the reaction functions

$p_1 = \frac{1-\gamma-\gamma c_2+2\gamma p_2}{2}$

$p_2 = \frac{1-\gamma+c_2+2\gamma p_1}{2}$

Combining the reaction functions we solve for the equilibrium cartel prices

$p_1 = \frac{1}{2}$

$p_2 = \frac{1+c_2}{2}$

This gives the following margins

$p_1 - c_1 = \frac{1}{2}$ (since $c_1 = 0$)

$p_2 - c_2 = \frac{1-c_2}{2}$

I.e. we get standard monopoly pricing.

Inserting the collusive prices in the demand functions gives us the quantities $q_1 = \frac{1+\gamma c_2-\gamma}{2(1-\gamma^2)}$

$q_2 = \frac{(1-c_2-\gamma)}{2(1-\gamma^2)}$

Hence the profit expressions are very simple

$\pi_1 = \frac{1}{2}\left(\frac{1+\gamma c_2-\gamma}{2(1-\gamma^2)}\right)$

$\pi_2 = \left(\frac{1-c_2}{2}\right)\left(\frac{(1-c_2-\gamma)}{2(1-\gamma^2)}\right)$

As stated above this solution forces the inefficient firm to shut down for specific parameter values (i.e. $q_2 = 0$). Since the inefficient firm's monopoly price is higher than the efficient firm's price - it will be forced out of the market when the products are sufficiently homogenous. Since the monopoly prices are higher than the non-cooperative prices the "drop-out" will occur at a lower degree of substitutability than in the non-cooperative game. The inefficient firm will drop out when

$q_2 = \frac{(1-c_2-\gamma)}{2(1-\gamma^2)} = 0$

Hence at $\gamma = 1 - c_2$ the inefficient firm will no longer have any sales. Zero sales (and profit) cannot be a equilibrium since the inefficient firm would generate a positive profit by reducing prices from it's monopoly price. Without side-payments, this cannot be the cooperative equilibrium.

Using non-negativity constraints on demand ($q_2 \geq 0$)in the optimization (Kuhn-Tucker) would only give us the results we already have. This as the non-negative quantity constraint would be binding at drop-out and hence $q_2 = 0$. Therefore the cartel's price setting need to include the constraint that the sales of the inefficient is always larger than 0.

This could be achieved by either 1) the inefficient firm dropping price, 2) the efficient firm increasing price or 3) a combination of both.

A.7 TIOLI prices in the general case

$$Max_{p_1,p_2}\ \pi_1\ s.t.\ \pi_2^{Tioli} \geq \pi_2^n + \overline{\pi} \quad (10)$$

$$\text{and } s.t. \delta_2 \geq \widehat{\delta}_2 \quad (11)$$

$\widehat{\delta}_i \equiv \frac{\pi_i^{Dev}(p,c_i,\gamma)-\pi_i^{Cart}(c_i,c_j,\gamma)}{\pi_i^{Dev}(p,c_i,\gamma)-\pi_i^n(c_i,c_j,\gamma)} = \frac{\pi_i^{Dev}(p,c_i,\gamma)-(\pi_i^n(c_i,c_j,\gamma)+\overline{\pi})}{\pi_i^{Dev}(p,c_i,\gamma)-\pi_i^n(c_i,c_j,\gamma)}$

From the second constraint we get that $\overline{\pi}$ should be such that $\delta_2 = \widehat{\delta}_2$. I.e.

$$\overline{\pi}_2 = (1-\delta_2)(\pi_2^{Dev} - \pi_2^n)$$

This may be plugged into the first constraint that with equality reads:

$$\pi_2^{Tioli} = \delta_2\pi_2^n + (1-\delta_2)\pi_2^{Dev}$$

When $\delta_2 = 1$, we are back in the case that is analysed in Section 4.3. But with $\delta_2 < 1$, the r.h.s. of the constraint becomes a convex combination of the counterfactual profits and the deviation profits. For any γ and c_2, this r.h.s. is just a number, so the TIOLI method still works.

A.8 Pricing when $\delta < 1$

With take-it or leave-it offers, firm 1 proposes prices that makes firm 2 indifferent to staying in the cartel or not. Thus, at lower prices than the proposed ones - there is no sustainable cartel because the prices are determined as boarder conditions. For $\delta_2 < 1$ firm 1 has to leave something on the table for firm 2. The amount that ensures stability is $\pi_2^n + \overline{\pi}$ where $\overline{\pi}$ is defined in section A.7. The constraint by firm 2 is hence given by $\pi_2^{Tioli} = \pi_2^n + \overline{\pi}$. This can be solved for $\overline{p}_2$ that hence depends on δ_2. Firm 1 determines both prices by maximizing equation (9) with $\tilde{p}_2$ substituted with $\overline{p}_2$.

