3rd generation (3G) mobile telecommunication services :Examining the effect of spectrum licence administration procedures on investment, pricing, and the regulatory environment from a national and pan-European perspective.

Mackley, James Richard Keith

James Richard Keith Mackley

Swansea University

2009

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Submitted to the University of Wales in fulfilment of the requirement for the Degree of Doctor of philosophy.

Summary

The European 3G mobile phone spectrum administrations, which took place between 1999 and 2002, used a variety of different methods for allocating licences. The total value of licence fees raised by auctions tended to be significantly higher than those achieved in countries which adopted a 'beauty contest' approach for assessing bidders. Post-administration, many of the licence-winning firms experienced financial distress. There were suggestions at the time that the firms that won licences through auction procedures had suffered a 'winner's curse'. There was a certain amount of support for this proposition; licence winners across Europe delayed the roll-out of 3G network infrastructure and, in a number of cases, handed back their licences or had them revoked. By pooling data across European spectrum administrations, this thesis presents an empirical analysis of how much was paid for licences and who won them. The analysis provides evidence for the proposition that administrators raised considerably higher revenues with auctions than was the case with beauty contests. In addition to this, the analysis also finds that a number of key revenue-raising factors were out of the control of the administering authorities. The second part of this thesis seeks to identify a winner's curse through a comparative event study of the German auction and the Swedish beauty contest. This analysis provides clear support to the proposition that some firms that won licences through auction procedures suffered a winner's curse. The final part of the thesis examines the role of regulation and regulatory bargaining in the mobile telecommunications industry. Through the application of real option theory, it can be shown that a high licence fee can cause delay in network infrastructure investment. A simple two stage Nash bargaining model can then be used to show how this may affect regulatory behaviour.

Declaration/Statements

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STATEMENT 1

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CONTENTS

Acknowledgements

This research was funded by a UWS doctoral studentship award. I owe special thanks to Andrew Henley and James Maw for challenging and encouraging me along the way. Thanks also go to Becky Stuttard, Mark Canies and Geoffrey Myers for their valuable comments and insights.

I am grateful for the support of Ruby and Jim Wiles, Lola, Marion and Bob Wingrove, Gabriele and Hans-Werner Leder, Miriam Story and the Andersons. Special thanks go to my parents, Jackie and Keith Mackley. This thesis would not have been written without the support of Kerstin Leder.

Tables and Figures

Tables

Figures

Abbreviations

1G	Analogue mobile technology	ITU	International Telecommunication Union
2G	Second-generation mobile technology	Kbps	Kilobits per second
2.5G	Intermediate technology between 2G and 3G	MDF	Main Distribution Frame
3G	Third-generation mobile technology	MSC	Mobile Switching Centre
AUC	Authentication Centre	MNO	Mobile Network Operator
BTS	Base Transceiver Station	MVNO	Mobile Virtual Network Operator
CU	Concentrator Unit	NRA	National Regulatory Authority
DJSU	Digital Junction Switching Unit	OMC	Operation and Maintenance Centre
DMSU	Digital Main Switching Unit	PSTN	Public Switching Telephone Network
EDGE	Enhanced data for GSM Evolution	SCP	Service Control Point
EIR	Equipment Identity Register	SIM	Subscriber identity module
ERC	European Radiocommunication Committee	SMS	Short Message Service
EU	European Union	UMTS	Universal mobile telecommunication system
FCC	Federal Communications Commission	VLR	Visitor Location Register
GSM	Global System for Mobile Communications	WAT	Wide Area Tandems
HLR	Home Location Register		
IMSI	International Mobile Station Identity		

Chapter 1: Introduction

1.1: The Beginnings of 3G

At the end of 1999, European Union (EU) countries began the process of administering licences to run the Third Generation (3G) of mobile telecommunication technology. This was in accordance with Decision No. 128/1999/EC of the European Parliament (1999), which laid down January 1st 2000 as the deadline by which European Union countries must have decided on the method of their licence administration and January 1st 2002 as the deadline for commercial services to be in place. At the time the 3G technology was considered to be a considerable improvement over its predecessors, first generation (an analogue service) and the then current second generation (2G), which in Europe was run on the Global System for Mobile Communications (GSM).

The technology that was adopted in Europe to run 3G services is also known as the Universal Mobile Telecommunication System (UMTS), which was one of the standards recommended by the International Telecommunication Union (ITU) as part of the IMT-2000 initiative. Due to the increased speeds offered by the new technology, mobile communication moved away from simply offering calls and basic data transfer to offering a variety of multimedia services and on demand internet access. In order to run these new services an additional portion of radio frequency was required to be assigned to operators. Due to the considerable growth in mobile subscription and the sizable profits that had been made by 2G operators, the spectrum that was to be used for 3G was seen as a scarce resource of considerable value. However, at the same time it was recognised by some countries that the speedy development of 3G services were in their national interest. In attempting to account for these two concerns, and depending on the priorities of the administrating authority, a range of different types of administrations were used across Europe.

The types of administration used can be broadly split into auctions and beauty contests. Both these types of administration varied in how successful they were both in terms of attracting entry, raising funds and administering all their licences. Two procedures that were particularly successful were the German and UK auctions raising €50.8 billion and €37.5 billion respectively Indeed the success of these auctions were acclaimed as a great success for the application of auction theory. Klemperer (2002) in particular gave credit to good auction design for those auctions that raised large sums and blamed bad auction design for the failure of some administrations. The assumption was that the licences had been administered to the bidders that valued them the most and would use them most efficiently. Despite the size of some of the licence fees it was assumed that licence fees would not impact on the post-administration mobile telecommunication market. This was accordance with standard economic theory that a one off lump sum fee will have no impact on the firm's behaviour. However with such high prices being paid headlines began to emerge questioning whether licence winners had paid too much. Headlines such as "2 bad for 3G" (Economist, 2003) and "Pass the Painkillers" (Economist, 2001) led to Klemperer defending his position in the media [Klemperer, 2002c, 2002d and 2002e].

Despite the initial optimism surrounding the 3G technology as licence winners debts began to rise, concerns emerged over the viability of firms in the industry. The level of fees that were being charged began to be blamed directly for the downgrading of some firms credit ratings (Del Monte, 2003). As the remaining licences were administered further concerns were raised as some licences went unadministered and others were sold for very low fees. These concerns continued into the post-administration market as licence winners failed to meet network roll-out targets that had been set in their licensing conditions. In a number of cases this led the regulating authority to reduce the coverage commitment or increase the amount of time that firms had to meet their commitments. As time went on it became clear that in a number of cases these relaxations were not sufficient and licence winners began to either hand back their licences or have them revoked. Those firms that did establish networks used the levels of debt they had incurred as a reason to request relaxations in the regulatory framework that they faced.

1.2: Thesis Structure

It is the method, consequences and response to the 3G licence administration that this thesis is interested in exploring. The particular questions that the thesis wishes to answer are; what factors determined how much was paid for licences and who won them? Is there evidence that too much was paid for the licences? Why was their delay in the roll-out of 3G networks and what evidence is there that the regulators responded to licence winning firms' financial distress through regulatory easing?

In addressing these questions, this thesis can be broadly split into three sections. The first part will focus on what happened in the auctions to run 3G licences. In particular, the development of different methods to administered spectrum and the results of the administration procedures. The second part considers in more detail whether winners of 3G licences paid too much for the licences that they won through auction procedures. The third section examines the regulation of telecommunications with a focus on mobile telecommunications and then goes on to examine whether there is any evidence that the administration of 3G licences impacted on the post-administration industry development and regulation.

1.1.2: Part 1. Who, Why and How Much?

Part 1 consists of Chapters 2, 3 and 4. Chapter 2 discusses the use of different methods to administer spectrum. It outlines the advantages and disadvantages of first-come-first-served, lotteries, beauty contests and actions as methods for administering spectrum. The chapter will give particular focus to the development of the use of auctions to administer spectrum. This description will trace the early auctions in Australia and New Zealand and the relatively successful FCC auctions in the USA. It was the success of these auctions that contributed to auctions being used to administer some of the licences to run 3G services in Europe.

Chapter 3 gives a more detailed examination of the administration of 3G licences in those European countries that administered their licences before 2004. This chapter will describe in detail the method used in each countries administration as well as the difficulties experienced in some administrations. These descriptions will also include some technical detail of each licence procedure. In addition to the detail of what occurred in each administration there will also be a discussion of some of the key post-administration events for each country in particular the circumstances around the hand back of some licences and the ability of firms to meet roll-out conditions. This will include a discussion of the current state of 3G development and network competition in each country. The chapter will attempt to consider those factors that have been suggested as causing some of the difference in licence fees. The chapter will end with a review of some of the reasons that have been put suggested to explain the post-administration behaviour. One element that this chapter will give particular focus to is the way in which both beauty contest and auction countries faced post-administration difficulties and how different countries dealt with them. Indeed, countries that used beauty contest faced a very similar number of licences being handed back as countries that used auction administrations.

Chapter 4 takes the analysis of the licence fees further by presenting an empirical analysis of how much was paid and who won, by pooling data across European spectrum administrations. This analysis tests those factors, whether they are country specific, administration specific or bidder specific variables that affected the size of each bidders observed bid. The chapter is particularly interested in the reasons for the difference in licence fees across countries. There will also be an analysis of those factors that determined which bidders won licences. The administration procedures will be examined as a whole data set with auctions and beauty contests together and before both types of administration are analysed separately. Some key findings from this first section are that some of the most important factors that impacted of the size of the observed bid were out of the control of the administering authority. Although, as expected, the type of administration procedure had a major impact on the bids that were placed within the administrations one of the key factors that affected the size of bids was the timing of the administration. In addition to this, and despite the desire of a number of countries to try and attract entry, being an incumbent was the most important factor in determining which bidders won licences.

1.1.2. Part 2. Was a Winner's Curse Present?

The second part consists of Chapters 5, 6 and 7. These chapters make a closer examination of two particular administrations and whether evidence from stock market reactions can provide support for or against a winner's curse in some 3G administrations. Chapter 5 will focus on the concept of a winner's curse. In particular it will highlight where and how the winner's curse has traditionally been identified. It will discuss why a winner's curse may have existed in some 3G auctions and the evidence that has been discovered thus far that supports or refutes the idea that there was a winner's curse in the 3G auctions. There will be a section that problematises the traditional method of searching for a winner's curse by examining the ex post returns of a licence winner. Chapter 5 will also begin the discussion of the method that this thesis will use to search for a winner's curse the event study.

Chapter 6 will provide an in depth discussion of the development and method behind the event study and the justification for the core assumption that underlies the use of event study. This assumption is that equity markets will price new information correctly and are thus, at least, semi-strong efficient. The reaction of the equity markets can then be used place a value on 3G licences. Attention will be given to the issues that arise with using an event study such as appropriate selection of estimation model and the problems with different types of estimation techniques. Much of this chapter will also focus on the particular problems associated with carrying out an event study on an event such as a licence administration procedure. The chapter will discuss how all these issues will be dealt with in the context of this study.

Chapter 7 reports the results of a comparative event study between two different administration procedures. The German auction and Swedish beauty contest are used for comparison due to their relative value in terms of regional strategic importance and the fact that they used very different methods of administration and raised very different levels of revenue. One important attribute of these two administrations was that both attracted a larger number or participants meaning the final outcomes of the administrations were uncertain. This is particularly important for the results of the event study to be interpreted correctly. The chapter will then also outline some of the particular technical difficulties with carrying out an event study on the German and Swedish procedures. The event study for Sweden and Germany are reported with three different estimation techniques to account for problems that can occur with estimation using ordinary least squares with market data. These results for Germany and Sweden will also be compared to an earlier event study on the UK auction. The broad finding of this comparative event study is that there is certain evidence of a winner's curse in some European administration procedures.

1.1.2: Part 3. Regulation and the Post-administration Environment

After Part 1 has dealt with the determination of licence fees and who won the licences and Part 2 has considered the evidence of overpayment for 3G licences in auction procedures; the next step is to consider the impact that the 3G licensing procedure has had on the post-administration market. Section 3 will move into the area of regulation and post-administration behaviour. The purpose of this section is to try and understand some of the complex relationships that occur between regulator and firm and explain some of the behaviour that was observed in the post-administration market. In order to give some context to the discussion of post-administration regulation Chapter 8 will begin with a discussion of the motivations and broad methods for regulation in the telecommunication and, in particular the mobile telecommunication sector. The chapter will then go onto lay down the regulatory framework that has been established at both a European and a national level, there will also be an examination of documentary evidence that there was regulatory easing at both the European and national level as a result of the 3G licensing procedure.

Chapter 9 will then seek to explain some of the behaviour that was seen in some markets post-administration. In particular it will seek to examine how inefficiencies in credit markets or firms undertaking irrational investment behaviour could bring about delay in infrastructure investment and abandonment of licences. The key finding here is that high licence fees can increase the value of delay to the firm. The consequence of this will be demonstrated through its effect on Rubinstein bargaining weights. The chapter will finish with a discussion of how these financial concepts could be used to explain the post-administration behaviour of regulators, in terms of regulatory easing, through a Nash bargaining mechanism. Chapter 10 will conclude this thesis with a discussion of the main findings of the research. In particular how there can be a conflict between the administrator social goals and revenue raising ability.

Part 1

Chapter 2: Allocating Spectrum Licences

The following three chapters that make up Part 1 examine the development and implementation of different methods of administering the European 3G licences. This chapter outlines the historical context for the development of different method of spectrum licence administration and the decisions that led to a range of methods being used in the administration across Europe. It will begin with a discussion of the theoretical arguments that were developed around spectrum allocation in the early Antipodean administrations and American FCC administrations. It then goes on to address the decisions that led to a number of different type of procedures being used in the European assignments. Finally, the chapter will begin to consider the different factors that determined the size of administered licences. Chapter 3 will go into the details of each administration procedure under consideration and some detail of the post-administration environment. Chapter 4 will examine those factors that affected the size of the licence fees and the probability of each bidding unit winning a licence.

2.1: Methods of Administering Spectrum

Historically, there was little focus on the best way to allocate spectrum to different uses. Demand was limited due to the small number of technologies that required spectrum. This led to spectrum being administered on a first-come-first-served basis. In many cases, particularly within the telecommunication sector, a single monopoly operator was designated by the government. However, with the considerable advances in wireless communication and transmission technologies, spectrum began to be considered a resource of great value. In order to avoid spectrum congestion, and the inevitable interference that would occur, and to ensure efficient and equitable use of the limited spectrum that was available, new methods of spectrum administration were needed. In addition to this, by pricing the spectrum the administering authorities were able to transfer part of the profit that the spectrum holder would earn, to the public purse. The need for a more efficient spectrum allocation method was identified as far back as Coase (1959). With the potential economic benefit of high speed wireless telecommunication it became critical to ensure a fast and efficient distribution of spectrum.

When allocating licences a number of key policy objectives can be identified. The primary aim of these procedures was to administer spectrum quickly and in a way that facilitates the conditions for market competition. After certain criteria have been fulfilled, the administering authority would aim to assign licences to those companies that put the highest value on them and which will use them most efficiently. A further aim, that is not usually explicitly stated, although as will be seen has often been a driving factor, is to raise revenue. Early administrations used differing forms of comparative selection or lottery to allocate spectrum. A breakdown of these administration types can be found in Hazlett (1998).

2.1.1: Lotteries

Lottery systems of administering spectrum are potentially the simplest method available. Those wishing to obtain a licence apply to the administering authority and the licence winner is then selected at random. It is possible that there are some qualification criteria that a bidder must meet to enter the competition but these will not be used to assess the bidders once they have qualified. The main advantage that lotteries have over other forms of administration is their speed and ease of use. With lotteries, very little time needs to be spent designing and assessing the procedure or the criteria used to assign the licences. Although the lottery system allocates licences quickly and cheaply, they are not necessarily the most efficient method of administration. There is little control over who will win a licence or what plans they have for the licences. It also presents the possibility that some firms will apply for licences not to win them, but to sell them on and acquire the revenue that could have gone to the licensing authority.

2.1.2: Beauty Contests

An alternative to the use of lotteries are comparative selection procedures also known as 'beauty contests'.[1] The use of beauty contests allows much greater control over who receives the licence and how it is used. The bidders that wish to obtain a licence submit a proposal to the administering authority. The licensing authority lays down certain

[1] An analysis of the benefits and costs of using beauty contests when compared to auctions can be found in OECD (2001).

conditions for the use of the licences and will select the winner on their proposal to fulfil these conditions. Although lottery winners could also have legal obligations placed on them, the beauty contest forces bidders to show how they will fulfil these conditions. The conditions usually include guarantees on the timeframe for the start of service provision, the level of geographical coverage, quality of service commitments and future financial viability through a business plan. The administering authority may or may not make the judgement criteria available before the proposals are judged. Even if the criteria are made available before proposals are submitted, the exact weightings of each criterion may not be.

In addition to these proposals, the administering authority may also charge a fee. This may be a small fee that just covers the costs of running the administration procedure or may be a much larger fee if they wish to extract some surplus from the firms. Depending on the size of this fee, there may also be a predefined payment schedule. Ideally, the beauty contest enables the licensing authority to achieve certain policy goals and ensure that the licenses will be used by the winner.

Although this strict command and control system has clear advantages over the use of lotteries it can be criticised from a number of perspectives. Clearly, judging the bidders' proposals is problematic and enforcing those claims made in them equally difficult. The licensing authority relies on the firm providing accurate information on their business plan and ability to meet quality commitments. If the bidders believe that the administering authority will take their claims at face value then a beauty contest could be considered to be a form of first price sealed bid auction. Instead of bidders making monetary bids, they bid through the commitments made in the bidders' proposal. Depending on the exact nature of these criteria there may be considerable difficulties in monitoring compliance. The question of regulatory action in the case of non-compliance may also be problematic. This will be particularly true if information on non-compliance action has not been explicitly laid down in the licence conditions. Even if non-compliance is identifiable once a licence has been administered it is possible that no action will be taken. Charging a fee also poses a problem in beauty contests. The administering authority will only have a general idea of how much the licences are worth. If the administrator charges too much then no firms will enter the contest, charge too little and they are depriving the public purse in favour of operating companies. Some administering authorities seek to avert the problem of mis-valuing the licences by charging a fee ex post. This option was usually conducted by charging a proportion of revenue or growth of traffic. However, this has the possibility of an impact on pricing and firm behaviour in the post-administration market that will not be present with a lump sum ex ante charge. A further draw back with beauty contests, particularly when compared to lotteries, is that organisation, submission and evaluation of a beauty contest can be quite a long, drawn out, and expensive procedure. The licensing authority would need time to analyse and grade submissions. It may also mean that the licensing authority will have to make decisions on technology that is still developing or risk delaying the introduction of technologies that were ready for service. If the administrator does not reveal ex ante the exact way in which submissions will be judged there is a danger that the process lacks transparency. This may be a particular problem when an industry engages in considerable lobbying and there is a suspicion of regulatory capture.

2.1.3 : **Auctions**

Auctioning spectrum licences has advantages over both comparative selection and lottery administrations. At a superficial level, simple auctions are quicker and easier to organise than beauty contests. In practice however, this is not always the case. As shall be discussed, a failure to anticipate the effect of certain auction design decisions can have a considerable impact on the outcome of an auction. Auctions are also not necessarily administratively light. Some spectrum auctions started with a form of beauty contest before bidders were able to enter the auction phase. Even if there was not an explicit beauty contest phase there was always some qualifying criteria, although these are often relatively simple. Even with these added complications, the FCC still estimated that using an auction can be up to six times cheaper than a beauty contest procedure (McMillan, 1995). Depending on the particular procedure, an auction should have a greater level of transparency. The winner of the administration should be easily identified as it will be the bidder which paid the most. This may be less true where sealed bid auctions are used and the bids that were placed are not made public.

Auctions, when carefully designed, are preferred to both lotteries and beauty contests on efficiency grounds (OECD, 2002). An auction should administer the licence to the bidder that values it most highly and, in turn, cause the bidder to reveal their willingness to pay for a licence. This will be the case as long as we are happy to assume that the bidder knows better than the administering authority how valuable the licence is to them. Those bidders who were best placed to deploy a network quickly and most profitably would value licences more highly and therefore enjoy a high probability of bidding successfully. As long as there is sufficient entry, and collusion is prevented, the administering authority should be able to maximise the revenue that they receive for the licences. However, if there is collusion present or entry has been deterred, and no reserve price has been set, the licences may sell for considerably less than their potential When bidders place bids they reveal information to the administering authority. This is an improvement on the administering authority having to request and trust the information that they are given. However, if by using an auction there is overpayment for licences and this has consequences for the post-administration industry then we may question the claim that auctions are more efficient. This will be particularly the case if this leads to post-administration regulatory easing.

2.1.3.1: A Brief Description of Auction Characteristics

Within the auction literature and throughout this and the next chapter a number of different types of auction will be referred to. This section will give a non-technical overview of the most common types which were used in spectrum administration. For a thorough review of types of auctions see Klemperer (1999, 2002a). There are three broad classifications that we can use for auctions; open or closed, ascending or descending and first price or second price. For instance, a second-price open ascending auction would involve the seller starting with a price and bidders bidding ever higher prices until the point at which there are no bidders left. At this point, the winning bidder will pay a price that is equivalent to the valuation of the second highest bidder. This is a well known type of auction refereed to as an English auction. It is referred to as a second price auction as it is equivalent to a closed (sealed bid) auction where the winner pays the price bid by the second highest bidder. The other commonly used auction type is the Dutch auction. The Dutch auction is a first-price open descending auction. This involves the seller starting with a price then gradually reducing this price until a bidder declares that they wish to buy. This is referred to as a first price auction as it is equivalent to a sealed bid auction where the winner pays their bid (Vickrey 1962, 1976). This will be an incremental price above the value of the second highest bidder's willingness to pay. Under the revenue equivalence theorem, these two prices will be equivalent as they will depend on the expectation of the second highest private valuation. The revenue equivalence theorem refers to auctions for goods with private values, not those with common values. Spectrum licences will clearly contain a private value portion but will also have a common value element. Due to this common value element revenue equivalence no-longer holds due to the potential for a winner's curse. Assuming that the bidders are aware of the winner's curse they will bid more cautiously for fear of paying too much. In this case those types of auction that reveal the most information about other bidders' valuations will raise the most revenue as they will reduce the risk to bidders of suffering a winner's curse. The winner's curse comes about in a common value auction where the value of the asset that is being auctioned has an uncertain value. As long as each bidder's estimate is conditionally independent and identically distributed then the mean of the estimates will be the true value. However, the bidder that wins the auction will not be the bidder with the mean estimate but rather the one with the highest. This will mean that the winning bidder will have overpaid for the asset. The threat of a winner's curse encourages the administrator to use open ascending auctions. A more in depth discussion of the existence and consequences of a winner's curse is provided in Chapter 5.

In addition to the standard auction types, another important characteristic which was used by all the 3G licence auctions is simultaneous multi-unit administration. A simultaneous multi-unit auction involves selling all the licences at the same time. One other specific detail is what was actually being auctioned. It most cases the licences were predefined not only in terms of size but also where on the frequency table they were located. However in two cases, Austria and Germany, the auction was set up in such a way that the bidders would be able to determine the number and size of these licences. The firms are able to decrease the number of operators in the post-administration industry by paying more for the licences. The bidding firms will know better than the licensing authority how much they value one less operator in the market and can bid accordingly. One peculiarity of this type of administration is that bidders were not given an indication, nor were able to influence, the position on the frequency band that they were actually buying. More detail on these two auctions is given in Chapter 3.

2.2: Development of Spectrum Auctions.

