

Predicting cartels

Economic discussion paper

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A report prepared for the Office of Fair Trading
by Paul A Grout and Silvia Sonderegger

FOREWORD

This report was commissioned by the Office of Fair Trading (OFT) from Professor Paul A Grout and Silvia Sonderegger from the University of Bristol. They were asked to conduct an empirical study into the economic and structural factors that are typically considered to contribute to the formation, maintenance or detection of cartels with a view to informing the assessment of cartels.

Any views expressed are those of the authors and they do not necessarily reflect the views of the OFT. This report is not and should not be treated as a guideline issued as a consequence of the obligation on the OFT to publish general advice and information under the Competition Act 1998 and Enterprise Act 2002.

This report is part of the OFT's economic discussion paper series, and is intended to inform current discussion within the competition policy community in the UK about cartel formation and detection. If you would like to comment on the paper, please write to me, Amelia Fletcher, at the address below. The OFT welcomes suggestions for future research topics on all aspects of UK competition and consumer policy.

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1 EXECUTIVE SUMMARY

Introduction

- 1.1 Cartels are agreements between firms to reduce the level of competition between them with the aim of raising prices and profitability. In modern times these agreements are frequently verbal, can be very harmful to competition but are often very difficult to detect. In the UK, the Enterprise Act has recently given strong powers to the competition authorities to help stimulate competition. Part of this policy has involved the introduction of criminal proceedings for those perpetrating cartels in the UK.
- 1.2 Although past evidence of cartel detection provides some indication of where cartels may exist, it would be helpful to understand more fully the factors that lead to cartel formation and use this information to identify the location of the cartels that have not yet been identified. Clearly, many of the critical factors will depend on the specifics of the individuals' involved and unique features of the case but there may be common economic factors that can help inform the process of deciding where to allocate effort in the detection process. This paper is concerned with this question.
- 1.3 The paper follows three approaches. One is a study of the economic theoretical literature to see what factors have proved useful in the modelling of cartel stability and formation. The second approach is empirical. We use existing recent evidence of legal cases and economic data to identify factors that are relevant to the identification of cartels and then to use the economic model to provide predictions of the probability of cartels within each of a large number of industry classifications. Finally, a number of case studies are undertaken. The findings of the three approaches are then brought together to provide an overall assessment that can be applied to any market to indicate how likely it is that the market contains a cartel.

Factors that facilitate or hinder collusion – the economic literature

- 1.4 The theoretical literature on cartels is primarily concerned with the compliance of independent firms with agreements that reduce competition within a market. Because anticompetitive practices are illegal, these arrangements cannot be the object of legal contracts and, as a consequence, can only exist if they are self-enforcing. Indeed, this is the way in which economists understand the term 'collusion': as a cooperative arrangement, that is self-enforced. To model self-enforcing agreements, economists have borrowed from the theory of repeated games. At the most general level, the sustainability of collusion depends on the interplay of the size of the (short-lived) gain that can be obtained by deviating from the collusive agreement, and the (long-run) cost of the resulting reversion to non-cooperative interaction (punishment). In particular, collusion is sustainable only when the potential short-term gain from a deviation is outweighed by the long-run losses from price competition.
- 1.5 The literature identifies several factors as facilitating cartel behaviour. In particular the theoretical literature suggests that:
- a smaller number of firms in the market facilitates collusion
 - higher entry barriers facilitate collusion
 - excess capacity and stocks are important variables and are generally thought to help sustain collusion
 - persistent demand instability in a market is thought to hinder collusion
 - demand growth facilitates collusion
 - frequency of interaction favours collusion
 - market transparency favours collusion
 - private information limits collusion

- cost asymmetries and quality differences restrict collusion
- horizontal product differentiation is important but its effect on collusion is ambiguous; and
- large, powerful buyers make collusion harder to sustain.

Chapter 3 of the paper provides a detailed discussion of the economics underlying these theoretic predictions.

- 1.6 The relationship between the theoretical literature review and the regression analysis and case studies is complex. One reason is that the theoretical literature on collusion has, until recently, underestimated or ignored the role communication plays in the sustainability of cartels. Insufficient emphasis has been placed upon the role of communication, and the exchange of information among firms, as the vehicle through which cooperation is achieved and sustained. In contrast, the legal literature qualifies as collusive only those agreements that are jointly arrived at, as a result of explicit communication. This creates a potential dichotomy between theoretical speculation, on one hand, and practical concerns, on the other. The need for cartel members to communicate intensifies precisely when collusion is harder to sustain. This observation suggests that parties might be more likely to engage in overtly collusive practices specifically in those circumstances that are predicted by the theory as being adverse to collusion. This suggests that there is unlikely to be a straightforward relationship between the theory and the empirical studies, and that the marrying up the evidence from the three approaches is not straightforward.

Empirical analysis

- 1.7 To undertake an empirical investigation a (dependent) variable is required that measures the extent of cartelisation in each industry sector. In this study we use the incidence of cartels in an industry as the measure of cartelisation, based on evidence drawn from EC and US cases. It is almost certainly the case that there are cartels that have yet to be discovered or indeed may never be discovered. For this reason the data used as the proxy for cartelisation suffers from an error in measurement

problem. That is, we only observe a selection of the evidence, namely those cartels that have already been discovered and prosecuted. Implicit in the approach is the assumption that the location across industries of known cartels is informative about the whereabouts of other cartels, or more precisely, informative about the whereabouts of cartels that can be discovered and prosecuted.

- 1.8 The investigation employs cartel evidence using EC cases from 1990 to the present and the US Department of Justice cases of horizontal price fixing from 1994 to present. We construct, for each jurisdiction, an index that gives the number of cartel cases discovered in that industry during the periods noted above. Despite the fact that less than 20 per cent of the cases are common between these two jurisdictions there is a strong positive correlation between the data sets. Having allocated the cartels to SIC three-digit classification we find the correlation between US and EU cartels is 0.68.

- 1.9 The statistical analysis is approached at a very disaggregated level (three-digit industry classification). In part this is necessary to obtain sufficient industries to conduct a meaningful cross-section investigation. However, it is also necessary if predictions are to bring significant additional insight to the evidence that can be gleaned directly from case studies and simple 'eye-balling' and manipulation of the data. Identifying, say, six specific industries where cartels may be particularly prevalent is more informative if these six are drawn from a classification with over one hundred categories than if they are drawn from, say, ten categories. There are obvious data problems in conducting the exercise due to measurement error and random industry factors. This makes it far harder to identify the significant variables and have confidence in the results. However, at a more fundamental level it is not obvious that, even with perfect data, economic factors 'work' at this level of disaggregation. That is, the 'economic' differences between, say, manufacturing and transport may be significant in determining cartel formation but it is not obvious whether the differences in manufacturing at a very disaggregated level (e.g. separating manufacture of knitted and crocheted fabrics from manufacture of knitted and crocheted articles as we do in the analysis) will be relevant. This may be because, at this level of disaggregation, any mismatch between markets and industry

classification is marked and the differences between industries may become too fine to significantly influence cartel formation, and hence identification. The main message from the analysis is that the approach does work at this level. That is, despite the data problems and the level of disaggregation we are able to find strong significant patterns in the data.

- 1.10 There are several clear messages that arise from the series of models we investigate. One is that demand factors are very important and follow the theoretically predicted pattern. That is, variability in growth is shown to have a negative impact on cartels. This is an extremely robust result holding in all models. Similarly, growth in turnover has a positive impact on cartel formation and again is extremely robust. In contrast, traditional entry barriers (measured in gross capital expenditure per firm, the level of stocks per firm and the level of R&D per firm) have little effect. The cost disadvantage ratio (a measure of economies of scale) is the sole entry barrier that is significant in explaining cartel presence, i.e. the higher economies of scale the more cartels. However, as indicated above, the interpretation of the lack of empirical evidence supporting the role of entry barriers requires care. The theory indicates that entry barriers should ease cartelisation. However, the data we are concerned with here is based on cartels that have been discovered. It may be the case that whenever entry barriers are weak a cartel will have to act to prevent entry from competitors and this increases the chances of being discovered. Therefore, one might expect to see mixed evidence on entry barriers. Interestingly there is some evidence drawn from case studies that also suggests that this may be the case. The regressions also show that scale, in the form of turnover in the industry, and concentration matters.
- 1.11 An interesting feature of the analysis is that the results indicate that elements of employment also seem to matter, i.e. employee costs are significant. These factors do not arise in the theoretical literature, possibly because there is no obvious reason why they should be critical for collusion. However, there are sensible reasons why they might matter for cartel detection. For example, industries with higher employment cost per employee may be more likely to have higher paid staff (who may, as a result, be privy to better information). Other things

being equal, this may increase the likelihood of a cartel being discovered and the relevant evidence being uncovered. To the extent that employees as opposed to shareholders carry much of the legal risks associated with setting up a cartel that may be detected (since they tend to be formed by management not shareholders) then this risk needs to find financial compensation. This provides a separate argument why there might be a positive correlation between employee costs and cartels, albeit with an opposite causation. However, while this is a robust theoretical explanation, it is hard to believe that such an effect will have a large impact on the total remuneration in a sector. Finally, the (logit) regressions typically explain somewhere between 14 per cent to 24 per cent of variability in the data on the location of cartels. That is, the economic variables explain about one fifth to one sixth of the variability in the cartel data. Given the measurement error problems in the data this is not an unreasonable figure.

- 1.12 The main purpose of this part of the report is to investigate whether econometric techniques can provide useful information as to where cartels may be located. Several models are used, all of which contain variables that are significant in explaining the location of cartels. One useful way to present the results is to provide for each industry a prediction of the probability that a cartel exists in that industry and then rank all industries. Then remove from the list any industries that already have had a cartel. Table 1.1 shows the top thirty industries in this final list (drawn from the three models), along with a prediction of the probability that they have a cartel.
- 1.13 The benefits of the approach become apparent when one compares the predictions with the raw cartel data. The allocation of EC and US cartels to SIC classification shows the well-known concentration on manufacturing and transport. Using this evidence as the basis for future investigation would imply a focus on manufacturing and transport sectors. The econometric approach allows a more detailed assessment. The econometric predictions of the most likely locations for cartels that may be convicted does indeed include several manufacturing industries where cartels have not yet been found (e.g. manufacture of aircraft and spacecraft, manufacture of paper and paperboard, manufacture of weapons) but significantly throw up other industries as being prime

candidates that would not have arisen from a simple non-econometric interpretation of the data. For example, secondary schools, auditing and tax consultancy, architecture and related consultancy, and telecommunications all come out extremely high on the 'hit list'. The stability of the schools market appears to be a factor that contributes significantly to its appearance towards the top of the list (this is also the case for auditing but the scale of the industry also appears to contribute). There has been significant media coverage of potential school cartels. The fact that schools are not present in the cartel variable and yet are thrown out as highly likely to contain cartels by the econometric analysis highlights the use of a disaggregated econometric approach.

Table 1.1

Ranking of industries where no cartels have yet been discovered		Prob.
1	Telecommunications	0.84
2	Manufacture of aircraft and spacecraft	0.65
3	Manufacture of grain mill products, starches and starch products	0.61
4	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0.55
5	Cargo handling and storage	0.50
6	Activities of travel agencies and tour operators; tourist assistance activities	0.46
7	Publishing	0.44
8	Manufacture of railway and tramway locomotives and rolling stock	0.44
9	Other land transport	0.43
10	Recycling of metal waste and scrap	0.40
11	Manufacture of articles of paper and paperboard	0.40
12	Manufacture of weapons and ammunition	0.39
13	Radio and television activities	0.39
14	Processing and preserving of fruit and vegetables	0.38
15	Manufacture of motorcycles and bicycles	0.38
16	Quarrying of sand and clay	0.37
17	Manufacture of prepared animal feeds	0.35
18	Non-scheduled air transport	0.34
19	Manufacture of domestic appliances not elsewhere classified	0.34
20	Mining and agglomeration of hard coal	0.34
21	Manufacture of glass and glass products	0.33
22	Other computer related activities	0.32
23	Architectural and engineering activities and related technical consultancy	0.30
24	Manufacture of cutlery, tools and general hardware	0.29
25	Other recreational activities	0.28
26	Manufacture of other chemical products	0.28
27	Printing and service activities related to printing	0.27
28	Secondary education	0.27
29	Manufacture of bricks, tiles and construction products, in baked clay	0.27
30	Postal and courier activities	0.25

Case studies

- 1.14 We have investigated many cartels including those in the two industries where they are most prevalent – shipping and basic chemicals. Here we summarise some common themes that emerge.

Demand factors, capacity and intensity of competition

- 1.15 Many of the case studies indicate that demand factors are important in the formation of cartels. However, it is extremely hard in the case studies to identify whether demand factors are the direct cause or whether demand works through other mechanisms. In particular 'negative' demand factors create excessive capacity and it may be the latter that is important in cartel formation. It is clear, however, that cartel formation appears to be generally linked with a decline in prices. This can take many forms, notably an abrupt price plunge that is triggered by a negative demand shock, or a gradual price decline. The latter may be caused by prolonged adverse demand conditions or intensified competition.
- 1.16 There are several examples where abrupt changes have triggered a cartel. For example, the Ferry Operators – Currency Surcharges Case (97/84/EC) fits this model very clearly. This case concerns five ferry operators and the driver here was the devaluation of sterling in September 1992, which had a detrimental effect on revenues for the five operators. Despite the differing impact on the companies they each announced identical surcharges in response to the devaluation with a common introduction date and common method of calculation. The French Beef (2003/600/EC) and German Banks (2003/25/EC) are other good examples.
- 1.17 The impact of prolonged adverse conditions is exemplified in many cases, e.g. Petrochemicals (94/599/EC), Seamless Steel Tubes (2003/382/EC) and Graphite Electrodes (2002/271/EC). In these cases the protracted nature of the adverse demand conditions typically resulted in the emergence of excess capacity, industry restructuring and exit. Sometimes the cartel manipulated and enforced the excess capacity. For example, in the Trans-atlantic agreement (TAA) case (94/980/EC)

differences in utilisation of the west and east bound routes were a factor in generating the excess capacity that was at the core of the cartel. The aim of the agreement was to limit the supply of transport on the market without reducing the real available capacity of ship-owners. Specifically, the ship-owners agreed not to utilize an agreed part (up to 25 per cent) of their available capacity.

- 1.18 Several cases also exhibit intense competition that precedes cartel formation. This was typically generated by the expansion – through acquisition and/or the building of new capacity – of one of the incumbents, or by a large new entrant. Citric Acid (2002/742/EC), Methionine (2003/674/EC), Soda Ash (2003/5/EC), Vitamins (2003/2/EC), and Plasterboard (2001/. /EC) are good examples.

Barriers to entry

- 1.19 Unfortunately, the legal cases at our disposal tend not to provide direct information on the scale of barriers to entry within the markets under inspection. The cases indicate that entry/potential entry is disruptive in that it destabilises the collusive agreement, often leading to the breakdown of the cartel (which we think of as 'internal' failure) and/or results in the cartel being discovered (which we think of as 'external' failure). Good examples of internal failure arise in the Methionine, Lysine, and Vitamins cases. In the Methionine case, for instance, after an initial smooth period that lasted from 1986 to 1989, the cartel became unstable in 1990, mainly owing to new entry. In Vitamins, in at least two cases (vitamin B6 and vitamin C), the cartels were eventually dismantled as a consequence of the fierce competition from Chinese importers, who disrupted the cartel agreements with their 'low prices and increasing volumes'.
- 1.20 In contrast, in shipping, much of the activity is to prevent entry rather than to police cartel members. The main market for the provision of sea and coastal water transport can be broken down into liner transport and tramp vessel transport. A liner service is the transport of goods on a regular basis on specified routes. Sailing is almost invariably timetabled and advertised in advance. In contrast, a 'tramp vessel service' is the transport of goods in bulk in a vessel chartered to shippers on the basis

of a voyage or time charter for irregular and/or non-advertised sailings. Liner cartels need to exclude tramp services. A good example of this exclusionary behaviour is the Cewal, Cowac and Ukwai Case (93/82/EEC) relating to sea transport of general cargo between France and several west and central African countries. A meeting of the Special Fighting Committee would be convened to decide who would offer reduced 'fighting rates', below the independent's rates, and these ships sailed close to the date that the outsider was scheduled to sail. With regard to the lost revenues, all conference members contributed to the cost of the fighting ships. These cartels provide examples of what we think of as external failure. The activities of the cartel, designed to exclude potential competition, provide evidence and raise complaints from other suppliers. Here entry barriers are not driving cartel formation; frequently it appears almost the reverse.

- 1.21 We can conclude that entry and potential entry is damaging, in that it is destabilising of cartels and increases the incumbents' need to coordinate their activities, thereby making their collusive agreement more explicit and easy to prove. This argument corroborates the theoretical view that an increase in the number of market participants, either in the present or in the future, renders collusion harder to sustain. Without new entry (or the possibility of new entry) agreements existing among the incumbents are less likely to become sufficiently explicit to allow a case to be built against them.

Transparency and communication

- 1.22 There are two potential scenarios that might arise. One is that the need for transparency is so strong that one will never see a cartel unless there is significant transparency in the market. An alternative is that cartels act to improve the transparency and hence one might expect that where cartels are convicted they have played an important role in the exchange of information over sales and price figures. There are many examples of the latter case.
- 1.23 For instance, in the Organic Peroxide case, meetings and information exchanges were very institutionalised. 'Swiss consultancy Treuhand played a key role in the cartel from 1993 organising meetings, often in

Zurich, producing 'pink' and 'red' papers with the agreed market shares which could not be taken outside Treuhand's premises and even reimbursing the travel expenses of participants to avoid leaving any traces about the illegal meetings'. Similarly, in the Citric Acid cartel, the companies held regular and frequent meetings, which were the hallmark of the cartel's organisation. A sophisticated monitoring system was established, whereby each company would report its monthly sales figures to Hoffman-La Roche, who would then contact the companies and provide each company's sales figures for the corresponding month. The data were subsequently compared to the aggregate sales figures published by European Citric Acid Association Manufacturers (ECAMA). Because the cartel members made up a significant part of total ECAMA sales, any cheating would be quickly identified.

- 1.24 Shipping is different from many markets in that an element of transparency and communication, indeed what one might think of as cartel-like behaviour, is sanctioned.¹ The problems in these markets appear to arise most frequently from these conferences and consortia overstepping the mark in terms of agreements, in particular entering into agreements that limit competition and/or raise prices in a manner that harms users rather than providing benefits to them.
- 1.25 The case studies appear to suggest that cartel behaviour is more common in markets that are not fully transparent. The apparent contradiction with the theoretical analysis is the result of two conflicting forces, which influence the relationship between transparency and the incidence of convicted cartels in opposite ways. On one hand, transparency facilitates collusion, as it makes it easier for the cartel members to monitor each other's activities. This observation suggests that we should expect collusion to be more likely in markets characterized by transparency. On the other hand, however, the cases indicate that many cartels were convicted thanks to the lack of transparency within their market, and their resulting need for frequent and institutionalized communication.

¹ The EC provides block exemptions from certain agreements in this market.

Size

- 1.26 The case studies confirm the theoretical prediction that the likelihood of collusion is inversely correlated with the number of firms and the degree of concentration in the market. However, a note of caution is needed in that the EU cases almost by definition are dealing with large firms. This may bias the evidence in favour of large firms. An industry with large firms does not have to exhibit high concentration, since the former is an absolute scale measure of a company whereas concentration is a relative measure within the industry. Thus the EU focus on large firms does not necessarily also bias the cases towards more concentrated industries. However, one should expect some bias of this type. Hence one has to be careful in using the case studies to indicate that cartels arise where one has large firms with high market shares. However, it is interesting that case studies are drawn from industries where there are few players.

Asymmetries

- 1.27 Different sizes between companies in a market is often taken as an indication that there are cost asymmetries between the parties. Cost asymmetries are frequently seen as making cartels less stable and difficult to form. Therefore, one may have expected to find a low correlation between industries with cartels and heterogeneous market shares of the leading firms. However, we clearly observe a considerable heterogeneity in the market shares held by cartel members. For instance, the Citric Acid case, the Methionine cartel, the Far Eastern Trade Tariff Charges and Surcharge Agreement (FETTCSA) case (2000/627/EC) and the Ferry Operators – Currency Surcharges case (97/84/EC) all exhibit considerable diversity of market shares between members of the cartels. This may suggest that any relationship between cartel formation and homogenous shares is weak, although one always has to bear in mind that the cartels we observe are biased towards those that are unstable.
- 1.28 Another basic asymmetry between parties that could arise is in the products that they sell. Product differentiation has been thought of as an important issue but that no clear picture has emerged as to the effect on cartel formation. Most of the cases we are dealing with have relatively homogeneous products. Shipping has limited product differentiation and

this is mostly true of basic chemicals. Exchanging Eurozone currencies, French Beef, Plasterboard, Steel Tubes, Carbonless Paper, Petrochemicals - the list of cases where there is limited scope for differentiation in the product is large. R&D is often taken as a measure of product differentiation, i.e. high R&D expenditures in an industry imply high product differentiation. We do not have a formal measure of product differentiation but the evidence on R&D for the industries covered in the case studies implies that R&D expenditures as a percentage of turnover were typically well below average.

Assessment

- 1.29 Using the evidence from the three approaches, what have we learnt in terms of assessing whether a market is likely to have a cartel that may be discovered and convicted? Each approach brings different insights and these need bringing together and balancing. Theory, the case studies and, in a limited sense through the R&D findings, the econometric analysis suggests homogeneous products are important. Similarly, the three approaches suggest sustained volatility is not likely to be associated with cartel behaviour. Finally, theory and the case studies indicate that stability among the leading players is important. We can think of these three features as fundamental characteristics. Then there are other features that are identified as important in some of the approaches. We can think of these as providing collaborative evidence. Finally, there are certain features that may give insight into when a cartel is likely to be formed. Here we pull these three (i.e. fundamental background, collaborative evidence and why and when) together in a sequential manner.
- 1.30 Clearly, each situation will be special and economic factors are only one part of the story. However, while it is a mistake to think that observable economic factors can define cartel location, it is clear from the three approaches that common factors emerge that will help inform whether a market is likely to have a cartel. We identify critical areas of assessment and group these into three sections – the fundamental background, the collaborative evidence and the why and where factor.

- 1.31 As indicated, the fundamental background reduces to three core issues – product, volatility and company criteria. The first core question is whether the industry has a homogeneous product or not. Cartels are far more likely if the product is fairly homogeneous between companies in the market. Considerable product differentiation has the opposite effect. Second, does the industry display volatile turnover over a sustained period of time? Cartels are more likely if output and market conditions are normally stable. This does not preclude occasional shocks to the market but these are not the norm. Also the lack of volatility does not imply a constant turnover but when there is decline it is likely to be persistent and relatively constant. Finally, are the leading players in the market large and relatively constant? If there are significant changes in market shares or regular exits and entrants then cartels are less likely. If year-on-year most of the players in the market remain constant then the opposite follows. Note, that this is long run relationship and there may be occasional years (possibly preceding cartelisation) when firms leave the industry.
- 1.32 We see these three factors as almost basic requirements for cartel formation so when considering whether the fundamental background of a market is consistent with cartel behaviour we suggest from our analysis that a market needs at least two high scores out of three to be likely to favour collusion.
- 1.33 The research has identified a series of factors that are associated with cartelisation or to be more precise discovery of cartels. None of these are essential but have been shown to be relevant factors. These are:
- Transparency – What is the level of transparency? If there is almost no transparency then cartels are less unlikely
 - Payroll effects – The statistical modelling identified payroll effects, i.e. relatively high payroll per employee, as factors. If these are comparatively high in the market then cartels are more likely
 - Big firms/number of firms in industry. Cartels more likely if concentration is large and/or there are relatively few firms in the market/industry

- Barriers to entry – High barriers to entry, or the ability to construct such barriers, make cartels more likely
- Capacity – Evidence of excess capacity makes cartels more likely. If capacity is apparently being used to the full with little scope for extra production then the opposite holds; and
- Ranking in econometric model.

- 1.34 Overall, a market that scores highly on these collaborative factors indicates that cartels may be present, however, we would suggest that there is little scope for trade-off between fundamental background and collaborative factors.
- 1.35 If a market has the fundamental background and strong collaborative evidence then the question why and when still needs to be addressed. Are there good reasons for these particular companies to be colluding at the present time? What is the key factor? These questions are the hardest to answer. Clearly, higher and safer profit relative to the counterfactual is at the core of any cartel but this is not hugely informative. However, it does lead on to the question – why is higher and safer profit an issue for this market at this time? We see this as a more productive question in the context of identifying cartels. The question tends to focus on demand factors and we know these have been identified in the research as very significant.
- 1.36 There are two categories where there is good evidence: (i) where there has been a long run decline in demand and/or prices affecting all or almost all companies and, (ii) where there is a sudden market shock that affects all companies in the market.
- 1.37 The idea that these will bite in markets that score highly in the three fundamental background tests is both believable at an intuitive level and is strongly backed up by the case study evidence. Where products are relatively homogeneous, there is little volatility in demand and the parties are familiar with each other the drive to jointly address a relentless trend

in the market is shown to be strong.² Similarly, if all companies are hit by a sudden shock that clearly requires response then the drive to find out how others are thinking of responding and to take the next step of co-ordinating responses will be strong. Therefore it makes sense to look for a decline or shock to the industry to highlight whether and when a cartel may have originated. Aside from these factors the research also indicates that the 'why' factor should consider the need to build transparency in the market and improve entry barriers where they are weak. Focusing on these questions may throw light on why a market needs to explicitly cartelise to achieve common objectives. However, in general, with the exception of demand factors the research provides less productive answers to the why and when question.

- 1.38 Overall, the three approaches taken in the report provide a framework that can help identify whether a particular market is likely or less likely to have a cartel. The three categories above provide help in assessing markets but one ought to emphasise again that economic factors can only provide part of the answer. In particular, the 'why' and 'when' category can only focus on some factors that will be critical. The absence of these factors does not imply that a cartel is unlikely. That is, whereas the fundamental background and collaborative evidence could almost take the form of a 'tick list', the 'why' and 'when' questions should not be interpreted this way.

² Note, that this conflicts somewhat with the theory and econometric analysis although to some extent this issue is about when a cartel is formed, something that the econometrics is ill equipped to deal with. The effect is so prevalent in the case studies that it is hard to ignore.