A.9 Graphs

Figure 8: *Deviation prices*

(a) *Efficient firm* **(b)** *Inefficient firm*

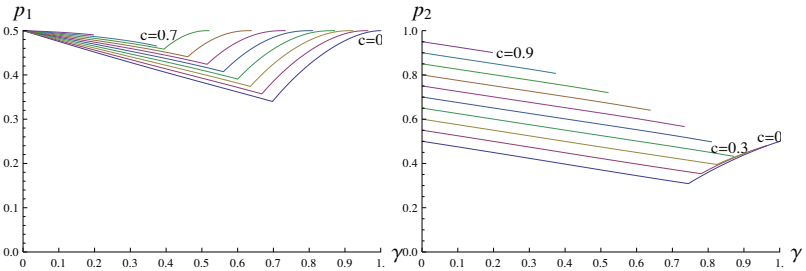


Figure 9: *Ratio: Tioli prices*

(a) *Efficient firm* **(b)** *Inefficient firm*

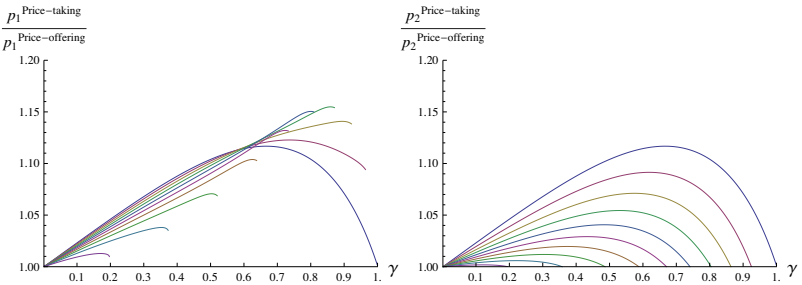


Figure 10: *Tioli ratios*

(a) *Damages* **(b)** *Net-utility*

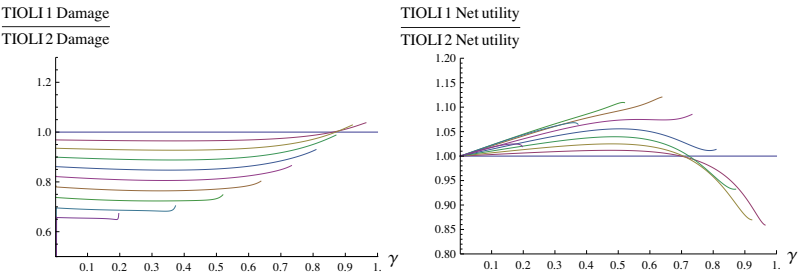
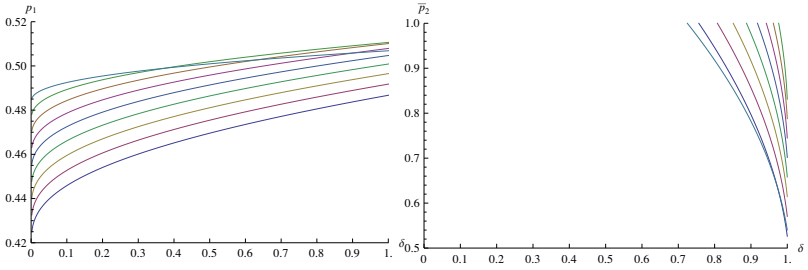


Figure 11: *Constrained pricing*

(a) *Efficient firm* **(b)** *Inefficient firm*



The above figures are calculated assuming $\gamma = 0.3$. For higher values of γ prices fall and firm 2 is not active for high values of c_2. The minimum sustainable δ is $1/2$ and since γ reduces sustainability $\widehat{\delta}_i > 1/2$ when $\gamma < 1$.

Knowledge sharing and innovation in asymmetric cartels

Petter Berg[a]
Copenhagen Business School

February 2012

Abstract

In Europe, cartels can in principle be exempted from the general prohibition if they generate efficiencies, such as lowering marginal costs. One way to achieve this is to share technology. This paper examines cartel members' incentives to share technologies and to individually undertake R&D efforts. Using a two-firm collusion model with asymmetric firms and endogenous technology sharing, the paper finds that an efficient firm has no incentive to share technology with an inefficient firm. Further, being member of a cartel will decrease the incentive for efficient firms to invest in R&D to reduce costs.

Keywords: Collusion, cost-asymmetries, knowledge-sharing.
JEL-Classification: L13, L24, L41

[a]Copenhagen Business School, Department of Economics, Porcelænshaven 16 A, DK-2000 Frederiksberg, e-mail: pbe.eco@cbs.dk.

1 Introduction

Both in the US and in Europe authorities have encouraged cooperation among firms to increase R&D.[1] In Europe, cartels can in principle be exempted from prohibition if they generate sufficient efficiencies.[2] But, all cost reductions cannot be taken into account. For example reduction of production, marketing or sales costs as a consequence of market power, are not considered to improve market efficiency and are therefore not valid in an exemption analysis.[3] On the other hand, agreements on cost savings without reducing production, such as sharing a new cost reducing technology between firms,[4] can improve market efficiency and hence possibly be exempted.[5] But should we believe that firms with anti-competitive agreements such as cartels, will share knowledge among the members?

Since the R&D policies balance pro- and anti-competitive effects, they spurred a vast economic literature on the effects on R&D and profits when firms can compete or collude in R&D and production, see Steen and Sørgard (2009) for a good summary.

Fershtman and Gandal (1994) question the traditional view that firms competing in quantities can increase profits by forming a cartel. They show that if firms prior to colluding, invest independently in cost reducing R&D, the firms will make ambitious R&D investments to capture more of the collusive profits. This results in more R&D, reduced costs and higher prices than in the non-collusive case. If investment costs are small enough, firms will invest so heavily in the investment stage to get a large share of the collusive profits, that the profits are even lower than in the non-cooperative case. That implies that the firms should choose the non-cooperative strategy. But, having incurred sunk investments, it is always more profitable to collude than to compete. Thus the firms would prefer to set R&D investments conditional on competing on the market, and when the investments have been undertaken, renegotiate to enforce collusion since such a strategy leaves R&D spendings unaffected by collusion. These results arise since both firms

[1] National Research Cooperation Act (1984) in the US and regulation 2659/2000 on research and development agreements in the EU.

[2] European Commission (2004), §46.

[3] European Commission (2004), §49.

[4] For example through licensing.

[5] European Commission (2004), §71.

make positive non-cooperative profits. Using a somewhat different model Brod and Shivakumar (1999) illustrate that the main results also hold when there are exogenous knowledge spillovers between the firms.

When firms instead jointly set R&D levels through some kind of R&D cooperation, the effect of collusion depends on the extent of knowledge spillovers between the firms. D'Aspremont and Jacquemin (1988) find that if exogenous knowledge spillover between firms are high, R&D investments are higher if firms collude in production than if they compete. Firms are however always better off when colluding in production. Using the same model Kultti and Takalo (1998) show that firms competing both in R&D and on quantities will find it profitable to share knowledge with each other.

There is empirical evidence suggesting that efficient cartel members share technological knowledge. Cortat (2009) describes how members in a Swiss cable cartel, operating from 1907 to the 1980s, initially competed with cost reducing innovation since market shares and prices were determined by contract. To eliminate competition in innovation the cartel decided in 1943 that the members were obliged to share their innovations if they threatened cartel stability. In reality the cooperation remained limited and no licenses were shared. From 1968 the members also agreed to refrain from introducing new products without consent from the other members, to share patents and to jointly decide on key R&D investments. Cortat concludes that without R&D regulations, price cartels can foster innovation, but with regulation they can increase diffusion of innovation. He hence portraits a rather positive image on the effect of cartels.

This raises two questions:

1. Are efficient firms interested in transferring knowledge to inefficient cartel members?

2. Do price cartels, without R&D regulations, foster innovation when firms are asymmetric?

There are two main reasons as to why efficient cartel members may want to transfer their knowledge to inefficient ones. First, as shown by Bae (1987) and Harrington (1991), cost asymmetry reduces the scope for collusion. Hence when the discount factor is low, it may be in the efficient firm's interest to

reduce the cost asymmetry by sharing knowledge, to maintain the cartel.[6] Second, if firms have asymmetric costs they have different views on the optimal cartel price. Knowledge sharing may be a way for cartel members to align preferences for cartel price and thus end up with a price that is closer to optimum for the efficient firm.

This paper focuses on the two questions above using a three stage model where two firms first independently decide whether to invest in R&D, then to share technology and finally what price to set in a cartel. The sequence follows from investment decisions being long-term decisions which should be considered fixed when the short-term pricing decisions are made (Selten, 1994, p. 4). It thus has a basic structure similar to that of Fershtman and Gandal (1994) with two firms making independent investments in R&D, and relates to D'Aspremont and Jacquemin (1988) through the notion of potential knowledge spillovers. I assume that only one firm can get access to the technology, for example through a patent race (e.g Tirole, 1988, p. 394). This leads to cost asymmetries and the firm with new technology can decide to share its knowledge or not. Also, in contrast to most of the innovation literature, competition in this model is in prices, not quantity.