Although auction literature had been around for some time, with early works by Vickrey (1961) and Wilson (1969) paving the way for future development, and even the idea of using auctions to distribute spectrum licences in Coase (1959), the practical use of auctions in spectrum allocation is a relatively recent phenomenon. The earliest spectrum auctions were carried out in New Zealand and Australia in the late 1980s and early 1990s. The use of spectrum auctions really came of age when the Federal Communication Commission (FCC) began to use auctions in 1994. Before the development of these auctions different forms of beauty contests and lotteries had been used. McMillan (1994), who was involved in the FCC design process, gives an overview of the decisions that were taken in order to develop what was to become a framework for many of the later spectrum auctions including the 3G auction.

McMillan recounts how the first stage was to learn from the early spectrum auctions in New Zealand and Australia. The New Zealand spectrum auction, for various cellular and television licences, used a second price sealed bid auction. As was reported by Mueller (1993), where there were small numbers of bidders with one valuing the licence particularly highly, the undesirable situation arose where the winning bidder paid considerably less than they bid and they were willing to pay. The situation was exacerbated by no reserve price being set in the auction. This meant that when there were only a few bidders, as was often the case in New Zealand, the revenue was far lower than expected. In an attempt to overcome these problems the Australian Government used a first price sealed bid auction. When the auction ended the winners refused to pay their bid. The Australian NRA had not insisted on a penalty for withdrawal or any restriction on submitting multiple bids. This led to the winners placing multiple bids which incrementally decreased and then reneged on all but the lowest bid. Winning bidders then paid considerable less than their highest bids. These two experiences were carefully considered when forming the FCC rules.

2.2.1: The FCC Auctions

A primary decision for the FCC was whether to use a sealed bid as with the Australian and New Zealand auction, or an open auction. The sealed bid auction has several advantages over open auctions. Riley and Samuelson (1981) showed that when bidders are risk averse the sealed bid auction will raise greater revenues and Milgrom (1987) found that bidder collusion would be considerable reduces if sealed bids are used. The major advantage that the open auction has is that it reduced the chance of the winner's curse, as first suggested by Capen, Clapp and Campbell (1971). If the winner's curse is present and the bidders are unaware of this then they may overpay and the industry is unstable. If bidders are aware of the winner's curse then they will adjust their bids downwards. A full discussion on the winner's curse and its particular importance in the 3G administration will be discussed in Chapter 5. To avoid this, the auctioneer must provide as much information about the asset being sold and the auctioning process. As such, an auction that is open and provides information about bidders and bids will minimise the chance of a winner's curse and the probability that winners will be overly cautious in downgrading their bids. McMillan reveals that the FCC felt that the risk of a winner's curse was greater than that of collusion, so they decided on an open auction.

After the decision to use an open auction the next issue faced by the FCC was whether to use a simultaneous or a sequential auction. From an administrative point of view it is easier to use a sequential auction to sell multiple assets. A simultaneous auction allows bidders to use information gathered during the bidding process to value the licences and change the combinations of licences they bid on as each bidding strategies became evident. As Pitchik and Schotter (1988) discuss, using a simultaneous auction will reduce the chance of predatory behaviour, with firms forcing the price up in early auctions so that the winners cannot afford to take part in later ones.

A further area of contention was whether to allow combinational bids. Clearly, as was discussed by Cassady (1967), the only reason to have combinational bids is if there are synergies associated with owning multiple licences. This is certainly the case for spectrum licences. Being able to operate regionally or nationally will bring clear economies of scale and having neighbouring licences will bring technical benefits. The use of combinational bids brings problems of their own. Palfrey (1983) and later Bykowsky, et al. (2000), Milgrom (2000) consider the possibility that combinational bids would lead to assets not going to the individual that valued them the most. They were particularly concerned with the threshold problem, which is a variant of the free-rider problem. Let us suppose we have two assets and three bidders. The first bidder only puts a value on the two items together. The other two bidders place a value on either individual asset and their combined value is greater than the value of the first bidder. The two bidders may place bids below their maximum, which is then topped by the package bid. Each bidder may then wait, hoping the other will increase their bid in order beat the package bid. If neither does then the first bidder will win. A further issue is the uncertainty about the correct level of combination bid. If all possible combinations are allowed, then a large auction would become extremely complicated. Rothkopf, et al. (1998), suggested ways of limiting the number of combinations but it is almost impossible to know what the efficient combinations would be. Due to these concerns, the FCC decided not to use combinational bids in their original auctions.

Several other implementation decisions that the FCC made are outlined by Cramton (2001). These included introducing a spectrum cap limiting the amount of spectrum an individual firm could hold in order to promote competition, the introduction of a deposit that was proportional to the size of the licence and the population that it covered, and allowing special terms for 'designated entities' such as discounts and relaxed instalment payment terms; minimum bids and activity rules to keep the auction rounds going; and finally, a withdrawal charge to avoid the Australian experience. This meant that if a winning bidder withdrew they would be liable for the difference between the final selling price and their bid. There would be an extra charge of 3 percent of the final sale price if they withdrew after the end of the auction.

Although the FCC auctions were generally considered a success, Scanlan (2001) gives an overview of some of the widely reported problems and how they were overcome. A major criticism came when an instalment process was introduced in the C block spectrum auction. Using instalment payments presented two problems; some of the risk of market information correction was shifted onto the seller, and the property rights surrounding the licences were less clear. It many ways winning a licence could instead be considered an option to buy a licence rather than a licence itself. To avoid the risk of winners not taking up their licences, the payment level at the end of the auction needed to be large enough to avoid the desire to treat the licence as an option. Also, the amount of time that was allowed to elapse between instalments needed to be kept to a minimum. The C block auction only required a 5 percent down payment on the licence price. After the C block auction, there was a substantial fall in the stock prices and credit ratings of winning companies. This led to some winning bidders not being able to raise the required level of capital to pay the balance on their licences. These licences then had to be revoked and readministered. Although the readministration raised lower fees than the original administration, it may not be correct to say they were underpriced as the original auction bids were inflated by the nature of the instalment process.

The exact nature of licence property rights became an issue when certain firms declared bankruptcy. Under US bankruptcy law, the ownership of the licences passed to the courts. This led to a long delay in readministration and network rollout as ownership was disputed. If instalments had not been used then it would have removed this part of the option element. There would have still been an option in the licence, but this would have been an option to develop the services rather than buy a licence. The more important issue was to make sure the ownership of property rights was made clear. In the end the FCC offered a number of debt forgiveness and return of licence options.

2.3: On to the 3G administration

The year 1999 saw the beginning of the process of administering the sale of additional radio spectrum for the purpose of developing third generation (3G) mobile phone services. In accordance with directive No 128/1999/EC of the European Parliament, within the European Union the date of 1st January 2000 was set as the point by which governments in member states should have chosen the process through which licences would be administered. The directive required that the process of licence administration would be completed by 1st January 2002. So between 1999 and 2002, Europe witnessed a rapid succession of licence administration processes across individual nation states.

Despite the success of the FCC auctions, the advice from the European Commission seemed to favour using at least some level of beauty contest procedure; "licences should be granted on the basis of objective, non-discriminatory, detailed and proportionate criteria, regardless of whether or not individual applicants for licences are existing operators of other systems" [Decision No 128/1999/EC (11)] and seemed to be cautious over licence pricing: "...any spectrum pricing method should not adversely impact on the competitive structure of the market, and respect the public interest, while ensuring efficient use of the spectrum as a valuable resource"[Decision No 128/1999/EC(18)]. Strong arguments were voiced at the time in favour of the use of "beauty contests". It was considered undesirable for regulators or governments to lose their discretion in the administration process. In an earlier Green Paper the European Commission (1994) expressed concern that high licence prices would affect the size of tariffs charged to consumers. This view is surprising since it ignores the prediction that a profit-maximising firm will price on the basis of its marginal cost, which would be unaffected by the sunk costs of a licence fee. There was concern that high licence fees would delay network roll-out. Because of the existence of significant wider network externalities, the full aggregate economic value of a well developed 3G infrastructure would be reduced. This again seems a strange logic. If it is profitable for a firm to create a network, this would be the case whether they were charged a fee or not. However, network investment would be affected by high licence fees if capital market frictions reduced the ability of more heavily indebted telecoms operators to borrow further for network investment. However the European Commission's views were only advisory and the final choice of licence administration method was left to the discretion of the individual member-states. However the final decision surrounding the exact nature of the design of the administration process was left in the hands of the national governments.

Clearly there was an incentive for countries to use an auction both to raise revenue but, even after having seen the success of the FCC auctions, a number countries still preferred to use comparative selection processes. The first EU member to allocate 3G spectrum was Finland, who followed European Commission advice by using a comparative selection process. The subsequent success of the UK authorities in raising €38bn through the auction of five 3G licences in April 2000 resulted in a shift in opinion towards the use of auctions. The UK adopted a simultaneous multi-unit ascending auction design. Bidders were able to bid for all five licenses at the same time.

However, the design of subsequent auctions varied considerably. Possibly the most complex design was that used by Germany and Austria. They auctioned undefined blocks of spectrum rather than licences. Blocks could be assembled to create licences to use spectrum segments of varying width. The consequence of this was that the bidding process could determine the final number of licence holders, within the range 4 to 6. All auctions except that in Denmark used an ascending format. Denmark used a fourth price sealed bid auction to allocate four individual licences. Even where auction methods were similar, final outcomes revealed considerable variation in the range of licence fees per capita of population paid.

2.3.1: Differences between licences.

Klemperer (2002a) gives an overview of the main European 3G licence auctions and the next chapter will give a thorough overview of all procedures. At the time these auctions began it was widely believed that the licences should have a similar per capita value.

However, the final results saw a large variation in the revenue raised. The design of the 3G auctions relied heavily upon the experiences learnt in the FCC auctions. Although these auctions were inspired by the FCC auctions there were some quite significant variations across different countries in terms of the number, type, and way licences were auctions.

The most successful of the auctions, in terms of funds raised, were in the German and UK cases raising €50.8 billion and €38 billion respectively. Among the worst performers were Denmark and Switzerland €510 million and €132 million respectively. Klemperer put the success of the auctions down to two factors, the ability to attract entry by competing firms and to prevent collusion between them, with the countries that raised the highest revenue achieving both of these goals[2]. Consequently the auctions that did achieve these goals led to the most efficient outcomes.

Despite the fact that Germany and the UK raised very similar sums, their auction designs were quite different. These auction designs are outlined in detail by Binmore and Klemperer (2002) for the UK auction and Grimm, Riedel and Wolfsetter (2001) for the German auction, with both sets of authors being involved in their own country's auctions process. Due to the authors' involvement in the design of the administrations they do give somewhat tendentious commentaries with little effort to identify weaknesses in their own design.

The UK auction was a relatively simple ascending auction whereas the Germans went for a more complex auction, with an uncertain number of licences between 4 and 6 depending on the conclusion of the ascending auction. Despite there being some disagreement over the best design for the auction both sets of authors prefer an auction over a beauty contest which they see as an inferior alternative. Binmore and Klemperer's paper gives a clear explanation of the merits of the UK ascending auction over a beauty

[2] Although in the German case Klemperer seemed to be suggesting this was achieved through luck rather than good auction design.

contest and the subsequent efficient outcomes. A complete discussion of how these administrations were carried out can be found in chapter 3.

2.4: The Size and Distribution of Revenues

With such high prices being paid in some of the auctions and the subsequent decrease in stock prices, claims in the press began to suggest that due to the nature of the auctions too high a price was paid for the licenses with headlines such as "2 bad for 3G"[3] and "A reason to celebrate may be hard to find"[4] leading Klemperer to publicly defend his position in the media (Klemperer, 2002d, 2002e, 2002f). Criticisms came from other academics, with John Ure of The Telecommunications Project being highly critical of the assumptions made by the UK and German auction designers, see Ure (2002, 2003a). Particular criticism of the German design came from Ewerhart and Moldovanu (2002) who identified the flexible design as potentially damaging to the consumer by allowing incumbents to fight entrants directly. By bidding more aggressively, bidders could reduce the number of licences from 6 to 4. Bidders did bid aggressively, although the final outcome saw the auction ended with 6 licences. If the bidders had not bid so aggressively and had stopped bidding when the final bidder dropped out they could have effectively paid €20 bn less for the licences.

The suggestion then, is that those companies that won the auction were in fact made worse off by winning the auction. This idea was reinforced when reports began to emerge that Standard & Poor, as well as other credit ratings agencies, had launched reviews of some of the winning firms' credit ratings.[5] There was a danger at the time that the European 3G auctions might become somewhat of a scapegoat for the woes of the telecommunication industry. This led to exaggerated claims such as in Ure (2003a) who, when referring to restructuring debt brought about by 3G, quotes an article in the Financial Times[6] as the true loss to the world wide economy being $1000 bn. Although this article did include the 3G licensing process, other major considerations such as over investment in fibre optics were also a major contributing factor. Yet the very idea that

[3] Economist (2003).
[4] Financial Times (2000).
[5] In fact four days after the end of the German auction S&P downgraded BT to an A rating.
[6] Roberts (2001).

the bidding companies paid too much is curious. As Binmore (2001) put it "nobody but a fool bids more in an auction than he thinks the licence is worth". However, it is the very fact that the bidder pays what he "thinks" the licence is worth when the licence value is uncertain that means the winner's curse can be brought about. The issue of a winner's curse will be one to which we return in Chapter 5.

As has been discussed, although a large amount of revenue was raised in the 3G administrations, this revenue was not equally distributed. This is especially problematic with the integrated European telecoms market. As telecoms operators attempted to build pan-European or regional European networks, the possibility has arisen that some countries have extracted large rents from winning bidders at the expense of other countries' regulatory stance and 3G network development. It then becomes important to determine those factors that influenced the size of the licence fees.

2.4.1: **Theoretically important factors**

A major factor in determining the size of the licence fees is likely to have been the method of licence administration. In general auctions fared considerable better in raising revenue than comparative selection processes. Mean per capita cost of an auctioned licence was almost four times greater than the mean of those paid by winners of beauty contest procedures (Table 3.1). Indeed when France attempted to charge comparable prices to those achieved in the UK and German auctions, this led to failure, with only two out of the four available licences receiving bids. However, even within the auction and beauty contest groups large variation is apparent.

Those factors that an administering authority may consider when they determine the fee for a licence in a comparative selection process may be different from those which would determine the willingness to pay of a bidder in an auction. There are certain factors that we may expect to cause differences in licence fees. For instance the size of the potential market may be expected to influence the size of the licence fee. This in turn may be related to income levels (GDP per capita) in the economy in question or current preference for mobile telephony as captured by existing mobile market penetration. However, within the western European countries under present consideration the variation across countries in these market specific factors is not particularly large. Section 2.2 highlights many of the past experiences and decisions that were taken in order to try and maximise the revenue received through an auction, however Klemperer (2002b, 2002c) states that, within those countries that used auctions, the most important factors in setting licence fees were the prevention of collusion, the encouragement of entry and the deterrence of predatory behaviour. Klemperer also suggests that other than providing insights on how to meet these requirements, the literature on auction theory was of little use for informing practical auction design.

Ascending auctions are also particularly susceptible to the problem of entry deterrence. This will be a particular problem in the 3G auctions where there are a number incumbents operating. It is not unreasonable to expect that incumbents might place a higher value on a licence than entrants. Other bidders will be aware of this and, if there are any associated costs of bidding, will have no incentive to enter the bidding process. Related to this problem is the issue of the winner's curse. Because these licences are only partial common value auctions, weaker bidders will be especially nervous. If they did win a licence then they would have done so by considerably overestimating the value of the licence. This will cause the weaker firms either not to bid or to be much more cautious in their bidding enabling the incumbent to win at a much lower price. Indeed, the incumbent may make it clear that they will bid very aggressively so guaranteeing a winner's curse to any weaker bidder that outbid them. This may have been done through advertising the fact or bidding very aggressively in early auctions with the hope of discouraging bidders in later auctions. This will be particularly a problem, as identified by Bikhchandani (1988), when the licences are complementary to licences sold at a later point. This could certainly be considered the case if a bidder is attempting to build a pan-European network. Indeed the very high fees paid for the early licences may have been an attempt to do just this.

Klemperer identified other potential problems linked to collusion and entry deterrence that might depress the size of the licence price. If we consider the possibility that collusion or entry deterrent behaviour has taken place then it is essential to protect the auction with an appropriate reserve price. Klemperer identifies the Swiss auction as a particular example of an administration where the reserve price was set far too low. In this case the government expected to raise 20 times the reserve price. Klemperer suggests that setting such a low reserve increased the attractiveness of collusion as bidders saw the possibility of getting a licence for a very low price. The risk of collusion has to be set against risk of not attracting enough bidders when the reserve price is set too high. Not attracting enough bidders to sell all the licences will be in effect a failure of the auction. This is the same problem faced by a country running a beauty contest but charging a very high fee. As was seen with France, when the price was set too high the administration was only able to sell two out of four licences. The political damage that a failed auction may cause provides considerable incentive to use a low reserve price. There is however a large potential range for a reserve price to ensure that it is low enough to guarantee that the licences are sold and high enough to discourage collusion. Once a reserve price has been set it must be enforced. For example in France, when they were unable to sell their licences at the original price, they then lowered the price and re-administered the remaining two licences. By doing this they effectively undermine the credibility of their price setting. There is a danger that bidders will not bid if there is a high price when they know the regulator will drop the price at a later date. This does of course present the administrating authority with the problem of what to do with any remaining licences if they wish to maintain credibility. The focus for the administering authority must be to set the correct reserve price.

Even if the design of the auction is able to prevent collusion the auction must have clear and credible rules. Due to the uncertainty around the technology and future market structure it can be difficult to lay down the precise regulatory regime in advance of selling the licences. Despite the problems seen in earlier FCC auctions many countries still left loopholes. When it became clear in the Italian auction that they were only going to raise a fraction of the expected licence fee they attempted to change the rules. The bidding firms objected to this and under the threat of legal action the Italian regulator caved in and ran the auction as originally stated. In many of the 3G administrations procedures the future regulatory regime was not clearly laid out. This varied between it not being clear what rights new entrants would have to roam on incumbents' existing 2G infrastructure, to the ability of licence holders to sell spectrum wholesale to a Mobile Virtual Network Operator (MVNO). Indeed if we take the case of Germany, because they were unable to define what MVNOs are, there was no mention of them in the licence agreements. Even when there were clear licence arrangements made, these were not always enforced post-auction. In several 3G administration procedures, the roll-out conditions were relaxed post auction when it became clear that some of the licence owners would not be able to meet them.

Although Klemperer was keen to ascribe the differences in licence fees to the design of auctions this may have been an overly simplistic view of the administrations. The importance of other factors as opposed to auction theory was raised by Melody (2001) and Van Damme (2002). As Kruse (2004) put it when discussing the position of auction theory in causing the differential in licence fees; "Industry-specific, time-specific, country-specific, or other real world factors may be even more relevant*"*[7]

2.4.2: Other Empirical Studies

There has only been a limited examination of the factors that influenced these licence fees. The European Commission commissioned McKinsey and Co to assess the relative success of the various spectrum assignment processes (European Commission 2002a). They identified three key ex ante sets of factors that may have affected the size of the licence fee. The first was the impact of the timing of the licence administration. Because of market conditions surrounding the mobile telecommunications sector at that time and the initially positive outlook for 3G technology, those countries that administered their licences first gained higher licences fees. Those who administered once the dotcom boom had ended may have fared worse. The second factor was the ability of a particular licensing authority to attract new entrants to join the bidding process. With a higher

[7] P. 199

number of potential entrants it may have been perceived that the 3G market in that country would be more competitive, and hence willingness to pay would be lower. McKinsey and Co's third set of factors concerned the specific characteristics of the award process. Auctions were expected to have produced, other things equal, higher licence fees. However the report finds little evidence that other characteristics of administration process had any significant impact on the size of licence fees. For example, the report finds no correlation between licence duration and the size of the licence fee. The study also examined the type of bidders that were successful. It is claimed that auctions favoured international operators, whereas comparative selection processes favoured incumbent national 2G operators. However, who constitutes an international operator is open to debate. The McKinsey and Co study in essence comprises a descriptive analysis of secondary data from the administration process. It is also limited to the extent that it focuses solely on licence administration within (then) EU member states, ignoring the experience of other neighbouring western European nations.

Less attention has been given in the literature to factors which may have affected the size of licence fees paid under comparative selection processes. The size of licence fees in beauty contests is determined by the licensing authority and may depend on specific policy objectives. If an administering authority believes a lower fee will improve roll-out speed then they may price to achieve this. These policy decisions are by their nature very difficult to measure, and particularly so as they were not always made explicit. However all licensing authorities will be aware that radio spectrum is a valuable public resource. We may expect country specific factors such as GDP per capita and mobile penetration to have been of greater importance for the beauty contests.

This chapter has outlined the development of spectrum administration and in particular the use of auctions. It then goes on to discuss the decisions that brought about the administrations in the European 3G procedure. The key question that arises from this chapter is what were and how important were different factors in determining the size of 3G licence fees. Chapter 3 continues to address this question as it gives a detailed description of how each country involved in the European 3G administration assigned their licences and the consequences of licence fees post-administration. In particular, Chapter 3 will demonstrate how the level of licence fees caused the failure, in the medium term, to attract entry into the European mobile telecommunications market. Finally, this section will attempt to quantify these effects in Chapter 4 through a cross-country empirical evaluation of the administration procedures.

Chapter 3: A review of the European licence administration process and the post-administration market.

The previous chapter gave a broad outline of different types of spectrum administration and how they were used in the European 3G administration and some of the problems faced. This chapter will give considerably more detail on how each of the administrations were conducted and some of the particular problems that were faced post-administration. The last chapter discussed the inability to attract entry as a problem both in terms of raising revenue in an auction and encouraging post-administration competition. This chapter will build on this theme and see how problems in the post-administration market had a direct effect on the level of competition in the new 3G market.

3.1: Problems in the European Procedures

The objectives of countries administering spectrum were broadly the same, although not always explicitly stated. However, these goals universally included the development of a sustainable, competitive 3G mobile telephone industry. After the success of the GSM standard during the 1990s a more hands on approach was taken with the formation of the 3G industry. In each country a 'big bang' approach was used to administer licences. This meant that multiple licences were awarded in one go rather than awarding licences over a period of time, and often on a first come first served basis, as was done during the development of 1st and 2nd generation mobile telecommunication. There was also a degree of organisation across Europe with a timeframe being put in place for when licences must be administered and when services should begin. This led to Gruber (2005) referring to the administration of licences as caused by regulatory push rather than demand pull. Administrations occurred when they did and in the way they did because it was politically desirable but not necessarily economically viable.

The administration process across Europe led to considerably different outcomes from country to country, in terms of funds raised and final market structure. Indeed the exact market structure is still fluid with returned and unadministered licences still being offered for sale. This section will review the results of the administration and significant post-administration developments in pre-2004 EU countries including Switzerland and Norway. Particular attention will be given to regulatory success, or lack of it, in encouraging entry and the handling of post-administration difficulties. The chapter looks at Europe as a whole and by necessity can not go into all the nuances of sector specific regulation for each country. Chapter 8 provides a case study of the post-administration regulatory environment in the UK and how sector specific regulation has developed in the shadow of the 3G licensing procedure.

There were a number of factors that influenced the success of the initial series of licence administrations, many of which were outlined in the previous chapter. Market expectations changed over time with sentiment deteriorating during the administration process. Apart from this, the characteristic of the award process, the number of licences, and the coverage obligations also played a factor. How these factors affected the administration outcome will be explored further in Chapter 4. When discussing these administration processes we can broadly split them into those that used auctions and those that used beauty contests. However, many procedures used a combination of the two. Indeed it could be said that all procedures had a certain beauty contest element as they all had qualification criteria for bidders. In the description of the procedures, auctions will be reviewed first and then beauty contests, both placed in chronological order. An abbreviated version of the information in the following two sections can be found in Table 3.1 and Table 3.2, which contain a summary of information on industry structure for auction and beauty contest procedures. They contain details on the licences that were offered, which bidder won them, when they launched their network and which firms own them now.[1]

[1] For other descriptions of the auction administration procedures see Curwen (2002) for a general discussion, Klemperer (2001) for a focus on auction administrations and European Commission (2002) for a focus on the European impact.