2 INTRODUCTION³

- 2.1 Cartels are agreements between firms to reduce the level of competition between them with the aim of raising prices and profitability. In modern times these agreements are frequently verbal, can be very harmful to competition but are often very difficult to detect. In the UK, the Enterprise Act has recently given strong powers to the competition authorities to help stimulate competition. Part of this policy has involved the introduction of criminal proceedings for those perpetrating cartels in the UK.
- 2.2 Past evidence of cartel detection provides some indication where cartels may exist but is a poor primary tool to use to focus resources since the process becomes self confirming, i.e. detection increases as more resources are employed which in turn justifies further resources. The process is likely to provide poor adjustment processes for resource allocation and disparate marginal returns to detection resources across industries. Therefore, it is helpful to understand more fully the factors that lead to cartel formation and use this information to identify the location of the cartels that have not yet been identified. Clearly, in any particular industry many of the critical factors will depend on the specifics of the individuals involved and unique features of the case that we cannot quantify but there may be common economic factors that can help inform the process of deciding where to allocate effort in the detection process. This paper is concerned with this question. It has three approaches.
- 2.3 One is a study of the economic theoretical literature to see what factors have proved useful in the modelling of cartel formation. This is given in Chapter 3 of the paper.
- 2.4 Second, is to use existing recent evidence of legal cases and economic data to investigate whether econometric techniques can provide useful information as to where cartels may be located and, if so, to use the economic model to provide predictions of the probability of cartels within

³ We would like to thank Matthew Dickson and Maraino Selvaggi for their assistance in producing this paper.

each of a large number of industry classifications. The statistical analysis is approached at a very disaggregated level. It is conducted using the SIC three-digit industry classification (see Annexe A for the list of three-digit industries). The disaggregated approach is necessary if predictions are to bring significant additional insight to the evidence that can be gleaned directly from case studies and simple 'eye-balling' and manipulation of the data.

- 2.5 There are obvious data problems in conducting the exercise due to measurement error and random industry factors. However, at a more fundamental level it is not obvious that, even with perfect data, economic factors 'work' at this level of disaggregation. That is, the 'economic' differences between, say, manufacturing and transport may be significant in determining cartel formation but it is not obvious whether the differences in manufacturing at a very disaggregated level (e.g. separating manufacture of knitted and crocheted fabrics from manufacture of knitted and crocheted articles as we do in the analysis) will be relevant. This may be because, at this level of disaggregation, any mismatch between markets and industry classification is marked and the differences between industries may become too fine to significantly influence cartel formation, and hence identification. The main message from the analysis is that the approach does work at this level. That is, despite the data problems and the level of disaggregation we are able to find strong significant patterns in the data. The approach and results of the empirical study is summarised in Chapter 4 of the paper. The details are given and discussed in Annexes B, C and D, and provide rankings of all industries at three-digit SIC classification.
- 2.6 To complement the regression analysis, a small number of case studies have been undertaken which look in more detail at cartels in specific industries. This is given in Chapter 5.
- 2.7 Finally, the findings of the three approaches are then brought together to provide an overall assessment. This is discussed in Chapter 6.

3 FACTORS THAT FACILITATE OR HINDER COLLUSION

Introduction

- 3.1 The theoretical literature on cartels is primarily concerned with the compliance by independent firms with agreements that reduce competition within a market. Because anticompetitive practices are illegal, these arrangements cannot be the object of legal contracts and, as a consequence, can only exist if they are self-enforcing. Indeed, this is the way in which economists understand the term 'collusion': as a cooperative arrangement, that is self-enforced. Notice that this definition does not imply that the collusive agreement is reached without resorting to communication. Rather, the emphasis is placed upon the self-sustainability of the arrangement, which is necessary in virtue of its illegality. Although communication plays no part, or is assumed away, in the majority of theoretical models of collusion, some recent work has started to shed light into its role. This is discussed in the analysis that follows.
- 3.2 To model self-enforcing agreements, economists have borrowed from the theory of repeated games. The analogy with repeated games arises because cooperation requires single firms to depart from their myopically optimal actions. In the absence of legally binding agreements, cooperation in the present may therefore only be sustained by the threat of future punishment in the event of a deviation. Hence, in economic theory firms can maintain collusive prices only if they can credibly threaten to punish deviations by aggressive competition in the future. Clearly, this presupposes repeated interaction. Moreover, collusion can only be sustained if interaction is infinitely repeated. Unless this is the case, the threat of future punishment cannot possibly act as a deterrent.
- 3.3 At the most general level, the sustainability of collusion depends on the interplay of the size of the (short-lived) gain that can be obtained by deviating from the collusive agreement, and the (long-run) opportunity cost of the resulting reversion to non-cooperative interaction (punishment). In particular, collusion is sustainable only when the potential short-term gain from a deviation is outweighed by the long-run

losses from a price war. This is the necessary condition that must hold, in order for collusion to be feasible.

- 3.4 In what follows, we review the industry characteristics that the literature has singled out as being relevant when assessing the sustainability of collusion within a market. It should be noted that these characteristics are neither necessary nor sufficient for collusion to be sustained, but simply affect the likelihood that collusion might be sustained.

Number of firms

- 3.5 We expect the correlation between the number of firms and the incidence of collusion within a market to be negative. This conclusion arises from the following considerations. Firstly, a high number of participants increase the probability that firms with different costs of production might coexist within the market; as explained later, this decreases the likelihood of collusion. Secondly, a large number of participants make deviations from the collusive agreement harder to monitor. Thirdly, as the number of firms increase, each firm gets a lower share of the pie. This makes (i) deviations more tempting and (ii) punishments less costly. Finally, when the cartel does not include all market participants, an increase in fringe size diminishes the stability of collusion by decreasing the total market share that the cartel is able to capture.
- 3.6 The Methionine and Lysine cases discussed in Chapter 5 provide good illustrations of these ideas. In both cases, cooperation was disrupted by the access to the market of a large new entrant (ADM in Lysine, Monsanto in the Methionine case). This made the cartel unstable, and eventually resulted in its collapse. In the Citric Acid case, for instance, the market leader Jungbunzlauer was perceived as being the major cause of trouble, and was attacked especially by ADM and Hartman & Reimer, the third and fourth largest members of the cartel. These difficulties carried on until, in 1995, 'it became clear that the cartel was in total disarray and was not working'. Similarly, in the Lysine case, the frequent clashes between Ajinomoto and ADM, the two largest cartel members resulted in Ajinomoto eventually approaching the Commission to denounce the agreement. Similarly, in the Methionine case after

Monsanto entered the market, 'the participants started having difficulties in coordinating'. This was because Rhone-Poulenc and Degussa, the two largest cartel members, had 'somewhat different agendas' on how to react to Monsanto's low prices. Eventually, the cartel came to an end in 1999, when Rhone-Poulenc (now Aventis) revealed the cartel's existence to the Commission.

Entry barriers

- 3.7 If entry barriers are low, high prices in the present will attract new competitors in the future. This decreases the future gains from collusion, making punishment less costly to bear. In markets where entry barriers are low, collusion is therefore harder to sustain, independently of the actual number of market participants.
- 3.8 A similar reasoning applies to markets where entry barriers are presently high, but expected to lower in the future. Consider a product that is protected by a patent, and suppose that the patent is to expire within a couple of years. The incumbent firms know that after the patent has expired, entry in the market will be unrestricted. If production does not entail significant fixed costs, this implies that after the expiry date the market will become perfectly competitive. Thus, collusion is necessarily short-lived and, as such, cannot be sustained.

Capacity constraints/stocks

- 3.9 The role played by capacity constraints on the feasibility of cartels is ambiguous. On one side, a capacity constrained firm has less to gain from undercutting its rivals, as it is able to accommodate only a fraction of the extra demand this would generate. On the other side, however, capacity constraints limit firms' retaliatory power. This is because the strongest penalty that firms can envisage is to produce at full capacity.
- 3.10 Brock and Scheinkman (1985)⁴ provide a good illustration of this ambiguous effect. Within a symmetric setting - where all the firms in a market have the same capacity constraint - these authors show that a

⁴ See also Abreu (1986) and Lambson (1987)

non-monotonic relationship exists between cartel sustainability and the size of the capacity held by each firm. When industry excess capacity⁵ is sufficiently small, the deviation-inhibiting effect of capacity constraints dominates. This implies that adding additional capacity makes collusion harder to sustain. When industry excess capacity is sufficiently large, on the other hand, the punishment-reducing effect of capacity constraints dominates. Adding additional capacity, therefore, makes collusion easier to sustain.

- 3.11 While Brock and Scheinkman treat capacity constraints as exogenously given, Davidson and Deneckere (1990)⁶ explicitly model the firms' capacity. They find that excess capacity is carried in all collusive equilibria. This is because excess capacity is necessary to punish deviations from the collusive scheme. In this setting, therefore, large capacities are a necessary condition for collusion to occur.
- 3.12 The importance of capacity constraints in affecting the market participants' ability to collude is corroborated by the case studies analyzed in Chapter 5. Indeed, the cases indicate that cartel formation is often linked with the emergence of excess capacity within the market, typically generated by a protracted downturn in demand conditions. In the Petrochemical cartel, for instance, this effect comes out very clearly: the sharp demand downturn that preceded the formation of the cartel resulted in structural overcapacity in the whole European market; the problem was so severe that during the period immediately preceding the formation of the cartel producers were often operating below break-even levels. It is in this climate that the cartel members started to meet, in order to figure out a way to 'share the pain'.⁷
- 3.13 Compte et al. (2000)⁸ analyze the effect that asymmetries in capacity constraints have upon the sustainability of cartels, focussing on the joint impact of asymmetry and aggregate capacity. Their findings share some similarities with those by Brock and Scheinkman; the introduction of

⁵ Defined as the ability of firms to exceed their equilibrium output production.

⁶ A similar idea is also explored in Rotemberg and Saloner (1989).

⁷ This is the actual title of one of the memoranda that was subsequently used as incriminating evidence.

⁸ See also Lambson (1996).

asymmetric capacities favours collusion when aggregate capacity is large, but hinders collusion when aggregate capacity is limited. This has interesting implications for assessing the impact that horizontal mergers may have upon the likelihood of collusion within a market. On one hand, a merger reduces the number of competitors within a market, thus facilitating collusion (see paragraphs 3.5 and 3.6); on the other hand, however, a merger also exacerbates the asymmetries in capacities within the market (this is especially true when the merger involves the largest firms). If aggregate capacity is limited, this second effect hurts the firms' ability to collude, as it creates a new entity that is extremely hard to discipline. The implication is that mergers are not necessarily anti-competitive; on the contrary, by hindering collusion mergers might actually promote competition within a market.

- 3.14 The ambiguous effect of changes the distribution of excess capacity is well exemplified in the case studies analyzed in Chapter 5. In several cases, cartel formation was preceded by a spell of intense competition, typically characterized by the expansion – through acquisition and/or the building of new capacity – of one of the smaller incumbents, or by the access to the market of a large new entrant. This evidence suggests that a decrease in the degree of asymmetry of the distribution of excess capacity facilitates collusion. On the other hand, however, the case studies also report that those cartels that were created following a reduction in the degree of asymmetry of excess capacity were generally unstable. This suggests that similarities in capacity constraints might be detrimental for cartel stability.
- 3.15 This dichotomy is particularly well illustrated in the Citric Acid case, where the period immediately preceding the formation of the cartel was characterized by a massive increase in the production capacity of Jungbunzlauer, which allowed Jungbunzlauer to become one of the market leaders, along with Hoffman-La Roche, ADM and Haarmann & Reimer. The result of this expansionary campaign was that Jungbunzlauer 'virtually tripled its production capacity for citric acid, mainly through the acquisition of Boehringer Ingelheim's citric acid manufacturing business in 1985 and Benckiser's organic acid division in 1988'. Thus, the case suggests that the reduction in the asymmetries in

capacity operated by Jungbunzlauer's expansion facilitated the formation of the cartel.

- 3.16 On the other hand, however, the case also reports that 'the considerable influx of citric acid imports for China (..) started difficulties between some of the cartel members, especially with respect of the lack of discipline on the part of certain members vis-à-vis adherence to the agreement'. The market leader Jungbunzlauer was perceived as being the major cause of trouble, and was attacked especially by ADM and Hartman & Reimer, the third- and fourth- largest members of the cartel. These difficulties carried on until in 1995 'eventually, it became clear that the cartel was in total disarray and was not working'. That same year, the cartel was discovered and dismantled by the Commission. Thus, the case also demonstrates that similarities in capacity constraints might be detrimental for cartel stability.

Demand/demand stability

- 3.17 In a classic article, Rotemberg and Saloner (1986) explore the response of oligopolies to fluctuations in the demand for their product. Taking a simple but illustrative view of the business cycle, they assume that the level of market demand is determined in an independent fashion each period, so that the expected level of future demand is independent of the current demand level. This ensures that the expected cost of punishment is independent of the present state of demand. Today's demand level, however, does affect the short-term incentive to cheat, since a price-cut is more attractive when demand is high. Intuitively, when the economy is experiencing a temporary boom, the temptation to undercut the collusive price, and capture the entire market, is stronger than - while the expected opportunity cost of punishment is the same as - when the economy is in a temporary slump. The implication is that, when demand is temporarily high, collusion is harder to sustain. The same argument can be applied to show that when demand is temporarily low, collusion is easier to sustain.
- 3.18 Haltinger and Harrington (1991) relax the assumption of demand independence across periods, and introduce a more realistic model of business cycle, where demand movements are cyclical over time. They

show that the most difficult point of the cycle for firms to collude is when demand is at its highest. Thus, collusion is more likely to break up when demand is currently high, but is expected to fall. The intuition behind the result is that, when demand is at a peak, short-term gains from deviation are maximal, because the economy is experiencing a boom, while the opportunity cost of punishment is at a minimum, because the economy is entering into a recession. By the same token, collusion is less likely to break up when demand is currently low, but is expected to grow. This is because when demand is at the lowest point of the business cycle, current gains from deviation are low, as the economy is currently in a recession, but future gains from collusion are high, because the economy is entering into an expansionary phase.

- 3.19 This theoretical prediction is supported by the case studies examined in Chapter 5; indeed, the cases indicate that unexpected negative shocks to demand are often associated with the emergence of collusive behaviour. For instance, in the French Beef case, six federations were fined for having taken part in an agreement to set a minimum price for some categories of beef and to suspend or, at the very least, limit imports of all types of beef into France. The cartel was set up in October 2001, one year after the beginning of the crisis that had been triggered by the discovery of the mad cow disease; the crisis had started in October 2000, and had resulted in a significant decline of prices. Similarly, in the German Banks case, five German banks were convicted for agreeing to charge no less than 3 per cent for the buying and selling of euro-zone banknotes. The agreement was aimed at compensating the banks for the future abolition of the lucrative selling and buying 'spread' charged by banks to exchange euro-zone currencies; this abolition occurred in 1999, when the bilateral exchange rates for currencies of the European Union became irrevocably locked.
- 3.20 Bagwell and Staiger (1997) extend the analysis to persistent business cycles –situations where demand movements are stochastic and persistent. They find that collusion can be more easily sustained if the expected duration of booms is sufficiently long, and that of recessions is sufficiently short. Moreover, transitory shocks make collusion harder to sustain, independently of whether the market is in a boom or a recession phase.

- 3.21 Staiger and Wolak (1992) explore the response of collusive prices to changing demand conditions when firms operate under capacity constraints. In their setting, periods of unexpectedly low demand result in the emergence of excess capacity; this, they argue, may destabilize the collusive agreement. Interestingly, Steiger and Wolak's prediction is at odds with the evidence we found in the case studies, where the emergence of excess capacity resulting from adverse demand conditions appears to facilitate, rather than hinder collusion.
- 3.22 Based on the above findings, we draw the following conclusions. Demand instability hinders collusion. This is because, with respect to the case where demand is stable at an average level, demand fluctuations tighten the requirements that ensure the sustainability of collusion. Moreover, demand growth facilitates collusion.⁹ When demand is on an upward trend, future economic conditions are more favourable than present ones. With respect to the case where demand is stable to its present level, demand growth increases the opportunity cost of punishment, and therefore decreases the firms' incentive to deviate from the collusive agreement. It should however be emphasized that this prediction is conditional on entry barriers being sufficiently high. In the absence of barriers to entry, demand growth will trigger new entry in the market. This will, at least partially, counteract the collusion-enhancing effect of demand growth.

Frequency of interaction and price adjustments

- 3.23 Frequent interactions/price adjustments facilitate collusion by shortening the time of reaction to deviations from the collusive agreement. If the amount of time that must elapse before any deviation can be punished is long, the gains from deviation can be enjoyed for longer. This makes deviation more attractive. Moreover, a longer reaction time pushes retaliation further in the future. When firms discount the future, this makes punishment less frightening.

⁹ The same argument can be applied to conclude that falling demand makes collusion harder to sustain.

- 3.24 Snyder (1996) argues that the impact of frequency of interaction upon the firms' ability to collude may be particularly important in the presence of large buyers. This is because large buyers can strategically concentrate their orders across time, in order to make firms' interactions less frequent and therefore make collusion harder to sustain.
- 3.25 It should however be emphasized that if firms can communicate, and secretly exchange conclusive information concerning their pricing practices on a regular basis, the relevance of the frequency of market-mediated interactions for the sustainability of collusion is greatly diminished.

Market transparency/private information

- 3.26 The importance of market transparency in determining the sustainability of tacit collusion was first highlighted by Stigler (1964), and subsequently formally established by Green and Porter (1984) and Abreu, Pierce and Stacchetti (1986). The logic of the argument can be seen as follows. Suppose that firms are unable to observe demand conditions, and to monitor their rivals' sales and prices. Moreover, assume that demand randomly fluctuates from period to period. In this setting, firms who register low sales are unable to establish whether this is the consequence of adverse overall demand conditions, or of secret undercutting by rival firms. How should they react?
- 3.27 Suppose that after a period of low sales, firms do not modify their behaviour, and stick to the collusive price. This would eliminate any punishment for undercutting, and would therefore encourage firms to deviate from the collusive agreement. It follows that collusion can be sustained only if firms react to low sales by launching a price war. In this setting, this implies that collusion can only be sustained in environments where price wars erupt whenever demand is low.
- 3.28 In comparison to the case where demand is observable, this reduces the expected future benefits from collusion, and makes undercutting more tempting. Thus, in the absence of communication, the firms' inability to distinguish between favourable and unfavourable demand conditions undermines their ability to collude. Importantly, however, this argument

ceases to be valid if firms can exchange verifiable information concerning their sales. If this is possible, firms can verify whether a deviation has occurred by scrutinizing the evidence advanced by their competitors. In this case, the firms' inability to directly observe demand is compensated by their ability to exchange information.

- 3.29 Finally, it is worth noting that the argument advanced by Green and Porter relies on the unpredictability of demand, and would not hold in markets where demand is deterministic. This is because when demand is deterministic, there exists no uncertainty over the current state of demand, and unexpectedly low sales can only result from price undercutting by rival firms.
- 3.30 On a similar note, the existence of private information makes collusion harder to sustain. Roberts (1985), Cramton and Palfrey (1990), Kihlstrom and Vives (1995), Athey and Bagwell (2001) and Athey, Bagwell and Sanchirico (2002) concentrate on the case where firms possess private information about their costs. The idea is that, at any given point in time, some firms may have high costs, while other enjoy low costs, due for instance to variations in local conditions, labour relations, inventory managements and so on.
- 3.31 In this setting, joint profit maximization prescribes that market shares should be inversely related to firms' costs; under constant returns to scale, for instance, when one firm has lower production costs than its rival, joint profit is maximized by allocating all production to the low cost firm. Because firms are unable to observe each other's costs, efficient market share allocation can only be achieved if firms can exchange information over their cost realizations. Thus, communication is necessary for joint profit maximization to occur.
- 3.32 This last point is particularly well exemplified in the Organic Peroxide case, where information exchange was so central to the existence of the cartel that a consultancy company was employed with the sole purpose of organizing meetings, produce 'pink' and 'red' papers with the agreed market shares, and even reimburse the travel expenses of participants to avoid leaving any traces about the illegal meetings.

- 3.33 Although communication is necessary for joint profit maximization, it is however not sufficient; because joint profit maximization requires them to relinquish market share, high-cost firms have strong incentives to misrepresent their true cost realizations. Truthful communication is therefore possible only if higher-cost firms are assured of side-payments, or some other forms of future benefits, by lower-cost fellow cartel-members. For instance, in the stylized illustration given above, the high cost firm will not be willing to relinquish the whole market, and therefore earn zero profits from production, unless the low cost firm guarantees an appropriate transfer in exchange. This however decreases the low-cost firm's incentive to abide to the collusive agreement. Thus, a trade-off exists between joint profit maximization and cartel enforceability, even when communication is feasible. As a consequence, enforceable market share arrangements are not necessarily efficient. This reduces the profitability of cartels, and makes collusion less attractive.
- 3.34 Compte (1998), Kandori and Matsushima (1998) and Verboven (1998) study the informational asymmetries that arise when firms hold diverse and imperfect information about each other's actions. This may for instance be the case when competition is somewhat localized, i.e. each firm only operates within a limited number of local sub-markets, that are not fully distinct but where cheating by one firm in a market can be more easily observed by the subset of firms in the local sub-market. If punishing a deviating firm is costly (for instance because it involves a price war that penalizes all firms in the market), this creates the following problem: a firm that suspects cheating by one of its competitors may consider concealing this information, in order to avoid having to enforce the costly punishment. Essentially, since the cartel covers the overall market but, say, only a local firm has knowledge of cheating then that firm is now in the position of co-ordinating responses to cheating (since it alone has the information) which may change their incentives to reveal information.
- 3.35 As an illustration, consider the situation where three firms are active in the whole market, but firms 1 and 2 are the only firms operating within a certain submarket. Suppose that the collusive agreement prescribes that if a firm deviates from the collusive price, all firms should revert to marginal cost pricing forever. Notice that this punishment results in all

firms earning zero profits. The implication is that if, say, firm 2 deviates from collusion in the local market where it competes only with firm 1, firm 1 will strictly prefer to ignore this deviation, rather than trigger punishment, and induce marginal cost pricing across all local markets. Predicting this, however, firm 2 would have no incentive to respect the collusive agreement, at least in the market where it only competes with firm 1.

- 3.36 We conclude that, in contrast to a setting where all information is public, the presence of private information imposes an additional constraint, arising from the trade-off that exists between the severity of the punishment that can be imposed after a deviation, and the likelihood that deviations will be discovered. This makes collusion harder to sustain. Compte and Kandori-Matsushima show that under these conditions communication may alleviate the problem. Thus, in the presence of asymmetric information among firms, communication-enhancing devices such as trade unions may promote collusion.

Cost asymmetries/quality differences

- 3.37 Cost asymmetries and differences in the quality of the products sold by different firms make collusion harder to sustain.¹⁰ In asymmetric settings, low-cost (respectively, high quality) firms are hard to discipline. This is because the harm that their high-cost (respectively, low quality) rivals can inflict upon them by triggering a price war is limited.
- 3.38 For instance, consider the damage that a firm producing a low quality good can inflict upon a high quality firm; even if the low quality good is sold at a slightly lower price, consumers will still purchase the higher quality good, because it possesses a higher intrinsic value. In order for the low quality firm to significantly affect the demand faced by its high quality rival, it must therefore charge a price that is considerably below what the rival is charging. This might however not be feasible, owing to cost restrictions. To compensate, collusive agreements should assign larger market shares to high quality firms, in order to offset the (relative)

¹⁰ See, for instance, Hackner (1994) for an analysis of the sustainability of collusive prices in markets where goods are vertically differentiated.

gains that such firms can obtain from deviation. This however adversely affects the low quality firms' incentives to participate the collusive agreement, creating a trade-off between incentive provision to high quality firms and to their low quality rivals.

- 3.39 The same reasoning applies to cost asymmetries; in order to be induced to participate to the collusive agreement, low cost firms should be allocated larger market shares. This however makes collusion less attractive for high cost firms. We conclude that cost asymmetries/quality differences make collusion harder to achieve, by limiting the range of market shares that are consistent with collusion.¹¹
- 3.40 An interesting application of this general point concerns the impact of innovation upon collusion. Because innovation fosters asymmetries in costs and/or qualities, we expect collusion to be less likely in innovative markets.¹²

Horizontal product differential

- 3.41 The effect of horizontal product differentiation upon the sustainability of collusion is ambiguous. When products are horizontally differentiated, different consumers rank equally priced products differently; this is because goods possess characteristics that appeal to different types of consumers. With respect to the situation where all goods are perfect substitutes, this decreases the elasticity of demand faced by any single firm; for any given price differential, consumers are more reluctant to abandon their favourite variety.
- 3.42 On one hand, this results in firms finding deviations less attractive; this is because the extra demand that firms can capture by slightly undercutting their rivals is limited.

¹¹ An exception to this prediction can be found in Eswaran (1997), within the context of business cycles, where some members of the cartel may go bankrupt during periods of slack demand. In this case a low-cost producer may help collusion by curtailing its own output in periods of slack demand, thereby ensuring the viability of the more inefficient cartel members.

¹² This point is made more formally in Ivaldi et al. (2003).

- 3.43 By the same token, however, a lower elasticity of demand also restricts the firms' retaliatory power, by limiting the harm that can be inflicted upon other firms by launching a price war. The net result of these opposing forces depends upon the exact nature of the case under scrutiny.¹³
- 3.44 Raith (1996) studies the impact of horizontal product differentiation upon the sustainability of collusion when firms are unable to observe the actions of their rivals, but can nonetheless draw inferences from their own demand.
- 3.45 In this setting, differentiation decreases the correlation between the demands faced by different firms. This results in deviations being harder to detect, and in collusion being harder to sustain. We conclude that, when market conditions are not transparent, horizontal product differentiation makes collusion harder to sustain.
- 3.46 Symeonidis (2002) considers the case where firms can sell more than one variety of a product, and finds that collusion becomes harder, the larger the number of varieties sold by each firm. This is because a rise in the number of varieties sold by a firm increases the profit that the firm can obtain by deviating from collusion (i.e. by becoming the market's sole supplier, albeit for a limited amount of time) more than it increases the profit that the firm obtains when it sticks to the collusive agreement (i.e. when it shares the market with other firms). It follows that selling a higher number of varieties increases the benefit from deviation more than it increases the opportunity cost of punishment.