The first stage in my model illustrate that if investment costs are sufficiently low, one or both firms will invest in cost reducing innovation. The innovation leads to cost asymmetries between the firms and in the second stage the efficient firm decides whether to share its knowledge with the inefficient firm. Despite that the firms will collude in the third stage, I find that the efficient firm will not share its knowledge with the inefficient firm. In the third stage firms decide on the collusive outcome, and the price is set in between the two firms' optimal level. For large cost asymmetries the price will be close to the efficient firm's monopoly price since it has a good outside option. The unwillingness to share information leads to higher cartel prices than if technology was shared, but also to it being harder for cartels to form. When firms are asymmetric the efficient firm has strongest incentives to invest in cost reductions. The asymmetries will therefore increase until the cartel can no longer be sustained. The investment incentives are however lower when firms collude than when they compete. Section (2.1) presents the basic set-up of the model and solves the non-cooperative equilibrium.

[6] This may be an explination of why ABB, the ringleader in the European pre-insulated pipes cartel, prohibited introduction of more efficient technology (case IV/35.691/E-4, par 114-115).

Since the model is solved through backward induction, section (2.2) describes the third stage of the model, the cartel outcome. The section solves the collusive game using Nash bargaining and investigates the effect of cost reductions on the cartel's price and market share allocation. The second stage in section (2.3) investigates the incentives for knowledge transfers and the first stage in section (2.4) solves the investment game and determines how much the firms are prepared to spend on R&D. The main conclusions of the paper are presented in section (3). All proofs are provided in the appendix.

2 Model

The analysis proceeds in a three stage framework. First the firms independently decide whether to invest in cost reducing innovation or not and in this game only one firm will get access to the technology. Second, the firm who acquired the new technology decides whether it wants to share the technology with the other firm. Third, the two firms decide if they want to form a cartel where prices and market shares are set using Nash bargaining.

The model is solved through backward induction and the first step is therefore to solve the third stage, how the firms in a cartel would set prices and market shares. From this they can also deduct the conditions needed for a cartel to be sustainable. Once the firms understand the cartel profits, they solve the second stag of the game, i.e. decide whether they will share information or not. When the firms know if the knowledge will be shared they make their investment decision in stage 1.

2.1 Basic set-up and non-cooperative equilibrium

The model is, in similarity to much of the literature on collusion and innovation, based on a duopoly producing homogenous products. Costs and demand are assumed to be linear and demand is defined as

$$Q = 1 - P \tag{1}$$

The two firms on the market compete in prices and demand is allocated to the firm offering the lowest price. If both firms offer the same price, they decide

how to allocate demand between them. This gives the individual demand function

$$q_i(P_i) = \begin{cases} 0 & \text{if} \quad P_i > P_j \\ s_i Q(P_i) & \text{if} \quad P_i = P_j \quad \text{where } i \neq j \\ Q(P_i) & \text{if} \quad P_i < P_j \end{cases} \tag{2}$$

where s_i it the market share for firm i. The marginal costs are denoted c_i. If one firm is more efficient than the other it follows that $c_E \leq c_I$, where E, I denote the efficient and inefficient firm.

In order for a cartel to be incentive compatible for an efficient firm, I assume that the cost difference is not drastic, i.e. $c_I < P_E^m$ where P_E^m is an efficient firm's monopoly price. According to this simple set-up, the only non-cooperative Nash equilibrium in the one-period game is the efficient firm charging $P_E^n = c_I$ and the inefficient firm producing nothing. It therefore follows that $\pi_E^n > 0$ and $\pi_I^n = 0$ where π^n denotes non-cooperative profits.[7] In the non-cooperative equilibrium the efficient firm's profit increases with own cost reductions. It decreases with cost reductions by the inefficient firm since this will enable it to charge a higher price, hence $\frac{\partial \pi_E^n}{c_E} < 0$ and $\frac{\partial \pi_E^n}{c_I} > 0$. Due to the latter, the efficient firm has no incentive to transfer knowledge to the inefficient firm (lower c_I) in the non-cooperative equilibrium.

When costs are asymmetric, non-cooperative prices are independent of the efficient firm's costs. A change in c_E therefore has a direct effect on the efficient firm's margin.

2.2 Collusive equilibrium

In the last stage, when the cost difference is not drastic, the firms will find it profitable to collude if the discount factor is sufficiently high. When products are homogenous, cartels must agree on both a price and on market shares. These decisions become more complicated when firms have different costs as $P_E^m < P_I^m$ where P^m is the monopoly price. Hence the inefficient firm prefers a higher price than the efficient firm. If cartel members can exchange side-payments between each other, the cartel will set price P_E^m, have the efficient firm produce market demand and divide the surplus between the members. But, for several reasons (e.g. Berg, 2011), side-payments are not realistic as

[7] $\pi_E^n \equiv (c_I - c_E)(1 - c_I)$.

a long term cartel mechanism[8] and they are therefore not allowed for in this model.[9] This paper hence disregards institutional features, such as the ones in Switzerland until the 1980s, where cartels are legal and their contracts can be enforced in court.

A standard assumption in collusion models is that cartel members maximize joint profits. But with asymmetric costs such a mechanism leads to the efficient firm producing market demand at monopoly price and the inefficient refraining from producing. Without the possibility for side-payments the inefficient firm would earn zero profits and have no incentive to stay in the cartel. It is therefore not an equilibrium.

This paper instead assumes that the cartel members simultaneous decide on both price (P^c) and market shares (s_i) using Nash bargaining. The profit from reaching an agreement is the cartel profits and the best alternative to the cartel is the non-cooperative Nash equilibrium. Cartel profits are given by $s_i(P^c - c_i)(1 - P^c)$.[10] Since $\sum_i s_i = 1$ the efficient firm's market share can be defined as s and the inefficient firm's as $1 - s$. The cartel's bargaining problem then becomes

$$\max_{P,s} \ (s\pi_E^c - \pi_E^n)(1 - s)\pi_I^c \tag{3}$$

where $s_i\pi_i^c$ and π_i^n denotes cartel and non-cooperative profits respectively. The inefficient firm earns no profit in the non-cooperative equilibrium and therefore has low bargaining leverage. Prices and market shares will be set using Nash bargaining as long as it is sustainable. When the bargaining solution is not sustainable, the members can either deviate to the non-cooperative equilibrium or find a constrained bargaining solution on which they can agree.

By taking the first order condition of the bargaining problem (3) with respect to s, the firms find the market share that maximizes the bargaining surplus. The optimal market share for the efficient firm is

$$\widehat{s} \equiv \frac{1}{2} + \frac{(c_I - c_E)(1 - c_I)}{2(P^c - c_E)(1 - P^c)} \tag{4}$$

[8]Levenstein and Suslow (2010) state (footnote 57) that *"Direct compensation raises the risk of detection by competition authorities and is not observed in the current legal environment"*.