3.2: Auction Procedures

3.2.1: United Kingdom

The UK 3G administration was the first auction for 3G spectrum to take place world wide and, as will be seen, the result shaped the future of European mobile telecommunication. There was in total 60MHz of paired and 20MHz of unpaired spectrum available. It was decided to split this spectrum into 5 licences. The largest was licence A made up of 15 MHz paired and 5 MHz unpaired spectrum.[2] Licence B was made up of 15MHz paired spectrum and licences C, D and E all contained 10MHz paired and 5MHz unpaired. The auction took a standard simultaneous multiple round form, with the exception that the licence A was reserved for a new entrant. This measure was taken in an attempt to encourage entry.

At the time the auction was carried out the telecommunication sector was on the crest of a wave. Expectations were very positive for the future of 3G services. In addition to this, the UK had encouraged entry with an entrant only licence leading to a large number of bidders. In addition to the incumbent, the four incumbent bidders were Vodafone, BT3G, One2One Personal (now T-mobile owned by Deutsche Telekom) and Orange 3G. The entrant companies were Crescent Wireless, Epsilon Tele.com, NTL Mobile (part backed by France Telecom), SpectrumCo (controlled by Sonera), TIW UMTS (with strong links to Hutchison Whampoa), Telefonica UK and WorldCom Wireless. An issue arose when Vodafone took over the German mobile operator Mannesmann. Mannesmann were the owners of Orange but as Vodafone had made it clear that they wished to divest Orange after the auction it was decided to go ahead as planned. This left the auction with 13 bidders.

The auction lasted 150 rounds and 39 days raising a total of £22.5bn (€38.4bn). At the time this was considerably higher than expected. The four incumbent GSM operators all won licences with the larger B licence being won by Vodafone. Vodafone paid a

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[2] When spectrum is allocated it is done so as paired or unpaired. Paired spectrum contains a portion of spectrum from an upper band and a portion of spectrum from a lower band. See appendix for a full description of the 3G technology.

premium of almost £2bn over the three smaller licences. The entrants licence was won by the Hutchison backed TIW UMTS. Soon after the end of the administration Hutchison took sole control of TIW. Hutchison posed an interesting issue as a question arose as to whether they should be able to bid for the entrant licence. The 2G incumbent Orange was formed and run by Hutchison. Orange was sold to Mannesmann in November 1999, shortly before the announcement that the UK would give preferential treatment to a new entrant. Hutchison was not allowed to bid directly due to its previous status but still gained the entrant licence through TIW. The fact that Hutchison 3G was the first 3G network to go live, in March 2003, suggests it was acting strategically in order to obtain the best licence. Vodafone followed with its network launch in April 2004 and then Orange in July 2004. The two other operators' networks went live in 2005, O2 in February and T-Mobile in October. Currently the UK has five 3G network operators; one more then they had 2G incumbents. The UK had relatively light roll-out obligations with 80 percent of the population needing to be covered by the end of 2007. Four operators met this deadline easily; however O2 missed the target with only 75.7 percent coverage. Ofcom extended the deadline by which this target must be met until June 2008. A complete analysis of the UK post-administration market and regulatory behaviour is given in the case study in Chapter 8.

3.2.2: **Netherlands**

The Dutch auction was the second to take place in Europe, and as in the UK auction a simultaneous multi-round auction was used. There were 5 licences auctioned. Licences A and B contained 15MHz paired spectrum and 5MHz unpaired. Licences C, D and E contained 10MHz paired and 5MHz unpaired spectrum. Unlike the UK auction no licences were set aside for an entrant. As there were five existing incumbent 2G operators the end result was somewhat of a certainty. A further problem faced by the auction designers was that Dutch telecommunication law forced the government to always allocate the whole amount of spectrum. This meant that they had to aim to allocate all the spectrum at the first attempt. As such, they were forced to start with a very low minimum opening price, indeed with the potential for the opening price to be zero. This, as discussed in Chapter 1, had the potential to seriously and negatively affect the size of the licence fees.

Despite the potential for problems in attracting entry that the Dutch auction design presented, at first they appeared to be quite successful. The deadline for signalling intent to bid was on June 5th and, at this time, there were a potential 10 bidders. However, after a succession of mergers and dropouts by the time the auction began on July 6th there were only six bidders remaining. Of these six there were the five incumbents KPN, Libertel (majority owned by Vodafone), Ben which had been recently bought by Deutsche Telekom, Dutchtone (controlled by France Telecom), and Telfort (controlled by BT) and one entrant company. The entrant Versatel did not have a large backer and it was suggested, even by the company themselves, that the only reason they were bidding was to force one of the incumbents to allow them to operate as an MVNO on a licence winner's network. The auction ended on July 24th after 306 rounds. The end of the auction was brought about when on July 21st Telfort's lawyers sent a letter to Versatel stating that as Versatel's only aim was to gain concessions from other participants this constituted a tort against Telfort and they would hold Versatel liable for any damages. Versatel complained to the regulator who dismissed their complaint. This led to Versatel withdrawing from the auction a couple of days latter. The final result saw all of the 2G incumbent operators winning licences. Libertel and KPN won the larger licences for 1,573 million and 1,567 million Dutch guilders respectively. Duchtone, Telfort and Ben won the smaller license paying 960 million, 947.6 million and 870.4 million Dutch guilders.

In an attempt to increase the speed of network roll-out the Dutch authority allowed a high degree of network sharing. Any network sharing agreement was allowed to go through as long as at least two networks were rolled out nationally. This led to two main network sharing agreements, one between KPN and Telfort Mobiel and the other Dutchtone and 3G-Blue. Initially the agreement between KPN and Telfort was a network sharing agreement. However, by 2005 KPN had taken over Telfort's operations. This then reduced the number of active 3G networks to four. Although this merger was allowed to go through, in April 2008 Telefort was threatened with a €40 million fine for non-use of the spectrum that they had been allocated. KPN's response to this was that it intended to use Telefort's spectrum and would not return or sell the licence. Further to this, Orange Nederland, the renamed licence winner Dutchtone, was sold to T-Mobile in August 2007. This now leaves only three 3G network operators, two less than the number of incumbent 2G operators.

3.2.3: Germany and Austria

Of all the European auctions the Austrian and German auctions were perhaps the most complicated. Instead of setting predetermined licences, they allow an endogenously determined number of licences. Despite their similarities the two auctions raised considerably different sums. The rules of these auctions allowed the amount of spectrum in each auction to depend on the bidding units strategies. The process was split into two stages. In stage one 60 MHz of spectrum was split into 12 5MHz blocks. A bidder has the option of bidding for a maximum of 3 blocks and a minimum of 2 blocks. This meant there would be between 4 and 6 licences administered depending on bidding strategy. If a bidder managed to gain at least 2 blocks in stage 1 then they would move to a second auction where an additional 5 blocks of 5MHz unpaired spectrum would be sold. It should be noted that, unlike the UK auction, these auctions did not set aside any licences for entrants, thus giving the incumbent companies the option to deter entry, as long as they were willing to pay for it.

3.2.3.1: Germany

Particular detail of the German administration procedure as given in the event study in Chapter 6. The German auction began on the 31st July 2000; it lasted for 173 rounds and finished on 17th August 2000. Initially there were 12 bidders, one of which was not approved by the regulator; then, subsequent to the auction, another five bidders withdrew or formed consortia. This left 7 bidders at the start of the auction, 4 of these were incumbents already holding licences to provide 2G services. These companies were T-mobile owned by Deutsche Telekom, Mannesmann owned by Vodafone, E-plus Hutchison owned by KPN and Hutchison Whampoa, and Viag Interkom later to become O2 Germany owned by BT and E.ON. There were three entrant companies, MobilCom part owned by France Telecom, Debitel part owned by SwissCom, and 3G owned as a joint venture by Telefonica and Sonera. Debitel dropped out on day 10 of the auction, at which time the block price for the licences stood at DM 5 billion. At this point the auction could have stopped and the bidders settled for six licence holders. In actual fact, the auction continued with prices increasing as incumbent firms appeared to attempt to prevent entry, to their finishing level of around DM 8.25 billion. No further bidder dropped out meaning that there were six eventual licence holders. This was then followed by a second auction at which additional spectrum was allocated. At this auction Viag Interkom was the only winner not to gain additional spectrum.

Licence winners were expected to cover 25 percent of the population by the end of 2003 and 50 percent by the end of 2005. Infrastructure would be allowed but operators had to maintain their 'Netzfunktionssherrschaft' (network infrastructure). In practice this meant they were allowed to share antennae and masts but not the core network infrastructure. Of these licence winning firms, Group 3G ceased operations in July 2002 and MobilCom returned its licence in December 2003 when it became clear they would not be able to meet the coverage commitments. T-mobile launched its network in April 2004 with E-plus following in August 2004. Vodafone and Viag Interkom launched in January and November 2005 respectively. This has now left four 3G network operators, the same number as there were 2G incumbents. However, there are seven main service providers, across 2G and 3G network operators, and one MVNO operating.

3.2.3.2: Austria

The Austrian auction began on the 2nd November 2000 and followed the rules of the German auction. However, in this case the auction lasted only 14 rounds ending the next day on the 3rd November 2000. The short duration of this auction can be put down to the inability to attract entry. The auction only managed to attract six bidders for the six licences. Of these bidders, four were current 2G licence holders. These were Mobilkom (owned by Telekom Austria), Max.mobil (owned by Deutsche Telekom), Connect One (owned by Connect Austria), and Tele.ring (a subsidiary of Vodafone). The two entrant bidders were Hutchison 3G (owned by Hutchison Whampoa) and 3G Mobile (owned by Telefonica). With only six bidders, the number of bidders matched the maximum number of licences. There was limited bidding, which did not last as the incumbents showed little sign of wishing to bar entry. The Austrian regulator suspended the auction on two occasions as it feared there was collusion between firms. However, they were unable to produce any evidence of collusion and so the auction was allowed to go ahead. The auction ended with all six bidders winning two blocks of spectrum each paying between €118 m and €144 m each. The second stage of the auction saw Hutchinson 3G winning one block with Max.mobil and Mobilkom winning two blocks each. The total amount raised by the auction was €832 m, considerably less than in previous auctions.

Of these licence holders, all established 3G networks apart from 3G Mobile which sold its licence in December 2003 to Mobilkom Austria. Tele.ring was first sold to Western Wireless and then in August 2005 sold on to T-mobile. Tele.ring's network was already in operation so strictly there are five 3G network in operation however two of these networks are under the control of T-mobile leaving a market with effectively four operators.

3.2.4: Italy

After the success of the German and UK auctions, Italy, with its large mobile market, had high expectations for its auction. Indeed during the summer of 2000, when the size of potential licence fees became clear, Italy switched from its initial plan of using a beauty contest to an administration by auction. The auction design they used was similar to the UK. The Italian auction sought to administer 5 licences each containing 10MHz paired and 5MHz unpaired spectrum and each lasting for 15 years. In order to encourage participation, any entrant company that won a licence would be eligible to engage in a second auction for two blocks of 5 MHz paired spectrum. A further important feature of the Italian auction was its method of encouraging competition. If only five bidders were present to bid for the five licences the number of licences would be reduced by one. As it was, there were 8 potential bidders. The four incumbent operators Telecom Italia Mobile, Omnitel (owned by Vodafone 76.9% and Verizon Communications 23.1%), Wind (owned by Enel 56.6% and France Telecom 43.4%) and Blu (owned by Autostrade Telecommunicazioni 32% and BT 20%). The entrant bidders were in general large consortia made up of a number of different companies. These were Tiscali (controlled by the Andala consortium), TU TLC (Atitalia, E-tech and ESVES), Atlanet (made up of Acea, Telefonica, Sonera and Fiat) and Dix.it (e.biscom, Pirelli, Ifil, Banaca di Roma, AEM and ePlanet). Before the auction began the Dix.it consortium collapsed with Baca di Roma and ePlanet joining the Atlanet consortium, now renamed as IPSE 2000. Hutchinson Whampoa bought a controlling stake in the Andala consortium and renamed the Tiscali bidder as Andala Hutchison. A further bidder, Anthill, was not approved in the primary phase of the auction. Apart from Anthill, the seven other bidders were approved but TU TLC dropped out when it did not pay the required deposit.

When the auction began on October 19th 2000 there were six bidders remaining, meaning there would be no reduction in the number of licences offered. The auction lasted 10 rounds and in the 11th round, three days after the auction began, Blu, the BT backed consortium, dropped out. This left five bidders for the five licences on offer and so, the auction ended with each licence priced around 47000bn lire (€24bn). The final winners were the three incumbents Omnitel, Wind and Telecom Italia and the two entrant firms Ipse and Andala. The two entrants were each awarded additional blocks of unpaired spectrum for the price of 16000bn lire (€8.3bn). An inquiry was started by the Italian authority into the possible collusive behaviour of Blu. The suggestion being that Blu only become involved in the auction in order to avoid there being a reduction in the number of licences. This inquiry found no evidence of collusive behaviour in the Italian auction.

The licences required that the winners cover the 20 regional capitals by the end of June 2004 and the provincial capitals by 2006. Incumbent operators with significant market power (SMP) were required to offer roaming to 3G entrants although this requirement was dependent on entrants achieving a certain level of network development. However, the winners of the Italian licences struggled with roll-out and network development.

Soon after the licences had been administered the Autorita per le Garanxie nelle Communicazioni (AGCON) took the step of increasing the licence duration from 15 to 20 years. Due to delays in roll-out there were requests by the new entrants to return the additional spectrum that they had been given. Initial problems in the Italian market manifested themselves in the collapse of the failed 3G bidder BLU, which at the time was only a 2G operator. This left three GSM operators and five 3G operators. There was significant restructuring of the 3G licence winners. Hutchison considerably increased its share of Andala and subsequently renamed it H3G. Telefonica increased its share of IPSE as Sonera reduced its stake. Despite Telefonica's actions in taking control of IPSE they put very little extra money into network infrastructure investment. This lack of investment was to such an extent that it was clear that they would not meet their roll-out commitments and would not launch a service. In 2004/2005 Telefonica attempted to sell IPSE to Enel but when this failed AGCOM undertook to revoke IPSE's licence. Ipse was given until 20th January 2006 to find a buyer for their licence, they could not and their licence was revoked 5 days later. This has left Italy with four operating 3G networks, the same number of GSM networks that were operating when the administration took place.

3.2.5: Switzerland

The Swiss auction followed an English ascending auction design with some modifications such as allowing bidders to pass on a round and giving the regulator the ability to change the size of incremental bids. These modifications were made in order to avoid 'excessive' bidding. There were 4 licences on offer, all consisted of 15MHz paired plus 5MHz unpaired spectrum and lasted for 15 years. Despite some of the problems faced by previous auctions, the Swiss seemed to be successful in attracting entry, with 10 bidders applying to be involved in the auction. These bidders included the three incumbents Mobile Com (owned by Swisscom), dSpeed (owned by diAx), and Orange. The entrant bidders were Teldotcom, Telenor, Cablecom Management (NTL), Hutchison 3G, T-Mobile, Sunrise and Team 3G (Owned by Telefonica, One.Tel and Sonera). The auction was due to begin on November 13th 2000. However, a week before the auction began, two bidders had dropped out, by three days before the start of the auction there were only five bidders remaining. The most significant event was the takeover by TDC of diAx and Sunrise with a view to merge the two. By the day the auction was due to start the only remaining bidders were the three incumbents and group 3G (by this point owned wholly by Telefonica). This left the auction with the same number of licences as bidders. Due to concerns that they would be only able to raise the reserve price the regulator, Comcom, postponed the auction. In order to try and increase revenue, Comcom planned to abandon the auction format and instead tried to impose an annual fee on licence holder. Legal action was threatened against Comcom by those bidders left in the original auction. Faced with this legal action and not being able to provide evidence of any collusive behaviour between bidders Comcom was forced to restart the auction.

The date that was set for this new auction was December 6th 2000 and, as expected, only the 4 bidders from the previous auction decided to bid. This inevitably meant that licences only reached their reserve price of $29.3m. This is with the exception of Orange, which paid an extra SF5m in order to obtain specific spectrum to ensure regional roaming. A coverage requirement of 50% of the population by 2004 was imposed on the winners. An issue arose with the entrant operator as the incumbent operators refused to allow the now renamed, UMTS Switzerland to roam on their 2G networks. Only once UMTS Switzerland had covered 20% of the population, with their own network, were the incumbents obliged to allow roaming. Team 3G had its licence revoked in April 2006 due to not meeting roll-out conditions. Swisscom had its network live by August 2004, Orange by September 2005. DiAx/Sunrise followed with their network in December 2005. Switzerland currently has three 3G networks in operations from the four licences they originally administered.

3.2.6: **Belgium**

The Belgium auction, like the French beauty-contest before it, was unable to distribute all of its licences. Unlike the French administration this was not because the licence price was set too high, rather they were unable to attract entrant bidders. The Belgium Institute of Postal Services and Telecommunication (BIPT), like many before it, settled on a simultaneous, ascending auction. The auction design was slightly unusual in that they split it into two stages. The aim of the first stage was to stop 'associated' companies from bidding in the main auction. Associated companies were those that owned shares in each other. BIPT only wanted unassociated firms to gain licences. All associated companies would be placed into groups in order to bid against each other, leaving only unassociated firms to bid for the actual licences in the second round. Initially it was thought there would be no requirement for an incumbent to allow roaming on its existing 2G network.

When the auction began only three companies had applied to bid and so the first stage was not needed. The companies that applied to bid were all existing incumbents, these being Proximus (owned by Belgacom and Vodafone), Mobistar (majority owned by France Telecom), and KPN Orange (owned by KPN). The auction began on 2nd March 2001 and, due to there being fewer bidders than licences, it lasted only one round with each bidder paying around €150 million. These licences were linked to coverage requirements of 30, 40 and 50 per cent after 3, 4 and 5 years respectively. In March 2002 it was announced that due to a "force majeure" the licence holders would be allowed a one-year delay in their roll-out conditions. This was required due to delays in acquiring network infrastructure and gaining planning permission. An additional concern to network operators was the Flemish government's plan to tax network infrastructure if they were placed in public areas. 3G roll-out was gradual with some operators offering an intermediate 2G platform (EDGE). By 2007 coverage was estimated by IBPT to exceed 40 percent, which is the level that was required under the licensing laws. Belgium currently has three active 3G networks.

3.2.7: Greece

The Greek auction began on the 13th July 2001 and was set to administer a maximum of four, 20 year licences. The Greeks attached a slightly complicated pricing structure to their licences. The basic principle was the greater the number of licences that were sold, the lower the upfront fee. The auction was split into two sections, the first administering a basic licence of 10 MHz paired and 5 MHz unpaired and the second administering any additional spectrum. The three incumbent operators Cosmote (OTE 59 percent and Telenor 18 percent), Panafon (majority Vodafone) and Stet Hellas (majority Telecom Italia) and an entrant firm Infoquest, which was operating in the Greek IT sector, all entered the competition. Infoquest pulled out of the procedure leaving only the incumbent bidders. Panafon ended with the largest licence consisting of 20 MHz paired and 5 MHz unpaired and costing €176,376,199. The Cosmote licence consisted of 15 MHz paired and 5 MHz unpaired costing €161,411,701. Stet Hellas only obtained a basic licence for which they paid €146,735,169. The licence winners were obliged to cover 25 percent of the population by December 2003 and 50 percent of the population by December 2006. There was also an additional requirement for the site of the Olympic Games to be covered by February 2004. This left Greece with three operating 3G networks. There were initial problems with the granting of permission to establish network infrastructure. This led to requests in 2004 to the Ministry of Transport and Communications for extensions of the roll-out conditions. However these licensing conditions were eventually met with no need for any extension.

3.2.8: **Denmark**

The final Western European auction was carried out in Denmark during September 2001. By this late stage any positive market sentiment had evaporated and demand for licences had deteriorated. This was partly born out by a number of countries switching away from auctions and back to beauty contests and by the deterioration in the equity prices of 3G licence holder. In addition to the negative sentiment towards 3G, the Danish regulator was of the opinion that the Danish market could only maintain four network operators. These factors led to the decision to only offer four licences all containing 15MHz paired and 5MHz unpaired spectrum. From a revenue raising perspective this was problematic as it meant there were the same number of licences as incumbent operators. These licences were attached to coverage obligations of 30% of the population by the end of 2004 and 80% by the end of 2008. There was no date by which services had to be in operation. 2G incumbents were under an additional obligation to accept any “reasonable” request for roaming from either entrant companies or MVNOs. Infrastructure sharing would be allowed but only at the mast level.

In order to try and encourage entry and avoid the outcome of other less successful auctions, it was decided to use a single round sealed bid auction. Due to the amount of information that had been released in previous administrations the potential for a winner’s curse would no longer be of such a concern. Incumbents were banned from forming consortia among themselves, although they were allowed to team up with entrant companies. All applicants were required to register and pay a deposit of DK200m (€91m). After this, each applicant provided a single sealed bid with a reserve of DK500m (€227m). The Licences were awarded to the four highest bidders with each bidder paying the same price, which is the price bid by the fourth highest bidder. The payment would be deferred so that 25% was due up front and the remainder was to be paid in instalments over 10 years. The winners of the auction were TDC, Telia, Orange and the new entrant Hi3G Denmark. Each bidder paid DK950m (€128mn) with total revenues of just over €500m. Sonofon, the biggest incumbent 2G operator, did not win a licence and so became an MVNO.

All operators met their commitment to achieve a 30 percent roll-out by 2004. At the end of 2004 TeliSonera announced that it would buy Orange Denmark and it was agreed with the regulator that Orange’s licence would be returned in 2005. This licence was reauctioned at the end of 2005 and won by the Norwegian operator Sonofon for DKK 533 million. This licence required 30 percent population coverage by 19 February 2009 and 80 percent by 19 February 2013. The licence holders were relatively slow to offer services with all four operators not being in service until December 2007. Telia was the final operator to offer services.

3.3: Beauty Contests

3.3.1: Finland

It is perhaps not surprising that Finland, the country with the highest mobile penetration rate in the world, was the first of the European countries to administer its 3G licences.

The Ministry of Transport and Communications of Finland carried out the first of the European 3G administration procedures, which also happened to be a beauty contest procedure. On the 18th March 2000 Finland awarded four licences which each consisted of 15MHz of paired spectrum and 5MHz unpaired. The licensing conditions required a network to be in place by 1st January 2002. However this was relaxed to a network being in place to 'a certain extent'. New 3G licence holders were allowed to roam on existing 2G infrastructure however these arrangements were set up as service provider agreements. This was criticised by the new entrants as not true roaming. The four licence winning firms were the three incumbents Sonera, Radiolinja, Suomen 3G and the new entrant Telia Finland (also known as DNA Finland).

All licence holders were considered to have met the January 1st 2002 requirement of networks to be in place "to a certain extent". They did this by setting up test networks. In December 2002, Telia and Sonera merged to form TeliaSonera. This would have meant that two licences would have been controlled by one operator. There were a number of firms interested in acquiring the assets of Telia. An agreement was finally reached with Finnet Ltd in 2004. Finnet now operates a 3G network under the DNA Finland brand. In May 2003, Tele2 acquired all the shares of Suomen 3G (some from Finnet) after previously having held 27.4 percent. However, Suomen 3G has its licence revoked in July 2005 after it did not meet the required coverage commitments. This licence was awarded to SkyWeb at the end of September 2005. Finland currently only has three 3G networks in operators from the four licences administered. This is the same number of operators as there were in the GSM market. In addition to problems in the home market there was also a debate in the Finnish parliament over the scale of the German licences. This led to Kimmo Sasi, the Finnish minister for transport and communications, calling on the German authority to refund the fee of any firm that wished to return its licence. This was partly linked to Sonera (a state owned firm) taking a large write down on the value of the licence (3Gnewsroom, 2002).