Multi-market contact

- 3.47 In the words of Edwards (1955): 'When firms encounter each other in several markets, the multiplicity of their contact may blunt the edge of their competition'. Bernheim and Whinston (1990) formalize this intuition by precisely identifying the conditions under which it holds. Intuitively, multi-market contact acts as an expansion of the market where the firms compete. This has an ambiguous effect: on one hand it magnifies the

¹³ See, for instance, Chang (1991) and Ross (1992).

gains of deviation, while on the other it increases the strength of the resulting punishments. In a perfectly symmetric setting - where identical firms with identical, constant-returns-to scale technologies meet in identical markets - these opposing forces exactly annul each other. In that case, multi-market contact has no impact upon the sustainability of collusion. In contrast, when markets and/or firms differ, or when technology exhibits decreasing returns to scale, multi-market contact may foster collusion. This is the case because the presence in several markets softens/offsets the anti-collusive incentives that may be generated within single markets.

- 3.48 To illustrate this point, consider a situation where firms have different costs of production, which are negatively correlated across markets. In that case, multi-market contract facilitates collusion, by allowing each firm to hold higher market shares in those markets, where it is more efficient. This allocation ensures that the greatest fraction of the extra demand that firms would generate by undercutting would come from the market where they have higher costs, and at the same time the greatest fraction of the profits lost in the event of a price war would come from the market where firms have lower costs. The first effect decreases the firms' gains from deviation, while the second effect increases the costs of punishment. We conclude multi-market contact relaxes the requirements that are necessary to sustain collusion.

Cross-ownership

- 3.49 There are many cases in which firms acquire their rivals' stocks as passive investments that give them a share in the rivals' profits but not in the rivals' decision-making. Malueg (1992) and Gilo and Spiegel (2003) study these passive investments /cross ownership patterns, and show that they may have two opposing effects upon the firms' inclination to collusion. On one hand, cross ownership weakens the incentive of firms to deviate; this is because firms internalize part of the losses that they inflict on rivals when they deviate. On the other hand, however, cross ownership may also soften the firms' incentive to impose a harsh punishment, following a breakdown of the collusive scheme. This makes deviation more tempting.

- 3.50 Finally, cross ownership facilitates communication. This decreases the informational asymmetries that exist among firms, and, as seen above, might therefore facilitate collusion. However, enhanced communication also encourages renegotiation, and might therefore render collusion harder to sustain.
- 3.51 We conclude that cross ownership agreements have an ambiguous effect upon the sustainability of collusion.

Buyer power

- 3.52 Large, powerful buyers make collusion harder to sustain. Because buyers benefit from price wars between sellers, large buyers will utilize their power strategically, in an attempt to break any collusive agreement that may exist among the sellers. This may for instance be achieved by concentrating orders across time, in order to make the sellers' interactions less frequent (Snyder 1996), or by shading current demand, in the hope that this will lead sellers to believe that a secret price cut has occurred (Compte 2000). Notice that communication among firms might, at least partially, counteract these conclusions.

Some general remarks

- 3.53 The theoretical literature on collusion has until recently underestimated or ignored the role played by communication in the sustainability of cartels. This is because, as a science, economics is chiefly concerned with equilibrium outcomes, and not with the specific manner in which these outcomes are attained. Within the context of collusion, this implies that not much emphasis has been placed upon the role of communication, and the exchange of information among firms, as the vehicle through which cooperation is achieved and sustained. In contrast, the legal literature qualifies as collusive only those agreements that are jointly arrived at, as a result of explicit communication. This creates a potential dichotomy between theoretical speculation, on one hand, and practical concerns, on the other. Economic theory fails to meaningfully account for one of the very factors – namely, communication – that define collusion legally.

- 3.54 In the preceding survey, we have reviewed the factors that the economic literature has highlighted as affecting the likelihood of collusion within a market. We have singled out those theoretical predictions that are constructed under the assumption that cartel members are unable to communicate. This is true, for instance, for the arguments advanced when discussing the role of market and price transparency, and private information, in the sustainability of collusion; clearly, the ability of cartel members to exchange (verifiable) information might counteract the effects described by the economic theory. For example, if the exchange of information on sales and prices allows firms to conclusively verify whether a deviation from the agreement has occurred, then we should expect the extent to which sales and prices are publicly observable within a market (transparency) to have no effect upon the firms' ability to collude. Similar concerns might be expressed with respect to frequency of interaction/price adjustments, and buyer power. It should be noted however that the necessity of frequent and detailed communication for the sustainability of collusion in the presence of specific characteristics also implies that cartels are most likely to be discovered – and convicted – precisely within those markets that possess these characteristics.
- 3.55 With regards to the other factors deemed to affect the likelihood of collusion – such as barriers to entry, number of firms, demand characteristics, cost asymmetries and product differentiation – the conclusions drawn by the literature do not appear to depend upon the firms' inability to communicate. Indeed, the relevance of these factors, and the influence that they might have upon the market participants' ability to collude, appear to be robust to changes in the degree of communication among firms.
- 3.56 However, the point made above – that the need for cartel members to communicate intensifies precisely when collusion is harder to sustain – is still valid. This observation suggests that parties might be more likely to engage in overtly collusive practices specifically in those circumstances that are predicted by the theory as being adverse to collusion.

4 EMPIRICAL ANALYSIS

Introduction

- 4.1 One of the objectives of this project is to provide an empirical investigation into the factors that encourage cartel formation and to use this analysis to provide a prediction for each individual industry of the probability that a cartel will exist in that industry. This Chapter provides a non-technical discussion of the main issues involved and the main results. A more formal discussion is given in Annexe B.
- 4.2 To execute the general approach in the section a (dependent) variable is required that measures the extent of cartelisation in each industry sector. This is based on the evidence drawn from EC and US cases. This evidence is summarised and discussed in paragraphs 4.3 – 4.13. The aim is then to explain how this 'cartel' variable differs between industries by the differences in economic variables between the industries (the independent variables). The approach is conducted using industry data at the three-digit Standard Industry Classification level. The variables and the approach are discussed in paragraphs 4.14 – 4.21. The approach provides a statistical model using the economic independent variables to explain the level of cartelisation in any industry. Given the specific values of the independent economic values in any industry the model can then be used to predict the probability that a cartel exists in that industry. Paragraphs 4.22 – 4.30 summarise the approach, the difficulties involved with the procedure and provides summary tables that give the probabilities that cartels exist in the industries where cartels are predicted most likely. Detailed rankings of all industries are given in Annexes C and D.

Cartel evidence

- 4.3 If one wishes to explain the difference in the extent of cartelisation between industries then the ideal measure of cartelisation for the exercise would be the number of cartels that exist in each industry. Obviously, this figure is not known. Indeed, if it is known where the cartels are, there is no point in trying to calculate the probability of a cartel existing in an industry since the answer would already be known.

The information that is available concerning the location of cartels must come from the data on the cases that have already been discovered. This data is used as the proxy for cartelisation in this paper. Since it is almost certainly the case that there are cartels that have yet to be discovered then the data we use as the proxy for cartelisation suffers from a measurement error problem. That is, we only observe a selection of the evidence, namely those cartels that have already been discovered and prosecuted. Implicit in this approach is the assumption that the location across industries of known cartels is informative about the whereabouts of other cartels.

- 4.4 The problem of measurement error selection is discussed in more detail later but it is worth outlining some of the issues here. Using existing cartels as the measure of cartelisation implies that some industries where there are cartels will be entered into the data as having no cartel. We cannot distinguish between industries that genuinely have no cartels and those that have cartels but these have not been discovered. Each appears as a zero in the cartel data set. As a result, if there are a significant number of industries where cartels have yet to be discovered, it will be difficult to fit a model to the cartel data even if economic variables explain a great deal of the location of cartels across industries. In such circumstances finding significant coefficients is challenging. The fact that we are able to find significant coefficients may therefore be interpreted as a heartening sign.
- 4.5 The scale of the problem of fitting a model to the data depends on the question we seek to answer. There are two separate exercises that we may wish to undertake. One is to predict where cartels exist and the other is to predict where cartels that can be successfully prosecuted exist. Measurement error is more of a problem for the former than the latter. In the latter case the missing evidence consists of cases where cartels exist that can be successfully prosecuted but remain to be discovered. In the former case we also need to add to this group the cartels that exist but cannot be successfully prosecuted and those that have been investigated but where prosecution has failed or not been attempted since it is believed that the chance of failure would be high. That is, the set of cartels available is a better approximation to the set of

cartels that are sought if the objective is to find cartels that can be successfully prosecuted than if the objective is to find all cartels.

- 4.6 The investigation employs cartel evidence from two jurisdictions – EC cases from 1990 to present and the US Department of Justice cases of horizontal price fixing from 1994 to present. In this paper we construct, for each jurisdiction, an index that gives the number of cartel cases discovered in that industry during the periods noted above. This is used in three forms. One is to use the index as stated. A second is to create a cartel variable that, for each industry, takes on the value one if there has been at least one cartel in that industry during the period and zero otherwise. A third constructs a variable which takes on the value zero if there have been no cartels, the value one if there has been one cartel and the value two if there have been more than one cartel in the industry.
- 4.7 Note that an investigation by a competition authority will be concerned with a company's or group of companies' behaviour in a defined market, not behaviour in a defined industry. However, economic data is not collected in market form but in industry form. Therefore, in each EU or US case the evidence has to be examined and the cartel allocated to a specific industry classification. It has proved possible to allocate the activity to an industry in every case.
- 4.8 In conducting this exercise there are 70 EC cases and recent raids since 1990.¹⁴ Table 4.1 shows the EC cases allocated to industries. The presence of cartels within the group of industries where there have been cartels is diverse. Most have only had one cartel but there are several industries with more than two. Most noticeable is shipping, where ten cartels were identified during this period, and basic chemicals, with eleven.

¹⁴ Recent raids raise a problem for classification since it is clear that these cases have not reached a conclusion and, given the general definition of cartel used in the report, should not be included. However, it would be inappropriate to enter these industries as having no cartel since the probability that there is a cartel in these industries should be viewed as quite high and including these as having no cartel is misleading. In light of the growing conviction rate in cartel cases we decided for current purposes to include these cases as if cartels had been convicted.

4.9 One needs some care in interpreting the US evidence. The Department of Justice often defines a case as involving a single firm or individual. Consequently, what may be a single case in the EC data set may be recorded as several in the Department of Justice data set.¹⁵ There are some cases that are common to both jurisdictions (notably in basic chemicals and non-metallic mineral products). However, this arises in a minority of cases (less than 20 per cent of the cases are common). Again we allocate these cases to industries under the SIC three-digit classification. Table 4.2 shows the US cases allocated to industries.

¹⁵ That is, there may be a small amount of 'over-representation' in the US data. This is not a very frequent occurrence and does not cause a relative bias across industries providing the 'over-represented' of US cases relative to the EU is allocated randomly over industries rather than following some systematic process that differs between industries. There is no evidence of a systematic bias.

Table 4.1 – List of industries in which there has been a cartel(s) discovered in the EU

SIC-Code	Industry	No. Cs
da151	Production, processing and preserving of meat and meat products	1
da152	Processing and preserving of fish and fish products	1
da158	Manufacture of other food products	3
da159	Manufacture of beverages	2
de211	Manufacture of pulp, paper and paperboard	2
dg241	Manufacture of basic chemicals	11
dg243	Manufacture of paints, varnishes and similar coatings, printing inks and mastics	1
dg244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4
dh251	Manufacture of rubber products	1
dh252	Manufacture of plastic products	1
di262	Manufacture of non-refractory ceramic goods other than for construction purposes	1
di265	Manufacture of cement, lime and plaster	1
di266	Manufacture of articles of concrete, plaster and cement	1
di268	Manufacture of other non-metallic mineral products	3
dj271	Manufacture of basic iron and steel and of ferroalloys	1
dj272	Manufacture of tubes	4
dj274	Manufacture of basic precious and other nonferrous metals	2
dk292	Manufacture of other general purpose machinery	1
dk293	Manufacture of agricultural and forestry machinery	1
dl316	Manufacture of electrical equipment not elsewhere classified	3
dm341	Manufacture of motor vehicles	1
dm342	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1
dm343	Manufacture of parts and accessories for motor vehicles and their engines	1
f452	Building of complete constructions or parts thereof; civil engineering	1
f453	Building installation	1
f454	Building completion	1
i603	Transport via pipelines	1
i611	Sea and coastal water transport	10
i612	Inland water transport	1
i621	Scheduled air transport	1
i632	Other supporting transport activities	1
i634	Activities of other transport agencies	1
k722	Software consultancy and supply	1
k748	Miscellaneous business activities not elsewhere classified	1
o921	Motion picture and video activities	1
o926	Sporting activities	1

Table 4.2 – List of industries in which there has been a cartel(s) discovered in the US

SIC-Code	Industry	No. Cs
da155	Manufacture of dairy products	1
da158	Manufacture of other food products	3
db175	Manufacture of other textile	1
de211	Manufacture of pulp, paper and paperboard	2
df232	Manufacture of refined petroleum products	2
dg241	Manufacture of basic chemicals	14
dg242	Manufacture of pesticides and other agrochemical products	2
dg243	Manufacture of paints, varnishes and similar coatings, printing inks and mastics	1
dg244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	8
dg245	Manufacture of soap and detergents, cleaning and polishing preparations, perfume and toilet preparations	1
dg246	Manufacture of other chemical products	5
dg247	Manufacture of manmade fibres	1
di268	Manufacture of other non-metallic mineral products	8
dj271	Manufacture of basic iron and steel and of ferroalloys	2
dj274	Manufacture of basic precious and other nonferrous metals	2
dj275	Casting of metals	2
dl316	Manufacture of electrical equipment not elsewhere classified	6
dn361	Manufacture of furniture	1
dn366	Miscellaneous manufacturing not elsewhere classified	1
i611	Sea and coastal water transport	1
k748	Miscellaneous business activities not elsewhere classified	1
n851	Human health activities	1
n852	Veterinary activities	1
o923	Other entertainment activities	1

4.10 The relationship between the EU and US cases is interesting. An obvious first question to consider is the correlation between the data sets. The surprising thing is that they are strongly positively correlated. The correlation between US and EU cartels using the raw numbers per industry is 0.678. This is surprisingly high.

4.11 The high correlation is interesting but it is not obvious what it implies. It provides some sketchy idea about how successful competition

authorities are and how useful the approach we are adopting here may be. If, on the one hand, the authorities are finding very few of the cartels that exist, then it is quite likely that the correlation between the US and EC cases would be quite low. That is, if the authorities are acting relatively independently and only a small number of cartels are being plucked from those that exist, we should expect to find little overlap across industries. On the other hand, if the drivers of cartel formation are common between countries and if authorities are relatively successful in discovering cartels then one would expect to find a high correlation between the jurisdictions. Thus the high correlation may be an indication that authorities are being somewhat successful in their actions. Furthermore, the high correlation suggests that there are common factors at an industry level that leads to cartel formation.

- 4.12 There are, however, factors that offset this optimism. One is that authorities may not be acting independently. If one country is successful in finding cartels in a particular market then others may focus extra effort in that area. This will increase the correlation between jurisdictions. Similarly, even though the cases are not common, discovery of one cartel may provide information that leads to discovery of others in the same market in other countries. In this case, the common location of cartels across industry is not only a sign of specific factors in that industry but the result of luck that spills over to other jurisdictions. Also, even if there are common factors that are industry based it does not follow that they are necessarily economic (hence, an economic approach may not be the most fruitful) although this is quite likely. Thus while the high correlation is heartening, it has to be interpreted with caution.
- 4.13 It is worth pointing out that a strong correlation between the EU and US data is not essential for the US evidence to be useful in understanding the location of cartels within European jurisdictions. In certain circumstances a low correlation can be quite valuable. For example, the true allocation of cartels may be similar within the two jurisdictions but cases are caught on a relatively random basis. In this scenario, if convicted cartels form a small number of all cartels in existence, there may be very little correlation between the two jurisdictions. However, the US evidence would be extremely useful since it would be another

random sample drawn from a similar 'true' distribution of cartels and hence be very informative as to the true distribution of cartels.

Industry level and data

- 4.14 The aim is to use economic data at an industry level to explain why cartels are more likely to appear in some industries than others and then to use this evidence to predict the probability that a particular industry contains a cartel. Industries are defined for our purposes by the Standard Industrial Classification (SIC) three-digit level. The classification uses letters to denote sections and subsections. These are then separated into divisions (2 digits over and above the two letters). Divisions are then broken down into groups (3 digits). This provides a very disaggregated level of classification. There are 204 three-digit industries although because of data restrictions we use slightly less. This meets the primary objective of enabling predictions to be focused on very small industry groupings. This degree of precision does come at a cost, however, since there are limitations on the amount of data that can be obtained at this disaggregated level. Annexe A shows the breakdown of industries at this SIC level.
- 4.15 The main independent economic variable data is drawn directly from the UK Office of National Statistics and OFT (2004).¹⁶ This is driven by the desire to use UK data to draw implications about the potential location of UK cartels but there is an implicit assumption being made, i.e. that cartel evidence from different jurisdictions can be married up with data from the UK. The implicit assumption is that the differences between industries are similar across jurisdictions. At the level of classification we are using this view is indeed backed up by the data. For example, the correlation between turnover at the SIC three-digit level in the EU and in the UK is 0.92. The way to interpret this number is that the ratio of

¹⁶ Note, we are assuming that cartel evidence from different jurisdictions can be married up with data from the UK. The implicit assumption is that the differences between industries are similar across jurisdictions. At the level of classification we are using this view is indeed backed up by the data. For example, the correlation between turnover at the SIC three-digit level in the UK is 0.92. The way to interpret this is that the ratio of turnover between any two industries is almost exactly the same in the EU as it is in the UK. Similarly, the correlation between number of firms is 0.94 and the correlation between number of employees is 0.95.

turnover between any two industries is almost exactly the same in the EU as it is in the UK. Similarly, the correlation between the number of firms is 0.94 and the correlation between number of employees is 0.95. Another assumption that is implicitly being made is that the type of cartels occurring in the UK are the same as the international cartels discovered by the EC. The fact that the EC cartels enforcement only focuses on cartels that are large enough to affect intra EU trade means that this may distort the type of cartels we are able to identify.

- 4.16 One of the reasons to use this data is that it is relatively easily available and consistent. Hence it can be updated easily. Three digit data is used to obtain sufficient industries to conduct a detailed cross-section study. As indicated, this precludes the use of some variables and others, such as R&D, have to be constructed from data collected at a higher (market) level. Hence R&D data is not available for all industries. We have also used industry data collected at the EU level but this has proved disappointing (see Annexe B).
- 4.17 The underlying methodology is that differences between industries of key economic variables are informative as to the differences in cartelisation between industries. This implies that a single snap shot of the differences between industries would be sufficient. Given the desire to provide an updated analysis this suggest that the most recent year could be used. However, there is a danger that one year may contain anomalies. To avoid this we use recent data but for more than one year, specifically four years (1999-2003). We introduce dummies for each year as a test as to whether specific years have special effects. Mostly they are insignificant indicating that using a single year would not be misleading. Indeed, regressions on specific year data (not reported) have proved extremely robust.
- 4.18 Chapter 3 has identified several economic factors that may encourage or hinder cartels. The core traditional economic factors included scale (size of market/concentration/number of firms), entry barriers, capacity constraints and demand factors. We use total turnover per firm as a scale measure and C3 (market share of largest three firms) as the concentration measure. We include two classic entry barriers. One is the level of investment per firm that is necessary to stay in the industry.

This is measured by two variables: net capital expenditure per firm and the capital entry barrier given in OFT (2004). The other is economies of scale (measured by the cost disadvantage ratio and MES). We use R&D, which is often thought of as an entry barrier but is also a measure of cost asymmetry. It has been argued that in industries where R&D is high there is likely to be less transparency, more uncertainty between firms as to rivals costs and greater asymmetry in costs at any time. The argument here is R&D is associated with innovation. Some firms are fortunate and others less so at one moment there will be larger differences in costs and less knowledge than in industries where there is less R&D and are less dynamic. Therefore, R&D can also proxy for transparency and cost asymmetries/quality differences. Unfortunately, we do not have R&D at the same level of disaggregation as the rest of the data. We are able to construct an R&D variable from data at a less disaggregated level but this is not available for all industries. The other leading entry barrier that has been discussed in the IO literature, although not explicitly in the cartel literature, is advertising. OFT (2004) provides advertising data but this is in a market not industry specification and cannot be transformed in a meaningful way. This is the one instance where conducting the investigation at an industry rather than market level causes a data problem. Of course, operating at a market level would render much of our data irrelevant. However, the case studies do not indicate advertising is a significant issue so its absence may not be too significant a loss. Excess capacity is often thought to be useful as a punishment strategy for those that deviate from cartel agreements. The value of works in progress will not have an effect on firms' ability to increase output but the value of total stocks was not available separately from works in progress. Hence, we include total stocks and work in progress as a key economic variable. Chapter 3 shows that demand factors enter the theoretic literature in two forms:

growth and variability. To capture these effects we use growth in turnover and variability of growth (specifically the standard deviation of growth). We also use a market share volatility index.¹⁷

- 4.19 All the above variables are set at the per firm level for each industry. We believe that this is the appropriate way to approach the problem since it is firms that create cartels. The industry data is a mechanism to get at the firm data and provide an appropriate cross-section. One could, however, approach the problem in terms of differences in shares of industry turnover between industries. For example, instead of addressing net capital expenditure per firm one could use net capital expenditure as a share of turnover as the independent variable. We believe this is less likely to capture the underlying mechanisms. For example, a market consisting of firms offering coach travel may have a high capital expenditure as a share of turnover (the coaches being expensive relative to drivers' wages) but is an easy industry to enter since one can enter on a small scale. That is, capital expenditure as a share of turnover capital may be high but capital expenditure per firm may be quite low and so entry is relatively cheap. In contrast, an industry where capital expenditure per firm is huge may be harder to enter even if the ratio as a share of turnover is lower. There is no definitive answer as to which is the correct approach but we believe the focus on firms is appropriate.
- 4.20 The exception to the per firm approach is that there has to be one industry-wide scale factor. The reason is that an industry classification may, say, group three industries as separate entities and another three relatively similar groupings as a single classification. Other things being equal, the number of cartels in the latter classification ought to be three times higher than each of the former. Failure to recognise this may give undue weight to the characteristics of the latter industry when explaining the location of cartels. Including industry turnover acts as a

¹⁷ Five of the variables have been taken from OFT (2004). These are C3 concentration ratio, cost disadvantage ratio, minimum efficient scale, capital entry barrier and market share volatility. These are all provided at four digit level and have been aggregated to three digit level by taking the mean across the appropriate four digit sub industries within each three digit industry. This process is likely to introduce some measurement error which may lead to some bias in the coefficients. However, this measurement error problem may be quite small relative to the measurement error arising from the inability to observe all cartels.

control for this effect although it may be a formal variable in its own right, i.e. it is not possible to distinguish between whether the industry size variable is capturing this effect or whether industry size is relevant to cartel formation in some more fundamental way. Note, there are also obvious restrictions on how the data is used. For example, once one has used turnover per firm and turnover in the industry as an independent variable, it is impossible to introduce the number of firms as another independent variable. This is because any one of these three can be perfectly constructed from the other two.

4.21 Finally, although the theoretical literature does not discuss employment matters, there are various reasons to think that this may play a role. More higher paid employees may make it harder to keep cartels quiet, etc. Given that we have included turnover, demand factors, investment, stocks, etc., it is interesting to see if employment effects play any role. For this reason we have include total employment cost per employee. All the economic variables are outlined in Table 4.3.

Table 4.3 – Variables: UK industry data

Total turnover in the industry
Total turnover per firm
Total net capital expenditure per firm
Total employment costs per employee
Total employment costs per firm
Total stocks and works in progress valued at the end of year per firm
Growth in turnover from 1999 to 2002 per firm (%)
Variability of growth
R&D per firm
C3 concentration ratio
Cost disadvantage ratio
Minimum efficient scale
Capital entry barrier
Market share volatility

Empirical results and predictions

- 4.22 There are a series of general observations that are important to understand the results of the statistical investigation. One is that the theory of collusion has predominantly focused on the factors that enable collusive outcomes and collusive-like outcomes to arise and be sustained. The distinction between tacit and explicit illegal exchanges has not been central to this literature. As one moves further away from the factors identified in the theoretical literature then collusive outcomes require more and more explicit communication and illegal enforcement. The data in this section is based on cases where clear evidence of explicit illegal communication and enforcement has been discovered. Therefore, it is not obvious that we should find that the theoretical factors identified in Chapter 3 are the driving factors in the data set. Indeed, the evidence we have is that there is some element of disconnection between the variables predicted by theory and the variables that are relevant here.
- 4.23 As indicated, the statistical problem has been approached at a very disaggregated level (three-digit industry classification). This is needed if predictions are to bring significant additional valuable insight to what can be gleaned from case studies and simple 'eye-balling' and manipulation of the data. It was not obvious before the exercise began that a cross-section analysis at this level of disaggregation would be fruitful. For example, this approach brings a data problem in that the greater the degree of aggregation then the less data is available. Furthermore, as cartels are allocated to more and more disaggregated classifications it becomes both more likely that random factors dominate and less likely the classification will map onto the market where the abuse has taken place.
- 4.24 Over and above such problems, it is not obvious that, even with perfect data, economic factors 'work' at this level of disaggregation. That is, the 'economic' differences between, say, manufacturing and transport may be significant in determining cartel formation but it is not obvious whether the differences between a hundred types of manufacturing (e.g. such as separating manufacture of knitted and crocheted fabrics from manufacture of knitted and crocheted articles) will be relevant. The

'highest' level message from the analysis is that the approach succeeds at this level. We find significance for several of the key variables, are able to throw light on the role of the theory and provide predictions as to the location of cartels at this level of disaggregation that appear to be robust to model specification.