[9]Bae (1987) and Harrington (1991) impose the same restriction on collusive strategies.

[10]For simplicity of notation I denote $(P^c - c_i)(1 - P^c)$ by π_i^c.

Without cost differences ($c_E = c_I$) the market is shared equal between the two firms. Since both c_E and c_I affect P^c, the cartel prices need to be determined before the total effect of changes in costs on the optimal market share can be determined. Using a general demand function Harrington (1991) proves that the cartel price, $\widehat{P} \in (P_E^m, P_I^m)$, where P^m denotes the monopoly price. For cartel prices in this range, the relation between the optimal market share and cartel price is positive ($\frac{\partial \widehat{s}}{\partial P^c} > 0$) and the efficient firm hence requires a higher market share for accepting prices above its monopoly price.

Substituting $\widehat{s}$ in equation (3), calculating the first-order condition and solving for P^c, the cartel price is defined as[11]

$$\widehat{P} \equiv \frac{1}{8}\left(2 + 7c_E - c_I + \varphi\right) \tag{5}$$

where $\varphi = \sqrt{4 + c_E^2 + 3c_I\left(4 - 5c_I\right) + 2c_E\left(9c_I - 10\right)}$. If there is no cost asymmetry, the cartel price is set at the (common) monopoly level $\left(P^m = \frac{1+c}{2}\right)$. But when the costs are asymmetric, the equilibrium price is $\widehat{P} \in (P_E^m, P_I^m)$, just as found by Harrington (1991), and the cartel price is therefore not only higher than in the non-cooperative equilibria, but also higher than if the efficient firm could monopolize the market.

Further cost reductions in the collusive setting have two distinct effects on the cartel price. First, they reduce a firm's optimal price and second, they affect the efficient firm's non-cooperative profits and hence its outside option. The effect on price from the change in bargaining leverage depends on which firm that reduces costs. A cost reduction can therefore have various effects on the cartel price.

Proposition 1. *Cost reductions by an efficient firm reduce the cartel price.*

If the efficient firm becomes more efficient, its optimal price will fall and the cartel price will be pushed downwards. This effect is reinforced by an increase in bargaining leverage for the efficient firm. A reduction in c_E leads to higher non-cooperative Nash profits for the efficient firm and hence stronger bargaining leverage (as manifested by an improved outside option to the cartel agreement). The efficient firm uses this additional leverage to negotiate

[11] This is the unconstrained Nash bargaining price. But as will be illustrated in section (2.3), the price may be set lower if the cartel is not sustainable at this price.

prices closer to its monopoly price, i.e. further lowering the cartel price. Since both effects pull in the same direction it follows that $\frac{\partial \widehat{P}}{\partial c_E} > 0$.

Proposition 2. *Cost reductions by the inefficient firm lead to lower cartel prices if the cost difference $c_I - c_E < \widehat{c}$ and to higher prices if the cost difference $c_I - c_E > \widehat{c}$.*

A cost reduction for the inefficient firm lowers the optimal price for the inefficient firm and push prices downward also in this case. But, a reduction in c_I reduces π_E^n and hence the efficient firm's bargaining leverage. As a result of this effect, prices will move towards the optimal price of the inefficient firm, i.e. upwards. For small cost differences $c_I - c_E < \widehat{c}$ (see proof of Proposition (2) in the appendix for derivation of $\widehat{c}$) the first effect is stronger, hence $\frac{\partial \widehat{P}}{\partial c_I} > 0$ as the bargaining leverage for the firm is low. But for large cost differences $c_I - c_E > \widehat{c}$ the latter effect is stronger and $\frac{\partial P}{\partial c_I} < 0$. Cost reductions may therefore result in higher prices and a lower consumer surplus. $\widehat{c}$ decreases with c_E, so the maximum level of cost asymmetry that still assures $\frac{\partial \widehat{P}}{\partial c_I} > 0$, is lower for high c_E.

By substituting the optimal cartel price $\widehat{P}$ for P^c in equation (4), the optimal market share can be defined as $\overline{s}$ (see derivation of $\overline{s}$ in the proof to Proposition (3)). It is a messy function depending on the level of cost asymmetry, but by performing comparative statics on $\overline{s}$ the total effects of cost reductions on the optimal market share become clear.

Proposition 3. *Reducing costs increases a firm's equilibrium market share.*

For the efficient firm the relation $\frac{d\overline{s}}{dc_E} < 0$ holds, i.e. becoming more efficient will increase the efficient firm's share of the market. This result is interesting given the previous findings that $\frac{\partial \widehat{P}}{\partial c_E} > 0$ and $\frac{\partial \widehat{s}}{\partial \widehat{P}} > 0$ which suggests that its market share should reduce when the efficient firm becomes more efficient as the cartel price will fall. But, c_E also enters $\widehat{s}$ directly where the partial derivative $\frac{\partial \widehat{s}}{\partial c_E} < 0$ and lower costs for the efficient firm increases its market share. This is caused by the increase in bargaining leverage for the efficient firm, not by price effects.

For the inefficient firm $\frac{d\overline{s}}{dc_I} > 0$ holds. The sign is fairly straightforward since the inefficient firm will require a higher market share $(1 - s)$ if it becomes

more efficient. This occurs since the bargaining leverage for the efficient firm is reduced. One should however note that in contrast to the effect of cost changes on cartel prices, this relation is monotonic in the level of cost asymmetry. The effect of cost asymmetries on market shares is therefore not affected by the change in bargaining leverage, in the same way optimal price is. This result confirms Bae's (1987) finding that $\frac{\partial s}{\partial c_I} > 0$ despite market shares in his model being determined to fulfil the balanced temptation equilibrium (Friedman, 1971).

2.3 Incentives for knowledge transfers

In the second stage of the model, when the firms have invested in technology and are asymmetric, they have a possibility to share technology. But will they?

Assume that the efficient firm can transfer its knowledge to the inefficient firm costlessly, for example by arranging a meeting with engineers or sharing blue prints of production processes. When the efficient firm decides whether to share the knowledge or not, it is fully aware of the implications that this will have on its profits from the analysis in section (2.2).

The possibility for cost reducing knowledge transfer between the two firms is denoted by $\theta \equiv c_I - c_E \geq 0$, i.e. the efficient firm has all knowledge the inefficient firm has plus some extra knowledge. It is assumed that the efficient firm can decide to share: all, none or part of its technology to the inefficient firm. θ is therefore regarded as continuous. As stated in the introduction, there are at least two explanations as to why the efficient firm would agree to share the knowledge: i) to save the cartel when it is constrained by a low discount factor and ii) to align preferences concerning the for cartel price. These two hypothesis are tested in the following.