3.3.2: Spain

The Spanish licences were awarded via comparative selection on the 13th March 2000. Four licences were administered consisting of 15MHz paired spectrum and 5MHz unpaired. Each licence was to last for 20 years and the licence winners were required to cover all cities with a population greater than 250,000 by August 2001. There were six applicants for the four licences. The three 2G incumbents were Telefonica, Amena Retevision Movil and Airtel, which was majority owned by Vodafone. The entrant applicants were Xfera, Jazztel which was majority owned by Deutsche Telecom, and Uni2 which was a subsidiary of France Telecom. The three incumbents won licences with Xfera winning the fourth licence. Each licence cost $130 million with an additional $5 million yearly levy. The Spanish authority was concerned that they had severely undervalued the licences and so increased the levy to $135 million in 2001. Initially only those 2G licence holders which obtained a 3G licence were obliged to offer roaming to new 3G licence holders.

The Spanish authority attempted to make additional revenue from 3G licences when they increased the fees for spectrum usage charges by 30 times. However this was appealed as the licence winners claimed it would negatively affect investment. The roaming restriction was changed in March 2002 when roaming on all networks was introduced based on commercial negotiation. At the same time, a new type of licence was created to allow the operation of MVNOs. The Spanish authority because the first country to allow an extension in the roll-out conditions with the launch of services being delayed from 1st August 2001 until 1st June 2002. This was then further relaxed on 8th April 2002 when it was announced that the 1st June launch would be performed on an 'experimental' basis only. In June 2004, a new agreement over roll-out deadlines was reached. This meant that two operators were cleared as they were close to offering commercial servicing in 2004. One other licence holder was expected to offer services by October 2004 and the final licence holder (Xfera Moviles) by October 2005.

Three operators had services in place by the end of 2004. However Xfera missed its 2005 deadline. By the start of April 2006 the Spanish government began proceedings against Xfera Moviles in order to remove their licence. The regulator gave Xfera Moviles a final deadline of June 2006 as a final deadline for network launch. Xfera failed to meet this deadline; however this did not lead to the removal of the licence. The Spanish government appeared to be appeased when in June 2006 TeliaSonera increased its holding in Xfera from 16.5 percent to 80 percent with a guarantee to launch services by the end of the year. Xfera's network finally went live, although on a limited basis, in December 2006. Another significant ownership change was the purchase of Amena by France Telecom in August 2005. Currently Spain has four 3G networks in operation after having initially administered four licences.

3.3.3: **Norway**

On the 31st May 2000 The Norwegian Post and Telecommunication Authority offered four licences consisting of 15 MHz paired and 5 MHz unpaired spectrum. The applicant firms were Broadband Mobile (Enitel and Sonera), Netcom, Tele2 Norge, Orange Norge, Telenor, BusinessNet (Tele 1 Europe, Western Wireless and Rix Telecom) and a consortium consisting of Orkla, Dagbladet, Hafslund, Hakon Gruppen, NorgesGruppen, OBOS/NBBL and Posten Norge. The firms that were awarded licence were Broadband Mobile, Netcom Telenor and Tele2 Norge.

The first of the licence winning firms that faced difficulties was Broadband Mobile. The consortium returned its licence in August 2001 after it went bankrupt. There was the possibility that another firm would purchase Broadband Mobile however, with no guarantee from the Norwegian regulator that they would receive the licence this did not happen. In November 2002, Tele2 Norge returned its licence and now operates as an MVNO on Telenor's network. Due to deteriorating market conditions and the hand back of licences the regulator sought to take action. On the 7th February 2003 the Norwegian authority agreed to extend the roll-out deadline by 15 months and decrease the coverage commitment from 40% coverage within 5 years to 30% in 6 years. In 2003 Norway offered the two licences that had been returned via an auction procedure. In September 2003 Hi3G Access Norway (Hutchison Whampoa 60%) was awarded a 3G licence for $8.2 million needing to cover 60% of the population within 6 years. As yet they have not activated their network. The fourth licence was not administered at this time. This final licence was offered again and this time won by Mobile Norway on 13th December 2007. Mobile Norway paid NOK 47 million and was guaranteed the licence as the only bidder in the administration. As of yet, Mobile Norway (Network Norway) has not established a network, they have however established a roaming agreement with Telenor. This leaves Netcom and Telenor as the only two networks currently operating 3G services.

3.3.4: **Sweden**

A greater amount of detail on the Swedish administration can be found in Chapter 6. The Swedish beauty contest was one of the most successful at attracting entry with ten applicants for the four licences on offer. The four licences each consisted of 15MHz of paired spectrum and 5MHz in unpaired spectrum and would last 15 years. In addition to the 3G spectrum there were an extra 2G licences on offer to all-comers, although an applicant could not apply for a 2G licence without applying for a 3G licence. An entry fee of €10000 was charged and at a later date it was decided that an additional charge of 0.15 per cent of yearly turnover would be imposed. The companies that applied for 2G and 3G licences were Telia, Telenordia (owned by BT and Telenor), Tenora Networks and Reach Out Mobile which is predominately owned by Telefonica and Sonera. Those applying for 3G licences alone were Europolitan (majority owned by Vodafone), Orange Sverige Consortium (made up of Orange, Skanska, Bredbands, the content provider Schibsted, and NTL), Hi3G (40 per cent owned by Investor AB and 60 per cent owned by Hutchison Whampoa), Broadwave Consortium (Tele 1 Europe, Western Wireless, the content provider Rix Telecom, Suomen 2G/3P Group and You Communication), and Mobility4Sweden (Deutsche Telekom, ABB Energy Ventures and the Swedish network operator Utfors).

Due to the large number of applicants a decision was delayed until 16th December 2000. The assessment criteria that the regulator used were based around the applicants' reliability, commercial feasibility, suitable experience and sufficient capital for roll-out. Further consideration was given to plans for geographic coverage, speed of roll-out and service availability. The winners were Europolitan, Tele 2, Hi3G Access and Orange Sverige. The big surprise here was that the largest 2G operator, Telia, did not win a licence. The company took the decision to appeal, which was subsequently rejected. However, during the appeals process Telia agreed a 50/50 joint venture with Tele2. At the time this joint venture was called NetCom, but is now known as Svenska UMTS-nat. Those that won licences were under an obligation to cover 8, 860, 000 inhabitants by the end of 2003, which is the equivalent of 99.98% of the population. In addition to Telia, Telenordia Mobil AB and Reach Out Mobile AB also appealed to the Country Administrative Court. However, in a judgment on the 27th June 2001, the court upheld the regulator's original decision. The option to form joint ventures was widely used. As has been discussed, Telia quickly joined Tele 2 in a joint venture to run UMTS services.[3] Two of the other winners, Hi3G and Europolitan formed a joint venture called 3G Infrastructure Services AB. This would involve the two operators sharing the majority of network infrastructure. In May of the same year,[4] Orange bought a share of 3G Infrastructure. However, Orange only remained in this agreement for 18 months.[5] Indeed, the withdrawal by Orange led to their eventual and total withdrawal from the Swedish market a month later.

The withdrawal of Orange came about after they had requested a relaxation of licensing conditions in the summer of 2002. They requested a 3 year extension on the first roll-out condition and also a reduction in the required population coverage. The justification that Orange gave for this was the financial conditions, delays brought about by Telia's appeal and delays due to planning regulations. All of these arguments were rejected by PTS. The cooperation between operators and withdrawal of one operator has led to a decrease in competition at the network level. At a latter date, Vodafone also applied for a relaxation of licensing conditions. Vodafone wanted a 2 year extension to the first roll-out condition. Vodafone not only sought to justify an extension due to building restrictions but also because the Swedish air forces were in the middle of an interference review that would impact on Vodafone's spectrum. Again, these requests were rejected

[3] This agreement was signed on the 15th March 2001.
[4] Agreement signed on 16th May 2001.
[5] Orange left on 20th December 2002.

on the grounds that the firm should have been well aware of these potential problems. This left Svenska and Hi3G, who both applied for relaxation of licensing conditions in 2003 but these were again rejected on similar grounds. In December 2003 Orange requested that its licence be transferred to Svenska. This request was rejected by PTS and in November 2004 Orange Sverige had its licence revoked.

3.3.5: **Portugal**

The Portuguese regulator administered four licences that would last 15 years consisting of 15 MHz of paired and 5 MHZ unpaired spectrum in January 2001. The applicants were the three incumbents 2G TMN (Portugal Telecom subsidiary), Telecel (majority Vodafone), and Optimus (Sonae, EdP and Orange) and the new entrants ONI-Way (Primarily ONI and Telenor), MobiJazz (Jazztel and Sonera) and a Vivendi consortia. The three incumbents gained licences and the one entrant ONI-Way. Each winner paid €100 million for licence and a small yearly fee. The companies that won were those that had generally committed themselves to the toughest roll-out conditions. The minimum roll-out condition was 20 percent population coverage by the end of 2002 and 60 percent by the end of 2006. In general, the winning companies had committed themselves to considerably stricter conditions than these. For instance ONI-Way committed itself to 90 percent coverage by the end of 2002, a target that even at the time seemed very unlikely that it would meet. There was a roaming agreement put in place to allow the new entrant to roam on the incumbents' 2G networks. However, this was challenged by two of the incumbents. One incumbent allowed roaming but the other two refused until ONI-Way had started operating its 3G network. This led to a drawn out period of appeals to the regulator with ANACOM finally forcing all the incumbents to allow roaming by September 2002. ANACOM allowed an initial delay of service launch until 31st December 2002 and then a further extension until 1st July 2004. However this was not enough for the new entrant ONI-Way, which at the request of the share holders had its licence revoked in January 2003. This fourth licence was not readministered; instead the spectrum was split between the existing operators. This left Portugal with three 3G network operators from the four licences initially administered.

3.3.6: France

The French authority, having seen the success of the UK and German auctions, sought to raise a similar sum but via a beauty contest. They offered four licences each consisting of 15 MHz paired and 5 MHz unpaired spectrum. Each licence would last for 15 years and roaming would be allowed over the 2G networks. Each licence would cost Ffr32.5 billion. However only half of this would be paid in the first two years; the remainder would be paid over the duration of the licence. Although there was a fair amount of initial interest, by the time the licences were administered there were only two applicants. The two companies Orange (France Telecom) and SFR were unsurprisingly confirmed as licence winners in May 2001.

By October 2001, after appeals from the licence winners and in an attempt to make the remaining licences more attractive, the licence duration was increased to 20 years. The two licences that had not been administered were offered at a greatly reduced fee of €619 million and a 1 percent levy on revenues. The new charge was also applied to the winners of the first two licences. Despite the lower fee, only one further licence was administered to Bouygues in September 2002. SFR's network went live in November 2004 with Orange following in March 2006. Bouygues did not launch its network until November 2007. However, even once it was launched, the network only had limited coverage (20 percent) and services were primarily focused at the mobile computing market.

During 2005 and 2006, plans were drawn up to attempt to administer the fourth 3G licence. An auction procedure to this effect occurred in March 2007. However, there was only one applicant for this licence, Iliad, whose offer was eventually rejected. The application was rejected on financial grounds given that Iliad wished to make the €619 million payment in instalments rather than as a lump sum. The proposal to administer a fourth licence was then abandoned in April 2008 in favour of a proposal to sell spectrum to MVNOs. Under this plan a MVNO would be switched to a partial network operator by allowing them to use other operators' networks as long as they had enough spectrum to cover 25 percent of the French population. This has left the French market with the same number of 3G operators as there were 2G incumbents and one less operator than licences administered.

3.3.7: Luxembourg

The Institut Luxembourgeois de Regulation (ILR) offered four licences consisting of 15 MHz paired and 5 MHz unpaired spectrum each lasting 15 years. The charge for each licence was partly dependent on revenues but was set at a minimum of €200 million. Despite the relatively low fee, there were only three applicants for the four licences. These applicants were the two incumbents, P & T Luxembourg (EPT) and Tango S.A., and the entrant Orange (France Telecom). A further licence was administered to VOXmobile on 15th July 2003.

Luxembourg had a number of specific problems with their roll-out conditions. Luxembourg had in place a particularly rigid set of regulations regarding where and how a transmission mast could be built. The regulations would mean that only 5 percent of land would be available to build masts on. Faced with these problems, the ILR undertook to ease some of the pressures faced by licence winners. During 2004 a series of court rulings not only made it more difficult to build 3G masts but also put some existing GSM masts under threat. Despite these problems three of the network operators had a least a limited service in operation by 2004. However, in December 2004 Orange handed back its licence as it removed itself from the Luxembourg market. This has left Luxembourg with three network operators, one more than before the process. In May 2007 VOXmobile was bought by Mobistar the France Telecom subsidiary allowing France Telecom to re-enter the Luxembourgish market. A point of interest is the possibility that France Telecom was behaving strategically here; by returning a licence through Orange and then re-entering the market they reduced the number of operators in Luxembourg to three.

3.3.8: Ireland

The Commission for Communications Regulation (CCR) followed a similar structure to the other beauty contest procedures by offering four licences of 15MHz paired and 5MHz unpaired spectrum. These licences would last for 15 years (this was subsequently increased to 20 years). CCR had originally planned to hold the beauty contest in May of 2001. However, with the industry turbulence and a series of mergers in the Irish market, the administration was delayed until the end of June 2002. There were two types of licence on offer. The licences were differentiated by the quantity of spectrum and the roll-out conditions. The A licence required 53 percent coverage (the 5 major cities) by 2005 and 80 percent of the population by 2007; additional spectrum would also be provided to the A licence holder to allow MVNOs. The B licence would require 33 percent coverage by June 2006 and 53 percent coverage by the end of June 2008. Each incumbent operator would be required to allow roaming once initial roll-out conditions had been met. In a further move, it was also announced that network infrastructure could be installed on public, commercial and industrial buildings without requiring planning permission. Despite these measures, when the administration finally took place, there were only three applicants for the four licences. These were the two incumbent operators Vodafone Ireland, O2 (formerly Esat Digifone) and Hutchison 3G Ireland. Hutchison won the A licence for a fee of €52.4 million the other two winners each paid €116 million for their licences. The companies that won licences were relatively successful in meeting coverage commitments and by July 2005 all companies were operating live networks. This led Comreg to take the decision to reoffer the fourth licence which had remained after the first administration.

The fourth licence was awarded to Smart Telecom in November 2005. Smart Telecom incurred a relatively small fee of €114.3 million with an additional fee of €2.2 million per year. However, Smart Telecom had its licence revoked in February 2006 when it was not able to provide a €100 million performance bond. This decision was appealed but the appeal was not successful. At that time and given the maturity of the 3G market it was questionable whether a new entrant operator could successfully establish itself. In 2006, this left Ireland with three 3G network operators and despite the legislation laid down for the A licence, there were no MVNOs operating in the Irish market. This was primarily due to technical issues with number portability. In March 2007, a decision was taken to administer the fourth licence to Eircom, the fixed line incumbent, again for a fee of €114.3 million. In the original procedure Eircom had signed an agreement with

Vodafone not to apply for a licence as a condition for Vodafone buying Eircell. Given Eircom's position in the fixed line market, it was hoped that they would be better placed than a new entrant to form a network. Eircom has yet to go live with its 3G network.

3.4: Discussion

In retrospect, the success of these administrations measured in terms of funds raised and stability of post-administration market is questionable. In particular, whether the method of licence administration had any effect on the development of 3G services is unclear. Gruber (2005) notes that of the 70 licences granted only 51 have been used to provide a service. Out of the 19 that have not been used 13 were from auction procedures. This may have partly been due to the countries that used auction procedures being more ambitious with the number of licences they offered. If we look at Tables 3.1 and 3.2 we can see that every beauty contest offered four licences. The number offered by auctions varied between six and four with an average of 4.8. Given this, it may not seem surprising that fewer licences ended up being used from auction procedures. Gruber's analysis does not include those licences that were not administered and is now a little out of date. If we look at the most recent information presented in tables 3.1 and 3.2, we get a slightly different picture from the one presented by Gruber. Of the 75 licences offered, 43 were through auctions and 32 through beauty contests. Of these licences three have never been administered, two from auctions and one from a beauty contest. Twelve licences have been revoked or returned at some point. Despite auctions administering considerably more licences, seven of those revoked were from beauty contests whilst five were from auctions.

It may seem peculiar that beauty contests had more licences returned than auctions. If a country has settled on using a beauty contest in the first place it suggests they are open to a dialogue with operators over the development of the industry. A certain amount of evidence to support this proposition can be seen from the number licences offered. Each beauty contest offered four licences, which is the number of licences requested by the UMTS Forum.[6] Borgers and Dustman (2003) link the lobbying power of incumbent

[6] UMTS Forum Report No. 5 (1998)

firms with the number of licences offered and the use of a particular administration procedure. The question is then why would more licences be revoked from countries that ran beauty contests. The post-administration picture is mixed however. There is a certain amount of evidence that countries that used beauty contests were less willing to renegotiate licensing conditions and started with much stricter roll-out conditions than auction procedures. The most obvious example of this is Sweden. The strong political forces that were at work meant that varied from country to country. We can find an alternative explanation if, instead of returned licences, we consider the number of operators in each country. Despite administering more licences and having less revoked, the average number of operators in each country that used auctions is 3.7. This seems strange when we consider that the average for beauty contests it is only slightly lower at 3.5. This reflects auction countries' preference for allowing current operators to take over licences that had been returned rather than revoking them and readministering to new entrants as was done in beauty contests. This would again seem to present us with evidence that, once the administration had taken place, countries that had used auctions were more interested in supporting those firms in the industry rather than encouraging new entry.

A number of issues have been raised in the last two chapters. The three main points that will be addressed in the remainder of this thesis are as follows: what determined how much was paid for the licences, is there evidence that winning bidders overpaid for licences, and how did regulatory conditions change in the aftermath of licence administration. Before addressing the evidence of a winner's curse and post-administration regulatory easing, the next step will be to examine those factors that affected the size of the licence fees and which bidding unit won licences. Chapter 4 will examine whether the size of bids that bidders placed were determined by licence and country specific factors, administrative specific factors or whether there were other determinants outside of the control of the administrating authority that had an effect. After accounting for differences in type of administration, are the differences in bids such as might be expected given the differences between countries and bidders? In addition to these questions, the issues of whether particular types of bidders were favoured in different licence administrations will also be addressed.

Table 3.1: Licences Administered via Auctions

	Licences Offered	Licence Winner	Date of administration	Date of Service Launch	Current Owner (2008)
United Kingdom	Licence A	TIW UMTS	Apr 2000	March 2003	Hutchison (3)
	Licence B	Vodafone	Apr 2000	Apr 2004	Vodafone
	Licence C	BT3G	Apr 2000	Feb 2005	Telefonica (02)
	Licence D	One2One	Apr 2000	Oct 2005	T-Mobile
	Licence E	Orange	Apr 2000	July 2004	France Telecom
Netherlands	Licence A	Libertel	Jul 2000	Nov 2004	Vodafone
	Licence B	KPN	Jul 2000	Oct 2004	KPN
	Licence C	Duchtone	Jul 2000	None	T-Mobile
	Licence D	Telfort	Jul 2000	None	KPN
	Licence E	Ben	Jul 2000	Nov 2005	T-Mobile
Germany	Licence A	T-mobile	Aug 2000	Apr 2004	T-Mobile
	Licence B	Mannesmann	Aug 2000	Jan 2005	Vodafone
	Licence C	E-Plus	Aug 2000	Aug 2004	KPN
	Licence D	Viag Interkom	Aug 2000	Nov 2005	Telefonica
	Licence E	MobilCom	Aug 2000	Returned 2003	None
	Licence F	Group 3G	Aug 2000	Returned 2002	None
Austria	Licence A	Max.Mobil	Nov 2000	Dec 2003	T-mobile
	Licence B	Mobilkom	Nov 2000	Apr 2003	Mobilkom
	Licence C	Hutchison 3G	Nov 2000	May 2003	Hutchison
	Licence D	Connect	Nov 2000	Dec 2003	One
	Licence E	Tele.ring	Nov 2000	Dec 2003	T-mobile
	Licence F	3G Mobile	Nov 2000	None	Mobilkom
Italy	Licence A	Omnitel	Oct 2000	Mar 2004	Vodafone
	Licence B	Ipse	Oct 2000	Revoked 2006	None
	Licence C	Wind	Oct 2000	Oct 2004	Wind
	Licence D	Andala	Oct 2000	Mar 2003	Hutchison
	Licence E	Telecom Italia	Oct 2000	Mar 2005	Telecom Italia
Switzerland	Licence A	Orange	Dec 2000	Sep 2005	France Telecom
	Licence B	Swisscom	Dec 2000	Aug 2004	Swisscom
	Licence C	Team 3G	Dec 2000	Revoked 2006	None
	Licence D	Sunrise	Dec 2000	Dec 2005	TDC
Belgium	Licence A	Proximus	Mar 2001	May 2004	Proximus
	Licence B	Mobistar	Mar 2001	2006 EDGE	France Telecom
	Licence C	KPN Orange	Mar 2001	Sep 2006	KPN
	Licence D	None	Mar 2001	None	None
Greece	Licence A	Cosmote	Jul 2001	May 2004	Cosmote
	Licence B	Panafon	Jul 2001	Nov 2004	Vodafone
	Licence C	Stet Hellas	Jul 2001	Sep 2004	Wind Hellas
	Licence D	None	Jul 2001	None	None
Denmark	Licence A	Hi3G	Sep 2001	Oct 2003	Hutchison
	Licence B	Orange	Sep 2001	Returned 2005	None
	Licence B (II)	Sonofon	Dec 2005	Sep 2006	Telenor
	Licence C	TDC	Sep 2001	Oct 2005	TDC
	Licence D	Telia	Sep 2001	Dec 2007	TeliaSonera

Sources: Various regulators, European Commission, GSMworld and UMTSworld.

Note: In the actual administrations not all licences were assigned a letter. In the above table letters have been given to all licences so it can be made clear when a licence has been readministered and who that licence previously belonged to.

Table 3.2: Licences Administered via Beauty Contests

	Licences Offered	Licence Winner	Date of administration	Date of Service Launch	Current Owner (2008)
Finland	Licence A	Sonera	Mar 1999	Oct 2004	TeliaSonera
	Licence B	Radiolinja	Mar 1999	Sep 2004	Elisa
	Licence C	Suomen 3G	Mar 1999	Revoked 2005	None
	Licence C (II)	SkyWeb	Sep 2005	None	SkyWeb
	Licence D	Telia Finland	Mar 1999	Dec 2005	Finnet
Spain	Licence A	Telefonica	Mar 2000	Feb 2004	Telefonica
	Licence B	Amena Retevision	Mar 2000	Nov 2004	France Tele
	Licence C	Airtel	Mar 2000	May 2004	Vodafone
	Licence D	Xfera	Mar 2000	Dec 2006	TeliaSonera
Norway	Licence A	Broadband Mobile	Nov 2000	Returned 2001	None
	Licence B	Netcom	Nov 2000	June 2005	TeliSonera
	Licence C	Telenor	Nov 2000	Dec 2004	Telenor
	Licence D	Tele2 Norge	Nov 2000	Returned 2002	None
	Licence A (II)	Hutchison	Sep 2003	None	Hutchison
	Licence D (II)	None	Sep 2003	None	None
	Licence D (III)	Mobile Norway	Dec 2007	None	Mobile Norway
Sweden	Licence A	Europolitan	Dec 2000	Jan 2004	Vodafone
	Licence B	Tele 2	Dec 2000	Mar 2004	Svenska
	Licence C	Hi3G Access	Dec 2000	Jan 2004	Hutchison
	Licence D	Orange Sverige	Dec 2000	Revoked 2004	None
Portugal	Licence A	TMN	Dec 2000	Apr 2004	TMN
	Licence B	Telecel	Dec 2000	Feb 2004	Vodafone
	Licence C	Optimus	Dec 2000	July 2004	Optimus
	Licence D	Oni-Way	Dec 2000	Revoked 2003	None
France	Licence A	Orange	May 2002	Mar 2006	France Tele
	Licence B	SFR	May 2002	Nov 2004	SFR
	Licence C	None	May 2002	None	None
	Licence D	None	May 2002	None	None
	Licence C (II)	Bouygues	Sep 2002	Nov 2007	Bouygues
	Licence D (II)	None	Sep 2002	None	None
Luxembourg	Licence A	P&T Luxembourg	May 2002	Jun 2003	P&T Lux
	Licence B	Tango S.A.	May 2002	Jul 2004	Tele2
	Licence C	Orange	May 2002	Returned 2004	None
	Licence D	None	May 2002	None	None
	Licence D (II)	VOXmobile	Jul 2003	May 2004	France Tele
Ireland	Licence A	Hutchison	Jun 2002	Jul 2005	Hutchison
	Licence B	Vodafone	Jun 2002	Nov 2004	Vodafone
	Licence C	O2	Jun 2002	Mar 2005	O2
	Licence D	None	Jun 2002	None	None
	Licence D (II)	Smart Telecom	Nov 2005	Revoked 2006	None
	Licence D (III)	Eircom	Mar 2007	None	Eircom

Sources: Various regulators, European Commission, GSMworld and UMTSworld.