- 4.25 There are several clear messages that arise from the series of models run in Annexe B. One is that demand factors are very important and follow the theoretically predicted pattern. That is, variability in growth is shown to have a negative impact on cartels. This is an extremely robust result holding in all models. Similarly, growth in turnover has a positive impact on cartel formation and again is extremely robust. This latter point appears to conflict with the evidence that arises in the case studies and is discussed later in Chapter 5. In contrast, traditional entry barriers (measured in gross capital expenditure per firm, the level of stocks per firm and the level of R&D per firm) have little effect. The one entry barrier that works well is the cost disadvantage ratio, a measure of economies of scale. Here the results indicate that economies of scale are positively associated with cartels. The lack of strong entry barrier evidence needs careful interpretation. The theory indicates that entry barriers should ease cartelisation. However, the data we are concerned with here is based on cartels that have been discovered and successfully prosecuted. It may be the case that where entry barriers are weak a cartel will have to prevent entry from competitors and this increases the chances of being discovered. Therefore, one might expect to see mixed evidence on entry barriers given this data set. Interestingly, as Chapter 5 will show, there is some evidence (albeit mixed) drawn from the case studies suggesting that this may be the case. The regressions also show that scale, in the form of turnover in the industry, and that concentration, in the form of C3, is significant.
- 4.26 An interesting feature of the analysis is that the results indicate that elements of employment also seem to matter a great deal. Employee costs are significant. These factors do not arise in the theoretical literature, since there is no obvious reason why they should be critical for collusion, but there are sensible reasons why they might matter for cartel detection. For example, industries with higher employment cost per employee have higher paid staff (who may, as a result, be privy to

better information). Other things being equal, both these factors may increase the likelihood of a cartel being discovered and the relevant evidence being uncovered. On the other hand it is possible that employment cost variables are proxying for another variable (interestingly in the raw data C3 and employee costs are strongly positively correlated). Therefore, we need to be careful in drawing too firm conclusions about the drivers of cartel formation based on the employee cost evidence. This is an area that might benefit from further research. Finally, the (logit) regressions typically explain somewhere between 14 per cent to 24 per cent of variability in the data on the location of cartels. That is, the economic variables explain about one fifth to one sixth of the variability in the cartel data. Given the measurement error arising from our inability to observe all cartels this is quite a high figure.

- 4.27 The main purpose of this section of the report is to use econometric techniques to help provide information as to where cartels may be located. We use three techniques. One (the logit model) provides a prediction to be produced for each industry of the probability that a cartel exists in that industry. A second (the ordered logit model) provides three probabilities for each industry - that no cartels, one cartel and more than one cartel exists in the industry. Finally, a third model (OLS) predicts the number of cartels (taken as a continuous number) that are likely to exist in an industry. Annexe C gives these probabilities (averaged over the four years) for each industry. Each industry has six numbers associated with it. The first is the number of EC cartels found in the industry. The second is the probability that there exists a cartel in the industry derived from the logit estimation and the third the predicted number of cartels in the industry derived from the OLS. The fourth, fifth and sixth are the probabilities that there are none, one or more than one cartel in the industry derived from the ordered logit model. Annexe D gives the same information ranked in descending order of the probability derived from the logit estimation.
- 4.28 Annexes C and D has large amounts of information drawn from one model. We have used three models and one way of obtaining a feel for which industries are predicted to have a high probability of a cartel is to look for the industries that are consistently high in each of the three

models. Therefore, for each of the three models we identify the top forty industries (in terms of likelihood of having a cartel) and then draw up a table of those industries that appear in at least two of these lists of forty. There are 37 such industries. These are listed in Table 4.4. That is, when one takes the top forty predictions across all industries then 37 of these industries appear in the top forty in at least two of the three models. This is a high number emphasising the robustness of the approach. Note, that 21 of the 37 industries do not have any evidence of a cartel in the cartel data set.

- 4.29 It is also possible to take the list of industries and remove from it any industries that already have had a cartel. That is, we remove any industry that appears in the cartel data set. We can then derive the top forty predicted industries from this group for each model and again draw up a list of industries that appear in at least two of these forty. This is given in Table 4.5, which has 39 entries.
- 4.30 The benefits of the approach become apparent when one compares the predictions with the raw cartel data. The allocation of EC and US cartels to SIC classification shows the well-known concentration on manufacturing and transport. Using this evidence as the basis for future investigation would imply a focus on manufacturing and transport sectors. The econometric approach allows a more detailed assessment. The econometric predictions of the most likely locations for cartels that may be convicted does indeed include several manufacturing industries where cartels have not yet been found (e.g. manufacture of aircraft and spacecraft, manufacture of paper and paperboard, manufacture of weapons are good examples) but significantly point to other industries as being prime candidates that would not have arisen from a simple non-econometric interpretation of the data. For example, schools, auditing and tax consultancy, architecture and related consultancy, and telecommunications all come out extremely high on the 'hit list'. The stability of the Schools market appears to be a factor that contributes significantly to its appearance towards the top of the list (this is also the case for auditing, although in this case the scale of the industry also appears to contribute - in fact it could be argued that the way that SIC codes arbitrarily divide up the economy to a certain extent drives which industries end up on the hit list, i.e. SIC codes with a larger turnover are

more likely to end up on the hit list, all other things being equal). There has been significant media coverage of potential school cartels. The fact that these schools are present as having no cartels in the variable that measures 'cartelisation' and yet are thrown out as highly likely to contain cartels by the econometric analysis shows the usefulness of a disaggregated econometric approach.

Conclusions

- 4.31 The cartel data that is used suffers from measurement error in that we do not observe a random selection of cartels in existence but only observe a selection of the evidence, namely those cartels that have already been discovered and prosecuted. Cartel cases from the EU and US since 1990 and 1994 respectively have been allocated to industries. Despite less than 20 per cent of the cases being common between jurisdictions there is a strong positive correlation between the data sets. Having allocated the cartels to SIC three-digit classification we find the correlation between US and EU cartels using the raw numbers per industry is 0.678.
- 4.32 This alone is informative since one can rule out certain scenarios. One scenario could be there is little systematic relationship between industry factors and cartels formation and discovery. In this case one would not expect the US and EU data to display a similar pattern when allocated to disaggregated industry classification. Another possibility could be that economic factors matter but that the set of convicted cartels is an extremely small fraction of the total cartels that exist and could be successfully prosecuted. Again, since we would then be looking at very small sample, and given that less than 20 per cent of the cases are common across jurisdictions, one would not expect a similar pattern. The high correlation suggests neither of these scenarios is true. However, if economic factors are very significant in determining where cartels arise, then it is reasonable to assume that there are still a significant number of undiscovered cartels. This conclusion arises because one would expect the correlation to be higher still if economic factors are paramount and most cartels have been discovered. The econometric results are able to explain around 14 per cent to 24 per cent of the allocation of cartels between industries, and the significant

variables and predictions are quite robust to model specification. Although without knowledge of the true scale of the cartel problem one cannot unravel the various factors, a reasonable interpretation of this evidence is that economic factors do matter even at this level of disaggregation, that other non-economic factors are also important and that the set of convictable cartels is probably significantly larger than what has been discovered to date. We have shown that demand factors, scale, concentration and employment factors are very significant whereas traditional entry barriers (save for economies of scale) appear to be less so. Finally, using the econometric models it is possible to provide a ranking of all industries according to the probability that they contain a cartel.

Table 4.4

	All industries	C(s)	Prob. logit 1	Prob. logit 2	Prob. logit 3
1	Building of complete constructions or parts thereof; civil engineering	1	0.98	0.89	0.92
2	Telecommunications	0	0.89	0.84	0.77
3	Activities of other transport agencies	1	0.71	0.80	0.85
4	Manufacture of cement, lime and plaster	1	0.76	0.77	0.74
5	Scheduled air transport	1	0.82	0.73	0.52
6	Manufacture of basic chemicals	11	0.77	0.72	0.63
7	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.59	0.71	0.65
8	Manufacture of motor vehicles	1	0.79	0.68	0.67
9	Software consultancy and supply	1	0.82	0.68	0.41
10	Manufacture of aircraft and spacecraft	0	0.78	0.65	0.61
11	Manufacture of grain mill products, starches and starch products	0	0.48	0.61	0.52
12	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0		0.55	0.58
13	Manufacture of other food products	3	0.56	0.52	0.65
14	Cargo handling and storage	0	0.60	0.50	0.45
15	Activities of travel agencies and tour operators; tourist assistance activities	0	0.66	0.46	0.49
16	Publishing	0	0.54	0.44	0.35
17	Manufacture of railway and tramway locomotives and rolling stock	0	0.56	0.44	0.39
18	Other land transport	0	0.58	0.43	0.50
19	Manufacture of tubes	4	0.45	0.41	0.24
20	Recycling of metal waste and scrap	0	0.43	0.40	0.39
21	Manufacture of articles of paper and paperboard	0	0.45	0.40	0.34
22	Manufacture of basic iron and steel and of ferroalloys	1	0.79	0.39	0.42
23	Manufacture of weapons and ammunition	0	0.21	0.39	0.36
24	Manufacture of beverages	2	0.55	0.39	0.46
25	Processing and preserving of fruit and vegetables	0	0.35	0.38	0.43
26	Manufacture of motorcycles and bicycles	0	0.11	0.38	0.37
27	Quarrying of sand and clay	0	0.35	0.37	0.42
28	Building installation	1	0.52	0.36	0.35
29	Sea and coastal water transport	10	0.33	0.35	0.28
30	Non-scheduled air transport	0	0.32	0.34	0.33
31	Manufacture of domestic appliances not elsewhere classified	0	0.29	0.34	0.35
32	Mining and agglomeration of hard coal	0	0.38	0.34	0.25
33	Manufacture of glass and glass products	0	0.30	0.33	0.36
34	Other computer related activities	0	0.43	0.32	0.27
35	Manufacture of agricultural and forestry machinery	1	0.23	0.31	0.33
36	Manufacture of plastic products	1	0.42	0.30	0.26
37	Transport via railways	0	0.46	0.25	0.39

Table 4.5

	Industries where no cartel(s) have yet been discovered	Prob. logit 1	Prob. logit 2	Prob. logit 3
1	Telecommunications	0.89	0.84	0.77
2	Manufacture of aircraft and spacecraft	0.78	0.65	0.61
3	Manufacture of grain mill products, starches and starch products	0.48	0.61	0.52
4	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy		0.55	0.58
5	Cargo handling and storage	0.60	0.50	0.45
6	Activities of travel agencies and tour operators; tourist assistance activities	0.66	0.46	0.49
7	Publishing	0.54	0.44	0.35
8	Manufacture of railway and tramway locomotives and rolling stock	0.56	0.44	0.39
9	Other land transport	0.58	0.43	0.50
10	Recycling of metal waste and scrap	0.43	0.40	0.39
11	Manufacture of articles of paper and paperboard	0.45	0.40	0.34
12	Manufacture of weapons and ammunition	0.21	0.39	0.36
13	Radio and television activities		0.39	0.24
14	Processing and preserving of fruit and vegetables	0.35	0.38	0.43
15	Manufacture of motorcycles and bicycles	0.11	0.38	0.37
16	Quarrying of sand and clay	0.35	0.37	0.42
17	Manufacture of prepared animal feeds	0.28	0.35	0.28
18	Non-scheduled air transport	0.32	0.34	0.33
19	Manufacture of domestic appliances not elsewhere classified	0.29	0.34	0.35
20	Mining and agglomeration of hard coal	0.38	0.34	0.25
21	Manufacture of glass and glass products	0.30	0.33	0.36
22	Other computer related activities	0.43	0.32	0.27
23	Architectural and engineering activities and related technical consultancy		0.30	0.23
24	Manufacture of cutlery, tools and general hardware	0.32	0.29	0.27
25	Other recreational activities		0.28	0.42
26	Manufacture of other chemical products	0.25	0.28	0.20
27	Printing and service activities related to printing	0.34	0.27	0.24
28	Secondary education		0.27	0.26
29	Manufacture of bricks, tiles and construction products, in baked clay	0.24	0.27	0.25
30	Postal and courier activities	0.23	0.25	0.33
31	Manufacture of jewellery and related articles	0.25	0.25	0.17
32	Transport via railways	0.46	0.25	0.39
33	Manufacture of furniture	0.31	0.24	0.23
34	Manufacture of other special purpose machinery	0.26	0.24	0.20
35	Human health activities		0.24	0.34
36	Camping sites and other provision of short stay accommodation		0.22	0.28
37	Manufacture of builders' carpentry and joinery	0.27	0.22	0.20
38	Site preparation	0.19	0.20	0.21
39	Manufacture of dairy products	0.17	0.19	0.29

5 CASE STUDIES OF EC CARTELS

Introduction

- 5.1 This section looks at a series of case studies, in order to identify common trends and messages. The cases have been selected either because they refer to the shipping or basic chemicals industries – i.e. the industries with the highest number of cartel cases in our data set – or because they feature among the cases that have generated the largest fines during the period 1998-2002.¹⁸ Table 5.1 summarises the total fines per case by year. We identify the critical factors that emerge from the study and summarise each one at the end of the relevant section.
- 5.2 The examination of case studies complements the econometric evidence in several ways. Firstly, it provides information on those market characteristics that are absent from the aggregate data. This is, for instance, true for the amount of transparency within the market, and for the importance of communication and information exchange in sustaining collusion; although these elements cannot be easily measured or quantified, they are discussed at length within the context of each single case.
- 5.3 Secondly, case studies allow us to scrutinize the information provided by the econometric evidence in greater depth. For instance, as will become clear below, the evidence provided by the cases allows us to better interpret the econometric evidence indicating that demand stability is one of the key factors in determining the likelihood of finding a cartel within a market. Indeed, the cases suggest that cartel formation is to be expected in connection with adverse demand shocks hitting markets that are otherwise stable. Moreover, the cases highlight the distinction between the direct effect of changes in demand conditions, and the indirect effects, operating through other mechanisms such as excess capacity.

¹⁸ The two exceptions to this rule, namely French Beef and Zinc Phosphate, have been chosen because they complement the other case studies particularly well.

5.4 Finally, the examination of the case studies allows us to verify whether the econometric evidence reflects patterns and effects that are uniform across all cases, or whether there exists some heterogeneity. For instance, we are able to verify whether big cases – that is, cases involving very large fines – differ somehow from other ones. As will become clear below, we find that the same themes run across all categories of cases, indicating a high degree of homogeneity. In what follows, we discuss these common trends and messages.

Table 5.1 – Total amounts of fines per case/year

(* indicates in case study data set)

Cases	Total (Euro million)
1998	
TACA *	273
Preinsulated pipes	92
British Sugar	49
1999	
Seamless Steel Tubes *	99
2000	
Amino acids (Lysine) *	110
2001	
Vitamins *	855
Carbonless Paper *	314
Graphite Electrodes *	219
Citric Acid *	135
German Bank Charges *	101
Belgian Breweries	91
Luxembourg Breweries	0.45
Sodium Gluconate	58
SAS/Maersk Air	53
Zinc Phosphate *	12
2002	
Plasterboard *	478
Methionine *	127
Austrian Banks 'Lombard'	124
Rond à Beton	85
Specialty Graphite	61
Industrial & Medical Gases *	26
Food Flavour Enhancers	21
Fine Art Auction Houses	20
Methylglucamine	3

Demand factors, capacity and intensity of competition

5.5 Many of the case studies suggest that demand factors are important in the formation of cartels. However, it is extremely hard to identify whether demand factors are the direct cause or whether demand works through other mechanisms. In particular, 'negative' demand factors create excessive capacity and it may be the latter that is important in cartel formation. What is clear, however, is that cartel formation is generally linked with a decline in prices; indeed, this finding is so widespread across the cases, that it is almost a stylized fact. This price decline can take many forms, notably (i) an abrupt price plunge that is triggered by a negative demand shock, or (ii) a gradual price decline. The latter may be caused by prolonged adverse demand conditions or intensified competition.

An abrupt price plunge

5.6 In several cases, cartel formation was preceded by a sudden price plunge, generated by an adverse demand shock. In the Ferry Operators – Currency Surcharges Case (97/84/EC), for instance, the devaluation of the Sterling in September 1992 acted as a negative shock, and had a detrimental effect on revenues for the five operators involved – namely P&O European Ferries, Stena Sealink, SNAT, Brittany Ferries and North Sea Ferries. Although the impact of the devaluation differed across the companies, depending on the balance between the location of their revenues and the location (inside or outside UK) of their main cost base, the companies announced identical surcharges with a common introduction date and common method of calculation. There are clear indications that the agreement was the result of detailed negotiations and threats between the parties as how to respond to the devaluation; for example, the case shows that a meeting of Sealink, SNAT and P&OEF took place to discuss proposals for rationalization of ferry services to compete with Eurotunnel and currency surcharges.

5.7 The French Beef (2003/600/EC) case has similar features. The cartel that was set up in 2001, when six French federations entered an agreement to set a minimum price and to limit imports of beef into France. The agreement was aimed at counteracting the crisis that had

been triggered by the discovery of the mad cow disease in October 2000, and that had resulted in a significant decline of prices; as an illustration, the slaughterhouse entry prices for culled cows - i.e. cows for slaughter - had declined by about 20 per cent between October 2000 and October 2001.

- 5.8 The German Banks (2003/25/EC) case relates to a 1997 agreement by five German banks to charge no less than three per cent for the buying and selling of euro-zone banknotes. The agreement was aimed at compensating the banks for the future abolition of the lucrative selling and buying 'spread' charged by banks to exchange euro-zone currencies that was to occur in 1999, when the bilateral exchange rates for currencies of the European Union would become irrevocably locked.

Prolonged adverse demand conditions

- 5.9 The impact of prolonged adverse demand conditions upon cartel formation is exemplified in several cases, e.g. Petrochemicals (94/599/EC), Seamless Steel Tubes (2003/382/EC), Graphite Electrodes (2002/271/EC), and French-West African Ship-Owners' Committees (92/262/EEC). As these cases illustrate, the protracted nature of the adverse demand conditions typically results in the emergence of excess capacity, industry restructuring and exit.
- 5.10 The Petrochemical (PVC) case refers to the agreement entered by all the major worldwide petrochemical producers (17 in total) to coordinate their commercial behaviour in the EC during the period 1980-84. Because bulk thermoplastic PVC is used in the production of durable goods – such as cars and housing – the PVC market was heavily hit by the crisis that was triggered in 1973-74 by the rise in the price of oil and raw materials, and that lasted until the early 1980s. As a result, during the period covered by the cartel the PVC market was characterized by structural overcapacity. Moreover, the prolonged nature of the crisis prompted a wave of plant rationalization and plant closures: while in 1977 about 30 manufacturers supplied the West European market, in 1988 the number of manufacturers was reduced to eight.

- 5.11 The Seamless Steel Tubes case refers to the conviction of Mannesmannrohren-Werke (Germany), Vallourec (France), British Steel (United Kingdom), Dalmine (Italy), Sumitomo Metal Industries, Nippon Steel, NKK and Kawasaki Steel (Japan) for operating a cartel in the market for seamless tubes between 1990 and 1994 (although there are indications that the infringement actually started as early as 1977). Although between 1960 and 1980 world consumption of pipes and tubes increased steadily at a rate of around 5 per cent per annum, after 1980 the market started to decline. This prompted a severe crisis; for instance, between 1988 and 1991, falling demand provoked the loss of 20'000 jobs. Moreover, after 1991 the market conditions within the EC worsened further, due to the closure of the market in the former USSR, and a general reduction in world demand for oil pipes and tubes. This caused the closure of several production mills in Germany, Italy and the United Kingdom. Finally, in the last 25 years, seamless pipes and tubes have gradually declined as a proportion of all pipes and tubes produced and consumed, in favour of the welded varieties.¹⁹ This process of substitution can be explained by technological progress in the manufacture of welded pipes and tubes, which, with lower production costs, has made it possible to achieve the requirements previously met only by seamless tube and pipes.
- 5.12 The Graphite Electrodes case concerns the price-fixing and market sharing agreements in the market for graphite electrodes, i.e. ceramic-moulded columns of graphite used primarily in the production of steel in electric furnaces. The conviction covers the period 1992-98, and involves SGL Carbon (Germany), UCAR International (USA), Tokai Carbon (Japan), Showa Denko K.K. (Japan), VAW Aluminium (Germany), SEC Corporation (Japan), Nippon Carbon (Japan) and The Carbide Graphite Group Inc. (USA). Up to and including the 1980s, the graphite electrode industry in Europe was characterized by a relatively large number of producers, operating at national level. During the 1980s, improvements in both electrodes and electric steelmaking led to a substantial decline in the specific consumption of electrodes per tonne of

¹⁹ Seamless steel pipes and tubes differ from welded ones in that they are made from pierced and hot reduced solid products, without removing any metal.

steel produced; moreover, this crisis was aggravated the by a generalized decline in steel production. The fall-off in the demand for electrodes resulted in a worldwide restructuring of the electrodes industry that started in the late 1980s / early 1990s; this process of rationalization reduced the number of Western producers from 16 to 9.

- 5.13 In the French-West African Ship-Owners' Committees Case, the cartel is linked to a fall in the flow of southbound goods of around 29 per cent in the 1980s, caused by external economic factors. In spite of the demand downturn and the productivity gains in the industry in this time, through collusion the ship-owners' committees were able to raise their rates by 39 per cent and 34 per cent respectively between 1980 and 1985 and held them at this level between 1985 and 1989. As in the previous cases, the prolonged fall in demand had resulted in the emergence of excess capacity.
- 5.14 The role played by capacity in facilitating collusion is also discussed in the Trans-Atlantic Agreement (TAA) case (94/980/EC), where excess capacity emerged as a result of differences in utilization of the west and eastbound routes. The TAA covers most eastbound and westbound shipping routes between Europe (most ports between Bayonne in France and the North Cape in Norway) and the United States. All the parties to the TAA participated in a capacity management programme on the westbound (i.e. Europe-US) sector of trade, whereby the ship-owners concurred not to utilize an agreed part (up to 25 per cent) of their available capacity. This equipped the cartel members with the means for flooding the market in the event of entry, and therefore constituted an effective barrier to entry. According to the Commission: 'By maintaining excess capacities in the transatlantic trade while raising rates, the TAA created conditions in which the arrival of new capacity in sufficient quantities to exert real competition would be liable to aggravate the excess capacities and to force down rates rapidly to unremunerative levels, thereby immediately making the new entrant's activities unprofitable. (...) Through the Capacity Management Programme, the members of the TAA wield considerable market power and are therefore in a position to exert pressure that can deter a potential competitor'.

Intensified competition

- 5.15 In several cases, the price plunge that preceded cartel formation was triggered by intense competition; this intense competition was typically generated by the expansion – through acquisition and/or the building of new capacity – of one of the smaller incumbents, or by the access to the market of a large new entrant. Citric Acid (2002/742/EC), Methionine (2003/674/EC), Soda Ash (2003/5/EC), Vitamins (2003/2/EC), and Plasterboard (2001/. /EC) are good examples.
- 5.16 In the Citric Acid case, the Commission fined Hoffmann-La Roche (Switzerland), Archer Daniels Midland ADM (USA), Jungbunzlauer (Switzerland), Haarmann & Reimer (USA) and Cerestar Bioproducts (Holland) for participating during the period 1991-95 in a price-fixing and market sharing cartel in citric acid, the world's most widespread acidulent and preservative. The cartel was created following a period of intense competitive pressure; sources report that: 'the average price of citric acid in Europe declined steadily between 1985 and 1990, falling by approximately 45 per cent. Prices at the end of this period were atypically low, a factor attributed in some quarters to the waging of a price war in Germany and the United Kingdom, launched by Jungbunzlauer, with the object to capturing extra market share'. Indeed, the result of this expansionary campaign was that Jungbunzlauer 'virtually tripled its production capacity for citric acid, mainly through the acquisition of Boehringer Ingelheim's citric acid manufacturing business in 1985 and Benckiser's organic acid division in 1988'. Moreover, in 1990, Cargill's entry had a negative impact on worldwide prices.
- 5.17 In the Methionine case, Degussa (Germany), Nippon Soda (Japan), and Aventis (former Rhone-Poulenc, France) were convicted for participating, between 1986 and 1999, to a worldwide cartel in the market for methionine, one of the world's most important amino acids, used mainly in animal feed for poultry and pigs. The cartel originated when Rhone-Poulenc and Degussa contacted Nippon Soda and Sumitomo 'because they felt that the Japanese producers were encroaching on their home markets'.

- 5.18 Similar evidence can be found in the Soda Ash case, where Solvay (the world and European largest producer of soda ash, an alkaline chemical commodity that is mainly used as a raw material for the manufacture of glass) entered into a collusive agreement with CFK (Chemische Fabric Calk) after it realized that 'CFK was applying a policy of price cutting in order to retain or regain market share (in Germany)'.
- 5.19 The Vitamins case concerns eight distinct secret market sharing and price-fixing cartels affecting vitamin products. Each cartel had a specific number of participants and duration, although they all operated between 1989 and 1999. The cartel participants were predominantly multinationals, and included the three largest producers of vitamins in the world: BASF, Hoffman-La Roche and Aventis (former Rhone-Poulenc). In practically all cases, cartel formation was preceded by a significant fall in prices. In several instances, the price decreases are explicitly described as the outcome of increased competition. For example, sources report that 'the dramatic fall in price in vitamin E was attributed by Roche to the price offence of Eisai in 1989, while (for the fall in prices) for vitamin A, Roche blamed the aggressive pricing policy of Rhone-Poulenc'.
- 5.20 The Plasterboard case refers to the cartel that operated between 1992 and 1998 in the EU market for plasterboard, a manufactured product used as a prefabricated construction material. The cartel comprised BPB (United Kingdom), Gebrüder Knauf Westdeutsche Gipswerke (Germany), Société Lafarge (France) and Gyproc Benelux (Belgium), and was founded with the intent of ending the price war that was taking place among market participants. Indeed, in previous years, the price of plasterboard had fallen sharply as a result of fierce competition.
- 5.21 The Zinc Phosphate (2003/437/EC) case is a bit of a hybrid, in that it incorporates more than one of the elements discussed above. The case concerns six companies - namely, Britannia Alloys & Chemicals, James M. Brown and Trident Alloys (United Kingdom), Dr Hans Heubach, (Germany), Société Nouvelle des Couleurs Zinciques (SNCZ) (France) and Waardals Kjemiske Fabrikker (Norway) - who, between 1994 and 1998, participated in a European-wide cartel through which they fixed the price and shared the market for zinc phosphate, a widely used anti-corrosion

mineral pigment used for the manufacture of industrial paint. Prior to 1994, the zinc phosphate market underwent a period of low prices, triggered by demand factors as well as aggressive price-cutting. For instance, sources report that 'Waardals, who enjoyed a 55 per cent share of the market in the United Kingdom and a 80 per cent market share in the Nordic market, was confronted in the 1990s with two simultaneous phenomena: a reduction in the zinc phosphate consumption in the Nordic countries, as many Scandinavian companies decided to build up their production facilities in the United Kingdom, and a severe economic decline in Finland, following the collapse of the Soviet Union. In addition, Pasminco Europe had started to enter the Norwegian market in 1990 with very low prices. As a consequence, Waardals felt forced to protect its market'. It is in this climate that competitors started to contact each other to 'work out a solution and put an end to price-cutting strategies'.