Hypothesis 1: Information is shared to save the cartel

Proposition 4. *When* $\delta < \underline{\delta} \equiv \frac{\pi_E^m}{\pi_E^m + \pi_E^c - \pi_E^n}$ *the efficient firm has no incentive to save the cartel by sharing information.*

A cartel is stable as long as all firms find it more profitable to stay in the cartel than to deviate. The incentive constraint facing the members is hence

$$\frac{1}{1-\delta}s_i\pi_i^c \geq \pi_i^d + \frac{\delta}{1-\delta}\pi_i^n \tag{6}$$

where $s_i\pi_i^c$, π_i^d, π_i^n are firm i's profits from collusion, deviation and non-cooperation respectively and δ is the common discount factor. Equation (6) can be solved for a critical discount factor $\tilde{\delta}_i$ for which a firm is indifferent between staying in the cartel or deviating, where

$$\tilde{\delta}_i \equiv \frac{\pi_i^d - s_i\pi_i^c}{\pi_i^d - \pi_i^n} \tag{7}$$

The firm with the highest critical discount factor binds the cartel. Since $\widehat{P} \in (P_E^m, P_I^m)$, the best deviation for the efficient firm is to deviate down to its monopoly price, hence $\pi_E^d = \pi_E^m$. The inefficient firm on the other hand is best off just undercutting the cartel price, thus $\pi_I^d \approx \pi_I^c$. For the efficient firm the incentive constraint can be re-arranged to $s \geq \underline{s} \equiv \frac{(1-\delta)\pi_E^m + \delta\pi_E^n}{\pi_E^c}$ and for the efficient firm it must hold that $s \leq \overline{s} \equiv \delta$. The requirements on market shares together constitute the collusive set and only market share allocations within this set are sustainable.

By substituting the optimal market share into the incentive constraint it is possible to show that $\widehat{\delta}_E \geq \widehat{\delta}_I$[12], where $\widehat{\delta}_i(\widehat{P}, \widehat{s})$ is the critical discount factor when price and market share are set by Nash bargaining. Therefore, the efficient firm always bind the cartel.

From the requirements on market shares it is clear that a cartel will only be sustainable if $\delta \geq \underline{\delta} \equiv \frac{\pi_E^m}{\pi_E^m + \pi_E^c - \pi_E^n}$. Thus when there is no asymmetry cartels can be sustained when $\delta \geq \frac{1}{2}$ as in standard models (Motta, 2004, p. 162).

When $\delta < \underline{\delta}$ there is no collusive set since the efficient firm would rather deviate. Sharing knowledge worsens the efficient firm's non-cooperative profits and deviation thus become less tempting.[13] Because $\frac{\partial\delta}{\partial\theta} > 0$ the efficient firm can reduce the critical discount factor by transferring knowledge. But since this occurs through reducing own non-cooperative profits, it is not a profitable strategy. The efficient firm would therefore deviate from the cartel

[12] $\widehat{\delta}_E > \widehat{\delta}_I \iff \frac{\pi_E^m - s\pi_E^c}{\pi_E^m - \pi_E^n} > s$. This can be re-arranged to $s < \frac{\pi_E^m}{\pi_E^m + \pi_E^c - \pi_E^n} = \underline{\delta}$ which holds when $s = \widehat{s}$.

[13] Both $\frac{\partial\overline{s}\pi_E^c}{\partial\theta}$ and $\frac{\partial\pi_E^n}{\partial\theta} > 0$ but the effect is direct and larger for the non-cooperative profits. Deviation profits are unaffected as $\frac{\partial\pi_E^m}{\partial\theta} = 0$.

rather than transferring knowledge. Knowledge sharing will thus not take place to save the cartel.

Proposition 5. *When $\delta \in [\underline{\delta}, \widehat{\delta}_E)$, the efficient firm has no incentive to reach a sustainable cartel by sharing information.*

When $\delta \in [\underline{\delta}, \widehat{\delta}_E)$, a cartel can be sustainable, but not when price and market share is set by Nash bargaining. In this situation the efficient firm has three options.

1. Deviate to the Bertrand equilibrium
2. Change the collusive price and market share
3. Transfer knowledge to the inefficient firm

Since $\delta > \underline{\delta}$ the most profitable strategy for the efficient firm is to stay with the cartel. Hence deviation to the Bertrand equilibrium is clearly not the best option. The question is instead if the inefficient firm would prefer to adjust the price and market share determined by Nash bargaining, or to transfer knowledge so that $\delta \leq \underline{\delta}$.

First look at the case when the cartel chooses another solution than the Nash bargaining solution. As $\delta < \widehat{\delta}_E$, the cartel cannot choose the Nash bargaining solution and instead needs to find a solution that satisfies $\tilde{\delta}_E$. By solving the pricing constraint $\delta = \tilde{\delta}_E$ for $s\pi_E^c$, the the pricing constraint can be substituted into the bargaining problem which then takes the form

$$\max_{P,s} \ (1-\delta)\left(\pi_E^m - \pi_E^n\right)(1-s)\,\pi_I^c \tag{8}$$

The bargaining surplus is decreasing in s and the optimal market share in the constrained bargaining problem is hence to agree on the lowest market share possible. By $\underline{s}$, this is achieved when the cartel price is set at P_E^m. At this price $\underline{s}(P_E^m) = (1-\delta)+\frac{\delta\pi_E^n}{\pi_E^m}$ and the market share for the efficient firm therefore decreases with the discount factor since it is less tempting to deviate for high discount factors. The efficient firm's profits at the constrained equilibrium are $\underline{s}(P_E^m)\pi_E^m(P_E^m, c_I)$.

Now turn to the other option where sustainability is achieved by sharing knowledge. If the efficient firm, instead of reducing price to P_E^m, decided to

share knowledge with the inefficient firm (i.e. reduce c_I), it would reduce the binding incentive constraint as $\frac{\partial \tilde{\delta}}{\partial c_I} > 0$. For low cost differences a transfer would also reduce the cartel price (from Proposition (2)). Both of these effects make the cartel easier to sustain.

For the cartel to be sustainable at the Nash bargaining solution $\underline{s}(\widehat{P}) \leq \widehat{s}(\widehat{P})$ has to hold, i.e. the minimum market share at the optimal price must be smaller than the optimal market share. Solving the relation (as an equality) for c_I gives $\overline{c}_I$, the highest c_I where a cartel is sustainable at prices set by Nash bargaining. The efficient firm's profits at this level of cost asymmetry are $\widehat{s}(\widehat{P})\pi_E(\widehat{P}, \overline{c}_I)$.

Comparing the efficient firm's profits from the two possible strategies, I find that $\underline{s}(P_E^m)\pi_E^m(P_E^m, c_I) > \widehat{s}(\widehat{P})\pi_E(\widehat{P}, \overline{c}_I)$ holds. Thus it is more profitable for the efficient firm to agree on a lower price than to transfer knowledge to the inefficient one. This is not entirely surprising since transferring knowledge implies giving up strategic advantage and the costs for reaching the collusive solution rests on the efficient firm alone. When the firms agree on a lower price the cost of collusion is shared between the two firms.