Note: In the actual administrations not all licences were assigned a letter. In the above table letters have been given to all licences so it can be made clear when a licence has been readministered and who that licence previously belonged to.

Chapter 4: Empirical Analysis of the 3G Administration

4.1: Introduction

Chapter 3 demonstrated the considerable range in the size of licence fees raised across countries. This chapter will seek to evaluate those factors that affected how much was paid for the licence fee and who won the licences through a cross-country econometric evaluation. Empirical studies of auctions have more commonly followed the positive goals of identifying whether bidders behave according to some equilibrium behaviour or whether bidders' behaviour is correlated and the nature of this correlation. Empirical evaluation of auctions has also sought to identify optimal auction design often in terms of the administration method to maximise revenue. For a thorough investigation of this type of empirical study see Hendricks and Porter (2007). This empirical analysis takes a slightly different approach. Firstly, the type of study mentioned previously would usually focus on one auction or a number of auctions of a similar type, for instance the auction of a particular type of coin on eBay (Bajari and Hortacsu, 2004). Although the present analysis looks only at 3G licences, the constitution of these licences and the design of the auctions would mean it would not be possible to conduct this type of study. In addition to the differences in the formation of the licences this analysis is also not only interested in auctions. The inclusion of the beauty contest procedure would exclude the type of analysis discussed in Hendricks and Porter. Instead, the analysis that will be carried out in this chapter will seek less to examine whether bidders followed equilibrium behaviour or the best auction design but rather examine strategic, design, economic and structural factors that have affected the bidding units' bidding behaviour. Due to the range of administration methods used this will be a difficult process, the results of which require careful consideration.

When examining the size of the licence bids, data will be pooled across the 16 European countries that administered their licences between March 1999 and June 2002 and are outlined in the previous chapter. These 16 countries carried out a total of 18 licence administration procedures over the period in question. The data set will be analysed as a whole but also split so that data for Auctions and Beauty Contest procedures can be analysed independently. The analysis will not look at the licence fees themselves. Due to the limited number of licences actually offered, an examination of the licence price would severely limit the number of observations. Rather the analysis will look at the individual bidding units and through their 'highest observed bid'. Although it would be preferable to examine the bidders' willingness to pay these data is not available. The second section will take the modelled highest observed bid and use it as an instrumented variable in a Probit estimation of a dependent variable for whether a bidding unit won a licence, in order to determine what affected the bidders' probability of winning. The key questions that this chapter seeks to answer are which factors determine the size of bidding units' bids, and which bidders were best placed to do well in the European licence administration process.

4.2: Modelling the winners and how much they paid

4.2.1: Bidding Units' Highest Observed Bid

This first section only covers the literature on the size of the bid placed by the bidding unit and does not motivate the probit equation for what factors are associated with a higher probability of winning. Discussions in the previous two chapters have outlined a numbers of areas, both in terms of administration design and country specific characteristics that may have influenced the amount that a bidder was willing to bid. Chapter 2 focused on the theoretical issues associated with administration design and Chapter 3 on the specifics of each administration procedure. From this, the first major factor in determining the size of the highest observed bid seems to have been the method of licence administration. In general, it would appear that auctions fared considerable better in raising revenue than the comparative selection procedure. Mean per capita cost of an auctioned licence was almost four times greater than the mean of those paid by winners of beauty contest procedures. Indeed, when France initially attempted to charge comparable prices to the UK and German auctions they failed to administer all of their licences, with only two out of the four available licences receiving bids. However, even within the auction and beauty contest groups a large variation is apparent. This can be seen in Table 4.1 which shows the variability between administration procedures. The purpose of this study is to attempt to identify those factors that have caused such a range of prices via examining the bidders' highest bid. These factors include the market that the licence is being sold for, the way the type of licence is being sold and the characteristics of the bidding unit itself. The exact form of these variables will be outlined in the next section.

A cross-country empirical analysis of the size of average licence fee charged in each country is severely limited by the small number of individual country observations. Consequently the present analysis takes individual bidding units as the unit of analysis.[1] The empirical strategy models two processes – the first being the "observed highest bid" of the bidder; the second being the probability that a particular bidder was able, as a result of determining a particular highest bid, to win a licence to operate a 3G network in a particular nation state. In the case of the countries which used an auction, observed highest bid is revealed in the highest bid made by the bidding unit. When the administration process was by comparative selection the licence fee was set *ex ante* and so the observed highest bid is the fee set by the administering authority. Given that bidders control the size of highest observed bid in auctions and the administering authority controls the highest observed bid in beauty contest, the question arises as to what we are actually measuring. The temptation here is to consider the bid information as willingness to pay; this is particularly attractive as the goal of an auction is to sell an asset to the individual that values it the most at their willingness to pay. In beauty contests no applicant unit that would have a willingness to pay lower that that charged by the country using a comparative selection. The bidding unit may have a willingness to pay much higher than the fee charged in a beauty contest. The data from the observed highest bid for bidding units that did not win licences can be considered willingness to pay. The drop-out bid for the losing bidders will be the highest value that they place on the asset. However, when it comes to the winners of an auction this is not the case.

There are a number of potential problems with identifying the price bid by a bidding unit as their willingness to pay. Firstly how close the winning bid is to the willingness to pay will depend on the structure of the auction and indeed the number of licences offered. If two licences were being auctioned in an English style auction then the winning bidder would pay the willingness to pay of the bidder with the second highest valuation. This would be equivalent to a second price sealed bid auction. When there are five licences being administered in an English style auction then each bidder will pay the willingness to pay of the bidder with the sixth highest valuation. As such, the willingness to pay will

[1] In many cases bidding units were not a single company but a consortium which may have been formed specifically to bid for a licence from a particular national telecommunication authority.

diverge from the price paid by a greater amount as additional licences are offered in a particular administration. However, these may vary from administration to administration. Where the licences that are being offered are asymmetrical, whether this be in terms of quantity of spectrum offered, position of the frequency or the conditions attached to the licence, the effect may not be as great as with symmetrical licences. Depending on the design of the auction asymmetric licences may mean we should treat each licence as being auctioned individually. As such it may be more correct to refer to the dependent variable as the observed highest bid. Hong and Shum (2003), although taking a different focus, take the bid at which a bidding unit drops out from an auction and attempt to determine the distribution of bidder valuations.

4.2.2: Modelling the Probability of Winning.

In general, no particular objectives were explicitly identified by administration organisers as to which bidders would win licences. As such, there is no definitive answer over what might be expected to affect the probability of a bidder winning a licence. Given that the auctions were intended to be open procedures that maximised the amount of revenue from the licences the only issue that determined how likely a bidder was to win a licence was the value that it placed on that licence. It is not entirely clear if the administering authority had any preference for which bidder won a licence. Although they usually, although not always, had published selection criteria exactly how these criteria were applied is not always clear. As was alluded to in the previous chapter, where an administering authority has decided to use a comparative selection they may have already come under pressure from the incumbent firms. If this is the case then we may expect to see this carried through to the decision on who wins a licence with the incumbent operators more likely to win. To that end, the structure of the winner equation will be investigated by including an instrumented highest bid variable.

4.3 : The Model and Description of Variables

Given the definitions of the dependent variables from section 4.2.1 as the observed highest bid and from section 4.2.2 as the probability that a bidding unit won a licence, the model can be summarized as follows:

$$BID_{it} = a_0 + a_1 X_{1i} + a_2 X_{2i} + a_2 Z_{it} + a_3 t + u_{it} \qquad (4.1)$$

$$\Pr(win_{it} = 1) = b_0 + b_1 Z_{it} + b_2 t + v_{it} \tag{4.2}$$

In addition to this, the instrumented highest bid could be included in the winners' probit equation to give:

$$\Pr(win_{it} = 1) = b_0 + b_1 Z_{it} + b_2 t + b_3 B\hat{I}D_{it} + e_{it} \tag{4.3}$$

Where i denotes the bidder i and t denotes the timing of the particular licence administration procedure. Equation **(4.1)** models *BID*, the highest bid price. X_1 are covariates describing the characteristics of the particular market for which the bidder seeks to obtain a licence, and X_2 are covariates describing the characteristics of the administration process. Z captures particular characteristics of the bidding unit at the time of the administration process. u and v are error terms. Equation **(4.2)** models the probability that a particular bidding unit will be successful (*win*=1) in terms of its particular characteristics. Equation **(4.3)** therefore models the probability that a particular bidding unit will be successful in terms of its particular characteristics and predicted highest bid, instrumented by the right-hand side variables contained in reduced form equation **(4.1)**.

As was discussed in section 4.2.1, for the auction bidders it would be anticipated that the specification will be appropriate if the highest bid observed accurately reflects willingness to pay. For bidders in beauty contests we would expect coefficient b_3 to be statistically insignificant, since winners were selected on the basis of characteristics other than the value that they placed on the licence or, in this case, their predicted highest bid. Equations **(4.1)** and **(4.2)** are estimated separately and jointly using an instrumental variable probit estimator.

Descriptive statistics for the whole dataset and the restricted dataset can be found in Table 4.2 and Table 4.3. All the data were collated by the author from National Regulatory Authorities, The International Telecommunication Union and EUStat. Highest bid is measured by the log of the licence price paid per capita of market population. In the case of unsuccessful bidders it is the highest recorded bid prior to the bidder leaving the auction, and the case of operators who registered and were accepted to bid, but did not in fact enter the auction, the variable is taken as the published reserve price. For participants in comparative selection administrations the variable is measured as the published licence price. Where a fee was also explicitly stated in the licensing conditions its present value was also included. Where this fee was a portion of revenues an estimate of revenue was taken at present value and included. To calculate a value for the revenue of each licence holder, the number of subscribers (S), change in the average revenue per subscriber (ARS) and the share of subscribers for each operator are calculated. In order to calculate these numbers the country subscriber penetration (SP) and subscriber growth (SG) were calculated and the number of subscribers per operator were also calculated. The ARS was assumed to increase at 5 percent per year for the first 10 years of the licence and then held constant for the remainder of the duration. The SP is included to account for the slowing growth as penetration increases, the subscriber growth is then calculated as:

$$SG_t = ASG \times (1 - SP_t^2) \quad \textbf{(4.4)}$$

Where ASG is average subscriber growth between 1997 and 2001 in the country in question. Subscriber growth is then used to calculate the number of subscribers in a country as:

$$S_t = S_{t-1} \times (1 + SG_t) \quad \textbf{(4.5)}$$

From this, the number of subscribers for licence holder i, which is an incumbent firm, is taken as:

$$S_{it} = MS_{it} \times (S - (S \times Yt)) \quad \textbf{(4.6)}$$

Where MS is the market share of the firm at time t and Y is the growth rate of an entrant firm. When the firm is an entrant into the particular country the number of subscribers is taken as:

$$S_{it} = Yt \times S_t \quad \textbf{(4.7)}$$

The revenue of an operator is the present value of the number of subscribers multiplied by the ARPS.

4.3.1: Description of Variables

Market characteristics (X_1) are captured by five variables. The first is GDP per capita measured at 1999 levels and converted to Euros using a 1999 exchange rate. This variable captures average income levels across countries. The second variable measures the physical size of the market by taking the population level in 1999. It is anticipated that both income and population will be positively associated with the value of a licence and in turn the bidding unit's willingness to pay which should be reflected in their observed bid. The third, fourth and fifth variables provide more specific information on the development of the national mobile telephony market. Variables three and four are used together as the level of mobile and internet penetration. The level of mobile phone market penetration prior to the 3G administration in question is used, measured by the number of subscribers per 100 of population at the 1999 level. The internet penetration takes the percentage of the population that have a fixed-line internet connection in 1999. The fifth variable, which is used as a substitute to the mobile penetration and internet penetration variables, is an index of market conditions compiled by the International Telecommunication Union (ITU). This composite indicator includes measures for the structure of the regulator, fixed line market and mobile market. The index takes a value between 0 and 100, the higher the value attached to a particular country the more open and accessible its market.[2] Again it is anticipated that these variables will be positively associated with willingness to pay, although the strength of the association may be attenuated if the existing market is already very highly saturated. We could infer from a high mobile penetration that a county's population are open to the use of mobile technology and there is a large potential market. However, a very high mobile penetration may also indicate limited possibilities for future growth. As such the mobile penetration will also be included as a quadratic equation. It may be anticipated that the internet penetration variable will have a positive coefficient as it indicates a developed technological infrastructure within a particular country. However, new broadband applicants and technologies such as Voice Over Internet Protocol (VOIP) and Wi-Fi, internet services may come into direct competition with mobile telecommunication. If fixed-line internet connections are seen as substitutes then it may be more appropriate to expect a negative coefficient.

[2] For a full explanation of the ITU mobile market index see International Telecommunication Union (2002, p. A72).

Administration-specific factors (X_2) are captured by a further five variables. The first is the number of licences offered in the particular administration. The number of licences on offer may provide an indication of the extent to which the administration process was designed to encourage entry. If there were only as many 3G licences on offer as current 2G licences there would be limited incentive for entrant companies to attempt to win a licence. Additional licences should then increase the competition in the auction and we would expect a positive coefficient. However a greater number of licences on offer will also mean more operators in the post-auction market. Greater post-auction competition will decrease the value of the licence and hence willingness-to-pay. In addition to this, as discussed in the next chapter, if a greater number of licences does encourage entry into the auction procedure, then bidders may adjust their bids downwards in order to avoid a winner's curse. Authorities opting for a "beauty contest" may also have been aware of the potential to increase competition by allocating extra licences. However, an authority may only offer additional licences if the market is deemed large enough to support them. The larger the market was, or was thought to be, then the higher the price that the administration authority may have set. In some cases the number of licences that could be won in an administration was determined by the bidders' behaviour. In each of these cases, the maximum number of licences that were made available to bidders were all administered, and so this number is taken as the number of licences offered.

The next variable is the duration of the licences on offer. Here a positive association with the value of the licence is anticipated since a longer operating period will be more valuable. However it should be noted that the McKinsey report (European Commission, 2003) found no relationship between the duration of the licence and the licence price. If we believe that once a bidding unit wins a licence and establishes its network then it will automatically be allowed to continue operating once the licence has expired, then the officially stated licence duration is arbitrary. In addition to this, given the speed of technological change the licence duration may outlast the life of the technology. A regulatory authority may withdraw the licence at a future date if a new technology is being introduced. In both these circumstances we would expect no effect from increased licence duration.

The timing of the administration within the sequence of European spectrum allocations may have determined willingness-to-pay, since market sentiment may have been influenced by bidders' and by other authorities' experiences in earlier auctions and comparative selections. Two variables are used interchangeably to try and capture any time effect. The first variable is defined as the date at which an administration procedure began in terms of the number of days after the first administration procedure (that of Finland). The second variable looks only at the order that the administrations took place in. The first administration is given a value of 1 and the final a value of 18. Given the considerable decline in stock prices and fall in confidence about the future of the 3G format, as the European administration process proceeded, it may be expected that both variables will have a negative association with the highest observed bid. However, once again this relationship may not be clear cut, in the previous chapter we saw how some beauty contests changed the size of their licence fees in response to the high fees raised in early auctions. If this is the case then we may expect to see considerably different coefficients when the data sets are separated.

A simple binary variable is included in the model to distinguish between a comparative selection and an auction, defined as one for an auction. This is to indicate the extent to which the licence price may have reflected revealed willingness-to-pay on the part of successful bidders, rather than ex ante valuation placed on the licence by the national authority. Since auctions were seen to be more successful in terms of revenue raised a positive association is expected. This is despite the fact that some countries that were running beauty contests responded to the size of auction licence fees by increasing their beauty contest fees.

The final administration-specific characteristic is the reserve price set on the licence by the administration authority. This variable is only included for the auction administrations as there would clearly be no reserve price in a beauty contest. If the reserve price was set too high then it may have discouraged bidders, particularly new market entrants. However, a high reserve may have offered a means of increasing the licence price if collusion was present or if there was a limited number of bidders. However, in almost all cases the per capita reserve prices were set relatively low compared to the final price. Ex ante it seems unlikely that they served to reduce competition. Whether collusion took place is a contested issue.[3] If collusion took place a positive association between reserve price and highest bid would be expected. In order to take account of any interaction between the number of bidders and the reserve price an additional variable will be included of the reserve price multiplied by the number of bidders in each administration procedure.

Four bidder-specific variables (*Z*) are included in the analysis. The first is a binary variable capturing if the bidder was an incumbent 2G licence holder in the market in question. This is included to test whether incumbents performed better in the administration processes. In the comparative selection administrations incumbents may have been perceived by the authorities as more attractive bidders, and therefore may have enjoyed, other things equal, a higher likelihood of success or may have had an advantage in terms of some form of regulatory capture. In auction procedures the incumbent bidders may place a greater value on licences due to synergies with their current 2G operations. In both cases the variable would be expected to have a positive coefficient.

Two variables capture the bidder's current 2G exposure across Europe and give an indication of whether the bidder could be considered an international operator. One is a binary variable capturing if bidder held licences in two or more European states that took part in the process under consideration. If the bidding unit or the constituent firms that make up the bidding unit operate in two or more countries the variable takes a value of 1. The other variable takes the total number of 2G licences held which should give a better reflection of the level of a bidding unit's international operations. Where a bidding unit consists of a number of different firms and consist of at least one international operator then this international operator will be counted as long as it holds more than 25 percent stake in the bidding unit. Where there is more than one international operator in the bidding unit then the number of 2G licences held by the operator with the most 2G licences will be included. The final bidder-specific information concerns planned 3G exposure at the time of the administration in question. A variable is included measuring

[3] See Klemperer (2002a) for further discussion on the likelihood of collusion in 3G spectrum auctions.

the number of 3G licences in other countries that are included in the study that had already been won by the bidder at the time of each administration process. One motivation for including variables capturing international market exposure was the assertion in the McKinsey & Co. report that international operators fared better in the administration procedures that used auctions and incumbent operators fared better in administrations that used beauty contests.

There is a discrepancy between the number of administration procedures described in the previous chapter (17) and the number of administrations used in this analysis (16). Data from one administration, Denmark, is omitted from the empirical analysis. Denmark operated a sealed bid fourth price auction. These sealed bids were not made public and the Danish regulator refused to release them into the public domain. Without bidding information, each bidding unit's highest observed bid cannot be determined. The only data that are available is the observed bid of the bidding unit with the fourth highest bid. As discussed in section 4.2.1, this may be a similar amount of data as that available in other auctions; however, this is also the only data that is available for the losing bidders as well. As such, it was deemed appropriate that this administration should be excluded.

4.3.2*:* Descriptive Statistics

Table 4.2 and Table 4.3 provide descriptive statistics on the model's dependent variables and each of the covariates. The descriptive information in Table 4.2 is presented on three sample definitions. The first column includes data on bidders in all administrations including comparative selections and includes information on bidders who were authorized to bid in auctions but did not in fact bid above the reserve price once the auction had started. The total number of observations is 102. The second column provides descriptives on bidders for just the auction administrations, reducing the sample to 59 or 58% of the total number of bidder observations. Like the first column, the second column includes the bidders that did not enter a bid. The third column shows the statistics for the Beauty Contest administrations only. This reduces the number of observations to 43, which is 42% of the total observations. Table 4.3, like Table 4.2, provides the descriptive statistics for the whole and auction dataset. However these data excludes those organizations authorized to bid but who did not in fact bid above the reserve licence price. This reduces the number of observations further by 12. All of the observations that have been removed were from auction procedures and so the auction only sample now consists of 47 observation or 52 percent of the total. The beauty contest sample does not change and is only included in Table 4.2.

The table shows clearly higher bidding in the auction procedures than beauty contests. The mean of the log of licence bid per capita in the auctions is between 0.9 and 1.2 Euros per capita more than the average across all administrations and between 2.2 and 2.6 greater than the average across beauty contest procedures. Of all bidding units, 66 per cent of all candidates were successful, although in the auctions for authorized bidders prepared to bid above the reserve (once announced) the success rate was rather higher at 80 per cent. Of those entering a beauty contest procedure 70 per cent were successful. Larger countries, in terms of population size, are more likely to have used an auction administration method. However there is no evidence in the data that wealthier countries preferred auctions with an almost identical mean for the GDP of auction countries and beauty contest countries. The number of additional licences offered averages barely above one, with auctions offering more than comparative selections. This number questions how committed authorities were to encouraging competition in the allocation process and post allocation market. Most licences were offered for between 15 and 20 years duration with auction administrations having, on average, slightly longer durations. Mobile penetration averaged just above 46 percent for the whole group with countries that used beauty contests having slightly higher mobile penetration than auction countries, 51 and 43 percent respectively. Countries that used beauty contests also had slightly higher internet penetration than auction countries with a level of 25 percent compared to 18 percent for auctions. The ITU market index was similar for both groups sitting between 87 and 88. There was a clear preference, as the European process progressed, for beauty contests to be held rather than auctions. Beauty contests have a mean of 660 days after the initial administration compared to between 548 and 563 days for auctions (unrestricted and restricted respectively).

On average, half of the bidders in any national administration process possessed a licence to operate 2G mobile services in that country. However over 70% of bidders had significant 2G market exposure elsewhere across Europe, with the average number of 2G licences held per bidder at around 3.5. Bidders who proceeded beyond the opening of the auction administrations had even higher average 2G exposure with an average of over 4 licences each. Bidders that entered into beauty contest procedures had both lower international exposure and a lower number of 2G licences when compared to those in auction procedures. However, there was not the same differential in the probability of winning for an incumbent bidder between auction and beauty contest procedures. They were also more likely to have been successful in earlier 3G licence administrations. The correlation matrix can be found in Table 4.13 to Table 4.17.

4.4: Empirical Results

4.4.1: Total Data Set

Table 4.4 reports estimates for equation (1) modelling bidder highest bid for the full data set. Estimates are presented for six different specifications. Results are presented for estimations where the mobile penetration and internet penetration variables are substituted for the ITU market index variable. Specifications are also shown where the two timing variables are interchanged. Column (5) in Table 4.4 has the addition of the mobile penetration squared variable and Column (6) excludes the GDP variable. The GDP variable is excluded because estimation of the model reveals some multicollinearity between GDP per capita and the variables capturing characteristics of the administration process. The inclusion of GDP per capita reduces the size and statistical significance of the coefficients on most of the administration characteristics variables. This is particularly a problem for the auction-only data and all the restricted data. As such, the restricted total data set in Table 4.7 includes the same specifications as the unrestricted table but the GDP variable is only included once. R-squared statistics indicate that the model explains between 68 and 86 percent of the variation in highest bid, with a higher degree of explanatory power for the restricted sample.