Discussion

- 5.22 The notion that sudden negative shocks and prolonged adverse conditions are connected with cartel formation is certainly intuitive as well as being grounded in theory. Clearly, if a shock hits all firms in an industry then each firm has to make a quick decision as to how to respond in a situation when each firm is aware that others are in the same position. The drive to find out how others are responding and to co-ordinate may be extremely strong, particularly if the industry is normally relatively stable and the large players in the market are well known to each other. In addition to this practical explanation, Chapter 3 identified the theoretical prediction that collusion is easier to sustain when demand is currently low, but is expected to recover. Intuitively, when demand is temporarily low the gains from aggressive behaviour in the present are minimized, while the benefits from cooperation in the future are maximized. Therefore, it is not surprising that sudden negative shocks may precipitate collusion.
- 5.23 Similarly, prolonged adverse demand conditions may encourage firms to seek to limit the damage to their businesses. However, this appears to contradict the theoretical prediction that falling demand should hinder, rather than facilitate collusion. This apparent dichotomy can nevertheless

be reconciled by noticing that steadily falling demand generates excess capacity; in turn, excess capacity might be conducive of collusion (this point is discussed below). Moreover, prolonged crises often result in exit; this decreases the number of market participants, and makes cooperation easier to achieve.

- 5.24 The price decline that preceded cartel formation appears to be connected with excess capacity. Excess capacity emerged as a consequence of prolonged demand downturn and or because additional capacity had been built or acquired with the purpose of capturing market share. In each case, these changes equipped the market participants with the ability to harm each other in a very serious manner, thus making cooperation more attractive; intuitively, the incentives to cooperate are greater, the more disastrous the consequences of disagreement. In this sense it is difficult to know whether it is the decline in demand itself or the excess capacity that it generates that is the primary driver to collusion.
- 5.25 Finally, it is worth noting that in the case studies we found only three instances of collusion in markets affected by strong demand volatility; these were Petrochemical, Seamless Steel Tubes and Lysine. Demand for PVC is volatile because PVC is principally utilized in the production of durable goods; as a consequence, PVC consumption is very sensitive to changes in consumer spending. Demand in the seamless steel tubes and pipes market is linked to the oil market; this is because the oil and the gas industries account for 50 per cent of the consumption of seamless steel tubes. Synthetic lysine is used to add lysine to feedstuffs that do not, or not sufficiently, contain natural lysine, for instance cereals. Feedstuffs to which lysine is added are therefore substitutes to those that contain sufficient natural lysine, such soybean. Demand for synthetic lysine is therefore tightly connected to the supply of cereals, which is in turn subject to large seasonal swings.

Table 5.2 – Standard deviation of turnover growth

Industry	
Mean of all industries	0.1144
Mean of case study industries	0.954
Manufacture of basic chemicals	0.0380
Sea and coastal water transport	0.1318
Manufacture of other non-metallic mineral products	0.2101
Manufacture of tubes	0.0976
Manufacture of articles of concrete, plaster and cement	0.0872
Manufacture of pulp, paper and paperboard	0.1147
Production, processing and preserving of meat and meat products	0.0789
Manufacture of electrical equipment not elsewhere classified	0.0471
Manuf. of pharmaceuticals, medicinal chemicals and botanical products	0.1100
Manuf. of non-refractory ceramic goods other than for construction	0.0394

5.26 Table 5.2 gives the data on the mean standard deviation of turnover growth for the industries under inspection. As we can see, all the values except two are below the aggregate mean calculated across all industries (although non-metallic mineral products is a clear outlier).

5.27 Thus, the majority of case studies concern industries that are overall rather stable. This confirms the theoretical view that demand volatility hinders collusion, and substantiates the econometric evidence found in Chapter 4.

Barriers to entry

5.28 Unfortunately, the legal cases at our disposal tend not to discuss the size of barriers to entry within the markets under inspection. Inferences over the relationship between entry barriers and the likelihood of collusion can, however, be based on the indirect evidence provided by discussions on the effect of entry and potential entry. The cases indicate that entry/potential entry is disruptive in that it destabilises the collusive agreement, often leading to the breakdown of the cartel (which we can

think of as internal failure) and/or results in the cartel being discovered (which we can think of as external failure).

- 5.29 Good examples of internal failure arise in the Methionine, Lysine, and Vitamins cases. In the Methionine case, for instance, after an initial smooth period that lasted from 1986 to 1989, in 1990 the cartel became unstable, mainly owing to new entry. Sources report that after Monsanto entered the market, 'the participants started having difficulties in coordinating'. This was because Rhone-Poulenc and Degussa, the two largest cartel members, had 'somewhat different agendas' on how to react to Monsanto's low prices. Furthermore, additional damage to the cartel's profitability was inflicted by the growth of imports from Russia during the period 1991-98. Eventually, the cartel came to an end in 1999, when Rhone-Poulenc (now Aventis) revealed the cartel's existence to the Commission.
- 5.30 The Lysine case (2001/418/EC) concerns a five-members cartel in the market for synthetic lysine, a substitute for natural lysine – an important amino acid, necessary in a balanced diet – that is used in animal feedstuff for nutritional purposes. The Commission found that Archers Daniels Midland (USA), Ajinomoto Co (Japan), Cheil (Korea), Kyowa Hakko (Japan) and Sewon (Korea) had fixed lysine prices worldwide from July 1990 to June 1995 (although there are indications of cooperation and price-fixing already in the 1970s and 1980s). While until 1990, Ajinomoto, Kyowa and Sewon were the only world producers of synthetic lysine, in 1990 it became apparent that two new contenders, ADM and Cheil, were investing in production capacity in order to enter the lysine market. These new entrants could hardly be ignored: for instance, ADM's plant virtually doubled the world's lysine production capacity. Although the two new entrants eventually became members of the cartel, stability was never reinstated, mainly because of the frequent clashes between Ajinimoto and ADM, the two largest cartel members. Eventually, the cartel broke down in 1995, when Ajinomoto approached the Commission to denounce the agreement.
- 5.31 In Vitamins, in at least two cases (vitamin B6 and vitamin C), the cartels were eventually dismantled as a consequence of the fierce competition from Chinese importers, who disrupted the cartel agreements with their

'low prices and increasing volumes'. In the case of vitamin B6, Chinese producers were already present in the market when the cartel was created, but considerably increased their production capacity over time, until the cartel participants recognized that 'the agreement was no longer viable, owing to the competition from the Chinese imports'. In the case of Vitamin C, Chinese manufacturers entered the market only after the formation of the cartel.

- 5.32 Examples of external failures abound in shipping, where the incumbents' desire to discourage entry increased the cartel's visibility, and raised complaints from other suppliers. Here entry barriers were not driving cartel formation; frequently it appears almost the reverse.
- 5.33 The main market for the provision of sea and coastal water transport can be broken down into liner transport and tramp vessel transport. A liner service is the transport of goods on a regular basis on specified routes; sailing is almost invariably timetabled and advertised in advance. In contrast, a 'tramp vessel service' is the transport of goods in bulk in a vessel chartered to shippers on the basis of a voyage or time charter for irregular and/or non-advertised sailings. Within the shipping industry, the product is defined as liner services, and entry is relatively easy for vessel owners, unless the existing market participants engage in exclusionary practices. As a result, much of the cartel activity within the industry is aimed at preventing entry.
- 5.34 A good example of exclusionary behaviour is the Cewal, Cowac and Ukwac case (93/82/EEC) relating to sea transport of general cargo between France and several west and central African countries. The case concerns three shipping conferences, Cewal (Associated Central West African Lines) Cowac (Continental West Africa Conference) and Ukwac (United Kingdom West Africa Lines Joint Service). Potential competition was prevented by blacklisting companies and operating fighting ships in order to preclude and damage entrants. For example, the case shows that Cewal would draw up blacklists of shippers using competitors' services even if only for small quantities and these shippers could no longer count on a normal adequate service from Cewal. To operate fighting ships Cewal's informed members of the dates of forthcoming departures scheduled by any independent company and the

identity of the shippers. A meeting of the Special Fighting Committee would be convened to decide who would offer reduced 'fighting rates', below the independent's rates, and these ships sailed close to the date that the outsider was scheduled to sail. With regard to the lost revenues, all conference members contributed to the cost of the fighting ships. Clearly, the cartel included extremely elaborate procedures to prevent competition from entering to take advantage of the higher rates.

- 5.35 The French-West African Ship-owners' Committees case (92/262/EEC) concerns conferences shipping to Senegal, Gabon, Central African Republic, Niger, Burkina Faso, Guinea, Congo, Mali, Togo, Benin and Cameroon. This case provides a good example of the use by cartels of agreements involving countries to enforce the exclusionary practices aimed at deterring entry; for instance, the France-Mali agreement that provides that 'the National Transport Office and the Mali structures in the ports of transit will, in conjunction with the competent authorities of the country of transit, impose the penalties provided for by Mali regulations in both the north-bound and the south-bound trades'. The Commission concluded that the ship-owners' committees had applied a 'co-option mechanism, which in practice amounted to excluding certain ship-owners from the trade or reducing their involvement to an extent bearing no relation to their competitive strength.'
- 5.36 Finally, the Seamless Steel and the Citric Acid cases are hybrids, in that entry coincided with both the internal and external failure of the cartel. In the Seamless Steel Tubes case, the rise of Latin American producers is mentioned as one of the causes of the crisis that the cartel underwent in 1993, i.e. one year before being uncovered. In the Citric Acid case, 'the considerable influx of citric acid imports for China had an important impact on the cartel's ability to maintain agreed prices. (...) From 1991 to 1993 the cartel members' world market share in terms of total sales had fallen from around 70 per cent in 1991 to 52 per cent in 1994. This started difficulties between some of the cartel members, especially with respect of 'the lack of discipline on the part of certain members vis-à-vis adherence to the agreement'. The market leader Jungbunzlauer was perceived as being the major cause of trouble, and was attacked especially by ADM and Hartman & Reimer, the third and fourth largest members of the cartel. These difficulties carried on until in 1995

'eventually, it became clear that the cartel was in total disarray and was not working'. That same year, the cartel was discovered and dismantled by the Commission.

Discussion

- 5.37 Entry/potential entry is damaging to cartels in two ways. Firstly, it reduces the cartel's present or future profitability, and accordingly fosters tensions and disagreements among the cartel members. This corroborates the theoretical view that an increase in the number of market participants, either in the present or in the future, renders collusion harder to sustain, and decreases the cartel's internal stability. Secondly, it enhances the cartel members' need to coordinate their activities, thereby making their collusive agreement more explicit and easy to prove. Without new entry (or the possibility of new entry) agreements existing among the incumbents are less likely to become sufficiently explicit to allow a case to be built against them; thus, entry/potential entry also decreases the cartel's external stability.
- 5.38 The finding that entry is detrimental to collusion gives indirect support to the view that barriers to entry are negatively correlated with the likelihood of finding cartels within an industry.

Transparency and communication

- 5.39 Chapter 3 indicates that transparency and communication are important for cartel stability. There are two potential scenarios that might arise. One is that the need for transparency is so strong that one never sees a cartel unless there is significant transparency in the market. An alternative view is that cartels act to improve the degree of transparency in the market, and hence one might expect that where cartels are convicted the exchange of information over sales and price figures played an important role in the organization of the cartel. We found many examples of the latter argument.
- 5.40 For instance, in the Methionine case, it is reported that 'the companies held regular meetings both at top level and at a technical level. During these meetings, the participants exchanged sales volumes, which would

then be compiled and used in the discussions to determine the target prices to be fixed'. In the Organic Peroxide case, meetings and information exchanges were even more institutionalized: 'Swiss consultancy Treuhand played a key role in the cartel from 1993 organising meetings, often in Zurich, producing 'pink' and 'red' papers with the agreed market shares which could not be taken outside Treuhand's premises and even reimbursing the travel expenses of participants to avoid leaving any traces about the illegal meetings'. Similarly, in the Citric Acid cartel, the companies held regular and frequent meetings, which were the hallmark of the cartel's organisation. A sophisticated monitoring system was established, whereby each company would report its monthly sales figures to Hoffman-La Roche, who would then contact the companies and provide each company's sales figures for the corresponding month. The data were subsequently compared to the aggregate sales figures published by European Citric Acid Association Manufacturers (ECAMA). Because the cartel members made up a significant part of total ECAMA sales, any cheating would be quickly identified.

- 5.41 The situation in shipping is interesting in this regard. In recognition of the difficulties of sustaining liner services the EC provides block exemptions, granted under Article 81(3) of the EC Treaty, for certain agreements that facilitate coordinating activities within the market. The exemptions are aimed at allowing firms to capture the benefits from synchronization, and include many caveats, such as the requirement that a fair share of the benefits achieved should be passed on to transport users and that exempted consortia must not be in a position to eliminate competition, implying that there are shares on the size of the consortia. Article 3 of Regulation 823/2000 exempts agreements, decisions and concerted practices of liner conferences that have (amongst others) the objectives of coordinating shipping timetables, sailing dates, frequency, regulation of the carrying capacity, and allocation of cargo or revenue among members. Similarly, Article 3 of regulation 4056/86 exempts in certain circumstances agreements that allow fixed rates by liner conferences.
- 5.42 In this sense sea shipping is different from many markets, in that an element of transparency and communication – indeed, what one might think of as cartel-like behaviour – is sanctioned. The problems in these

markets appear to arise most frequently from these conferences and consortia overstepping the mark in terms of agreements, in particular entering into agreements that limit competition and/or raise prices in a manner that harms users rather than providing benefits to them. One particular feature of the shipping cases is that the Commission have used Article 86 (now Article 82) rather than Article 85 (now Article 81) as the cause for fines in several of the cases. Furthermore, where there have been Article 85 based fines sometimes these have been explicitly symbolic rather than significant. This is related to the role of the block exemptions in that some of the cases have been taken with a view to clarifying where the boundaries of the block exemptions sit. Again, this emphasizes the narrow line that competition policy faces in this area between fostering communication to achieve broad benefits and outlawing cartel behaviour.

Discussion

- 5.43 The case studies appear to suggest that cartel behaviour is more common in markets that are not fully transparent. The apparent contradiction with the theoretical analysis is the result of two conflicting forces, which influence the relationship between transparency and the incidence of convicted cartels in opposite ways. On one hand, transparency facilitates collusion, as it makes it easier for the cartel members to monitor each other's activities. This observation suggests that we should expect collusion to be more likely in markets characterized by transparency. On the other hand, however, the cases indicate that many cartels were convicted thanks to the lack of transparency within their market, and their resulting need for frequent and institutionalized communication. This suggests that the authorities may find evidence and conviction easier where there is lack transparency, as it is precisely in those markets that convictable cartels are bound to operate.

Number of firms and market shares

- 5.44 In the majority of cases analyzed, the markets within which the cartel operated were very concentrated. For instance, in the Citric Acid case, the cartel members (five firms in total) controlled 56-61 per cent of the

world market, and 60-70 per cent of the European market. Similar evidence holds for Plasterboard, Lysine, Vitamins and Zinc Phosphate; for instance, the market for lysine currently contains only five worldwide producers, while the plasterboard European market is dominated by four firms, who detain virtual monopolies in their counties of origin. Furthermore, in both the PVS and the Graphite Electrode cases, the number of firms and concentration in the market were initially quite high, but decreased immediately before and during the duration of the cartel, as a consequence of the protracted crisis affecting the market. Finally, in the area of shipping the cartels accounted for the majority, indeed sometimes 100 per cent, of the market.

- 5.45 Moreover, the markets under inspection appear to be characterized by a small number of firms. This impression is corroborated by the fact that the mean number of firms in the case study industries is below the aggregate mean value for all industries (Table 5.3) and that C3 and C5 are significantly larger for the cartel case study group than the mean of all industries. Furthermore, in most cases the companies involved in a cartel have been competitors in the same market for a significant period.
- 5.46 On the whole, therefore, the case studies evidence confirms the theoretical prediction that the likelihood of collusion is inversely correlated with the number of firms and the degree of concentration in the market. However, there needs to be a note of caution here in that the EU cases almost by definition are dealing with large firms and so, although this does not imply that the companies have high market shares, it would be surprising if they did not. Hence one has to be careful in using the case studies to indicate that cartels arise where one has large firms with high market shares.

Table 5.3 – Number of firms

Industry	No. firms	C3	C5
Mean of all industries	7544	39.86	46.55
Mean of case study industries	843	48.05	56.82
Manufacture of basic chemicals	1262	57.90	68.04
Sea and coastal water transport	1033	53.51	62.73
Manufacture of other non-metallic mineral products	399	42.37	49.82
Manufacture of tubes	379	48.45	58.07
Manufacture of articles of concrete, plaster and cement	1086	62.52	69.59
Manufacture of pulp, paper and paperboard	476	36.75	41.51
Production, processing and preserving of meat and meat products	1173	36.62	47.08
Manufacture of electrical equipment not elsewhere classified	2405	31.09	40.36
Manuf. of pharmaceuticals, medicinal chemicals and botanical products	476	59.26	71.69
Manuf. of non-refractory ceramic goods other than for construction	844	52.08	59.28

Asymmetries

- 5.47 We observe a considerable heterogeneity in the market shares held by cartel members. For instance, in the citric acid case, the market shares of different cartel members ranged from 15-25 per cent (Hoffman-La Roche) to 7 per cent (Haarmann & Reimer) or 8 per cent (Cerestar). Similarly, the Methionine cartel included Degussa, the world's biggest producer, and Nippon Soda, a company five times smaller than Degussa.
- 5.48 Similar evidence is found within shipping; a good illustration is provided by the Far Eastern Trade Tariff Charges and Surcharge Agreement (FETTCSA) case (2000/627/EC). This case involved shipping lines operating on the North Europe/Far East trade routes. A central feature of the case concerned an agreement not to offer discounts, which the Commission saw as significantly reducing the ability of lines to compete. The Commission found no grounds to separate the parties in terms of participation, i.e. there were no obvious followers or ringleaders, and so imposed fines across the board, in part in relation to the relative size of

companies in 1994. The case provides a detailed discussion of the comparative size of the companies involved, where size is measured as the annual turnover arising from carriage of cargo where there was a maritime element. Normalising the largest company (Maerk) at 100 the remaining companies relative turnovers were 58, 55, 52, 49, 46, 41, 34, 30, 28, 23, 23, 17, 14, 11, and 6. Clearly, there is an enormous spread of relative sizes with no clear clustering emerging. Although there was one very large player, it is not the case that they were the ringleaders. The conclusion that the cartel was robust despite the varied relative size of members is clear.

- 5.49 There is a similar finding in the Ferry Operators – Currency Surcharges case (97/84/EC). The case evidence suggests that the five companies involved - namely P&O European Ferries, Stena Sealink, SNAT, Brittany Ferries and North Sea Ferries – differed considerably in terms of their the size within the relevant market. The Commission points out that 'P&OEF stated that as the three operators present represented the larger operators, there was an expectation that their intention to adopt a surcharge would find favour with small operators such as Sally line and Brittany Ferries'. In this case the two largest firms were the clear ringleaders but all five companies were part of the cartel and all carried fines, again indicating that there is no evidence of cartels being more predominant where participants are equally placed in the market.
- 5.50 Indeed, there is evidence to the contrary; in several cases, smaller players who chose to enter the market did so through the cartel, or by adopting similar pricing practices without joining. For example, in the TAA case some small independent lines benefited from the cartel but chose to free ride on the tariffs rather than radically undercut them to obtain market share. Evergreen almost doubled its market share from 7 per cent but 'amended its schedule of tariffs in line with the changes made by the TAA and introduced rate increases comparable to, but slightly lower than, those made by the TAA so as to safeguard its competitive position'.

Discussion

- 5.51 If differences in size are to be interpreted as arising from cost/quality asymmetries, or (in the case of economies of scale) resulting in cost differences among firms, these findings are in conflict with the theoretical prediction that cost differentials should hinder collusion. The first hypothesis is however weakened by the observation that R&D expenditure is limited within the industries under inspection, indicating that cost/quality innovations do not play a big role (this is discussed in greater detail below).
- 5.52 To the extent to which size similarities reflect comparable excess capacity holdings, our findings can be interpreted in the light of the theoretical work on the effect of changes in the degree of asymmetry in capacity constraints over the sustainability of collusion. In particular, from Chapter 3 we know that asymmetry in capacity constraints favours collusion when capacity is large, but hinders it when capacity is limited.
- 5.53 Finally, the evidence presented in the Citric Acid and Lysine cases might help us gain further understanding over our findings. In both cartels, the similarity in size of the largest cartel participants resulted in conflicts and clashes, generated by the desire to conquer the leadership position; these collisions ultimately destabilized the cartel. In the Citric Acid case, for instance, 'the market leader Jungbunzlauer was perceived as being the major cause of trouble, and was attacked especially by ADM and Hartman & Reimer, the third and fourth largest members of the cartel. These difficulties carried on until, in 1995, 'it became clear that the cartel was in total disarray and was not working'. Similarly, in the Lysine case, the frequent clashes between Ajinomoto and ADM, the two largest cartel members resulted in Ajinomoto eventually approaching the Commission to denounce the agreement. These illustrations point out that similarities in size can be detrimental, as they are more conducive to conflict. Organization is easier to achieve when there is one clear leader, rather than several contenders to the leadership position.

Product differentiation and cost asymmetries

- 5.54 In Chapter 3, we saw that both horizontal (brand) and vertical (quality) product differentiation might affect the sustainability of collusion. Although we do not have a direct measure of horizontal product differentiation, casual empiricism suggests that most of the cases we are dealing with concern markets with relatively homogeneous products. This is corroborated by the observation that advertising appears to be unimportant in virtually all the cases. Intuitively, the scope for brand differentiation in shipping, basic chemicals, currency exchange, tubes, carbonless paper, petrochemicals, and electrodes appears to be limited. This confirms the theoretical view that horizontal product differentiation renders collusion harder to sustain by limiting the cartel members' retaliatory power and by making it harder to reach a consensus over the modalities of the collusive agreement.
- 5.55 The scope for vertical product differentiation (quality differences) and/or cost asymmetries also appears to be rather limited. The finding that, within the industries under scrutiny, the mean value of R&D expenditure as a proportion of total turnover is much lower than the mean value across all industries corroborates this observation (Table 5.4) can be seen as a reliable proxy for the amount of product/cost innovation within an industry. The cases therefore appear to be consistent with the theoretical view that cost/quality asymmetries hinder collusion.

Table 5.4 – Mean R&D expenditure as a proportion of total turnover

Industry	
Mean of all industries	0.2905
Mean of case study industries	0.0516
Manufacture of basic chemicals	0.0359
Sea and coastal water transport	0.0029
Manufacture of other non-metallic mineral products	0.0462
Manufacture of tubes	0.0247
Manufacture of articles of concrete, plaster and cement	0.0124
Manufacture of pulp, paper and paperboard	0.0116
Production, processing and preserving of meat and meat products	0.0233
Manufacture of electrical equipment not elsewhere classified	0.1153
Manuf. of pharmaceuticals, medicinal chemicals and botanical products	0.2151
Manuf. of non-refractory ceramic goods other than for construction	0.0295

6 CONCLUSIONS AND MARKET ASSESSMENT

6.1 The paper follows three approaches. One is a study of the economic theoretical literature to see what factors have proved useful in the modelling of cartel stability and formation. The second approach is empirical. We use existing recent evidence of legal cases and economic data to identify factors that are relevant to the identification of cartels and then to use the economic model to provide predictions of the probability of cartels within each of a large number of industry classifications. Finally, a number of case studies are undertaken. The findings of the three approaches are then brought together to provide an overall assessment that can be applied to any market to indicate how likely it is that the market contains a cartel.

6.2 The literature identifies several factors as facilitating cartel behaviour. In particular the theoretical literature suggests that:

- a smaller number of firms in the market facilitates collusion
- higher entry barriers facilitate collusion
- excess capacity and stocks are important variables and are generally thought to help sustain collusion
- persistent demand instability in a market is thought to hinder collusion
- demand growth facilitates collusion
- frequency of interaction favours collusion
- market transparency favours collusion
- private information limits collusion
- cost asymmetries and quality differences restrict collusion
- horizontal product differentiation is important but its effect on collusion is ambiguous; and

- large, powerful buyers make collusion harder to sustain.

6.3 The relationship between the theoretical literature review and the regression analysis and case studies is complex. One reason is that the theoretical literature on collusion has, until recently, underestimated or ignored the role communication plays in the sustainability of cartels. Insufficient emphasis has been placed upon the role of communication, and the exchange of information among firms, as the vehicle through which cooperation is achieved and sustained. In contrast, the legal literature qualifies as collusive only those agreements that are jointly arrived at, as a result of explicit communication. This creates a potential dichotomy between theoretical speculation, on one hand, and practical concerns, on the other. The need for cartel members to communicate intensifies precisely when collusion is harder to sustain. This observation suggests that parties might be more likely to engage in overtly collusive practices specifically in those circumstances that are predicted by the theory as being adverse to collusion. This suggests that there is unlikely to be a straightforward relationship between the theory and the empirical studies, and that the marrying up the evidence from the three approaches is not straightforward.