The efficient firm will hence not share information to save a cartel from collapsing when the discount factor is too low, or as a mechanism to make collusion sustainable when the Nash bargaining equilibrium is not sustainable. The second theory of information sharing is that it aligns the two firms' pricing preferences.

Hypothesis 2: Information is shared to align optimal prices

Proposition 6. *The efficient firm has no pricing incentives to share information with the inefficient firm.*

Another reason for information sharing could be to align preferences regarding the collusive price, thereby reducing the cartel price towards the efficient firms optimal price.[14]

The optimal level of cost asymmetry $\widehat{\theta}$ is attained by reducing c_I, given the original cost asymmetry $\overline{\theta}$. The efficient firm chooses c_I given that it knows the cartel profits in the last stage from section (2.2).

[14]That reducing the asymmetry can reduce cartel prices when cost differences are small is shown in Proposition (2).

How much information to share with the inefficient firm is given by the solution to the problem

$$\max_{c_I} \; s\pi_E^c \text{ subject to } \theta \leq \overline{\theta} \tag{9}$$

since the efficient firm cannot increase the costs of the inefficient firm. The analysis reveals that the optimal knowledge sharing $\widehat{\theta} = \frac{1-c_E}{2}$ which implies $c_I = \frac{1+c_E}{2} = P_E^m$. If possible, the efficient firm would thus prefer to make the inefficient firm drastically inefficient and thereby become a monopolist. The relation holds for all levels of cost asymmetry as long as the cost difference is not drastic, and the efficient firm therefore has no incentive to share its knowledge with the inefficient firm. The explanation for this is simple. Despite the efficient firm getting a price closer to optimum when costs are reduced (cost differences are small), Proposition 3 illustrates that its equilibrium market share will also reduce. The net effect is lower profits.

Thus when making the investment decisions in the first stage, the firms know that the other cartel member will not help them reduce their costs to save the cartel, nor to align pricing preferences.

2.4 Investments in R&D

Before determining the cartel price and before deciding whether to share knowledge, the firms decide whether to invest in cost reducing technology or not. They hence compete in R&D, as in the Swiss cable cartel, but collude in pricing. By backward induction the firm is aware that there will be no technology transfers to a firm without the new technology (from section (2.3)), and that a cartel will be formed if $\delta > \underline{\delta}$.

To keep things simple I assume that the firms decide whether or not to invest a fixed amount r in R&D that will give them the cost reduction, $c_I - c_E$. Only one firm gets access to the technology, for example though patenting (e.g. Tirole, 1988, p. 394). If both firms invest, the probability of getting access to the technology is assumed to be one-half (e.g. Scotchmer, 2004, p. 190). If none of the firms invest they get the default profit which can be shown to be $\frac{\pi_I^m}{2}$. The game is symmetric since there are no cost differences prior to the investment. The strategic form of the game is illustrated in Figure (1) where I and N indicates investment and no investment.

Figure 1: *Investment game - symmetric firms*

		Firm j: I	Firm j: N
Firm i	I	$(\frac{\pi_E+\pi_I}{2}-r),(\frac{\pi_E+\pi_I}{2}-r)$	$(\pi_E-r),(\pi_I)$
	N	$(\pi_I),(\pi_E-r)$	$(\frac{\pi_I^m}{2}),(\frac{\pi_I^m}{2})$

It is obvious from Figure 1 that the investment cost (r) and the benefit ($c_I - c_E$), will determine the firms optimal strategies. If the rival invests, a firm should not invest if $r > \frac{\pi_E-\pi_I}{2}$ as the expected profit in that case would be negative. If the rival does not invest the firm should only refrain from investing if the investment costs are very high, $r > \pi_E - \frac{\pi_I^m}{2}$. Hence, for both investment decisions the decision rule is given by $MR_r > r$. It is easy to show that a firm is willing to undertake higher investments if the rival does not invest since the expected profit of the investment is higher.[15]

By ranking the outcomes in Figure (1) when the cartel can agree on the Nash bargaining solution, I find that the pure strategy Nash equilibriums of the game are

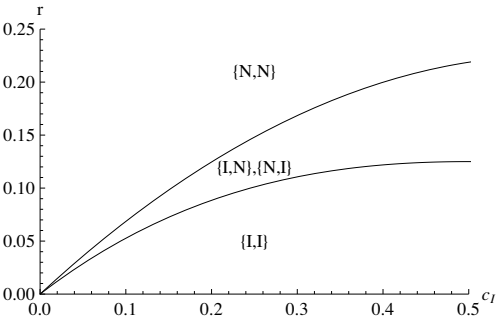
$$NE = \begin{cases} \{N,N\} & \text{if} \quad r > \pi_E - \frac{\pi_I^m}{2} \\ \{I,N\},\{N,I\} & \text{if} \quad \frac{\pi_E-\pi_I}{2} < r < \pi_E - \frac{\pi_I^m}{2} \\ \{I,I\} & \text{if} \quad r < \frac{\pi_E-\pi_I}{2} \end{cases} \tag{10}$$

Hence investment will take place if $r < \pi_E - \frac{\pi_I^m}{2}$ and when this condition is fulfilled the firms play the game modelled in sections (2.2) and (2.3). If the investment cost is higher than this threshold the firms don't invest and end up with $\frac{\pi_I^m}{2}$ when they collude. The investment condition is monotonically increasing in cost differences, hence the investments firms are prepared to make increase with the expected benefits, see Figure (2).[16]

[15] The maximum investment cost is higher when the rival does not invest if $\pi_E+\pi_I > \pi_I^m$, which always holds.

[16] To illustrate cost differences the figure is drawn for $c_E = 0$ and the maximum c_I is therefore $P_E^m = 1/2$.

Figure 2: *Maximum investment costs and cost asymmetries*



The ranking is the same when the firms cannot agree on the Nash bargaining outcome but instead selects the price P_E^m. But since the constrained cartel profits for the efficient firm are lower than unconstrained profits $\left(\widehat{s}(\widehat{P})\pi_E^c(\widehat{P}) > \underline{s}(P_E^m)\pi_E^m(P_E^m)\right)$ the maximum investments are lower when pricing is constrained.

Proposition 7. *The efficient firm has less incentive to reduce costs when it is part of a cartel than when it acts non-cooperatively.*

An efficient firm has larger incentives to invest in R&D when firms compete. This is similar to Arrow's (1962) argument that firms have larger investment incentives when they are in a competitive industry then when they are monopolists.

In the non-cooperative equilibrium only the efficient firm is active and it is trivial to show that $\frac{\partial \pi_E^n}{\partial c_E} < 0$. Lower costs increase profits also in the cartel, thus $\frac{\partial \pi_E^c}{\partial c_E} < 0$ and it can be shown that $\frac{\partial \pi_E^c}{\partial c_E} > \frac{\partial \pi_E^n}{\partial c_E}$, hence the efficient firm has less incentive to invest in cost reductions when it is member of a cartel. In a non-cooperative setting, innovation is crucial since the entire market will be served by the low cost firm. When the firms collude however, the investment incentive is relaxed as both firms will have positive production. Because of the bargaining the efficient firm will only be rewarded with part of the benefits from innovation.