GDP per capita in those equations in which it is included attracts a negative coefficient in all but one instance. In both columns 1 and 3 of Table 4.4 this coefficient is statistically significant. This is somewhat surprising but what it may indicate is that in wealthier markets the potential for 3G roll-out may have been perceived to be more limited. This is because current levels of 2G market penetration may be higher and therefore it would be more challenging to persuade existing customers to upgrade, whereas in less developed markets 3G roll-out would be concerned to a greater extent in recruiting entirely new customers to mobile communications services. However there is a strong hint in the results with higher GDP per capita may have also offered a greater number of licences (higher potential future competition) and licences of shorter duration, making bidding less attractive.

The significant positive coefficient on population does indicate that, other things equal, a larger market was seen as more attractive. In the full sample evaluated at sample mean population of 29 million, a one percent increase in population is associated with a 0.84 to 1.1 percent increase in observed bid, for the restricted data this figure is between 0.87 and 1.1 percent evaluated at a sample mean of 28 million. An improvement in market conditions as measured by the ITU index is also associated with an increase in observed bid in the full sample model, although not for the restricted sample. The level of mobile penetration is positively associated with the observed bid in all cases, although not always significant in the restricted sample. When the quadratic mobile penetration specification is used, mobile penetration is still positive but the squared variable is negative. This would suggest that as mobile markets became saturated the effect decreased.

Turning to the characteristics of the administration process, the results reveal a positive association between the number of additional licences on offer and licence fee in the full sample and the restricted sample. The licence duration has a negative coefficient in the majority of cases although this is significant in only a small number of instances. The positive significant coefficient on the two administration timing variables in the full and restricted sample suggests that either regulators become "greedier" as the European process developed or bidders became willing to pay more. This will only be determined once the data set has been split.

The coefficient on the administration method included in the full sample reveals the extent to which those countries which adopted a comparative selection method lost out in terms of revenue. Auction bidders highest observed bids regardless of success was, other things equal, around 169 and 187 percent higher than the equivalent fee set in a comparative section administration across both the restricted and unrestricted samples. This difference reflects the difference ex ante between the valuation placed on the opportunity to provide improved mobile telephony by regulatory authorities and by bidders. The size of this relationship strongly encourages the examination of the data as separate auction and beauty contest sub-sets.

Any association between bidder characteristics and willingness to pay is quite weak in terms of statistical significance. Local 2G incumbents do appear to have been prepared to bid more by as much as 40%. However this association disappears in the restricted auction sample, suggesting that once weaker potential bidders (who did not in fact enter the full bidding process) are excluding no such incumbent effect remains. This does however suggest that existing incumbents were better placed in getting to the start of the bidding compared to newly formed, untested potential operators. The scale of a bidder's current 2G operations, as indicated by holding more than two other 2G licences is also positively associated with highest observed bid in all cases. However this relationship is only significant for the full data sample The 3G licences won to date attracts a weak negative coefficient in nearly all cases, there is no significant evidence to suggest that if a bidder had won in the early allocations that they were discouraged from continuing to commit funds to acquiring further 3G licences.

4.4.2: *Auction Data Subset*

Table 4.5 to Table 4.8 contain the results for the auction data set for the total and restricted samples respectively. The specifications are the same as for the combined data sets apart from the exclusion of the binary variable for the type of administration used and the inclusion of a reserve price variable. Unlike the combined data the positive relationship between population and observed bid is only significant for the restricted data. The magnitude of the relationship is also smaller than with the combined data. Likewise, the ITU index is only significant for the restricted data and surprisingly takes a negative sign.

The coefficient on the additional licence variable reverses sign when considering auctions alone (although only becomes significant when GDP per capita is omitted). This combined with the full data set results would suggest that regulators, where comparative selection was adopted, set higher fees if they had more licences to allocate. However for auction bidders, greater potential competition reduced the attractiveness of licences and therefore the highest bid they would place. As anticipated, there is also a positive association between licence duration and observed bids in the case of auction bidders (again particularly if GDP per capita is omitted). Unlike the combined data, auction bidders appear to reveal a significant drop in the observed bid as the process continued. The coefficients for the timing variables in Table 4.5 suggest that highest observed bid fell, other things equal, by 0.5 to 0.8 percentage points per day. For every administration that took place the observed bid dropped between 20 and 27 percentage points. Table 4.8 reports similar results a daily fall of between 0.6 and 0.7 percent and an administration decrease of between 23 and 24 percent. The results also reveal a positive association between auction reserve price and the highest observed bid. This was the case in all but two specifications (one of which is significant). This suggests that a higher reserve price indicates that opportunity for collusion may have been present. There is no suggestion in the results that a higher reserve price discouraged bidding. This is supported by the positive and significant coefficient for the reserve price multiplied by the number of bidders variable.

There is a stronger association between the bidder characteristics and observed bid than with the combined data. 2G incumbents bid around 45% more in unrestricted and 17% more in the restricted data. However the incumbent variable has a lower significance level than the international operator (more than two 2G licences) variable, which was also positive in all cases. This is in contrast to the number of 2G licences held which although positive were not significant in any case. There is also no statistical evidence that the number of 3G licences won previously had an impact on highest bid in later administration procedures.

4.4.3: Beauty Contest Data Subset

Table 4.6 reports the results from the beauty contest data subset. As no beauty contest observations were removed for the restricted sample these results are consistent across both. As with the auction subset the binary method variable is removed and as discussed earlier the reserve price variable is not included. There appears to be no evidence that regulators have set higher charges for longer licences where comparative selection was adopted. This perhaps reinforces the idea that the length of the licence was not considered to be realistic. As was expected from the combined and auction results, where the regulator administered additional licences they also charged a higher price. Also, as time went on regulators became greedier and increased their charges. This was around 0.3 percent a day or 25 percent per administration. Unsurprisingly the bidder characteristics had very little influence over the size of the licence fee charged by the regulator. The bidder characteristic variables are only significant in two instance and these are only at the 90% level.

4.4.4: Probability of Winning Equation

The second stage of the empirical analysis is to consider the question of what factors, if any, are associated with the likelihood of winning a licence in the European administration process. Two specifications are reported. The first is a simple model which seeks to predict winner status on the basis of bidder characteristics as shown in equation **(4.2)**. The second specification reports the results of an instrumental variable probit regression in which instrumented highest observed bid is included shown in equation **(4.3)**. This variable is, in effect, predicted from the appropriate corresponding equation in Table 4.4, Table 4.5 and Table 4.7.

Table 4.9 reports the results of probit regressions for the probability of being a licence winner (winner = 1). The table contains the same specification for the entire data set, auction only, beauty contest only, the total restricted and auction restricted. In all cases being an incumbent in administering country increase the probability of winning a licence. Being an international operator only increases the probability of winning for auction administrations.

Table 4.10 to Table 4.12 report the results of the reduced form equations and the instrumented variable probit. A result for the restricted auction subset could not be obtained due to the small number of observations. The results for the IVProbit are reported as marginal effects. A key finding in all of these tables is that instrumented highest bid is not significantly associated with the probability of winning a licence.[4] In the case of the full sample this would not be a surprising result if those regulators administering a comparative selection process used criteria other than the value of the licence to a bidder as the dominant means of allocating licences to winners. This was, of course, the case since by indicating their willingness to be considered as a bidder each candidate must have been prepared to pay the pre-published licence fee, and winner selection would have been conducted on the basis of other additional criteria. The regression findings are far more surprising for the auction sample found in Table 4.11. In the case of the auctions, actual willingness to pay, revealed by contestants' highest bids, by definition explains who won. The models reported in Table 4.11 to predict willingness to pay, despite explaining the majority of the variance in final bidding, appear to omit other information which determined who was prepared to remain in the bidding longest.

All the probit results suggest that incumbent 2G operators had a huge advantage in bidding to win licences in countries in which they were already established operators, under both comparative selection and auction administration processes. There is also some evidence, particularly in the instrumental variables models, that possession of a number of current 2G operator licences conferred a further advantage. Being an incumbent increased the probability of winning a licence between 45 and 57 percentage points for the combined and auction data. The relationship between incumbency and winning a licence appears to break down for the beauty contest data when the instrument observed bid is included. In the auction sub-sample holding two or more 2G licences also increased the probability of winning a licence between 54 and 58 percentage points.

4.5: Assessment

Chapters 1 and 2 discussed how governments realise that radio spectrum is a highly valuable public resource and how they attempted to administer it in the European 3G

[4] The first stage of the reduced form equation is estimated with a maximum likelihood estimator in order to be able to obtain marginal effects for the probit analysis.

mobile communications licence allocation whilst attempting to achieve a number of goals. The analysis presented in this chapter highlights a number of key findings. Firstly it documents the scale to which those countries which allocated spectrum on a fixed fee comparative selection process lost out by ignoring lessons from elsewhere in the world that auctioning radio spectrum could be made to work successfully. Results presented here suggest that, other things equal, revenues per capita of population raised by such "beauty contests" could have been as much as 160 percent higher if auctioning had been adopted. Changes in market sentiment as the European process progressed resulting in lower bidder valuations, but higher valuations being set by authorities adopting comparative selection as their administration method. This served to narrow the gap between the two methods, but only very partially. This left some countries, though little fault of their own, with little revenue from their licence allocations but the same regulatory problems as other countries.

The second key feature is that incumbent operators appear to have enjoyed a considerable advantage over new bidders in the allocation process even under auctions. This was partly understood in advance by some authorities who reserved particular licences for new entrants. However the results from this chapter suggest that incumbent advantage was very great and that further efforts to improve the contestability of the 3G market may have been warranted. In deciding which administration method to adopt, the European Commission left individual member states to their own devices. Removing this option would have reduced the discrepancy. Introducing issues of timing mean that the matter becomes more complicated. If an auction had been universally adopted then in principle it would have been possible to have conducted a single multi-unit European auction. This would, though, have been very complicated and exacerbated apparent information asymmetries between entrant bidders and 2G incumbent bidders. Adopting comparative selection on a universal basis may have resolved this but would have led to other inefficiencies. Not least of these the potential loss in revenues from a beauty contests. Across Europe there are overlapping regulatory concerns and so the more appropriate method of licence administration is far from certain.

Thirdly, variation in national market conditions and in administration processes is associated with variation in the highest observed bid (or "willingness to charge" in the case of comparative selection allocations). The greater or more promising the market potential the higher was the willingness to pay. However simple levels of economic well-being (GDP) do not correlate easily with greater market potential. Bidders may have preferred licences in less developed markets where the opportunity to bring entirely new customers to mobile telephone communications were greater. Selling to new customers may have been at least as attractive as persuading existing 2G subscribers to upgrade and use expanded services. In the auction allocations greater market competition (a larger number of eventual operators) reduced the attractiveness of licences. Market and administration characteristics, combined to some extent with information on bidder characteristics, explain a high proportion of the variance in highest observed bid. But predicted highest bid does not appear to be associated with a higher probability of winning a licence. This suggests that other unobserved or unobservable information was present in the bidding process.

This chapter's analysis supports some of the findings of the McKinsey and Co. report (European Commission, 2002a) on the operation of the administration process. However it also finds some key differences. Although the timing of administration was negatively associated with the highest bid for the auction bidders, there was a positive association for the whole dataset and, in particular, for the beauty contest dataset. Some support is also found for the McKinsey assertion that offering additional licences increased licence fees, but only when data from auctions and comparative selections is pooled. For the auction-only sample this relationship is found to be negative. McKinsey and Co. stated the view that additional licences increased competition in bidding, causing more aggressive bidding and higher licence fees. Our results suggest that the opposite is true - offering more licences appears to have been taken as a signal that eventual market competition would be higher and therefore licences less attractive. The results also seem to suggest, in contrast to the official European Commission report, that licence duration is positively associated with highest bid placed.

The past three chapters have primarily focussed on those factors that determined the level of licence fees in the European administrations. Given the way that licence administration procedure have interacted with each other particularly, over timing a question remains of whether too much was paid. Although some decisions made by the administering authority did impact on their revenue raised, there were other determinants that were luck rather than judgement. The size of effect from the timing variables is a key example. With the integrated nature of the European telecommunications market, overpayment in one country can impact upon others. The next three chapters will explore the issue of overpayment in the 3G administration. If overpayment has occurred then the winners may have suffered a winner's curse. The possibility of a winner's curse will be explored and the possible regulatory implications of this considered.

Table 4.1: European 3G spectrum administration

Country	*Date*	*Method*	*No. of Bidders*	*No. of Licences awarded*	*Total Revenue Raised (€m)*	*Revenue per capita (€)*
Finland	16/03/99	CS	4	4	5.6	1.1
Spain	13/03/00	CS	6	4	301	7.6
UK	27/04/00	Auction	13	5	36,880	619.9
Netherlands	24/07/00	Auction	5	5	2,690	169.6
Germany	18/08/00	Auction	9	6	50,810	618.4
Italy	23/10/00	Auction	8	5	13,820	240.9
Austria	03/11/00	Auction	6	6	704	86.1
Norway	29/11/00	CS	7	4	94.4	21.3
Switzerland	06/12/00	Auction	9	4	132	18.4
Sweden	16/12/00	CS	9	4	28.3	3.2
Portugal	20/12/00	CS	7	4	399	40.0
Belgium	02/03/01	Auction	4	4	450	44.4
France (1)	31/05/01	CS	2	4	9,900	168.9
Greece	13/07/01	Auction	4	4	485	45.6
Denmark	20/09/01	Auction	5	4	510	95.9
Luxembourg (1)	22/05/02	CS	3	4	8.4	19.5
Ireland	25/06/02	CS	3	4	284	76.8
France (2)	27/09/02	CS	1	2	1033	17.6
Luxembourg (2)	15/07/03	CS	1	1	2.8	6.5

Source: collated by the author from data published by European national regulatory authorities.
Note: CS denotes Comparative selection ("Beauty contest")

Table 4.2: Descriptive Statistics

	(1) All administrations N=102		(2) Auctions only N=59		(3) Beauty Contests only N=43	
	Mean	Std. dev.	Mean	Std. dev	Mean	Std. dev
Dependent variables:						
Log licence bid per capita (1999 €)	0.556	1.77	1.492	1.291	-0.727	1.519
Licence winner	0.657	0.477	0.627	0.488	0.698	0.465
Market characteristics:						
GDP per capita 1999€ '0000s	2.719	0.845	2.72	0.641	2.717	1.073
Population (m)	28.982	27.873	39.484	29.606	14.572	17.038
ITU market conditions index	87.096	4.361	87.846	4.959	86.068	3.149
Mobile Penetration	0.464	0.105	0.427	0.108	0.505	0.112
Internet Penetration	0.213	0.117	0.177	0.006	0.252	0.154
Administration characteristics:						
No. of licences in addition to 2G licences	1.049	0.635	1.119	0.646	0.953	0.615
Licence duration (yrs)	17.392	2.822	18.136	2.439	16.372	3.016
Administration timing (elapsed days)	604.177	248.996	563.136	119.649	660.488	351.725
Administration timing (ordering)	7.696	4.402	6.508	3.266	7.860	5.672
Administration method (auction=1)	0.578	0.496	-	-	-	-
Reserve licence price, € per capita	-	-	8.658	11.694	-	-
Bidder characteristics:						
2G incumbent in market	0.490	0.502	0.492	0.504	0.488	0.506
Two or more 2G licences held	0.706	0.458	0.712	0.457	0.698	0.465
Total 2G licences held	3.598	4.108	3.559	4.236	3.651	3.975
Total 3G licences won to date	1.804	2.221	1.661	1.872	2.00	2.637

Source: author's computations from data published by national regulatory authorities. Population and GDP data from European Commission: Statistical Office of the European Communities.

Table 4.3: Descriptive Statistics (Restricted Sample)

	(1) All administrations (Restricted Sample) N=90		(3) Auctions only (restricted sample) N=47	
	Mean	Std. dev.	Mean	Std. dev
Dependent variables:				
Log licence bid per capita (1999 €)	0.634	1.846	1.879	1.081
Licence winner	0.744	0.439	0.787	0.414
Market characteristics:				
GDP per capita 1999€ '0000s	2.678	0.835	2.642	0.544
Population (m)	28.205	27.075	40.678	28.645
ITU market conditions index	87.135	4.53	88.11	5.35
Mobile Penetration	0.464	0.105	0.427	0.082
Internet Penetration	0.217	0.117	0.175	0.044
Administration characteristics:				
No. of licences in addition to 2G licences	1.033	0.643	1.106	0.667
Licence duration (yrs)	17.433	2.864	18.404	2.355
Administration timing (elapsed days)	660.488	351.726	548.213	154.35
Administration timing (ordering)	6.933	4.63	6.085	3.249
Administration method (auction=1)	0.522	0.502	-	-
Reserve licence price, € per capita	-	-	8.17	11.522
Bidder characteristics:				
2G incumbent in market	0.544	0.501	0.596	0.414
Two or more 2G licences held	0.744	0.439	0.787	0.414
Total 2G licences held	3.944	4.23	4.212	4.477
Total 3G licences won to date	1.9	2.293	1.809	1.952

Table 4.4: Highest Bid Equation

Dependent variable: log licence bid per capita	(1) All	(2) All	(3) All	(4) All	(5) All	(6) All
Constant	-11.786*** (2.571)	-5.059*** (1.391)	-7.965*** (2.766)	-4.554*** (1.478)	-17.379*** (2.434)	-5.336*** (-3.87)
Market characteristics:						
GDP per capita	-0.475*** (0.136)	-0.231 (0.184)	-0.303** (0.15)	0.02 (0.178)	-0.252 (0.156)	-
Population	0.029*** (0.005)	0.033*** (0.005)	0.034*** (0.005)	0.038*** (0.005)	0.036*** (0.005)	0.035*** (0.005)
ITU market conditions index	0.111*** (0.027)	-	0.072** (0.029)	-	-	-
Mobile Penetration	-	0.059*** (0.0152)	-	0.063*** (0.016)	0.654*** (0.097)	0.063*** (0.015)
Mobile Penetration ^{2}	-	-	-	-	-0.007*** (0.001)	
Internet Penetration	-	-0.039** (0.017)	-	-0.058*** (0.017)	0.008 (0.018)	-0.053*** (0.013)
Administration characteristics:						
No. of additional licences offered	0.542*** (0.170)	0.403** (0.174)	0.512*** (0.191)	0.369** (0.183)	0.827*** (0.171)	0.32* (0.162)
Licence duration	-0.081* (0.042)	-0.024 (0.047)	-0.081* (0.047)	-0.044 (0.049)	0.005 (0.042)	-0.021 (0.047)
Administration timing (Elapsed Days)	0.004*** (0.001)	0.003*** (0.001)	-	-	-	0.003*** (0.000)
Administration timing (Ordering)	-	-	0.173*** (0.036)	0.139*** (0.035)	0.093*** (0.03)	-
Administration method (auction=1)	1.685*** (0.223)	1.833*** (0.247)	1.758*** (0.252)	1.755*** (0.261)	1.134*** (0.242)	1.711*** (0.228)
Bidder characteristics:						
2G incumbent in market	0.392* (0.228)	0.116 (0.233)	0.353 (0.258)	0.082 (0.247)	0.365* (0.213)	0.116 (0.233)
Two or more 2G licences held	0.649** (0.251)	0.721*** (0.258)	0.572** (0.284)	0.731*** (0.273)	0.571*** (0.231)	0.73*** (0.258)
Total 2G licences held	0.036 (0.0326)	0.045 (0.033)	0.042 (0.037)	0.052 (0.036)	0.027 (0.03)	0.045 (0.034)
Total 3G licences won to date	-0.069 (0.060)	-0.064 (0.061)	-0.068 (0.071)	-0.077 (0.068)	-0.046 (0.057)	-0.061 (0.061)
R^2	0.743	0.738	0.675	0.709	0.850	0.733
N	102	102	102	102	102	102

Table 4.5: Highest Bidder Equation (Auction Data)

Dependent variable: log licence bid per capita	(1) Auction	(2) Auction	(3) Auction	(4) Auction	(5) Auction	(6) Auction	(7) Auction
Constant	4.225 (2.891)	2.636 (2.821)	-2.554 (2.119)	-2.866 (2.32)	0.638 (3.462)	451.87 (582.032)	2.732 (2.784)
Market characteristics:							
GDP per capita	-0.966* (0.532)	-	-	-	-	-	-
Population	0.006 (0.006)	0.006 (0.006)	0.005 (0.006)	0.014 (0.012)	0.02** (0.01)	-0.014 (0.045)	0.004 (0.006)
ITU market conditions index	0.027 (0.040)	-0.027 (0.027)	0.003 (0.023)	-	-	-	-0.039 (0.028)
Mobile Penetration	-	-	-	0.024 (0.03)	0.038 (0.024)	-33.976 (43.872)	-
Mobile Penetration ^{2}	-	-	-	-	-	0.425 (0.549)	-
Internet Penetration	-	-	-	-0.014 (0.044)	-0.063 (0.047)	4.784 (6.252)	-
Administration characteristics:							
No. of additional licences offered	0.143 (0.381)	-0.458** (0.194)	-0.458** (0.189)	-0.499*** (0.186)	-0.431** (0.197)	-36.203 (46.14)	-0.562*** (0.19)
Licence duration	0.0006 (0.160)	0.269*** (0.062)	0.269*** (0.06)	0.224** (0.098)	0.124 (0.086)	5.661 (7.141)	0.314*** (0.068)
Administration timing (Elapsed Days)	-0.007*** (0.002)	-0.008*** (0.002)	-	-	-0.005** (0.003)	0.0955 (0.13)	-0.007*** (0.002)
Administration timing (Ordering)	-	-	-0.271*** (0.054)	-0.204* (0.103)	-	-	-
Reserve licence price	0.010 (0.026)	0.051*** (0.051)	0.043*** (0.012)	0.023 (0.03)	0.005 (0.024)	-0.424 (0.554)	-
Reserve Price x N.O bidders							0.007*** (0.002)
Bidder characteristics:							
2G incumbent in market	0.455* (0.244)	0.503** (0.248)	0.477* (0.242)	0.455* (0.244)	0.455* (0.244)	0.447* (0.245)	0.486* (0.246)
Two or more 2G licences held	0.606** (0.264)	0.534** (0.267)	0.562** (0.257)	0.604** (0.264)	0.606** (0.264)	0.659** (0.273)	0.548* (0.264)
Total 2G licences held	0.004 (0.033)	0.011 (0.033)	0.007 (0.257)	0.004 (0.033)	0.004 (0.033)	0.004 (0.033)	0.01 (0.033)
Total 3G licences won to date	-0.009 (0.0743)	-0.041 (0.074)	-0.018 (0.0742)	-0.009 (0.074)	-0.009 (0.0742)	-0.02 (0.076)	-0.032 (0.073)
R^2	0.751	0.733	0.747	0.75	0.751	0.75	0.74
N	59	59	59	59	59	59	59

Table 4.6: Highest Bidder Equation (Beauty Contest Data)