6.4 The empirical investigation employs cartel evidence using EC cases from 1990 to the present and the US Department of Justice cases of horizontal price fixing from 1994 to the present. We construct, for each jurisdiction, an index that gives the number of cartel cases discovered in that industry during the periods noted above. The statistical analysis is approached at a very disaggregated level (three-digit industry classification). This is necessary if predictions are to bring significant additional valuable insight to the evidence that can be gleaned from case studies and simple 'eye-balling' and manipulation of the data. There are obvious data problems in conducting the exercise due to measurement error and random industry factors. However, at a more fundamental level it is not obvious that, even with perfect data, economic factors 'work' at this level of disaggregation. This may be because, at this level of disaggregation, any mismatch between markets and industry classification is marked and the differences between industries may become too fine to significantly influence cartel formation, and hence identification. The main message from the analysis is that the approach

succeeds at this level. That is, despite the data problems and the level of disaggregation we are able to find strong significant patterns in the data.

- 6.5 There are several clear messages that arise from the series of models we investigate. One is that demand factors are very important and their influence follows the theoretically predicted pattern. That is, variability in growth is shown to have a negative impact on cartels. This is an extremely robust result holding in all models. Similarly, growth in turnover has a positive impact on cartel formation and again is extremely robust. In contrast, traditional entry barriers (measured in gross capital expenditure per firm, the level of stocks per firm and the level of R&D per firm) have little effect. The cost disadvantage ratio (a measure of economies of scale) is the only traditional entry barrier to work. However, as indicated above, the limited role for entry barriers has to be interpreted with care. The theory indicates that entry barriers should ease cartelisation. However, the data at our disposal concern cartels that have been discovered. It may be the case that whenever entry barriers are weak a cartel will have to act to prevent entry from competitors and this increases the chances of being discovered. Therefore, one might expect to see mixed evidence on entry barriers given this data set. Interestingly there is some evidence drawn from case studies that also suggests that this may be the case. The regressions also show that scale, in the form of turnover in the industry or turnover per firm, matters. Concentration is also significant. Higher concentration being positively associated with cartels.
- 6.6 An interesting feature of the analysis is that the results indicate that elements of employment also seem to matter a great deal. Employee costs are significant in virtually every regression. These factors do not arise in the theoretical literature, possibly because there is no obvious reason why they should be critical for collusion. However, there are sensible reasons why they might matter for cartel detection. For example, industries with higher employment cost per employee will have higher paid staff (who may, as a result, be privy to better information). Other things being equal, this may increase the likelihood of a cartel being discovered and the relevant evidence being uncovered. To the extent that employees as opposed to shareholders carry much of the legal risks associated with setting up a cartel that may be detected

(since they tend to be formed by management not shareholders) then this risk needs to find financial compensation. This provides a separate argument why there might be a positive correlation between employee costs and cartels, albeit with an opposite causation. However, while this is a robust theoretical explanation, it is hard to believe that such an effect will have a large impact on the total remuneration in a sector. Finally, the (logit) regressions typically explain somewhere between 14 per cent to 24 per cent of variability in the data on the location of cartels. That is, the economic variables explain about one fifth to one sixth of the variability in the cartel data. Given the measurement error problems in the data this is not an unreasonable figure. The main purpose of this section of the report is to use econometric techniques to help provide information as to where cartels may be located. Annexes C and D give for each SIC three-digit industry a prediction of the probability that they have a cartel.

- 6.7 The benefits of the approach become apparent when one compares the predictions with the raw cartel data. The allocation of EC and US cartels to SIC classification shows the well-known concentration on manufacturing and transport. Using this evidence as the basis for future investigation would imply a focus on manufacturing and transport sectors. The econometric approach allows a more detailed assessment. The econometric predictions of the most likely locations for cartels that may be convicted does indeed include several manufacturing industries where cartels have not yet been found (e.g. manufacture of aircraft and spacecraft, manufacture of paper and paperboard, manufacture of weapons are good examples) but significantly throw up other industries as being prime candidates that would not have arisen from a simple non-econometric interpretation of the data. For example, secondary schools, auditing and tax consultancy, architecture and related consultancy, and telecommunications all come out extremely high on the 'hit list'. The stability of the Schools market appears to be a factor that contributes significantly to its appearance towards the top of the list (this is also the case for auditing but the scale of the industry also appears to contribute). There has been significant media coverage of potential school cartels. The fact that schools are not present in the cartel variable and yet are thrown out as highly likely to contain cartels by the

econometric analysis highlights the use of a disaggregated econometric approach.

6.8 We have investigated many cartels including those in the two industries where they are most prevalent – shipping and basic chemicals. The following factors are important:

- demand factors, capacity and intensity of competition
- barriers to entry
- transparency and communication
- size; and
- asymmetries.

6.9 Using the evidence from the three approaches, what have we learnt in terms of assessing whether a market is likely to have a cartel that may be discovered and convicted? Each approach brings different insights and these need bringing together and balancing. Theory, the case studies and, in a limited sense through the R&D findings, the econometric analysis suggests homogeneous products are important. Similarly, the three approaches suggest sustained volatility is not likely to be associated with cartel behaviour. Finally, theory and the case studies indicate that stability among the leading players is important. We can think of these three features as fundamental characteristics. Then there are other features that are identified as important in some of the approaches. We can think of these as providing collaborative evidence. Finally, there are certain features that may give insight into when a cartel is likely to be formed. Here we pull these three (i.e. fundamental background, collaborative evidence and why and when) together in a sequential manner.

6.10 Clearly, each situation will be special and economic factors are only one part of the story. However, while it is a mistake to think that observable economic factors can define cartel location, it is clear from the three approaches that common factors emerge that will help inform whether a market is likely to have a cartel. We identify critical areas of assessment

and group these into three sections – the fundamental background, the collaborative evidence and the why and where factor.

- 6.11 As indicated, the fundamental background reduces to three core issues – product, volatility and company criteria. The first core question is whether the industry has a homogeneous product or not. Cartels are far more likely if the product is fairly homogeneous between companies in the market. Considerable product differentiation has the opposite effect. Secondly, does the industry display volatile turnover over a sustained period of time? Cartels are more likely if output and market conditions are normally stable. This does not preclude occasional shocks to the market but these are not the norm. Also the lack of volatility does not imply a constant turnover but when there is decline it is likely to be persistent and relatively constant. Finally, are the leading players in the market large and relatively constant? If there are significant changes in market shares or regular exits and entrants then cartels are less likely. If year-on-year most of the players in the market remain constant then the opposite follows. Note, that this is long run relationship and they may be occasional years (possibly preceding cartelisation) when firms leave the industry.
- 6.12 We see these three factors as almost basic requirements for cartel formation so when considering whether the fundamental background of a market is consistent with cartel behaviour we suggest from our analysis that a market needs at least two high scores out of three to be likely to favour collusion.
- 6.13 The research has identified a series of factors that are associated with cartelisation or to be more precise discovery of cartels. None of these are essential but have been shown to be relevant factors. These are:
- Transparency – What is the level of transparency? If there is almost no transparency then cartels are less unlikely
 - Payroll effects – The statistical modelling identified payroll effects, i.e. relatively high payroll per employee, as factors. If these are comparatively high in the market then cartels are more likely

- Big firms/number of firms in industry. Cartels more likely if concentration is large and/or there are relatively few firms in the market/industry
- Barriers to entry – High barriers to entry, or the ability to construct such barriers, make cartels more likely
- Capacity – Evidence of excess capacity makes cartels more likely. If capacity is apparently being used to the full with little scope for extra production then the opposite holds; and
- Ranking in econometric model.

- 6.14 Overall a market that scores highly on these collaborative factors indicates that cartels may be present, however, we would suggest that there is little scope for trade-off between fundamental background and collaborative factors.
- 6.15 If a market has the fundamental background and strong collaborative evidence then the question why and when still needs to be addressed. Are there good reasons for these particular companies to be colluding at the present time? What is the key factor? These questions are the hardest to answer. Clearly, higher and safer profit relative to the counterfactual is at the core of any cartel but this is not hugely informative. However, it does lead on to the question – why is higher and safer profit an issue for this market at this time? We see this as a more productive question in the context of identifying cartels. The question tends to focus on demand factors and we know these have been identified in the research as very significant.
- 6.16 There are two categories where there is good evidence: (i) where there has been a long run decline in demand and/or prices affecting all or almost all companies and (ii) where there is a sudden market shock that affects all companies in the market.
- 6.17 The idea that these will bite in markets that score highly in the three fundamental background tests is both believable at an intuitive level and is strongly backed up by the case study evidence. Where products are relatively homogeneous, there is little volatility in demand and the parties

are familiar with each other the drive to jointly address a relentless trend in the market is shown to be strong.²⁰ Similarly, if all companies are hit by a sudden shock that clearly requires response then the drive to find out how others are thinking of responding and to take the next step of co-ordinating responses will be strong. Therefore it makes sense to look for a decline or shock to the industry to highlight whether and when a cartel may have originated. Aside from these factors the research also indicates that the why factor should consider the need to build transparency in the market and improve entry barriers where they are weak. Focusing on these questions may throw light on why a market needs to explicitly cartelise to achieve common objectives. However, in general, with the exception of demand factors the research provides less productive answers to the why and when question.

- 6.18 Overall, the three approaches taken in the report provide a framework that can help identify whether a particular market is likely or less likely to have a cartel. The three categories above provide help in assessing markets but one ought to emphasise again that economic factors can only provide part of the answer. In particular the why and when category can only focus on some factors that will be critical. The absence of these factors does not imply that a cartel is unlikely. That is, whereas the fundamental background and collaborative evidence could almost take the form of a 'tick list', the why and when questions should not be interpreted this way.

²⁰ Note, that this conflicts somewhat with the theory and the econometric analysis although to some extent this issue is about when a cartel is formed, something that the econometrics is ill equipped to deal with. The effect is so prevalent in the case studies that it is hard to ignore.

ANNEXES

A LIST OF THREE DIGIT (SIC) INDUSTRIES

SIC-Code	Industry
a014	Agricultural and animal husbandry service activities, except veterinary activities
a015	Hunting, trapping and game propagation including related service activities
a020	Forestry, logging and related service activities
b050	Fishing
ca101	Mining and agglomeration of hard coal
ca103	Extraction and agglomeration of peat
cb131	Mining of iron ores
cb132	Mining of nonferrous metal ores, except uranium and thorium ores
cb141	Quarrying of stone
cb142	Quarrying of sand and clay
cb143	Mining of chemical and fertilizer minerals
cb144	Production of salt
cb145	Other mining and quarrying, not elsewhere classified
da151	Production, processing and preserving of meat and meat products
da152	Processing and preserving of fish and fish products
da153	Processing and preserving of fruit and vegetables
da154	Manufacture of vegetable and animal oils and fats
da155	Manufacture of dairy products
da156	Manufacture of grain mill products, starches and starch products
da157	Manufacture of prepared animal feeds
da158	Manufacture of other food products
da159	Manufacture of beverages
da160	Manufacture of tobacco products
db171	Preparation and spinning of textile fibres
db172	Textile weaving
db173	Finishing of textiles
db174	Manufacture of made-up textile articles, except apparel
db175	Manufacture of other textile
db176	Manufacture of knitted and crocheted fabrics
db177	Manufacture of knitted and crocheted articles
db181	Manufacture of leather clothes

db182	Manufacture of other wearing apparel and accessories
db183	Dressing and dyeing of fur; manufacture of articles of fur
dc191	Tanning and dressing of leather
dc192	Manufacture of luggage, handbags and the like, saddlery and harness
dc193	Manufacture of footwear
dd201	Saw milling and planing of wood, impregnation of wood
dd202	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards
dd203	Manufacture of builders' carpentry and joinery
dd204	Manufacture of wooden containers
dd205	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials
de211	Manufacture of pulp, paper and paperboard
de212	Manufacture of articles of paper and paperboard
de221	Publishing
de222	Printing and service activities related to printing
de223	Reproduction of recorded media
df231	Manufacture of coke oven products
df232	Manufacture of refined petroleum products
df233	Processing of nuclear fuel
dg241	Manufacture of basic chemicals
dg242	Manufacture of pesticides and other agrochemical products
dg243	Manufacture of paints, varnishes and similar coatings, printing inks and mastics
dg244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
dg245	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
dg246	Manufacture of other chemical products
dg247	Manufacture of manmade fibres
dh251	Manufacture of rubber products
dh252	Manufacture of plastic products
di261	Manufacture of glass and glass products
di262	Manufacture of non-refractory ceramic goods other than for construction purposes
di263	Manufacture of ceramic tiles and flags
di264	Manufacture of bricks, tiles and construction products, in baked clay
di265	Manufacture of cement, lime and plaster
di266	Manufacture of articles of concrete, plaster and cement
di267	Cutting, shaping and finishing of stone
di268	Manufacture of other non-metallic mineral products

dj271	Manufacture of basic iron and steel and of ferroalloys
dj272	Manufacture of tubes
dj273	Other first processing of iron and steel and production of nonECSC ferro alloys
dj274	Manufacture of basic precious and other nonferrous metals
dj275	Casting of metals
dj281	Manufacture of structural metal products
dj282	Manufacture of tanks, reservoirs and containers of metal; manufacture central heating, radiators and boilers
dj283	Manufacture of steam generators, except central heating hot water boilers
dj284	Forging, pressing, stamping and roll forming of metal; powder metallurgy
dj285	Treatment and coating of metals; general mechanical engineering
dj286	Manufacture of cutlery, tools and general hardware
dj287	Manufacture of other fabricated metal products
dk291	Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines
dk292	Manufacture of other general purpose machinery
dk293	Manufacture of agricultural and forestry machinery
dk294	Manufacture of machine tools
dk295	Manufacture of other special purpose machinery
dk296	Manufacture of weapons and ammunition
dk297	Manufacture of domestic appliances not elsewhere classified
dl300	Manufacture of office machinery and computers
dl311	Manufacture of electric motors, generators and transformers
dl312	Manufacture of electricity distribution and control apparatus
dl313	Manufacture of insulated wire and cables
dl314	Manufacture of accumulators, primary cells and primary batteries
dl315	Manufacture of lighting equipment and electric lamps
dl316	Manufacture of electrical equipment not elsewhere classified
dl321	Manufacture of electronic valves and tubes and other electronic components
dl322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
dl323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus
dl331	Manufacture of medical and surgical equipment and orthopaedic appliances
dl332	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
dl333	Manufacture of industrial process control equipment
dl334	Manufacture of optical instruments and photographic equipment

dl335	Manufacture of watches and clocks
dm341	Manufacture of motor vehicles
dm342	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
dm343	Manufacture of parts and accessories for motor vehicles and their engines
dm351	Building and repairing of ships and boats
dm352	Manufacture of railway and tramway locomotives and rolling stock
dm353	Manufacture of aircraft and spacecraft
dm354	Manufacture of motorcycles and bicycles
dm355	Manufacture of other transport equipment not elsewhere classified
dn361	Manufacture of furniture
dn362	Manufacture of jewellery and related articles
dn363	Manufacture of musical instruments
dn364	Manufacture of sports goods
dn365	Manufacture of games and toys
dn366	Miscellaneous manufacturing not elsewhere classified
dn371	Recycling of metal waste and scrap
dn372	Recycling of non-metal waste and scrap
e401	Production and distribution of electricity
e402	Manufacture of gas; distribution of gaseous fuels through mains
e403	Steam and hot water supply
e410	Collection, purification and distribution of water
f451	Site preparation
f452	Building of complete constructions or parts thereof; civil engineering
f453	Building installation
f454	Building completion
f455	Renting of construction or demolition equipment with operator
h551	Hotels
h552	Camping sites and other provision of short stay accommodation
h553	Restaurants
h554	Bars
h555	Canteens and catering
i601	Transport via railways
i602	Other land transport
i603	Transport via pipelines
i611	Sea and coastal water transport
i612	Inland water transport
i621	Scheduled air transport
i622	Non-scheduled air transport

i631	Cargo handling and storage
i632	Other supporting transport activities
i633	Activities of travel agencies and tour operators; tourist assistance activities
i634	Activities of other transport agencies
i641	Postal and courier activities
i642	Telecommunications
k701	Real estate activities with own property
k702	Letting of own property
k703	Real estate activities on a fee or contract basis
k711	Renting of automobiles
k712	Renting of other transport equipment
k713	Renting of other machinery and equipment
k714	Renting of personal and household goods not elsewhere classified
k721	Hardware consultancy
k722	Software consultancy and supply
k723	Data processing and database activities
k725	Maintenance and repair of office, accounting and computing machinery
K726	Other computer related activities
K741	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy
k742	Architectural and engineering activities and related technical consultancy
k743	Technical testing and analysis
k744	Advertising
k745	Labour recruitment and provision of personnel
k746	Investigation and security activities
k747	Industrial cleaning
k748	Miscellaneous business activities not elsewhere classified
m801	Primary education
m802	Secondary education
m803	Higher education
m804	Adult and other education
n851	Human health activities
n852	Veterinary activities
n853	Social work activities
o911	Activities of business, employers and professional organisations
o912	Activities of trade unions
o913	Activities of other membership organisations
o921	Motion picture and video activities
o922	Radio and television activities

o923	Other entertainment activities
o924	News agency activities
o925	Library, archives, museums and other cultural activities
o926	Sporting activities
o927	Other recreational activities
o930	Other service activities

B EMPIRICAL ANALYSIS

Estimation techniques

- B.1 This subsection briefly summarises the regression techniques that have been used in the report.
- B.2 If we wish to estimate the probability that a cartel exists in an industry then the Logistic Regression (Logit) Model is appropriate. Logit models are used when we have a binary dependent variable y_i , such that $y_i = 1$ if an event occurs, $y_i = 0$ if not. In the context of this report the dependent variable y_i is the presence or not of a cartel in the industry. The probability of the event occurring is assumed to be a function of the explanatory variables. There are several problems with attempting to fit a standard linear probability regression model in this situation. One problem is that the probability of the event occurring must lie between 0 and 1. This implies that the sum of each of the explanatory variables multiplied by its coefficient must lie between 0 and 1. This will only happen however if the values of the explanatory variables are bounded in some way and if certain restrictions are placed on the coefficients. Moreover, in order to get an unbiased estimator of the true probability from the OLS model, we need to make assumptions about the distribution of the error term. However, we are unable to make the necessary assumptions because of the discrete nature of the dependent variable, and the result is that even if we could bind the data in the way that we require, the estimate that we derive from the model would be biased. The logical way to model a binary dependent variable is to adopt a distribution function approach. One of the most commonly used distribution functions for models such as this is the logistic distribution function, which leads to the logit model, and is the approach employed in the report to obtain probabilities of cartels.
- B.3 The logit model uses the representation of cartels across industries as 0 (if no cartel has yet been found) or 1 (if a cartel has been found). The problem with this is that it is not using all the data on cartels. For example, shipping in the EC data has 10 cartels whereas pesticides have 2 and manmade fibres have one. In the binary variable these industries are treated as being identical but clearly they are not. That is, they all

are represented with a unit value (since they display at least one cartel over the period) but the scale of activity differs hugely between the three industries. Although in most industries there has only been one cartel, there are several where the number is greater than one. Furthermore, the number of cartels in an industry is quite varied (ranging from 0 to 11). There are a number of possible ways of using this information. One is to assume that the number of cartels is a continuous unbounded number and in this case OLS can be used. Another is to use the ordered logit model. This model is computationally similar to the logit model but differs in that it estimates the probability of being in each of several discrete categories – for example the probability of finding 0 cartels, the probability of finding 1 cartel, and the probability of finding 2 or more cartels. In this paper logit, OLS and ordered logit regressions will be used.

- B.4 The previous subsection indicated that the independent variable data is taken over four years. However, the data over the four years is not independent, i.e. a particular feature of a specific industry will tend to be present in all four years of data and the dependent variable will also be the same for the four years. For this reason the errors will not be independent across all of the observations. A regression that does not take account of this dependence will tend to underestimate the standard errors and so variables will falsely appear significant. However, if one specifies the unit within which we suspect that there will be correlation in the error terms (i.e. industry in our model) we can adjust the standard errors accordingly and ensure that the testing procedures are valid. This process is called clustering. In our case clustering should take place on each industry's SIC classification to ensure that the estimation is efficient and inference is consistent. All regressions in the report have clustered on SIC classification.

Regressions

- B.5 Chapter 4 identified variables that are readily available at a disaggregated level, are updated regularly and may have a direct effect on cartel formation. Initially this section shows the results of a rough specification of the model that simply include almost all variables and dummies for the specific years (this is referred to as model 1). These are given in Tables

B.1 – B.3. Table B.1 provides logit estimates. As indicated in the previous subsection a fundamental premise is that the differences between industries are similar across jurisdictions. In general this will be the case but there are some instances where this may not be the case. The fact that shipping has had many cartels in the EU but not in the US (unlike basic chemicals which tops both lists) suggests that there may be something special in this industry in the EU that is not replicated elsewhere. This is a particular concern for the OLS estimates but for all regressions we have considered whether shipping is an outlier in the data set. The results given in this Annex are robust to the exclusion of shipping. Table B.2 provides an OLS estimate and B.3 gives ordered logit estimates where the classification is zero cartels, one cartel and more than one cartel.

Table B.1 – Logit 1

Depvar: cartel dummy	Coef.
Constant	-2.332 **
tot. turnover industry	0.000
tot. turnover PF	-0.011
tot. net capital exp PF	0.021
tot. emp costs per employee	0.063
tot. emp costs PF	0.151
stocks PF	0.200
Growth in turnover PF	2.805 ***
s.d. growth	-10.731 **
R&D exp PF	-0.302
mean C3 concentration ratio, 1998-2002	0.011
mean minimum efficiency scale, 1998-2002	-0.816
mean cost disadvantage ratio, 1998-2002	-0.104
mean capital entry barrier, 1998- 2002	-0.026
mean market share volatility, 1998-2002	0.060
year = 2000	-0.203
year = 2001	-0.093
year = 2002	-0.153
R-squared	0.24
N	467

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

Table B.2 – OLS 1

Depvar: cartels	Coef.
Constant	-0.882
Tot. turnover PF	-0.005
Tot. net capital exp PF	0.082
Tot. emp costs per employee	0.066
Tot. emp costs PF	-0.123
stocks PF	0.108
growth in turnover PF	1.150 **
s.d. growth	-3.071
R&D exp PF	-0.040
mean C3 concentration ratio, 1998-2002	0.007
mean minimum efficiency scale, 1998-2002	-0.042
mean cost disadvantage ratio, 1998-2002	-0.041
mean capital entry barrier, 1998- 2002	0.014
mean market share volatility, 1998- 2002	0.019
year = 2000	-0.065
year = 2001	-0.078
year = 2002	-0.102
R-squared	0.17
N	467

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

Table B.3 – Ordered logit 1

Depvar: cart multi	Coef.
tot. turnover industry	0.000 *
tot. turnover PF	-0.019
tot. net capital exp PF	0.104
tot. emp costs per employee	0.073 *
tot. emp costs PF	-0.042
stocks PF	0.384
growth in turnover PF	2.728 ***
s.d. growth	-11.680 **
R&D exp PF	-0.250
mean C3 concentration ratio, 1998-2002	0.018
mean minimum efficiency scale, 1998-2002	-1.392
mean cost disadvantage ratio, 1998-2002	-0.081 *
mean capital entry barrier, 1998- 2002	-0.001
mean market share volatility, 1998-2002	0.067
year = 2000	-0.148
year = 2001	-0.079
year = 2002	-0.115
R-squared	0.17
N	467

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

B.6 Taking the results from Tables B.1 – B.3 there are several points that emerge. First, we are able to explain between 17 per cent to 24 per cent of the location of cartels by these variables. That is, the economic variables explain about one fifth to one sixth of the variability in the cartel data. Given the measurement error problems this is quite a high figure. Second, growth in turnover and the variance of growth in turnover appear to be particularly robust independent variables. Both

have the sign as predicted in the theory outlined in Chapter 3. Scale factors, in the form of total turnover, are sometimes present as is the cost disadvantage ratio and total employee costs per employee. No year dummies are significant which suggests that there is no single year that has a particular effect on the analysis.

Table B.4 – Logit 2

Depvar: cart dummy	Coef.
constant	-2.573 ***
tot. turnover industry	0.000 *
tot. net capital exp PF	0.058
tot. emp costs per employee	0.063 *
stocks PF	0.026
growth in turnover PF	2.504 ***
s.d. growth	-10.480 ***
mean C3 concentration ratio, 1998-2002	0.022
mean minimum efficiency scale, 1998-2002	-0.897
mean cost disadvantage ratio, 1998-2002	-0.157 **
mean capital entry barrier, 1998-2002	-0.024
mean market share volatility, 1998-2002	0.051
year = 2000	-0.062
year = 2001	-0.136
year = 2002	-0.238 *
R-squared	0.17
N	604

Key:

- * significant at the 10% level
- ** significant at the 5% level
- *** significant at the 1% level

B.7 The first model is very rough and there is significant correlation between some of the coefficients. Tables B.4 – B.6 provide a more considered model (we refer to this as model 2). Here we remove total turnover per

firm (since we have a concentration measure in C3), remove one of the employee variables (total employee costs per firm) and remove R&D. As indicated above the R&D data is drawn from a different sample from the rest of the data and covers fewer industries. For this reason it is useful to remove it.

Table B.5 – OLS 2

Depvar: cartels	Coef.
	-0.663
tot. turnover industry	0.000
tot. net capital exp PF	0.014
tot. emp costs per employee	0.052 *
stocks PF	-0.053
growth in turnover PF	1.185 **
s.d. growth	-3.009 *
mean C3 concentration ratio, 1998-2002	0.009 *
mean minimum efficiency scale, 1998-2002	-0.112
mean cost disadvantage ratio, 1998-2002	-0.031
mean capital entry barrier, 1998-2002	0.011
mean market share volatility, 1998-2002	0.028
year = 2000	-0.043
year = 2001	-0.129 *
year = 2002	-0.162 *
R-squared	0.15
N	604

Key:

- * significant at the 10% level
- ** significant at the 5% level
- *** significant at the 1% level

B.8 The general picture in model 2 is the same as for model 1. Growth in turnover and variance of growth in turnover are strongly significant as the theory indicated. Total turnover, employee costs per firm and C3 are significant.