3 Conclusions

This paper questions the logic that firms with anticompetitive agreements, such as cartels, will share information between them to the benefit of consumers.

The paper presents three possible reasons for knowledge sharing to take place, but concludes that neither of them are valid. In this specific model an efficient firm is always better of withholding its knowledge than to share it with the inefficient firm. This suggests that the finding by Cortat (2009) that cartel members share knowledge and arrange meetings among engineers to increase profits, is not a general cartel behaviour. His results may however hold for other set-ups.

As long as firms invest in R&D independently, an efficient firm has larger incentives to conduct cost reducing innovation than an inefficient firm. The cost differences will therefore grow over time until the cartel is no longer sustainable. The efficient has then no incentive to save the cartel by reducing the cost asymmetry. This could be an explanation of why the Swiss cable cartel chose to implement strict knowledge sharing. It does however not answer why an efficient firm would accept to enter into such an agreement.

Since the incentives for cost reductions are lower for cartel members than for firms acting non-cooperatively, it is a poor policy to allow cartels in order to promote innovation.

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A Appendix

A.1 The Nash bargaining solution

The bargaining problem is $\max_{P,s} \ (s\pi_E^c - \pi_E^n)(1-s)\pi_I^c$. The first-order condition w.r.t s is $(1-P)(P-c_I)\left(c_E(-2Ps+P+2s+c_I-2)+(P-1)P(2s-1)-c_I^2+c_I\right)=0$ which can be solved for $\widehat{s}=\frac{1}{2}+\frac{(c_I-c_E)(1-c_I)}{2(P-c_E)(1-P)}$. Inserting $\widehat{s}$ in the bargaining problem, the first-order condition w.r.t is $\frac{(P-c_I)^3(-c_E+P+c_I-1)^2}{4(P-c_E)}=0$ which can be solved for $\widehat{P}=\frac{1}{8}(2+7c_E-c_I+\varphi)$. This makes the equilibrium profits
$\pi_E^c=\frac{1}{64}\left(3c_E^2+c_E\left(-32+26c_I-3\varphi\right)+2\left(2+\varphi\right)+c_I\left(24-25c_I+\varphi\right)\right)$ and
$\pi_I^c=\frac{1}{64}\left(-41c_E^2+c_E\left(88-6c_I-23\varphi\right)+2\left(2+\varphi\right)+3c_I\left(-32+17c_I+7\varphi\right)\right)$. The efficient firm makes higher profit since $\pi_E^c-\pi_I^c=(c_E-c_I)\left(-30+11c_E+19c_I+5\varphi\right)$ and $\pi_E^c>\pi_I^c$ holds for all $c_I\in[c_E,P_1^m]$.

A.2 Proofs

The effect of P on optimal market share: $\frac{\partial\widehat{s}}{\partial P}=-\frac{(1+c_E-2P)(c_I-c_E)(1-c_I)}{2(P-c_E)^2(1-P)^2}$. The denominator and the two last parenthesis in the numerator are positive. Hence if $(1+c_E-2P)$ is positive the relation is negative. Since $P>P_1^m=\frac{1+c_E}{2}$ it follows that $(1+c_E-2P)<0$ and thus $\frac{\partial\widehat{s}}{\partial P}>0$.

Proof of Proposition 1. The effect of c_E on cartel price: $\frac{\partial\widehat{P}}{\partial c_E}=\frac{1}{8}\left(7+\frac{9c_I+c-10}{\varphi}\right)$. From the assumption that $c_I<\widehat{P}$ it follows that $c_I<\frac{1+c_E}{2}$. Substituting the minimum and maximum values of c_I, i.e. c_E and $\frac{1+c_E}{2}$ in the FOC gives $\frac{1}{4}$ and 24, i.e. both positive. The solution to $\frac{\partial\widehat{P}}{\partial c_E}=0$ has two optima but none of these lies within $c_I\in[c_E,\frac{1+c_E}{2}]$ and therefore $\frac{\partial\widehat{P}}{\partial c_E}>0$. □

Proof of Proposition 2. The effect of c_I on cartel price: $\frac{\partial\widehat{P}}{\partial c_I}=\frac{1}{8}\left(-1+\frac{6-9c_E-15c_I}{\varphi}\right)$. $\frac{\partial\widehat{P}}{\partial c_I}=0$ when $\widehat{c}_I\equiv\frac{1}{15}\left(6+\sqrt{6}\left(c_E-1\right)+9c_E\right)$. For $c_I>\widehat{c}_I$ it holds that $\frac{\partial\widehat{P}}{\partial c_I}<0$ and for $c_I<\widehat{c}_I$ it follows that $\frac{\partial\widehat{P}}{\partial c_I}>0$. At the maximum and minimum values for c_I, i.e. $\left(\frac{1+c_E}{2},c_E\right)$ the derivatives are $-\frac{1}{5},\frac{1}{4}$. □

Proof of Proposition 3. Inserting $\widehat{P}$ in the equilibrium market share $\widehat{s}$ gives optimal share $\overline{s}\equiv-\frac{2(-1+6c_E-5c_I)(-1+c_I)}{3c_E^2-2\varphi-c_I(-8+5c_I+\varphi)+c_E(-8+2c_I+3\varphi)}$. Taking the FOC of $\overline{s}$ w.r.t. c_E and substituting c_I with the minimum and maximum value gives $\frac{2}{-1+c}$ and 0. The solution to $\frac{d\overline{s}}{dc_E}=0$ has three optima but none of these lies within $c_I\in\left(c_E,\frac{1+c_E}{2}\right)$. Hence $\frac{ds}{dc_E}<0$. Differentiating $\overline{s}$ w.r.t c_I gives the opposit signs, hence $\frac{ds}{dc_I}>0$. □

Proof of Proposition 4. $\underline{\delta}$ solves can be solved explicitly as $\frac{(c_E-1)^2}{2c_E^2-\delta(c_E-2c_I+1)^2-4c_Ec_I+4(c_I-1)c_I+2}$. Differentiating $\underline{\delta}$ w.r.t c_I gives $\frac{4(c_E-1)^2(1-\delta)(c_E-2c_I+1)}{\left(2c_E^2-\delta(c_E-2c_I+1)^2-4c_Ec_I+4(c_I-1)c_I+2\right)^2} > 0$. □

Proof of Proposition 5. The case when price and market share is changed: The lowest discount factor for the efficient firm, $\tilde{\delta}_E$, can be re-arranged to $s\pi_E^c = (1-\delta)\pi_E^m + \delta\pi_E^n$. Substituting this into the bargaining function gives $\max_{P,s} \ (1-\delta)\left(\pi_E^m - \pi_E^n\right)(1-s)\,\pi_I^c$. The first-order condition of the constrained bargaining problem, with respect to s is negative, i.e. a corner solution. The minimum market share is given by a price at P_E^m. At this price the minimum required market share is given by $\underline{s}(P_E^m) = (1-\delta) + \frac{\delta\pi_E^n}{\pi_E^m}$. Profits are hence $\pi_E^m\left((1-\delta) + \frac{\delta\pi_E^n}{\pi_E^m}\right)$.