Dependent variable: log licence bid per capita	(1) Beauty Contest	(2) Beauty Contest	(3) Beauty Contest	(4) Beauty Contest	(5) Beauty Contest	(6) Beauty Contest
Constant	-0.964 (7.368)	-22.044*** (7.449)	-3.449* (1.91)	-46.119*** (3.596)	-12.706*** (4.502)	-2.5** (1.129)
Market characteristics:						
GDP per capita	-0.628*** (0.134)	-	-	-	-	-0.406*** (0.102)
Population	0.019** (0.019)	0.041*** (0.01)	0.036*** (0.012)	0.052*** (0.005)	0.039*** (0.008)	0.021** (0.008)
ITU market conditions index	-0.015 (0.077)	0.193** (0.08)	-	-	0.081* (0.048)	-
Mobile Penetration	-	-	0.046 (0.032)	1.741*** (0.14)	-	-0.018 (0.019)
Mobile Penetration ^{2}	-	-	-	-0.019*** (0.002)	-	-
Internet Penetration	-	-	-0.056*** (0.018)	0.071*** (0.013)	-	0.000 (0.013)
Administration characteristics:						
No. of additional licences offered	1.323*** (0.17)	1.048*** (0.204)	0.997*** (0.189)	2.168*** (0.125)	1.354*** (0.163)	1.455*** (0.137)
Licence duration	-0.055 (0.043)	-0.005 (0.0528)	-0.112* (0.055)	0.208*** (0.035)	0.025 (0.043)	-0.026 (0.038)
Administration timing (Elapsed Days)	0.003*** (0.001)	0.004*** (0.001)	0.003*** (0.000)	-0.001** (0.000)	-	-
Administration timing (Ordering)	-				0.259*** (0.032)	0.234*** (0.02)
Bidder characteristics:						
2G incumbent in market	0.42* (0.211)	0.302 (0.268)	0.215 (0.259)	0.16 (0.11)	0.061 (0.221)	0.207 (0.169)
Two or more 2G licences held	0.12 (0.244)	0.156 (0.311)	0.314 (0.294)	0.069 (0.126)	0.23 (0.253)	0.184 (0.19)
Total 2G licences held	-0.012 (0.035)	0.003 (0.044)	0.01 (0.042)	0.011 (0.018)	0.028 (0.036)	0.011 (0.027)
Total 3G licences won to date	0.096* (0.054)	0.101 (0.069)	0.063 (0.066)	-0.012 (0.029)	0.016 (0.059)	0.026 (0.044)
R^2	0.886	0.807	0.841	0.972	0.839	0.902
N	43	43	43	43	43	43

Table 4.7: Highest Bidder Equation (Restricted)

Dependent variable: log licence bid per capita	(1) All (restricted)	(2) All (restricted)	(3) All (restricted)	(4) All (restricted)	(5) All (restricted)	(6) All (restricted)
Constant	-2.764 (-2.764)	-3.968* (2.335)	-1.07 (1.182)	-4.681** (2.337)	-1.823 (1.216)	-13.786*** (2.251)
Market characteristics:						
GDP per capita	-0.391*** (0.138)	-	-	-	-	-
Population	0.031*** (0.005)	0.033*** (0.005)	0.034*** (0.005)	0.037*** 0.005	0.038*** (0.005)	0.035*** (0.004)
ITU market conditions index	0.0326 (0.025)	0.029 (0.026)	-	0.033 (0.026)	-	
Mobile Penetration	-	-	0.024 (0.015)	-	0.03* (0.015)	0.571*** (0.088)
Mobile Penetration ^{2}	-	-	-	-	-	-0.006*** (0.001)
Internet Penetration	-	-	-0.04*** (0.013)	-	-0.04*** (0.013)	0.005 (0.013)
Administration characteristics:						
No. of additional licences offered	0.572*** (0.162)	0.434*** (0.161)	0.45*** (0.154)	0.48*** (0.158)	0.481*** (0.151)	0.814*** (0.139)
Licence duration	-0.112*** (0.042)	-0.072* (0.041)	-0.102** (0.044)	-0.73* (0.041)	-0.095** (0.043)	-0.044 (0.037)
Administration timing (Elapsed Days)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	-	-	0.001* (0.000)
Administration timing (Ordering)	-	-		0.149*** (0.03)	0.122*** (0.028)	.
Administration method (auction=1)	1.697*** (0.23)	1.63*** (0.239)	1.625*** (0.224)	1.869*** (0.232)	1.83*** (0.223)	1.068*** (0.204)
Bidder characteristics:						
2G incumbent in market	-0.209 (0.233)	-0.138 (0.242)	-0.232 (0.231)	-0.149 (0.238)	-0.252 (0.228)	0.102 (0.197)
Two or more 2G licences held	0.205 (0.253)	0.193 (0.264)	0.307 (0.256)	0.291 (0.262)	0.39 (0.253)	0.296 (0.21)
Total 2G licences held	0.027 (0.031	0.028 (0.033)	0.028 (0.031)	0.035 (0.032)	0.035 (0.031)	0.011 (0.026)
Total 3G licences won to date	-0.011 (0.056)	-0.000 0.059	-0.004 (0.057)	-0.056 (0.062)	-0.04 (0.06)	0.007 (0.046)
R^2	0.793	0.772	0.792	0.779	0.801	0.864
N	90	90	90	90	90	90

Table 4.8: Highest Price Equation (Auction Data Restricted)

Dependent variable: log licence bid per capita	(1) Auction (restricted)	(2) Auction (restricted)	(3) Auction (restricted)	(4) Auction (restricted)	(5) Auction (restricted)	(6) Auction (restricted)	(7) Auction (restricted)
Constant	7.569*** (0.937)	6.694*** (0.977)	6.734*** (1.117)	2.344*** (0.735)	256.243 (168.302)	1.976*** (0.666)	6.772*** (0.934)
Market characteristics:							
GDP per capita	-0.519*** (0.177)	-	-	-	-	-	-
Population	0.017*** (0.002)	0.016*** (0.002)	0.025*** (0.003)	0.017*** (0.004)	0.006 (0.013)	0.017*** (0.002)	0.015*** (0.002)
ITU market conditions index	-0.05*** (0.014)	-0.079*** (0.01)	-	-	-	-0.051*** (0.008)	-0.087*** (0.01)
Mobile Penetration	-	-	0.008 (0.008)	-0.009 (0.01)	-18.803 (12.689)	-	-
Mobile Penetration ^{2}	-	-	-	-	0.235 (0.159)	-	-
Internet Penetration	-	-	-0.148*** (0.016)	-0.086*** (0.014)	2.534 (1.809)	-	-
Administration characteristics:							
No. of additional licences offered	-0.119 (0.123)	-0.433*** (0.066)	-0.135** (0.063)	-0.22*** (0.059)	-19.921 (13.346)	-0.44*** (0.06)	-0.507*** (0.064)
Licence duration	0.14** (0.055)	0.285*** (0.026)	-0.006 (0.027)	0.12*** (0.032)	3.057 (2.066)	0.281*** (0.023)	0.315*** (0.027)
Administration timing (Elapsed Days)	-0.006*** (0.001)	-0.007*** (0.001)	-0.006*** (0.001)	-	0.049 (0.038)	-	-0.007*** (0.001)
Administration timing (Ordering)	-	-	-	-0.257*** (0.035)	-	-0.234*** (0.02)	-
Reserve licence price	0.012 (0.009)	0.034*** (0.005)	-0.019** (0.008)	0.005 (0.01)	-0.256 (0.160)	0.026*** (0.004)	-
Reserve Price x N.O bidders	-	-	-	-	-		0.005*** (0.001)
Bidder characteristics:							
2G incumbent in market	0.168** (0.081)	0.158* (0.089)	0.167** (0.08)	0.168** (0.081)	0.162** (0.079)	0.168** (0.08)	0.162* (0.094)
Two or more 2G licences held	0.194** (0.091)	0.151 (0.098)	0.198** (0.09)	0.195** (0.09)	0.235** (0.092)	0.188** (0.088)	0.16* (0.094)
Total 2G licences held	0.005 (0.01)	0.01 (0.011)	0.005 (0.01)	0.005 (0.01)	0.005 (0.01)	0.005 (0.01)	0.008 (0.01)
Total 3G licences won to date	0.006 (0.024)	-0.015 (0.026)	0.005 (0.024)	0.006 (0.024)	-0.001 (0.024)	0.005 (0.024)	-0.007 (0.025)
R^2	0.971	0.964	0.971	0.971	0.973	0.971	0.958
N	47	47	47	47	47	47	47

Table 4.9: Winner Probit Equation

	(1) All	(2) Auction	(3) Beauty Contest	(4) All (Restricted)	(5) Auction (Restricted)
	Probit	Probit	Probit	Probit	Probit
2G incumbent in market	0.556*** (0.09)	0.617*** (0.132)	0.524*** (0.129)	0.471*** (0.098)	0.428*** (0.156)
Two or more 2G licences held	0.264 (0.150)	0.465** (0.203)	0.054 (0.207)	0.186 (0.143)	0.297 (0.214)
Total 2G licences held	0.002 (0.019)	0.011 (0.028)	-0.011 (0.027)	-0.002 (0.015)	0.001 (0.015)
Total 3G licences won to date	0.039 (0.033)	0.040 (0.054)	0.050 (0.041)	0.033 (0.026)	0.028 (0.031)
N	102	59	63	90	47
Log likelihood	-40.156	-20.329	-17.805	-32.884	-13.737
Pseudo R^2	0.388	0.478	0.324	0.357	0.435

Table 4.10: Reduced Form Highest Bidder Equation

Dependent variable: log licence bid per capita	(1) All	(2) All	(3) All	(4) All	(5) All	(6) All
Constant	-12.768*** (2.32)	-4.979*** (1.319)	-9.599*** (2.491)	-4.429*** (1.395)	-17.746*** (2.2)	-5.323*** (1.307)
Market characteristics:						
GDP per capita	-0.503*** (0.121)	-0.243 (0.175)	-0.335*** (0.129)	-0.004 (0.171)	-0.346** (0.148)	-
Population	0.03*** (0.004)	0.033*** (0.005)	0.035*** (0.005)	0.038*** (0.005)	0.036*** (0.004)	0.035*** (0.005)
ITU market conditions index	0.127*** (0.025)	-	0.095** (0.026)	-	-	-
Mobile Penetration	-	0.058*** (0.015)	-	0.061*** (0.016)	0.682*** (0.088)	0.063*** (0.014)
Mobile Penetration ^{2}	-	-	-	-	-0.007*** (0.001)	-
Internet Penetration	-	-0.038** (0.016)	-	-0.055*** (0.017)	0.022 (0.017)	-0.053*** (0.012)
Administration characteristics:						
No. of additional licences offered	0.494*** (0.151)	0.396** (0.164)	0.45*** (0.167)	0.357** (0.172)	0.827*** (0.154)	0.318** (0.155)
Licence duration	-0.097*** (0.037)	-0.025 (0.044)	-0.099** (0.041)	-0.046 (0.046)	0.002 (0.038)	-0.021 (0.044)
Administration timing (Elapsed Days)	0.004*** (0.000)	0.003*** (0.001)	-	-	-	0.002*** (0.000)
Administration timing (Ordering)	-	-	0.179*** (0.031)	0.14*** (0.033)	0.093*** (0.027)	-
Administration method (auction=1)	1.666*** (0.203)	1.844*** (0.233)	1.705*** (0.232)	1.78*** (0.245)	1.151*** (0.218)	1.712*** (0.215)
Bidder characteristics:						
2G incumbent in market	0.428** (0.214)	0.122 (0.218)	0.39 (0.241)	0.091 (0.232)	0.409* (0.198)	0.118 (0.22)
Two or more 2G licences held	0.648*** (0.236)	0.718*** (0.241)	0.591** (0.266)	0.726*** (0.255)	0.543** (0.216)	0.73*** (0.243)
Total 2G licences held	0.033 (0.031)	0.044 (0.031)	0.039 (0.035)	0.051 (0.033)	0.023 (0.03)	0.045 (0.032)
Total 3G licences won to date	-0.057 (0.056)	-0.063 (0.057)	-0.064 (0.065)	-0.076 (0.064)	-0.041 (0.053)	-0.061 (0.058)
IVProbit						
Highest Bid Instrument	-0.041 (0.032)	0.000 (0.033)	-0.056* (0.033)	-0.05 (0.034)	-0.027 (0.032)	0.005 (0.033)
2G incumbent in market	0.547*** (0.089)	0.556*** (0.09)	0.537*** (0.09)	0.556*** (0.09)	0.569*** (0.089)	0.555*** (0.09)
Two or more 2G licences held	0.282** (0.143)	0.262* (0.15)	0.285** (0.141)	0.265* (0.15)	0.298** (0.15)	0.261* (0.151)
Total 2G licences held	0.003 (0.017)	0.002 (0.019)	0.004 (0.017)	0.002 (0.019)	-0.002 (0.018)	0.002 (0.019)
Total 3G licences won to date	0.033 (0.033)	0.04 (0.033)	0.033 (0.033)	0.039 (0.033)	0.042 (0.034)	0.04 (0.033)
N	102	102	102	102	102	102
Log Likelihood	-169.846	-174.147	181.267	-179.344	-158.944	-175.105

Table 4.11: Reduced Form Highest Bidder Equation (Auction Data)

Dependent variable: log licence bid per capita	(1) Auction	(2) Auction	(3) Auction	(4) Auction	(5) Auction	(7) Auction
Constant	2.669 (1.949)	0.802 (2.075)	-2.025 (2.341)	-2.302 (2.152)	-0.242 (2.543)	0.887 (2.055)
Market characteristics:						
GDP per capita	-0.765** (0.326)	-	-	-	-	-
Population	0.016*** (0.004)	0.014** (0.007)	0.015 (0.005)	0.023*** (0.007)	0.027*** (0.006)	0.013 (0.006)
ITU market conditions index	0.021 (0.03)	-0.013 (0.021)	0.003 (0.025)	-	-	-0.021 (0.021)
Mobile Penetration	-	-	-	0.021 (0.019)	0.028* (0.015)	-
Mobile Penetration ^{2}	-	-	-	-	-	-
Internet Penetration	-	-	-	-0.022 (0.031)	-0.057 (0.033)	-
Administration characteristics:						
No. of additional licences offered	0.014 (0.227)	-0.514**8 (0.143)	-0.486** (0.126)	-0.476*** (0.164)	-0.431*** (0.157)	-0.575*** (0.143)
Licence duration	-0.017 (0.09)	0.23*** (0.05)	0.23*** (0.043)	0.172** (0.081)	0.1 (0.075)	0.264*** (0.057)
Administration timing (Elapsed Days)	-0.004*** (0.001)	-0.006*** (0.002)	-	-	-0.003** (0.001)	-0.006*** (0.002)
Administration timing (Ordering)	-	-	-0.184*** (0.05)	-0.127** (0.059)	-	-
Reserve licence price	-0.005 (0.015)	0.03*** (0.015)	0.021*** (0.011)	0.001 (0.018)	-0.011 (0.016)	-
Reserve Price x N.O bidders						0.004*** (0.002)
Bidder characteristics:						
2G incumbent in market	0.51** (0.215)	0.558** (0.221)	0.529* (0.216)	0.51** (0.215)	0.511** (0.215)	0.544** (0.218)
Two or more 2G licences held	0.576** (0.239)	0.539** (0.242)	0.538** (0.238)	0.574** (0.293)	0.567** (0.239)	0.547** (0.239)
Total 2G licences held	-0.000 (0.029)	0.004 (0.030)	0.001 (0.029)	-0.003 (0.03)	0.001 (0.029)	0.004 (0.029)
Total 3G licences won to date	-0.021 (0.063)	-0.043 (0.065)	-0.03 (0.064)	-0.021 (0.064)	-0.021 (0.064)	-0.038 (0.064)
IVProbit						
Highest Bid Instrument	-0.068 (0.063)	-0.063 (0.075)	-0.072 (0.068)	-0.068 (0.063)	-0.073 (0.061)	-0.054 (0.073)
2G incumbent in market	0.487*** (0.174)	0.555*** (0.182)	0.475** (0.211)	0.486*** (0.175)	0.468*** (0.169)	0.561*** (0.179)
Two or more 2G licences held	0.393*** (0.147)	0.461*** (0.169)	0.391** (0.17)	0.391*** (0.147)	0.381*** (0.14)	0.458*** (0.169)
Total 2G licences held	-0.009 (0.021)	-0.004 (0.024)	-0.006 (0.021)	-0.09 (0.021)	-0.009 (0.02)	-0.005 (0.025)
Total 3G licences won to date	0.007 (0.044)	0.003 (0.052)	-0.002 (0.048)	0.007 (0.044)	0.005 (0.043)	0.007 (0.052)
N	59	59	59	59	59	59
Log Likelihood	72.265	-75.225	-73.235	-72.356	-72.186	-74.576

Table 4.12: Reduced Form Highest Bidder Equation (Restricted)

Dependent variable: log licence bid per capita	(1) All (Restricted)	(2) All (Restricted)	(3) All (Restricted)	(4) All (Restricted)	(5) All (Restricted)	(6) All (Restricted)
Constant	-2.731 (1.878)	-3.886** (1.954)	-1.483 (1.025)	-4.244** (2.067)	-2.143** (1.073)	-12.086*** (2.259)
Market characteristics:						
GDP per capita	-0.408*** (0.118)	-	-	-	-	-
Population	0.025*** (0.005)	0.027*** (0.005)	0.029*** (0.005)	0.033*** (0.005)	0.035*** (0.005)	0.032*** (0.004)
ITU market conditions index	0.029 (0.021)	0.024 (0.022)	-	0.024 (0.023)	-	
Mobile Penetration	-	-	0.025* (0.014)	-	0.03* (0.014)	0.489*** (0.092)
Mobile Penetration ^{2}	-	-	-	-	-	-0.005*** (0.001)
Internet Penetration	-	-	-0.04*** (0.011)	-	-0.041*** (0.013)	-0.002 (0.012)
Administration characteristics:						
No. of additional licences offered	0.621*** (0.139)	0.497*** (0.139)	0.509*** (0.133)	0.545*** (0.141)	0.547*** (0.133)	0.808*** (0.127)
Licence duration	-0.0925** (0.036)	-0.053 (0.036)	-0.082** (0.038)	-0.057 (0.027)	-0.082** (0.038)	-0.0458 (0.033)
Administration timing (Elapsed Days)	0.003*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	-	-	0.001*** (0.000)
Administration timing (Ordering)	-	-		0.169***	0.145*** (0.025)	-
Administration method (auction=1)	1.736*** (0.201)	1.664*** (0.211)	1.641*** (0.199)	1.956*** (0.213)	1.9*** (0.202)	1.176*** (0.196)
Bidder characteristics:						
2G incumbent in market	-0.373 (0.22)	-0.301 (0.231)	-0.380 (0.219)	-0.256 (0.226)	-0.353* (0.214)	-0.033 (0.198)
Two or more 2G licences held	0.22 (0.241)	0.216 (0.253)	0.331 (0.243)	0.308 (0.248)	0.418 (0.238)	0.307 (0.197)
Total 2G licences held	0.042 (0.03)	0.043 (0.031)	0.042 (0.03)	0.046 (0.031)	0.047 (0.029)	0.022 (0.025)
Total 3G licences won to date	-0.066 (0.053)	-0.057 0.057	-0.055 (0.053)	-0.097 (0.059)	-0.092 (0.056)	-0.022 (0.047)
IVProbit						
Highest Bid Instrument	0.032 (0.026)	0.036 (0.027)	-0.035 (0.027)	0.03 (0.026)	-0.03 (0.026)	0.013 (0.024)
2G incumbent in market	0.454*** (0.101)	0.457*** (0.101)	0.463*** (0.102)	0.463*** (0.099)	0.464*** (0.102)	0.455*** (0.099)
Two or more 2G licences held	0.192 (0.146)	0.187 (0.145)	0.228 (0.141)	0.169* (0.141)	0.195 (0.15)	0.18 (0.143)
Total 2G licences held	-0.002 (0.016)	-0.004 (0.016)	0.005 (0.016)	-0.005 (0.015)	-0.005 (0.015)	-0.001 (0.015)
Total 3G licences won to date	0.037 (0.025)	0.037 (0.027)	0.037 (0.027)	0.039 (0.025)	0.038 (0.026)	0.031 (0.026)
N	90	90	90	90	90	90
Log Likelihood	-136.851	-142.634	-137.024	-143.976	-138.094	-124.408

Table 4.13: Correlation Matrix All

	Bid	GDP	Pop	ITU index	Mobile Penetration	Mobile Penetration^2	Internet Penetration	Additional Licences	Licence Duration	Number of Days	Order	Method	Win or Lose	Incumbent	Inter-national	Number of 2g	Number of 3G
Bid	1																
GDP	-0.149	1															
Pop	0.6047	-0.2503	1														
ITU index	0.1094	-0.0934	0.1088	1													
Mobile Penetration	-0.376	0.2385	-0.4879	0.2404	1												
Mobile Penetration^2	-0.4251	0.2422	-0.4683	0.2164	0.9925	1											
Internet Penetration	-0.4517	0.5545	-0.325	0.2092	0.6879	0.7264	1										
Additional Licences	0.2627	0.2178	0.3106	-0.0327	-0.1339	-0.0912	-0.0246	1									
Licence Duration	0.3011	-0.373	0.4648	0.1491	-0.5464	-0.5288	-0.5277	0.1493	1								
Number of Days	0.0822	0.2846	-0.3016	-0.5243	-0.095	-0.1395	-0.139	-0.0941	-0.2153	1							
Order	-0.1279	0.1912	-0.4956	-0.4419	0.0087	-0.0249	-0.0564	-0.2	-0.2517	0.9197	1						
Method	0.6226	0.0016	0.4435	0.2023	-0.4054	-0.4366	-0.3288	0.129	0.3101	-0.194	-0.3175	1					
Win or Lose	0.097	0.0055	-0.1379	-0.2838	0.0028	0.0056	-0.1464	0.0234	0.0936	0.1314	0.1196	-0.0734	1				
Incumbent	0.1194	-0.1359	-0.0633	-0.1745	-0.0558	-0.0584	-0.1894	-0.1071	0.1354	0.0618	0.0904	0.0031	0.5848	1			
International	0.133	0.0191	-0.0509	-0.0568	-0.0971	-0.0949	0.0315	0.016	0.0595	-0.0225	-0.0006	0.0154	0.3492	0.1595	1		
Number of 2g	0.1551	-0.0736	0.0047	-0.1455	-0.1491	-0.1561	-0.0988	-0.1024	0.0317	0.0639	0.0594	-0.0111	0.3735	0.4562	0.4681	1	
Number of 3G	0.002	0.0746	-0.2547	-0.1863	-0.0799	-0.0974	-0.0661	-0.1054	-0.0224	0.3798	0.4678	-0.0758	0.2349	0.0781	0.449	0.4818	1

Table 4.14: Correlation Matrix Auction

	Bid	GDP	Pop	ITU index	Mobile Penetration	Mobile Penetration^2	Internet Penetration	Additional Licences	Licence Duration	Number of Days	Order	Reserve Price	Reserve Price x Bid	Win or Lose	Incumbent	Inter-national	Number of 2g	Number of 3G
Bid	1																	
GDP	-0.4169	1																
Pop	0.6134	-0.2356	1															
ITU index	0.2242	0.1387	0.0794	1														
Mobile Penetration	0.1607	-0.1003	-0.2146	0.3233	1													
Mobile Penetration^2	0.1809	-0.1267	-0.1673	0.276	0.9958	1												
Internet Penetration	-0.0551	0.8387	0.0619	0.4597	0.0764	0.0356	1											
Additional Licences	0.0779	0.2728	0.4264	-0.156	-0.2041	-0.1428	0.112	1										
Licence Duration	0.3387	-0.3711	0.3181	0.1996	-0.3763	-0.3615	-0.3035	0.4167	1									
Number of Days	-0.6039	-0.195	-0.6058	-0.4298	-0.1962	-0.1953	-0.6005	-0.2286	-0.1377	1								
Order	-0.6381	-0.0957	-0.6525	-0.2699	-0.2605	-0.2723	-0.5004	-0.2417	-0.0629	0.9731	1							
Reserve Price	0.0132	-0.4283	0.0588	-0.1416	0.4035	0.441	-0.4799	-0.2499	-0.4583	0.3456	0.2359	1						
Reserve Price x Bid	0.0898	-0.3318	0.1721	-0.0579	0.503	0.5421	-0.3105	-0.1711	-0.5136	0.1622	0.0464	0.9724	1					
Win or Lose	0.2174	-0.13	-0.1965	-0.3272	0.0407	0.0515	-0.2457	-0.0213	-0.0147	0.1649	0.1103	0.0172	-0.0304	1				
Incumbent	0.1327	-0.239	-0.1949	-0.2339	0.0279	0.0272	-0.291	-0.1823	-0.0131	0.2389	0.1911	0.0657	0.0035	0.6179	1			
International	0.1868	0.1244	-0.0876	-0.0917	-0.1819	-0.1878	0.0606	0.0595	0.1285	-0.0715	-0.0388	-0.2828	-0.3057	0.4381	0.1764	1		
Number of 2g	0.1508	-0.0283	-0.0646	-0.1457	-0.1085	-0.1184	-0.0197	-0.1445	-0.0392	0.0242	0.0102	-0.1103	-0.133	0.4616	0.523	0.4412	1	
Number of 3G	-0.2508	0.0439	-0.3632	-0.1057	-0.2231	-0.2306	-0.2081	-0.0518	0.0669	0.4456	0.4968	-0.0005	-0.1103	0.2746	0.143	0.4081	0.3918	1