Table B.6 – Ordered logit 2

Depvar: cart multi	Coef.
tot. turnover industry	0.000 **
tot. net capital exp PF	0.032
tot. emp costs per employee	0.065 **
stocks PF	0.035
growth in turnover PF	2.389 ***
s.d. growth	-10.714 ***
mean C3 concentration ratio, 1998-2002	0.025 *
mean minimum efficiency scale, 1998-2002	-1.296
mean cost disadvantage ratio, 1998-2002	-0.102 **
mean capital entry barrier, 1998-2002	-0.013
mean market share volatility, 1998-2002	0.074
year = 2000	-0.052
year = 2001	-0.155
year = 2002	-0.239 **
R-squared	0.14
N	604

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

Table B.7 – Logit 3

Depvar: cart dummy	Coef.
Constant	-2.029 ***
tot. turnover industry	0.000 **
tot. net capital exp PF	0.059
stocks PF	0.087
growth in turnover PF	2.433 ***
s.d. growth	-9.527 ***
mean C3 concentration ratio, 1998-2002	0.029 **
mean cost disadvantage ratio, 1998-2002	-0.213 ***
year = 2000	-0.037
year = 2001	-0.013
year = 2002	-0.061
R-squared	0.16
N	604

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

Table B.8 – OLS 3

Depvar: cartels	Coef.
Constant	-0.080
tot. turnover industry	0.000
tot. net capital exp PF	0.027
stocks PF	-0.002
growth in turnover PF	1.125 **
s.d. growth	-2.630 *
mean C3 concentration ratio, 1998-2002	0.018 **
mean cost disadvantage ratio, 1998-2002	-0.070 **
year = 2000	-0.013
year = 2001	-0.012
year = 2002	-0.026
R-squared	0.11
N	604

Key:

* significant at the 10% level

** significant at the 5% level

*** significant at the 1% level

Table B.9– Ordered logit 3

Depvar: cart multi	Coef.
tot. turnover industry	0.000 * * *
tot. net capital exp PF	0.051
stocks PF	0.097
growth in turnover PF	2.314 * * *
s.d. growth	-9.881 * *
mean C3 concentration ratio, 1998-2002	0.031 * *
mean cost disadvantage ratio, 1998-2002	-0.152 * * *
year = 2000	-0.022
year = 2001	-0.006
year = 2002	-0.049
R-squared	0.12
N	604

Key:

- * significant at the 10% level
- ** significant at the 5% level
- *** significant at the 1% level

B.9 As indicated the underlying methodology is that the differences between industries at the firm level account for the explanation of the location of cartels. The reason for the 'per firm' approach is the belief that it is firms within an industry that enter into illegal agreements. While theoretically sound, one problem with this approach is that there is inevitably collinearity between some of the variables. For the main purpose of the paper this is not a problem. The aim is to use industry level data drawn over the last four years to predict where cartels may be found in the coming period. While multi-collinearity makes it difficult to obtain efficient standard errors and hence predict which of two collinear variables is significant, this does not matter for the purposes of predicting. If two variables are highly correlated this is not a problem for prediction purposes providing the relationship between the variables remains the same in the future as it has in the past. Collinearity is only a problem if the relationship between the two collinear variables changes in the future (i.e. they do not remain collinear) since it is then important

to know which one is most significant. Of the nine variables three have high correlation and two (stocks and total turnover per firm) are highly collinear. The average correlation between these two is approximately 0.85 and has remained close to this level for all four years. Generally, any correlation over 0.8 is taken as a signal that there is a significant multi-collinearity problem. Model 2 removed some of the most highly collinear variables from model 1. Here in model 3 we remove further variables.

- B.10 Model 3 is probably the best model to provide insight into which variables are most significant in explaining cartel behaviour even though not necessarily the best model for prediction. Employee cost per employee and C3 are correlated. Model 2 shows that both are marginally significant. We decided to remove the employee cost variable rather than the concentration variable from the regression since theory indicates a stronger 'pedigree' for concentration measures. MES and the cost disadvantage ratio aim to capture similar concepts (i.e. economies of scale) and since MES is not significant this is removed. Similar arguments apply to the mean capital entry barrier, which is similar to net total capital expenditure per firm. Finally, volatility of market share has proved insignificant so is removed. The results using model three are given in Tables B.7 – B.9.
- B.11 The main messages from Model 3 echo those of Model 2 but are more robust. Tables B.7 – B.9 show total turnover, growth in turnover, variance in turnover, cost disadvantage ratio, and C3 are all very significant. Model 3 is a strong verification of many of the theoretical predictions, i.e. growth of turnover, variability, concentration and economies of scale are all significant at 5 per cent or 1 per cent and all have the correct sign.

Predictions

- B.12 Each logit regression enables a prediction to be produced for each industry of the probability that a cartel exists in that industry. Similarly the OLS estimates produces an estimate of the number of cartels that may exist in an industry. The OLS approach assumes that the number of cartels is continuous which is clearly not valid and so the predictions

deliver non-integer figures. Finally, the ordered logit provides an estimate for each industry of the probability of there being no cartels, the probability of there being one cartel and the probability of there being more than one cartel. These predictions are delivered for each separate year. [Thus for a specific single model with a specific data set there are four probabilities per industry per year and one OLS prediction of the number of cartels. This gives 3,125 values for every single model specification and data set]. Given the three models used and the two data sets (with and without shipping) this delivers 30,750 values. Of course, the predictions for each specific year are of limited value and so for presentation purposes the average for the four years is presented. This reduces the output considerably. Annex C gives these averaged values for model 2. Annex D gives the same information ranked in descending order of the probability derived from the logit estimation.

- B.13 As a first step in deciding how to use this information and similar predictions to provide insight into the location of cartels it is important to consider how robust the approach is. There are two critical issues. One is the extent that one can have confidence in the predictions since they must inevitably be sensitive to the precise specification of the model. Second, the measurement error problem needs consideration.
- B.14 Paragraphs B.5 – B.11 has employed three separate models. Although each of these models has been informed by the variables discussed in Chapter 2 they differ significantly in terms of the variables they employ. Furthermore, the differences have been driven mostly by poor data (the case with R&D) and high correlation of variables.
- B.15 A logit regression of a particular model provides for each industry a probability that a cartel exists in that industry. For any two models it is then possible to calculate the correlation between the predictions from the two models. A correlation of zero would arise if the models give completely independent predictions and a correlation of unity would indicate that the predictions are absolutely identical between the two models. Taking the predictions from the logit regressions gives three sets of predictions that can be correlated.

Table B.10 – Correlations between the predications using the Logit model

	Logit 1	Logit 2	Logit 3
Logit 1	1		
Logit 2	0.9459	1	
Logit 3	0.9121	0.9468	1

- B.16 Table B.10 shows the relevant correlations, which are very high. These correlations show that the overall predictions are not particularly sensitive to the precise model that is being estimated. However, interest is likely to focus on the industries where the predictions are high rather than across the whole sample. It follows that a tougher test of robustness across models would be useful, i.e. that the industries in the upper tail (high probability of cartel) were also relatively robust to model specification. To assess this situation the top (i.e. predicted the most likely to contain cartels) forty industries have been taken for each model (by averaging the annual predictions for each industry) and a list drawn up of those industries that feature in at least two of the three models. Note the reason we have not defined a list that focuses only on industries that appear in all three lists is that just over 30 per cent of the industries have no data on R&D. Thus almost one third of the industries have to be left out of the estimation for Model 1. Requiring industries to enter the top forty for all three models would bias the results against those industries that have no data on R&D. Table 4.4 in the main text gives the list of those drawn from all industries and Table 4.5 gives the list when interest is restricted to those industries where there is no cartel in the data set.
- B.17 Tables B.11 – B.16 give the twenty-five industries with highest probabilities according to Models 1, 2 and 3 respectively (ranked using the logit probabilities). Again these are given for all industries and then for those industries where there is no cartel. There are some interesting examples such as legal, accounting and bookkeeping and auditing activities, which appears close to the top both for Models 2 and 3.

Table B.11

	All industries	C(s)	Prob. logit 1
1	Building of complete constructions or parts thereof; civil engineering	1	0.98
2	Telecommunications	0	0.89
3	Scheduled air transport	1	0.82
4	Software consultancy and supply	1	0.82
5	Manufacture of basic iron and steel and of ferroalloys	1	0.79
6	Manufacture of motor vehicles	1	0.79
7	Manufacture of aircraft and spacecraft	0	0.78
8	Manufacture of basic chemicals	11	0.77
9	Manufacture of cement, lime and plaster	1	0.76
10	Activities of other transport agencies	1	0.71
11	Activities of travel agencies and tour operators; tourist assistance activities	0	0.66
12	Cargo handling and storage	0	0.60
13	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.59
14	Other land transport	0	0.58
15	Manufacture of other food products	3	0.56
16	Manufacture of railway and tramway locomotives and rolling stock	0	0.56
17	Manufacture of beverages	2	0.55
18	Publishing	0	0.54
19	Building installation	1	0.52
20	Manufacture of grain mill products, starches and starch products	0	0.48
21	Transport via railways	0	0.46
22	Manufacture of tubes	4	0.45
23	Manufacture of articles of paper and paperboard	0	0.45
24	Recycling of metal waste and scrap	0	0.43
25	Other computer related activities	0	0.43

Table B.12

	Industries where no cartel(s) have yet been discovered	Prob. logit 1
1	Telecommunications	0.89
2	Manufacture of aircraft and spacecraft	0.78
3	Activities of travel agencies and tour operators; tourist assistance activities	0.66
4	Cargo handling and storage	0.60
5	Other land transport	0.58
6	Manufacture of railway and tramway locomotives and rolling stock	0.56
7	Publishing	0.54
8	Manufacture of grain mill products, starches and starch products	0.48
9	Transport via railways	0.46
10	Manufacture of articles of paper and paperboard	0.45
11	Recycling of metal waste and scrap	0.43
12	Other computer related activities	0.43
13	Mining and agglomeration of hard coal	0.38
14	Quarrying of sand and clay	0.35
15	Processing and preserving of fruit and vegetables	0.35
16	Printing and service activities related to printing	0.34
17	Manufacture of cutlery, tools and general hardware	0.32
18	Non-scheduled air transport	0.32
19	Manufacture of furniture	0.31
20	Manufacture of glass and glass products	0.30
21	Manufacture of domestic appliances not elsewhere classified	0.29
22	Manufacture of prepared animal feeds	0.28
23	Manufacture of builders' carpentry and joinery	0.27
24	Manufacture of other special purpose machinery	0.26
25	Manufacture of jewellery and related articles	0.25

Table B.13

	All industries	C(s)	Prob. logit 2
1	Building of complete constructions or parts thereof; civil engineering	1	0.89
2	Telecommunications	0	0.84
3	Activities of other transport agencies	1	0.80
4	Manufacture of cement, lime and plaster	1	0.77
5	Scheduled air transport	1	0.73
6	Manufacture of basic chemicals	11	0.72
7	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.71
8	Manufacture of motor vehicles	1	0.68
9	Software consultancy and supply	1	0.68
10	Manufacture of aircraft and spacecraft	0	0.65
11	Manufacture of grain mill products, starches and starch products	0	0.61
12	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0	0.55
13	Manufacture of other food products	3	0.52
14	Cargo handling and storage	0	0.50
15	Activities of travel agencies and tour operators; tourist assistance activities	0	0.46
16	Publishing	0	0.44
17	Manufacture of railway and tramway locomotives and rolling stock	0	0.44
18	Other land transport	0	0.43
19	Manufacture of tubes	4	0.41
20	Recycling of metal waste and scrap	0	0.40
21	Manufacture of articles of paper and paperboard	0	0.40
22	Manufacture of basic iron and steel and of ferroalloys	1	0.39
23	Manufacture of weapons and ammunition	0	0.39
24	Manufacture of beverages	2	0.39
25	Radio and television activities	0	0.39

Table B.14

	Industries where no cartel(s) have yet been discovered	Prob. logit 2
1	Telecommunications	0.84
2	Manufacture of aircraft and spacecraft	0.65
3	Manufacture of grain mill products, starches and starch products	0.61
4	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0.55
5	Cargo handling and storage	0.50
6	Activities of travel agencies and tour operators; tourist assistance activities	0.46
7	Publishing	0.44
8	Manufacture of railway and tramway locomotives and rolling stock	0.44
9	Other land transport	0.43
10	Recycling of metal waste and scrap	0.40
11	Manufacture of articles of paper and paperboard	0.40
12	Manufacture of weapons and ammunition	0.39
13	Radio and television activities	0.39
14	Processing and preserving of fruit and vegetables	0.38
15	Manufacture of motorcycles and bicycles	0.38
16	Quarrying of sand and clay	0.37
17	Manufacture of prepared animal feeds	0.35
18	Non-scheduled air transport	0.34
19	Manufacture of domestic appliances not elsewhere classified	0.34
20	Mining and agglomeration of hard coal	0.34
21	Manufacture of glass and glass products	0.33
22	Advertising	0.32
23	Other computer related activities	0.32
24	Architectural and engineering activities and related technical consultancy	0.30
25	Manufacture of cutlery, tools and hardware	0.29

Table B.15

	All industries	C(s)	Prob. logit 3
1	Building of complete constructions or parts thereof; civil engineering	1	0.92
2	Activities of other transport agencies	1	0.85
3	Telecommunications	0	0.77
4	Manufacture of cement, lime and plaster	1	0.74
5	Manufacture of motor vehicles	1	0.67
6	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.65
7	Manufacture of other food products	3	0.65
8	Manufacture of basic chemicals	11	0.63
9	Manufacture of aircraft and spacecraft	0	0.61
10	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0	0.58
11	Manufacture of grain mill products, starches and starch products	0	0.52
12	Scheduled air transport	1	0.52
13	Other land transport	0	0.50
14	Activities of travel agencies and tour operators; tourist assistance activities	0	0.49
15	Manufacture of beverages	2	0.46
16	Cargo handling and storage	0	0.45
17	Processing and preserving of fruit and vegetables	0	0.43
18	Manufacture of basic iron and steel and of ferroalloys	1	0.42
19	Other recreational activities	0	0.42
20	Quarrying of sand and clay	0	0.42
21	Software consultancy and supply	1	0.41
22	Recycling of metal waste and scrap	0	0.39
23	Manufacture of railway and tramway locomotives and rolling stock	0	0.39
24	Transport via railways	0	0.39
25	Manufacture of motorcycles and bicycles	0	0.37

Table B.16

	Industries where no cartel(s) have yet been discovered	Prob. logit 3
1	Telecommunications	0.77
2	Manufacture of aircraft and spacecraft	0.61
3	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0.58
4	Manufacture of grain mill products, starches and starch products	0.52
5	Other land transport	0.50
6	Activities of travel agencies and tour operators; tourist assistance activities	0.49
7	Cargo handling and storage	0.45
8	Processing and preserving of fruit and vegetables	0.43
9	Other recreational activities	0.42
10	Quarrying of sand and clay	0.42
11	Recycling of metal waste and scrap	0.39
12	Manufacture of railway and tramway locomotives and rolling stock	0.39
13	Transport via railways	0.39
14	Manufacture of motorcycles and bicycles	0.37
15	Manufacture of glass and glass products	0.36
16	Manufacture of weapons and ammunition	0.36
17	Publishing	0.35
18	Manufacture of domestic appliances not elsewhere classified	0.35
19	Human health activities	0.34
20	Manufacture of articles of paper and paperboard	0.34
21	Postal and courier activities	0.33
22	Non-scheduled air transport	0.33
23	Canteens and catering	0.33
24	Manufacture of dairy products	0.29
25	Camping sites and other provision of short stay accommodation	0.28

US and EU data

- B.18 Before concluding this section we address the question of US cartel data and more general use of EU data.
- B.19 We have argued that US data on cartels may be informative as to the location of cartels in other jurisdictions. In the context of the report this data can be used in two forms. One is to replace the EU cartel data with US cartel data in the regressions we have calculated above. Another is to amalgamate the EU and US data into a single data set indicating the presence of cartels. Overall the empirical estimates for either approach are less satisfactory than those based on EC cases but indicate that the same variables are likely to be significant in explaining cartel formation. The only unusual thing is that R&D expenditure is strongly significant in Model 1, the sole model to use R&D expenditure, whether the US or joint cartel data set is used. This is the first, albeit quite weak, evidence to show that R&D might matter. The sign is positive which is somewhat consistent with the entry barrier story in Chapter 3, i.e. higher entry barriers increase the likelihood of a cartel, but not with the transparency and cost asymmetry interpretation.
- B.20 The use of EU data for industry characteristics has proved difficult because of the paucity of data at the four-digit level. Eurostat has such data available but there are major gaps across a broad array of industries rendering the regressions very unreliable. We have run regressions using the Eurostat data but there is little evidence to give any confidence although R&D is again significant in the estimates. One interesting feature is that the degree of specialisation variable is very significant in the OLS regressions. One could interpret this variable as measuring the extent of multi-market contact, which is thought in the theory to favour cartel formation, or as measuring horizontal product differentiation which is considered a relevant variable but which theoretically has conflicting implications. However, in general there is no clear message emerging from the EU data, which we feel is a fair reflection on the quality of the data.

C PROBABILITIES ACCORDING TO THE LOGIT, ORDERED LOGIT AND OLS ESTIMATIONS FOR EACH INDUSTRY

Ordered by industry code						
Industry	C(s)	Logit Prob.	OLS Pred No.	OL Pr(0)	OL Pr(1)	OL Pr (2+)
Agricultural and animal husbandry service activities, except veterinary activities	0					
Hunting, trapping and game propagation including related service activities	0					
Forestry, logging and related service activities	0					
Fishing	0					
Mining and agglomeration of hard coal	0	0.34	1.01	0.66	0.25	0.10
Extraction and agglomeration of peat	0					
Mining of iron ores	0					
Mining of nonferrous metal ores, except uranium and thorium ores	0					
Quarrying of stone	0	0.00	-0.87	1.00	0.00	0.00
Quarrying of sand and clay	0	0.37	1.16	0.62	0.27	0.11
Mining of chemical and fertilizer minerals	0					
Production of salt	0					
Other mining and quarrying, not elsewhere classified	0					
Production, processing and preserving of meat and meat products	1	0.24	0.52	0.76	0.18	0.06
Processing and preserving of fish and fish products	1	0.17	0.18	0.81	0.14	0.04
Processing and preserving of fruit and vegetables	0	0.38	0.86	0.59	0.29	0.13
Manufacture of vegetable and animal oils and fats	0	0.05	1.10	0.95	0.04	0.01
Manufacture of dairy products	0	0.19	0.60	0.80	0.15	0.05
Manufacture of grain mill products, starches and starch products	0	0.61	1.54	0.36	0.37	0.27
Manufacture of prepared animal feeds	0	0.35	0.88	0.62	0.27	0.11
Manufacture of other food products	3	0.52	0.92	0.50	0.33	0.17
Manufacture of beverages	2	0.39	0.90	0.61	0.27	0.11
Manufacture of tobacco products	0	0.21	0.33	0.75	0.18	0.07
Preparation and spinning of textile fibres	0	0.05	-0.16	0.94	0.04	0.01
Textile weaving	0	0.09	0.24	0.91	0.07	0.02
Finishing of textiles	0	0.07	-0.05	0.92	0.06	0.02
Manufacture of made-up textile articles, except apparel	0	0.11	-0.08	0.88	0.09	0.03
Manufacture of other textile	0	0.19	0.37	0.79	0.16	0.05
Manufacture of knitted and crocheted fabrics	0	0.04	-0.29	0.95	0.04	0.01
Manufacture of knitted and crocheted articles	0	0.03	-0.49	0.97	0.03	0.01
Manufacture of leather clothes	0					
Manufacture of other wearing apparel and accessories	0	0.11	-0.10	0.89	0.09	0.02
Dressing and dyeing of fur; manufacture of articles of fur	0					
Tanning and dressing of leather	0	0.13	0.30	0.86	0.11	0.03
Manufacture of luggage, handbags and the like, saddlery and harness	0	0.16	0.11	0.84	0.12	0.04
Manufacture of footwear	0	0.11	0.20	0.89	0.09	0.03
Saw milling and planing of wood, impregnation of wood	0	0.20	0.27	0.79	0.16	0.05
Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board fibre board and other panels and boards	0	0.14	0.49	0.88	0.09	0.03
Manufacture of builders' carpentry and joinery	0	0.22	0.36	0.79	0.16	0.05
Manufacture of wooden containers	0	0.03	-0.29	0.98	0.02	0.01

Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials	0	0.10	0.09	0.90	0.08	0.02
Manufacture of pulp, paper and paperboard	2	0.20	0.72	0.78	0.17	0.06
Manufacture of articles of paper and paperboard	0	0.40	0.90	0.60	0.28	0.12
Publishing	0	0.44	0.95	0.59	0.29	0.13
Printing and service activities related to printing	0	0.27	0.51	0.75	0.18	0.06
Reproduction of recorded media	0	0.09	0.26	0.90	0.08	0.02
Manufacture of coke oven products	0					
Manufacture of refined petroleum products	0					
Processing of nuclear fuel	0					
Manufacture of basic chemicals	11	0.72	1.69	0.31	0.38	0.31
Manufacture of pesticides and other agrochemical products	0	0.09	0.62	0.90	0.08	0.02
Manufacture of paints, varnishes and similar coatings, printing inks and mastics	1	0.23	0.63	0.77	0.18	0.06
Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.71	1.63	0.28	0.37	0.35
Manufacture of soap and detergents, cleaning and polishing preparations, perfume and toilet preparations	0	0.21	0.50	0.79	0.16	0.05
Manufacture of other chemical products	0	0.28	1.03	0.68	0.23	0.09
Manufacture of manmade fibres	0	0.07	0.49	0.91	0.07	0.02
Manufacture of rubber products	1	0.27	0.72	0.72	0.21	0.08
Manufacture of plastic products	1	0.30	0.50	0.72	0.20	0.07
Manufacture of glass and glass products	0	0.33	0.76	0.66	0.25	0.10
Manufacture of non-refractory ceramic goods other than for construction purposes	1	0.26	0.85	0.70	0.22	0.08
Manufacture of ceramic tiles and flags	0	0.15	0.48	0.84	0.13	0.04
Manufacture of bricks, tiles and construction products, in baked clay	0	0.27	0.57	0.70	0.22	0.08
Manufacture of cement, lime and plaster	1	0.77	2.50	0.25	0.35	0.40
Manufacture of articles of concrete, plaster and cement	1	0.16	0.48	0.84	0.12	0.04
Cutting, shaping and finishing of stone	0					
Manufacture of other non-metallic mineral products	3	0.10	0.45	0.89	0.08	0.02
Manufacture of basic iron and steel and of ferroalloys	1	0.39	0.69	0.58	0.29	0.13
Manufacture of tubes	4	0.41	1.08	0.50	0.33	0.17
Other first processing of iron and steel and production of nonECSC ferro alloys	0	0.07	0.25	0.92	0.06	0.02
Manufacture of basic precious and other nonferrous metals	2	0.15	0.61	0.85	0.12	0.04
Casting of metals	0	0.07	0.08	0.93	0.06	0.02
Manufacture of structural metal products	0	0.14	0.28	0.87	0.10	0.03
Manufacture of tanks, reservoirs and containers of metal; manufacture central heating, radiators and boilers	0	0.09	0.17	0.91	0.07	0.02
Manufacture of steam generators, except central heating hot water boilers	0					
Forging, pressing, stamping and roll forming of metal; powder metallurgy	0	0.08	0.05	0.91	0.07	0.02
Treatment and coating of metals; general mechanical engineering	0	0.10	0.02	0.90	0.07	0.02
Manufacture of cutlery, tools and general hardware	0	0.29	0.71	0.70	0.22	0.08
Manufacture of other fabricated metal products	0	0.13	0.16	0.86	0.11	0.03
Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines	0	0.19	0.64	0.81	0.14	0.04
Manufacture of other general purpose machinery	1	0.20	0.42	0.81	0.15	0.05
Manufacture of agricultural and forestry machinery	1	0.31	0.75	0.67	0.24	0.09
Manufacture of machine tools	0	0.13	0.47	0.87	0.10	0.03

Manufacture of other special purpose machinery	0	0.24	0.63	0.75	0.18	0.06
Manufacture of weapons and ammunition	0	0.39	1.06	0.60	0.28	0.12
Manufacture of domestic appliances not elsewhere classified	0	0.34	0.72	0.65	0.25	0.10
Manufacture of office machinery and computers	0	0.14	0.50	0.86	0.11	0.03
Manufacture of electric motors, generators and transformers	0	0.11	0.21	0.88	0.09	0.03
Manufacture of electricity distribution and control apparatus	0	0.07	0.15	0.94	0.05	0.01
Manufacture of insulated wire and cables	0	0.07	0.02	0.93	0.06	0.02
Manufacture of accumulators, primary cells and primary batteries	0	0.01	0.13	0.98	0.01	0.00
Manufacture of lighting equipment and electric lamps	0	0.08	-0.07	0.91	0.07	0.02
Manufacture of electrical equipment not elsewhere classified	3	0.28	0.73	0.73	0.20	0.07
Manufacture of electronic valves and tubes and other electronic components	0	0.08	0.10	0.91	0.07	0.02
Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	0	0.05	0.41	0.95	0.04	0.01
Manufacture of television and radio receivers, sound or video recording or reproducing apparatus	0	0.04	-0.16	0.96	0.04	0.01
Manufacture of medical and surgical equipment and orthopaedic appliances	0	0.17	0.40	0.83	0.13	0.04
Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	0	0.12	0.40	0.87	0.10	0.03
Manufacture of industrial process control equipment	0	0.13	0.41	0.86	0.11	0.03
Manufacture of optical instruments and photographic equipment	0	0.02	-0.41	0.98	0.01	0.00
Manufacture of watches and clocks	0	0.01	-0.53	0.99	0.01	0.00
Manufacture of motor vehicles	1	0.68	1.09	0.36	0.37	0.27
Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1	0.28	0.51	0.70	0.22	0.08
Manufacture of parts and accessories for motor vehicles and their engines	1	0.24	0.56	0.77	0.17	0.06
Building and repairing of ships and boats	0	0.07	0.18	0.93	0.05	0.01
Manufacture of railway and tramway locomotives and rolling stock	0	0.44	1.00	0.54	0.31	0.15
Manufacture of aircraft and spacecraft	0	0.65	1.18	0.35	0.37	0.27
Manufacture of motorcycles and bicycles	0	0.38	0.97	0.57	0.29	0.13
Manufacture of other transport equipment not elsewhere classified	0	0.10	0.15	0.88	0.09	0.03
Manufacture of furniture	0	0.24	0.43	0.76	0.18	0.06
Manufacture of jewellery and related articles	0	0.25	0.65	0.66	0.25	0.10
Manufacture of musical instruments	0	0.08	0.18	0.92	0.06	0.02
Manufacture of sports goods	0	0.03	-0.24	0.97	0.03	0.01
Manufacture of games and toys	0	0.06	0.31	0.92	0.06	0.02
Miscellaneous manufacturing not elsewhere classified	0	0.17	0.18	0.83	0.13	0.04
Recycling of metal waste and scrap	0	0.40	0.90	0.60	0.28	0.12
Recycling of non-metal waste and scrap	0	0.05	-0.22	0.96	0.03	0.01
Production and distribution of electricity	0	0.03	1.10	0.93	0.05	0.01
Manufacture of gas; distribution of gaseous fuels through mains	0					
Steam and hot water supply	0					
Collection, purification and distribution of water	0	0.04	-0.11	0.97	0.02	0.01
Site preparation	0	0.20	0.52	0.79	0.16	0.05
Building of complete constructions or parts thereof; civil engineering	1	0.89	1.26	0.25	0.37	0.38
Building installation	1	0.36	0.57	0.69	0.23	0.08
Building completion	1	0.14	0.04	0.88	0.10	0.03
Renting of construction or demolition equipment with operator	0	0.12	0.18	0.88	0.09	0.03
Hotels	0	0.09	-0.19	0.91	0.07	0.02