The case when information is shared: The minimum market share at the optimal price is the same as the Nash bargaining solution when $\underline{s}(\widehat{P}) = \widehat{s}(\widehat{P})$. Solving this equality for c_I gives the maximum c_I where a sustainable cartel can set prices using Nash bargaining. $\overline{c}_I = \frac{1}{2}\left(1 + c_E + \frac{|c_E-2P+1|}{\sqrt{2\delta-1}}\right)$. Substituting the maximum cost difference gives the following profits for the efficient firm $\widehat{s}\pi_E^c(\widehat{P},\widehat{s},\overline{c}_I)$.

Comparing the profits reveal that as long as $\delta \in [\underline{\delta},\widehat{\delta}_E)$ it holds that $\pi_E^m\left((1-\delta) + \frac{\delta\pi_E^n}{\pi_E^m}\right) > \widehat{s}\pi_E^c(\widehat{P},\widehat{s},\overline{c}_I)$. It is thus more profitable to change price than to share knowledge. □

Proof of Proposition 6. $\frac{\partial\pi_E^c}{\partial\theta} = \frac{\left(8+8c_E^2+12\varkappa-2c_E(8-3\theta+6\varkappa)-\theta(6+15\theta+25\varkappa)\right)}{32\varkappa}$ where $\varkappa = \varphi$ with c_I replaced for $\theta + c_E$. Solving $\frac{\partial\pi_E^c}{\partial\theta} = 0$ for θ gives four solutions and the one maximizing π_E^c is $\theta = \frac{1-c_E}{2}$. □

Proof of Proposition 7. $\frac{\partial\pi_E^n}{\partial c_E} < 0$ and $\frac{\partial\pi_E^c}{\partial c_E} < 0$. $\frac{\partial\pi_E^n}{\partial c_E} < \frac{\partial\pi_E^c}{\partial c_E}$ as long as $c_E < c_I$ and $c_I < P_E^m$. □

Conclusion

Article 101 of the Treaty on the Functioning of the European Union prohibits agreements, concerted practices and decisions "which have as their object or effect the prevention, restriction or distortion of competition within the internal market". Since the l990s the European Commission treats cartels as agreements with the object of restricting competition and cartels are therefore prohibited. This is very similar to the per se illegality of cartels in the US. Actual effects of cartels are therefore of little importance in both legislations. This stands in stark contrast to the increasingly important private litigation of cartels, where injured customers sue cartels for damages. The private litigation cases rely on adequate restitution to the customers and hence the notion of harm. This thesis is part of the debate of cartel damages. It consists of four papers that focus on the harm caused by cartels and explores how damages are affected by cost asymmetries. Together they illustrate the importance of the counterfactual when determining damages.

The first chapter investigates how the perception of harm has affected the cartel legislation in Sweden. I show that until the 1950s the theory of harm from cartels was mixed and there were arguments both in favour and against cartels and there was no real cartel legislation. From the 1950s cartel legislation was introduced and is was gradually strengthened as a response to the contemporary theories of harm. In the 1950s-1960s it was believed that cartels caused efficiency losses and the legislation was geared towards alleviating this type of harm. Despite an understanding that cartels caused price increases from the 1970s, prohibition was not introduced until the 1990s. This lag was caused by industry lobbying and a reluctance to legal reforms. But as the industry at large was price regulated during the 1970s - the government was not concerned with the effects of cartels. With the change of law in the 1990s, cartels became prohibited by object. This was an important departure from the previous legislation that had been effects-based and only allowed for negotiations with cartels that increased prices too much. Despite the object based legislation, effects-arguments were still used in Swedish courts in the beginning of the 21 century. The current enforcement however does not involve effects analysis. In 2008 Sweden got a new cartel legislation, but the 744 page long legislative report does not mention the effect of cartels. The theory of harm hence seems to be lost.

In the second chapter I join two theories of harm, efficiency and price effects,

and assess how they interact. The efficiency/inefficiency element is captured by introducing cost asymmetries between firms in a standard collusion model. I then analyse the effect of these asymmetries on cartel sustainability and prices. Cartels are inherently unstable since there is an incentive for the members to deviate from the agreed price and supply the entire market. With cost asymmetries and more than two-players, collusion is not only threatened by unilateral deviation from the cartel, efficient firms may also deviate to smaller cartels. This makes collusion more difficult to sustain when the cost differences are large as the temptation to deviate to the sub-cartel becomes strong. Efficient firms that deviate to a sub-cartel have a better outside option than firms deviation to a competitive situation. This advantage translates into bargaining leverage for efficient firms when it comes to deciding the price for the large cartel and cartel prices are lower of the efficient firms can threaten to deviate jointly. The effect of a cartel hence depends on the counterfactual, i.e. the market structure without the large cartel. If the efficient firms become more efficient, the cartel price will fall. The effect of the inefficient firm reducing costs depends on how large the cost difference is.

Collusion models are important tools to estimate the negative effect of cartels and in the third chapter I focus on cartel damages. In the model, firms do not only have different production costs, they also sell differentiated products. With two-firms on the market, one efficient and one inefficient, collusive prices are only marginally affected by product differentiation. Prices in the counterfactual situation on the other hand depend critically on the degree of product differentiation. We find that the standard case of homogeneous products and symmetric costs is the worst situation for consumers both in terms of their welfare loss and the degree to which the restitution of damages compensate them for this loss. This is because the overcharge is large due to a low counterfactual price and because consumers prefer variety and demands less when there is only one product. Product differentiation mitigates these effects both by increasing counterfactual prices and by making quantities less sensitive to price changes. Cost asymmetries also assuage the problem, mainly by increasing the counterfactual price.

The fourth paper questions the logic that firms with anticompetitive agreements, such as cartels, will share information between them to the benefit of consumers. The model consists of two firms that decide whether to invest (independently) in cost reducing innovation, whether to share the knowledge

with each other and finally, what price to set in the cartel. The model is solved through backward induction. The first stage illustrates that if investment costs are sufficiently low, one or both firms will invest in cost reducing innovation. The innovation leads to cost asymmetries between the firms. The paper presents three possible reasons for why the efficient firm may want to share knowledge with the inefficient firm, but concludes that neither of them are valid. In this specific model an efficient firm is always better of withholding its knowledge than to share it with the inefficient firm. In the third stage firms decide on the collusive outcome, and the price is set in between the two firms' optimal level. For large cost asymmetries the price will be close to the efficient firm's monopoly price since it has a good outside option. The unwillingness to share information leads to higher cartel prices than if technology was shared, but also to it being harder for cartels to form.

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