Camping sites and other provision of short stay accommodation	0	0.22	0.30	0.74	0.19	0.07
Restaurants	0	0.15	-0.12	0.87	0.10	0.03
Bars	0	0.13	-0.19	0.88	0.09	0.03
Canteens and catering	0	0.17	0.14	0.84	0.12	0.04
Transport via railways	0	0.25	1.41	0.72	0.20	0.07
Other land transport	0	0.43	0.60	0.64	0.26	0.10
Transport via pipelines	1					
Sea and coastal water transport	10	0.35	1.46	0.61	0.27	0.12
Inland water transport	1	0.04	-0.10	0.95	0.04	0.01
Scheduled air transport	1	0.73	1.76	0.29	0.38	0.34
Non-scheduled air transport	0	0.34	1.03	0.63	0.26	0.11
Cargo handling and storage	0	0.50	1.04	0.50	0.33	0.17
Other supporting transport activities	1	0.20	0.73	0.80	0.15	0.05
Activities of travel agencies and tour operators; tourist assistance activities	0	0.46	0.68	0.62	0.27	0.11
Activities of other transport agencies	1	0.80	1.09	0.41	0.36	0.23
Postal and courier activities	0	0.25	0.58	0.76	0.18	0.06
Telecommunications	0	0.84	1.86	0.22	0.36	0.42
Real estate activities with own property	0	0.02	0.16	0.97	0.02	0.01
Letting of own property	0	0.07	0.00	0.92	0.06	0.02
Real estate activities on a fee or contract basis	0	0.09	0.71	0.88	0.09	0.03
Renting of automobiles	0	0.02	-0.31	0.98	0.01	0.00
Renting of other transport equipment	0	0.13	0.60	0.88	0.09	0.03
Renting of other machinery and equipment	0	0.15	0.30	0.85	0.11	0.03
Renting of personal and household goods not elsewhere classified	0	0.11	0.01	0.88	0.10	0.03
Hardware consultancy	0	0.02	-0.48	0.99	0.01	0.00
Software consultancy and supply	1	0.68	1.38	0.39	0.37	0.24
Data processing and database activities	0	0.23	1.03	0.73	0.20	0.07
Maintenance and repair of office, accounting and computing machinery	0	0.16	0.43	0.84	0.12	0.04
Other computer related activities	0	0.32	0.79	0.73	0.20	0.07
Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0	0.55	0.83	0.59	0.29	0.13
Architectural and engineering activities and related technical consultancy	0	0.30	0.61	0.73	0.20	0.07
Technical testing and analysis	0	0.16	0.57	0.84	0.12	0.04
Advertising	0	0.32	0.81	0.70	0.22	0.08
Labour recruitment and provision of personnel	0	0.13	-0.11	0.89	0.08	0.02
Investigation and security activities	0	0.18	0.16	0.82	0.14	0.04
Industrial cleaning	0	0.08	-0.35	0.92	0.06	0.02
Miscellaneous business activities not elsewhere classified	1	0.27	0.41	0.79	0.16	0.05
Primary education	0	0.04	-0.60	0.97	0.03	0.01
Secondary education	0	0.27	0.46	0.74	0.19	0.07
Higher education	0	0.15	1.14	0.79	0.16	0.05
Adult and other education	0	0.09	0.00	0.91	0.07	0.02
Human health activities	0	0.24	0.28	0.77	0.17	0.06
Veterinary activities	0	0.04	-0.47	0.96	0.03	0.01
Social work activities	0	0.10	-0.01	0.91	0.07	0.02
Activities of business, employers and professional organisations	0	0.27	0.74	0.73	0.20	0.07
Activities of trade unions	0					

Activities of other membership organisations	0	0.02	0.04	0.98	0.02	0.00
Motion picture and video activities	1	0.07	-0.04	0.92	0.06	0.02
Radio and television activities	0	0.39	1.14	0.64	0.26	0.10
Other entertainment activities	0	0.09	-0.04	0.90	0.08	0.02
News agency activities	0					
Library, archives, museums and other cultural activities	0	0.08	0.22	0.92	0.06	0.02
Sporting activities	1	0.25	0.35	0.76	0.18	0.06
Other recreational activities	0	0.28	0.53	0.76	0.18	0.06
Other service activities	0	0.08	-0.18	0.93	0.06	0.02

D PROBABILITIES ORDERED ACCORDING TO THE PROBABILITY FROM THE SECOND SPECIFICATION OF THE LOGIT MODEL

Industry	C(s)	Logit Prob.	OLS Pred No.	OL Pr(0)	OL Pr(1)	OL Pr (2+)
Building of complete constructions or parts thereof; civil engineering	1	0.89	1.26	0.25	0.37	0.38
Telecommunications	0	0.84	1.86	0.22	0.36	0.42
Activities of other transport agencies	1	0.80	1.09	0.41	0.36	0.23
Manufacture of cement, lime and plaster	1	0.77	2.50	0.25	0.35	0.40
Scheduled air transport	1	0.73	1.76	0.29	0.38	0.34
Manufacture of basic chemicals	11	0.72	1.69	0.31	0.38	0.31
Manufacture of pharmaceuticals, medicinal chemicals and botanical products	4	0.71	1.63	0.28	0.37	0.35
Manufacture of motor vehicles	1	0.68	1.09	0.36	0.37	0.27
Software consultancy and supply	1	0.68	1.38	0.39	0.37	0.24
Manufacture of aircraft and spacecraft	0	0.65	1.18	0.35	0.37	0.27
Manufacture of grain mill products, starches and starch products	0	0.61	1.54	0.36	0.37	0.27
Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy	0	0.55	0.83	0.59	0.29	0.13
Manufacture of other food products	3	0.52	0.92	0.50	0.33	0.17
Cargo handling and storage	0	0.50	1.04	0.50	0.33	0.17
Activities of travel agencies and tour operators; tourist assistance activities	0	0.46	0.68	0.62	0.27	0.11
Publishing	0	0.44	0.95	0.59	0.29	0.13
Manufacture of railway and tramway locomotives and rolling stock	0	0.44	1.00	0.54	0.31	0.15
Other land transport	0	0.43	0.60	0.64	0.26	0.10
Manufacture of tubes	4	0.41	1.08	0.50	0.33	0.17
Recycling of metal waste and scrap	0	0.40	0.90	0.60	0.28	0.12
Manufacture of articles of paper and paperboard	0	0.40	0.90	0.60	0.28	0.12
Manufacture of basic iron and steel and of ferroalloys	1	0.39	0.69	0.58	0.29	0.13
Manufacture of weapons and ammunition	0	0.39	1.06	0.60	0.28	0.12
Manufacture of beverages	2	0.39	0.90	0.61	0.27	0.11
Radio and television activities	0	0.39	1.14	0.64	0.26	0.10
Processing and preserving of fruit and vegetables	0	0.38	0.86	0.59	0.29	0.13
Manufacture of motorcycles and bicycles	0	0.38	0.97	0.57	0.29	0.13
Quarrying of sand and clay	0	0.37	1.16	0.62	0.27	0.11
Building installation	1	0.36	0.57	0.69	0.23	0.08
Manufacture of prepared animal feeds	0	0.35	0.88	0.62	0.27	0.11
Sea and coastal water transport	10	0.35	1.46	0.61	0.27	0.12
Non-scheduled air transport	0	0.34	1.03	0.63	0.26	0.11
Manufacture of domestic appliances not elsewhere classified	0	0.34	0.72	0.65	0.25	0.10
Mining and agglomeration of hard coal	0	0.34	1.01	0.66	0.25	0.10
Manufacture of glass and glass products	0	0.33	0.76	0.66	0.25	0.10
Advertising	0	0.32	0.81	0.70	0.22	0.08
Other computer related activities	0	0.32	0.79	0.73	0.20	0.07
Manufacture of agricultural and forestry machinery	1	0.31	0.75	0.67	0.24	0.09
Architectural and engineering activities and related technical consultancy	0	0.30	0.61	0.73	0.20	0.07

Manufacture of plastic products	1	0.30	0.50	0.72	0.20	0.07
Manufacture of cutlery, tools and general hardware	0	0.29	0.71	0.70	0.22	0.08
Other recreational activities	0	0.28	0.53	0.76	0.18	0.06
Manufacture of electrical equipment not elsewhere classified	3	0.28	0.73	0.73	0.20	0.07
Manufacture of other chemical products	0	0.28	1.03	0.68	0.23	0.09
Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1	0.28	0.51	0.70	0.22	0.08
Manufacture of rubber products	1	0.27	0.72	0.72	0.21	0.08
Activities of business, employers and professional organisations	0	0.27	0.74	0.73	0.20	0.07
Miscellaneous business activities not elsewhere classified	1	0.27	0.41	0.79	0.16	0.05
Printing and service activities related to printing	0	0.27	0.51	0.75	0.18	0.06
Secondary education	0	0.27	0.46	0.74	0.19	0.07
Manufacture of bricks, tiles and construction products, in baked clay	0	0.27	0.57	0.70	0.22	0.08
Manufacture of non-refractory ceramic goods other than for construction purposes	1	0.26	0.85	0.70	0.22	0.08
Postal and courier activities	0	0.25	0.58	0.76	0.18	0.06
Manufacture of jewellery and related articles	0	0.25	0.65	0.66	0.25	0.10
Transport via railways	0	0.25	1.41	0.72	0.20	0.07
Sporting activities	1	0.25	0.35	0.76	0.18	0.06
Manufacture of furniture	0	0.24	0.43	0.76	0.18	0.06
Manufacture of other special purpose machinery	0	0.24	0.63	0.75	0.18	0.06
Production, processing and preserving of meat and meat products	1	0.24	0.52	0.76	0.18	0.06
Human health activities	0	0.24	0.28	0.77	0.17	0.06
Manufacture of parts and accessories for motor vehicles and their engines	1	0.24	0.56	0.77	0.17	0.06
Manufacture of paints, varnishes and similar coatings, printing inks and mastics	1	0.23	0.63	0.77	0.18	0.06
Data processing and database activities	0	0.23	1.03	0.73	0.20	0.07
Camping sites and other provision of short stay accommodation	0	0.22	0.30	0.74	0.19	0.07
Manufacture of builders' carpentry and joinery	0	0.22	0.36	0.79	0.16	0.05
Manufacture of tobacco products	0	0.21	0.33	0.75	0.18	0.07
Manufacture of soap and detergents, cleaning and polishing preparations, perfume and toilet preparations	0	0.21	0.50	0.79	0.16	0.05
Manufacture of other general purpose machinery	1	0.20	0.42	0.81	0.15	0.05
Site preparation	0	0.20	0.52	0.79	0.16	0.05
Manufacture of pulp, paper and paperboard	2	0.20	0.72	0.78	0.17	0.06
Other supporting transport activities	1	0.20	0.73	0.80	0.15	0.05
Saw milling and planing of wood, impregnation of wood	0	0.20	0.27	0.79	0.16	0.05
Manufacture of other textile	0	0.19	0.37	0.79	0.16	0.05
Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines	0	0.19	0.64	0.81	0.14	0.04
Manufacture of dairy products	0	0.19	0.60	0.80	0.15	0.05
Investigation and security activities	0	0.18	0.16	0.82	0.14	0.04
Processing and preserving of fish and fish products	1	0.17	0.18	0.81	0.14	0.04
Manufacture of medical and surgical equipment and orthopaedic appliances	0	0.17	0.40	0.83	0.13	0.04
Miscellaneous manufacturing not elsewhere classified	0	0.17	0.18	0.83	0.13	0.04
Canteens and catering	0	0.17	0.14	0.84	0.12	0.04
Maintenance and repair of office, accounting and computing machinery	0	0.16	0.43	0.84	0.12	0.04
Manufacture of articles of concrete, plaster and cement	1	0.16	0.48	0.84	0.12	0.04
Technical testing and analysis	0	0.16	0.57	0.84	0.12	0.04

Manufacture of luggage, handbags and the like, saddlery and harness	0	0.16	0.11	0.84	0.12	0.04
Manufacture of ceramic tiles and flags	0	0.15	0.48	0.84	0.13	0.04
Renting of other machinery and equipment	0	0.15	0.30	0.85	0.11	0.03
Restaurants	0	0.15	-0.12	0.87	0.10	0.03
Manufacture of basic precious and other nonferrous metals	2	0.15	0.61	0.85	0.12	0.04
Higher education	0	0.15	1.14	0.79	0.16	0.05
Manufacture of structural metal products	0	0.14	0.28	0.87	0.10	0.03
Manufacture of office machinery and computers	0	0.14	0.50	0.86	0.11	0.03
Building completion	1	0.14	0.04	0.88	0.10	0.03
Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards	0	0.14	0.49	0.88	0.09	0.03
Manufacture of other fabricated metal products	0	0.13	0.16	0.86	0.11	0.03
Renting of other transport equipment	0	0.13	0.60	0.88	0.09	0.03
Tanning and dressing of leather	0	0.13	0.30	0.86	0.11	0.03
Manufacture of machine tools	0	0.13	0.47	0.87	0.10	0.03
Labour recruitment and provision of personnel	0	0.13	-0.11	0.89	0.08	0.02
Bars	0	0.13	-0.19	0.88	0.09	0.03
Manufacture of industrial process control equipment	0	0.13	0.41	0.86	0.11	0.03
Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	0	0.12	0.40	0.87	0.10	0.03
Renting of construction or demolition equipment with operator	0	0.12	0.18	0.88	0.09	0.03
Manufacture of electric motors, generators and transformers	0	0.11	0.21	0.88	0.09	0.03
Renting of personal and household goods not elsewhere classified	0	0.11	0.01	0.88	0.10	0.03
Manufacture of made-up textile articles, except apparel	0	0.11	-0.08	0.88	0.09	0.03
Manufacture of other wearing apparel and accessories	0	0.11	-0.10	0.89	0.09	0.02
Manufacture of footwear	0	0.11	0.20	0.89	0.09	0.03
Manufacture of other non-metallic mineral products	3	0.10	0.45	0.89	0.08	0.02
Manufacture of other transport equipment not elsewhere classified	0	0.10	0.15	0.88	0.09	0.03
Treatment and coating of metals; general mechanical engineering	0	0.10	0.02	0.90	0.07	0.02
Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials	0	0.10	0.09	0.90	0.08	0.02
Social work activities	0	0.10	-0.01	0.91	0.07	0.02
Reproduction of recorded media	0	0.09	0.26	0.90	0.08	0.02
Real estate activities on a fee or contract basis	0	0.09	0.71	0.88	0.09	0.03
Adult and other education	0	0.09	0.00	0.91	0.07	0.02
Manufacture of pesticides and other agrochemical products	0	0.09	0.62	0.90	0.08	0.02
Hotels	0	0.09	-0.19	0.91	0.07	0.02
Textile weaving	0	0.09	0.24	0.91	0.07	0.02
Other entertainment activities	0	0.09	-0.04	0.90	0.08	0.02
Manufacture of tanks, reservoirs and containers of metal; manufacture central heating, radiators and boilers	0	0.09	0.17	0.91	0.07	0.02
Other service activities	0	0.08	-0.18	0.93	0.06	0.02
Forging, pressing, stamping and roll forming of metal; powder metallurgy	0	0.08	0.05	0.91	0.07	0.02
Library, archives, museums and other cultural activities	0	0.08	0.22	0.92	0.06	0.02
Manufacture of lighting equipment and electric lamps	0	0.08	-0.07	0.91	0.07	0.02
Manufacture of musical instruments	0	0.08	0.18	0.92	0.06	0.02
Manufacture of electronic valves and tubes and other electronic components	0	0.08	0.10	0.91	0.07	0.02

Industrial cleaning	0	0.08	-0.35	0.92	0.06	0.02
Finishing of textiles	0	0.07	-0.05	0.92	0.06	0.02
Motion picture and video activities	1	0.07	-0.04	0.92	0.06	0.02
Casting of metals	0	0.07	0.08	0.93	0.06	0.02
Manufacture of insulated wire and cables	0	0.07	0.02	0.93	0.06	0.02
Manufacture of manmade fibres	0	0.07	0.49	0.91	0.07	0.02
Manufacture of electricity distribution and control apparatus	0	0.07	0.15	0.94	0.05	0.01
Letting of own property	0	0.07	0.00	0.92	0.06	0.02
Building and repairing of ships and boats	0	0.07	0.18	0.93	0.05	0.01
Other first processing of iron and steel and production of nonECSC ferro alloys	0	0.07	0.25	0.92	0.06	0.02
Manufacture of games and toys	0	0.06	0.31	0.92	0.06	0.02
Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	0	0.05	0.41	0.95	0.04	0.01
Manufacture of vegetable and animal oils and fats	0	0.05	1.10	0.95	0.04	0.01
Recycling of non-metal waste and scrap	0	0.05	-0.22	0.96	0.03	0.01
Preparation and spinning of textile fibres	0	0.05	-0.16	0.94	0.04	0.01
Collection, purification and distribution of water	0	0.04	-0.11	0.97	0.02	0.01
Inland water transport	1	0.04	-0.10	0.95	0.04	0.01
Manufacture of television and radio receivers, sound or video recording or reproducing apparatus	0	0.04	-0.16	0.96	0.04	0.01
Manufacture of knitted and crocheted fabrics	0	0.04	-0.29	0.95	0.04	0.01
Primary education	0	0.04	-0.60	0.97	0.03	0.01
Veterinary activities	0	0.04	-0.47	0.96	0.03	0.01
Manufacture of sports goods	0	0.03	-0.24	0.97	0.03	0.01
Manufacture of knitted and crocheted articles	0	0.03	-0.49	0.97	0.03	0.01
Manufacture of wooden containers	0	0.03	-0.29	0.98	0.02	0.01
Production and distribution of electricity	0	0.03	1.10	0.93	0.05	0.01
Real estate activities with own property	0	0.02	0.16	0.97	0.02	0.01
Activities of other membership organisations	0	0.02	0.04	0.98	0.02	0.00
Renting of automobiles	0	0.02	-0.31	0.98	0.01	0.00
Manufacture of optical instruments and photographic equipment	0	0.02	-0.41	0.98	0.01	0.00
Hardware consultancy	0	0.02	-0.48	0.99	0.01	0.00
Manufacture of accumulators, primary cells and primary batteries	0	0.01	0.13	0.98	0.01	0.00
Manufacture of watches and clocks	0	0.01	-0.53	0.99	0.01	0.00
Quarrying of stone	0	0.00	-0.87	1.00	0.00	0.00
Agricultural and animal husbandry service activities, except veterinary activities	0					
Hunting, trapping and game propagation including related service activities	0					
Forestry, logging and related service activities	0					
Fishing	0					
Extraction and agglomeration of peat	0					
Mining of iron ores	0					
Mining of nonferrous metal ores, except uranium and thorium ores	0					
Mining of chemical and fertilizer minerals	0					
Production of salt	0					
Other mining and quarrying, not elsewhere classified	0					
Manufacture of leather clothes	0					
Dressing and dyeing of fur; manufacture of articles of fur	0					
Manufacture of coke oven products	0					

Manufacture of refined petroleum products	0					
Processing of nuclear fuel	0					
Cutting, shaping and finishing of stone	0					
Manufacture of steam generators, except central heating hot water boilers	0					
Manufacture of gas; distribution of gaseous fuels through mains	0					
Steam and hot water supply	0					
Transport via pipelines	1					
Activities of trade unions	0					
News agency activities	0					

E BIBLIOGRAPHY

- Abreu, D. (1986), 'Extremal Equilibria of Oligopolistic Supergames', *Journal of Economic Theory*, 39: 191-223.
- Abreu, D., D. Pearce and E. Stacchetti (1985), ' Optimal Cartel Equilibria with Imperfect Monitoring', *Journal of Economic Theory*, 39: 251-269.
- Athey, S. and K. Bagwell (2001), 'Optimal collusion with Private Information', *The Rand Journal of Economics*, 32(3): 428-465.
- Athey, S. , K. Bagwell and C. Sanchirico (2004), 'Optimal Collusion with Private Information', *Review of Economic Studies*, forthcoming.
- Bernheim,D. and M. Whinston (1990), 'Multimarket Contact and Collusive Behaviour', *Rand Journal of Economics*, 21: 1-26.
- Brock, W. A. and J. Scheinkman (1985), 'Price Setting Supergames with Capacity Constraints', *Review of Economic Studies*, 52: 371-382.
- Chang, M-H. (1991), 'The Effects of Product Differentiation on Collusive Pricing', *International Journal of Industrial Organisation*, 9: 453-469.
- Compte, O. (1998), 'Communication in Repeated Games with imperfect Private Monitoring', *Econometrica* 66(3): 597-626.
- Compte, O., F. Jenny and P. Rey (2002), ' Capacity Constraints, Mergers and Collusion', *European Economic Review*, 46(1): 1-29.
- Compte, O. (2000), 'Secret Price Cutting and Strategic Buyers: an Illustration of the Divide and Conquer Tactic', Unpublished Manuscript, CERAS, Ecole Nationale des Ponts et Chausees, Paris.
- Cramton, P.C. and T.R. Palfrey (1990), 'Cartel Enforcement with Uncertainty about Costs', *The Rand Journal of Economics*, 31: 17-47.
- Edwards, C.D. (1955), 'Conglomerate Bigness as a Source of Power', In *Business Concentration and Price Policy*, NBER Conference Report, Princeton, Princeton University Press.

Eswaran, M. (1997), 'Cartel Unity over the Business Cycle', *Canadian Journal of Economics* 30(3): 644-672.

Gilo, D. and Y. Spiegel (2003), 'Partial Cross Ownership and Tacit Collusion', Unpublished Manuscript, Tel Aviv University.

Green, E. and R. Porter (1984), 'Non-Cooperative Collusion under Imperfect Price Information', *Econometrica* 55: 87-100.

Hackner, J. (1994), 'Collusive Pricing in Markets for Vertically Differentiated Products', *International Journal of Industrial Organisation*, 12: 155-177.

Haltiwanger, J. and J. Harrington (1991), 'The Impact of Cyclical Demand Movements on Collusive Behaviour', *The Rand Journal of Economics*, 22: 89-106.

Kandori, M. and H. Matsushima (1998), 'Private Observations, Communication and Collusion', *Econometrica* 66: 627-652.

Kihlstrom, R. and X. Vives (1992), 'Collusion by Asymmetrically Informed Firms', *Journal of Economics and Management Strategy*, (1): 371-396.

Ivaldi, M., B. Jullien, P. Seabright and J. Tirole (2003), 'The Economics of Tacit Collusion' Unpublished Manuscript, IDEI, University of Toulouse.

Lambson, V. E. (1987), 'Optimal Penal Codes in Price-Setting Supergames with Capacity Constraints', *Review of Economic Studies*, 54: 385-397.

Lambson, V. E. (1994), 'Some Results on Optimal Penal Codes in Asymmetric Bertrand Supergames', *Journal of Economic Theory*, 62: 444-468.

Lambson, V. E. (1996), 'Optimal Penal Codes in Nearly Symmetric Bertrand Supergames with Capacity Constraints', *Journal of Mathematical Economics*, 62: 444-468.

Malueg, D. A. (1992), 'Collusive Behaviour and Partial Ownership of Rivals', *International Journal of Industrial Organisation*, 10: 27-34.

McCutcheon, B. (1997), 'Do Meetings in Smoke-Filled Rooms Facilitate Collusion?', *The Journal of Political Economy*, 105(2): 330-350.

Office of Fair Trading, (2004), Empirical Indicators for Market Investigations, (OFT749a).

Raith, M. (1996), ' Product differentiation, Uncertainty, and the stability of Collusion', London School of Economics, STICERD Discussion Paper Series EI/16: 49.

Roberts, K. (1985), 'Cartel Behaviour and Adverse Selection', *Journal of Industrial Economics*, 33: 401-413.

Ross, T. W. (1992), 'Cartel Stability and Product Differentiation', *International Journal of Industrial Organization*, 10: 1-13.

Rotemberg, J. and G. Saloner (1989), ' The Cyclical Behaviour of Strategic Inventories', *The Quarterly Journal of Economics*, 104(1): 73-97.

Rotemberg, J. and G. Saloner (1986), ' A Supergame-Theoretic Model of Business Cycles and Price Wars during Booms', *American Economic Review*, 76: 390-407.

Snyder, C.M. (1996), ' A Dynamic Theory of Countervailing Power', *The Rand Journal of Economics*, 27: 747-769.

Staiger, R. and F. Wolak (1992), 'Collusive Pricing with Capacity Constraints in the Presence of Demand Uncertainty', *The Rand Journal of Economics* 23: 203-220.

Stigler, G. (1964), 'A Theory of Oligopoly', *Journal of Political Economy*, 72: 4-61.

Symeonidis, G. (2002), 'Cartel Stability with Multiproduct Firms', *International Journal of Industrial Organization*, 20: 339-352.

Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press.

Verboven, F. (1998), ' Localized Competition, Multimarket Operation, and Collusive Behaviour', *International Economic Review*, 39(2): 371-398.