Table 4.15: Correlation Matrix Beauty Contest

	Bid	GDP	Pop	ITU index	Mobile Penetration	Mobile Penetration^2	Internet Penetration	Additional Licences	Licence Duration	Number of Days	Order	Win or Lose	Incumbent	Inter-national	Number of 2g	Number of 3G
Bid	1															
GDP	-0.0387	1														
Pop	0.2546	-0.4403	1													
ITU index	-0.4785	-0.4261	-0.1963	1												
Mobile Penetration	-0.4635	0.4852	-0.7523	0.4837	1											
Mobile Penetration^2	-0.5128	0.4733	-0.7095	0.5281	0.995	1										
Internet Penetration	-0.4823	0.5509	-0.5574	0.3597	0.8817	0.8935	1									
Additional Licences	0.4312	0.1895	-0.0443	0.1538	0.0296	0.0518	-0.0177	1								
Licence Duration	-0.0381	-0.4146	0.5874	-0.0818	-0.5741	-0.5348	-0.5913	-0.2342	1							
Number of Days	0.6434	0.4368	-0.1057	-0.8258	-0.2083	-0.2817	-0.1639	-0.0088	-0.1949	1						
Order	0.6342	0.3562	-0.1978	-0.6945	-0.061	-0.1483	-0.104	-0.1139	-0.2471	0.9473	1					
Win or Lose	0.1425	0.1234	0.0692	-0.1731	-0.106	-0.1042	-0.1963	0.1162	0.286	0.1236	0.1006	1				
Incumbent	0.1716	-0.0593	0.2135	-0.0725	-0.1503	-0.1441	-0.2037	-0.0018	0.3151	-0.0063	0.0195	0.5418	1			
International	0.1252	-0.0653	-0.0174	-0.0006	-0.0184	-0.0272	0.0376	-0.0503	-0.0198	0.0003	0.0416	0.2282	0.1366	1		
Number of 2g	0.2802	-0.1192	0.2043	-0.1555	-0.2388	-0.2468	-0.1759	-0.036	0.1282	0.0965	0.1079	0.238	0.3591	0.5086	1	
Number of 3G	0.3248	0.0936	-0.1139	-0.3164	-0.0475	-0.0941	-0.0712	-0.1467	-0.0509	0.3749	0.4538	0.1943	0.0179	0.5052	0.5974	1

Table 4.16: Correlation Matrix All Restricted

	Bid	GDP	Pop	ITU index	Mobile Penetration	Mobile Penetration^2	Internet Penetration	Additional Licences	Licence Duration	Number of Days	Order	Method	Win or Lose	Incumbent	Inter-national	Number of 2g	Number of 3G
Bid	1																
GDP	-0.1073	1															
Pop	0.6832	-0.2354	1														
ITU index	0.1129	-0.156	0.2157	1													
Mobile Penetration	-0.4769	0.3093	-0.5154	0.2256	1												
Mobile Penetration^2	-0.5224	0.316	-0.5025	0.206	0.9926	1											
Internet Penetration	-0.4619	0.5535	-0.3308	0.1924	0.7261	0.7637	1										
Additional Licences	0.3163	0.2158	0.2448	0.0097	-0.085	-0.0472	-0.0333	1									
Licence Duration	0.3306	-0.3483	0.471	0.215	-0.5497	-0.5368	-0.5315	0.1322	1								
Number of Days	0.2967	0.2834	-0.0698	-0.4255	-0.2571	-0.2997	-0.3231	0.0292	0.0606	1							
Order	0.009	0.2181	-0.3601	-0.4826	-0.1194	-0.154	-0.2051	-0.0935	-0.0986	0.873	1						
Method	0.7093	-0.0451	0.4843	0.2265	-0.3738	-0.4057	-0.3279	0.1193	0.3564	0.0977	-0.1926	1					
Win or Lose	0.0427	0.0905	-0.126	-0.3517	-0.1442	-0.1377	-0.2171	0.0703	0.0891	0.5673	0.4231	0.1026	1				
Incumbent	0.0827	-0.0642	-0.0274	-0.194	-0.1396	-0.1395	-0.2081	-0.0569	0.1157	0.2796	0.2194	0.1077	0.5382	1			
International	0.145	-0.0041	0.0166	-0.0993	-0.155	-0.15	-0.0062	0.0305	0.0623	0.1016	0.0579	0.1026	0.2992	0.129	1		
Number of 2g	0.1402	-0.0588	0.0354	-0.1645	-0.2197	-0.2244	-0.127	-0.0942	0.0243	0.1746	0.1536	0.0667	0.3071	0.4281	0.4464	1	
Number of 3G	-0.0012	0.0678	-0.2415	-0.2176	-0.1081	-0.1253	-0.0896	-0.1042	-0.0258	0.3753	0.5084	-0.0419	0.2089	0.0577	0.3988	0.4685	1

Table 4.17: Correlation Matrix Auction (restricted)

	Bid	GDP	Pop	ITU index	Mobile Penetration	Mobile Penetration^2	Internet Penetration	Additional Licences	Licence Duration	Number of Days	Order	Reserve Price	Reserve Price x Bid	Win or Lose	Incumbent	Inter-national	Number of 2g	Number of 3G
Bid	1																	
GDP	-0.2842	1																
Pop	0.8665	-0.1281	1															
ITU index	0.2279	0.0849	0.227	1														
Mobile Penetration	-0.0783	-0.0888	-0.221	0.2929	1													
Mobile Penetration^2	-0.0549	-0.1037	-0.1865	0.2482	0.996	1												
Internet Penetration	0.1546	0.7803	0.2246	0.4852	0.0974	0.0595	1											
Additional Licences	0.2285	0.3196	0.3524	-0.1036	-0.1308	-0.0681	0.0811	1										
Licence Duration	0.3751	-0.2439	0.255	0.3237	-0.3313	-0.3239	-0.1716	0.4562	1									
Number of Days	-0.7108	-0.2867	-0.5931	-0.5032	-0.2096	-0.1966	-0.7354	-0.1432	-0.1145	1								
Order	-0.7427	-0.2124	-0.6176	-0.3469	-0.2765	-0.2748	-0.657	-0.1547	-0.0103	0.9738	1							
Reserve Price	-0.111	-0.436	0.055	-0.1528	0.3402	0.377	-0.4847	-0.225	-0.5007	0.3782	0.2828	1						
Reserve Price x Bid	0.002	-0.3418	0.1832	-0.0586	0.4456	0.4836	-0.3094	-0.1516	-0.5381	0.1879	0.0837	0.972	1					
Win or Lose	-0.3106	0.05	-0.3829	-0.5469	-0.1285	-0.1128	-0.2956	0.005	-0.2444	0.4783	0.4181	0.1083	0.0252	1				
Incumbent	-0.2035	-0.0691	-0.2651	-0.3215	-0.0561	-0.0537	-0.2336	-0.13	-0.192	0.3474	0.305	0.1178	0.0541	0.5252	1			
International	0.0726	0.1338	-0.0536	-0.2125	-0.2799	-0.2788	0.0147	0.0838	0.0902	0.0044	0.0138	-0.2544	-0.2852	0.3649	0.1014	1		
Number of 2g	-0.0291	0.0342	-0.0932	-0.2039	-0.1895	-0.1992	-0.0112	-0.1533	-0.132	0.1145	0.0989	-0.0759	-0.1076	0.3654	0.4801	0.3889	1	
Number of 3G	-0.4522	0.0023	-0.3917	-0.1709	-0.2794	-0.2823	-0.3173	-0.0508	0.0503	0.5602	0.6127	0.0683	-0.0619	0.2446	0.1204	0.2715	0.358	1

Part 2

Chapter 5: The Winner's Curse and 3G Auctions

5.1: Introduction

In the previous three chapters the primary focus was the outcome of the European administration procedures and which factors affected how much was bid and who won the licences. One of the key conclusions from the last chapter was that some of the most influential factors that affected licence fees were out of the control of the administering authority. The question that now becomes particularly important is whether some licence winners overpaid and suffered a winner's curse. It is clear from the discussion in the previous section that not all licence winners paid too much for their licences. In some administrations, both auctions and beauty contests, very small licence fees were charged. However, there were certain administrations where there was at least an impression that overpayment occurred. Due to the integrated nature of the European Telecommunications market, overpayment in one country has knock on effects to development of the 3G industry in other countries. Chapter 3 outlined the difficulty that some countries faced with their 3G roll-out and indeed how this was not confined to countries with high licence fees.

The next three chapters will seek to identify if in some administrations the licences winners paid too much for their licence. In particular if the winners of 3G licences suffered a so called winner's curse. Section 5.2 to 5.4 of this chapter will discuss the development of the concept of a winner's curse, how it has been identified and controversy around the evidence of its existence. Section 5.5 will then examine the rationale behind the presence of a winner's curse in the 3G auctions. Section 5.6 examines the evidence that has been presented thus far that supports the supposition that there was a winner's curse in some 3G administrations. The chapter finishes in Section 5.7 with a discussion of how overpayment may impact on the post-administration industry.

5.2: Concept of the Winner's Curse

The idea that bidders may do badly by buying assets at an auction is certainly not a new one. If it was the case that an auction winner paid more for an asset than its value, then they may have experienced a winner's curse. Klemperer and Temin (2001) suggest that one of the earliest examples of the winner's curse was in Rome around AD193, when Sulpicianus and Julianus were involved in a bidding war over the Emperorship of the Roman Empire. Julianus won the bid but defaulted and was executed.

The modern concept of the winner's curse, without the same fatal consequences, was first explored by Capen, Clapp and Campbell (1971)[1] in relation to oil and gas drilling rights. When buying the drilling rights to a 'wild tract' piece of land, that is land in previously unexplored areas, a firm will be able to perform certain exploitative activities such as seismic studies. This provides each firm with information from which an estimate can be made over the quantity of oil that could be extracted. In addition to the estimation of the quantity of oil, the firm may also wish to make some estimate over the future value of the oil due to future price changes. Clearly there is a difficulty in valuing the tracts of land that are being auctioned, and so the estimated value of the land by different firms will vary considerably. Even if the firms bid somewhat less than their estimated value of the asset, those firms with the higher estimates will bid more aggressively due to their view of the higher value for the land. In an auction, this would lead to the highest bidder, and hence the wining bidder, being the one with the highest estimated value. As oil and gas are internationally traded commodities the value of the extracted material will be the same for each firm. This will mean that, apart from some relatively small differences in costs brought about through variations in the cost of extraction, once it is known how much oil and gas the tract contains, the value of the tract will be the same for each firm. As such, it is possible to say that the asset that is being auctioned has a common value. If we assume that the estimates of the value of each tract are unbiased then the mean of the estimates will be equal to the common value of the asset. However, the winning firm will not be the one with the mean estimate but

[1] For a thorough account of the development of the winner's curse theory see Thaler (1992).

the one with the highest estimate. This will lead the winning firm to pay more than the tract is worth.

More generally, when a common value asset, which has an uncertain value, is sold through an auction mechanism, the winning bidders will overpay and suffer a winner's curse. Once a bidder has won an asset there are two possible ways in which they can be cursed. If the winning bid is greater than the true value of the asset, this is known as the strong form of the winner's curse, or version 1 winner's curse. Quite simply the winning bidder has paid too much for the asset. Alternatively, the value of the asset is less than the expected value placed on the asset by the firms. This may manifest itself so that the firm has lower than expected profits, which is the weaker form of the curse, version 2 winner's curse. When Capen, Clapp and Campbell calculate the ex post returns from the purchase of these oil and gas drilling rights they found them to be negative. A result that they conclude shows that the winners of these auctions suffered a version 1 winner's curse.

When a bidder wins a common value auction it is an informative event. Winning the auction conveys the information to the winner that the value of the assets was higher than all the other bidders' valuations. A bidder should then condition their bidding strategy on winning the auction. If bidders do behave in this way then attracting too many bidders can decrease the revenue raised by the seller. Indeed, Bulow and Klemperer (2002) find the rationing of an asset or exclusion of potential buyers will increase prices in sales of common value goods. The greater the number of bidders, the more a bidder will need to adjust for the winner's curse. This leads to the counterintuitive outcome that limiting the amount of competition can be revenue enhancing.

It was suggested by Cox and Isaac (1984) that the winner's curse can not occur if the bidders are rational, which it is assumed that they are. Hence the existence of a winner's curse will pose some sort of anomaly. This suggestion misses the problem that acting rationally within this type of auction can be extremely difficult. It involves not only determining the expected value with limited information availability, but also taking into account the number of other bidders and their bidding strategies. Even if a bidder can avoid a version 1 winner's curse they may not be able to avoid version 2. Due to the complexities associated with different types of auctions identifying whether an auction may suffer from the winner's curse is impossible to say with theory alone. The identification of a winner's curse must be an empirical matter.

5.3: Experimental evidence

Two papers by Bazerman and Samuelson (1983, 1985) report on experiments to test for the existence of the winner's curse. These experiments were conducted by giving a number of MBA students certain assets to value within the context of an auction. The authors found that students systematically overvalued these assets, which provided support for the winner's curse. A question can be raised regarding these experiments as to whether the results would persist. The suggestion here is that those involved in the auction learnt from the mistakes they were making. As learning occurred, the students reduced their bids to avoid the winner's curse. If this was the case, then the winner's curse could only exist in auctions for new assets or those auctions that involve new bidders who did not have experience in valuing assets. To test for this, an extension of Bazerman and Samuelson's second experiment was carried out in a study by Ball, Bazerman and Carroll (1991). This experiment explicitly considered the students' ability to learn when having to value assets on a number of occasions. Of 69 students only five demonstrated the ability to learn, and this began to be observed after 8 attempts. Very little learning ability was found with the remaining 64 students.

Further support for the winner's curse is provided in a study by Kagel and Levin (1986). They conducted a study in which students took part in a sealed bid auction. The students were provided with a range of values for the assets in the auction and are then required to bid. Kagel and Levin did not just wish to examine whether the bidders made a profit or a loss. They decided to also calculated what the result of the auction would be if all bidders behaved rationally. They called this the risk-neutral Nash equilibrium the (RNNE) model. They found that in smaller groups there were average profits of 65.1%

below that which RNNE predicted. When bidding occurred in larger groups the participants experienced losses, whereas the RNNE predicted considerably higher profits. This comes about bidders need to bid more aggressively when there are a greater number of bidders, which was discussed in section 5.2

5.4: Field Data

Further research on field data in addition to Capen, Clapp and Campbell are broadly supportive of the winner's curse. Studies by Mead, Moseidjord and Sorensen (1983) and Hendricks, Porter, and Boudreau (1987), using the Capen, Clap and Campbell methodology, but with more complete data, find mixed evidence of the winner's curse. Mead, Moseidjord and Sorensen calculated the present value of the oil tracts. Using a discount rate of 12.5%, they found an average loss of $192,000. Of the leases sold, 62% were dry, 16% were unprofitable (on an after tax basis) and 22% of licences were profitable. Of these profitable tracts, the average post-tax return was 18.74%. Even those companies that did perform well only did so because they were helped by the fact that oil prices increased from $3 to $35 per barrel between 1970 and 1981. The results from Mead, Moseidjord and Sorenson would at least be consistent with version 2 of the winner's curse, that the licence winners obtained smaller returns than they expected and probably shows a version 1 winner's curse. Hendricks, Porter and Boudreau use a slightly different methodology and a discount rate of 5%. They find that those firms that made profits would have done so even if oil prices had not increased. On average then, the winning firms made a profit from buying a licence and so there would appear to reject the existence of a winner's curse. However, they also find support for the winner's curse. When comparing the firms' actual bids to their optimal bidding behaviour, they find that 12 out of the 18 firms overbid, with an average overbid of just under 50 percent. If winning firms had reduced their bid by a constant factor then, assuming that all others bidders keep their bids the same, they could have increased their profits. In some cases the size of this reduction was by a factor of almost seven. This result would suggest that the winning firms were not sufficiently able to condition their bids to account for the winner's curse. Indeed, it would appear that they suffered at least a version 2 winner's curse.

Hendricks and Porter (2007) are critical of the studies on oil and gas drilling tracts, in particular the time-frame used by Capen, Clapp and Campbell. The Capen, Clapp and Campbell study was performed before the end of the productive life of the tracts and so did not include all of the potential revenues. Hendricks and Porter cite a study by Meade et al. (1980), which uses a longer time period and found that the rate of return on oil tracts was almost 7 percent. In addition to this, they cite the problem of some 'unpredictable adverse common payoff shock' causing the results to be skewed in favour of a winner's curse. Unpredictable adverse common payoff shock occurs when a common value asset is sold but the returns are realised over a period of time. During this returns realisation period unanticipated events can occur that change the value of the asset. An example of this sort of event in the oil tract auctions in spike in oil prices during the 1970s. Although the problem of unpredictable adverse common payoff shocks poses a valid criticism of the study of ex-post returns, one which will be returned to later in the chapter, the same argument could be made for an unpredictable favourable common payoff shock. Indeed, it is entirely possible that the sharp increase in oil prices during the late 1970s poses one of these favourable common payoff shocks.

Although Hendricks and Porter's only use of the concept of payoff shocks is to criticise Capen, Clapp and Campbell, they actually form part of a more fundamental problem. These common payoff shocks present an important flaw with the study of ex-post returns data for determining whether a winner's curse is present. The research will not only have difficulty in adjusting for any potential shock that are observed but also having to identify unobserved positive or negative common payoff shocks. These issues are discussed in more detail in Section 5.5 and 5.6, when the winner's curse is applied to 3G auctions. Hendricks and Porter (2007) report on studies that search for the winner's curse in two types of oil and gas leases for the Outer Continental Shelf. They take the leases for wild tracts and drainage leases, which are for unexplored tracts of land and tracts of land where a commodity has already been discovered respectively. When using two different types of tract there is different information available to each potential bidder depending on if they already hold a licence in an adjacent tract. Hendricks, Pinkse and Porter (2003) find that bidders on wildcat tracts do make on average positive rents from winning a tract but these average rents are approximately equal to the cost of entry. As such the winning firms make zero economic profit. They also find evidence that bidders are aware of the potential for a winner's curse and attempt to correct for it by bidding less than their estimated tract value. They calculate that this correction is so large in some cases that the firm bids less than their tract value conditional on winning. This would appear to be an extreme form of winner's curse avoidance. However they did find evidence that this correction was only adequate in tracts that attracted large numbers of bidders. Bidders seemed to not identify a need to correct their bid for the winner's curse in less competitive auctions. The bidders appeared to believe that a lower number of bidders reduced their chance of a winner's curse. Although this is understandable, Hendricks, Pinkse and Porter report that bidders appeared to be overconfident in these auctions as the result of them not correcting their bids led to overpayment.

This is an interesting, although slightly strange result. Although Hendricks, Pinkse and Porter argue against the existence of the winner's curse, one possible explanation of their findings is that bidders are particularly bad at adjusting for a winner's curse. When there are a large number of bidders there is an over-reaction and when only a small number there is an under-reaction. An alternative explanation is simply that those tracts that were worth less attracted fewer bidders. Entry into an auction then becomes an informative event. Those bidders in auctions with only a small number of bidders are those which have overvalued the asset. If the bidders take the traditional view of the winner's curse, that when there are a small number of bidders they will only perform a small adjustment to their valuation, then they will overbid for the asset. Instead of treating the lack of bidders as positive, they should have interpreted it as a sign that other bidders were not willing to incur the costs that were associated with entering the auction. Rather than seeing the auction as having only a small number bidders it would be more accurate to see them as having the same number of bidders as any other auction but many of these bidders place such a low valuation on the asset that they drop out before the auction begins. This assumes that the only reason that bidders choose not to enter an auction procedure is because they place such a low value on the asset being auctioned.

The experimental research has shown how the winner's curse occurs in auction setting. And the field data has provided examples of auctions where the winner's curse is believed to have occurred. However, they do not provide an adequate method for analysing whether the winner's curse is present within a particular auction, or, as with the oil tract research, not until a considerable amount of time has passed. In these auctions a winner's curse was not identified until at least some of the licence winner's revenues had been observed. If a winner's curse is going to alter regulatory stance then information on its existence needs to be identified at an earlier point in the term of the licence.

5.5: The 3G Winner's Curse.

Given that the auctions for 3G licences were carried out when there existed considerable uncertainty over the value of the licences, it is possible that a winner's curse occurred. However, should we expect a winner's curse within these auctions? The winner's curse that has been discussed thus far has been within common value auctions. Licences to run 3G services cannot be considered to be common value assets; T-mobile with its customer base and existing GSM infrastructure will make better use of a licence than a much smaller firm such as MobilCom. This private part of the valuation of the licences will be made up of factors such as current size of market share, projections for future market share, current network infrastructure etc. Indeed, in Chapter 4 it was shown that incumbency and international status had a significant effect on observed highest bid. However, it would not be accurate to treat these licences as private value assets. A large part of the value of a licence will be determined by common factors. Rather, it is better to refer to an auction of this type of asset as an affiliated value auction. An affiliated value auction occurs when the value of the asset depends on private information but also a particular state of the world. It could be agued that there will even be asymmetries in the information to make estimates over the future state of the world. An incumbent will be in a better place to judge the probabilities of future states of the world. However, given the uncertainty that surrounded the future of the 3G technology and its future market, it is difficult to see how an incumbent would have sufficient additional information to gain an advantage. As was discussed in Chapter 2, the auction designers were well aware of the winner's curse and as such set up the auctions to try to maximize the amount of information to the bidders by using open multi-round auctions. The participating firms will have been aware of the winner's curse so why would they not just adjust their bids downwards in order to account for it? There were also a low number of bidders, although as has been discussed this may have given bidders a false sense of security.

5.5.1: How can the winner's curse be present?

Despite the licences to run 3G services not being pure common value assets, they did have a certain common value element which was determined by the success of the technology and the future market conditions. And, due to the uncertainty that existed within this technology it is feasible that a winner's curse could be present. Anandalingam and Lucas (2005) give an overview of why the high tech sector is particularly prone to the winner's curse. They assign blame for this to uncertainty over future market conditions and lack of experience with new technologies. Even if the bidders did adjust their bids to take account of the winner's curse, due to the uncertainty around this type of technology this adjustment may not have been sufficient. As was seen from Hendricks and Porter's work, adjustments may be difficult to calculate and do not provide a guarantee of avoiding a winner's curse. Even if the adjustment was sufficient, winners may still have suffered from version 2 of the curse. In Capen, Clapp and Campbell's original example this was relatively easy to assess when compared to the 3G licences. The value of the tract could be measured by how much oil is removed from the ground. The only decision that needed to be made was whether to price the oil according to the price at which it was actually sold or the market price when the licences were acquired. This is an important distinction considering the large increases in the price of oil that occurred during the 1970s. Taking the original market price would assume that the winning firms did not take into account price variations in their estimation of tract worth. Is it unreasonable to believe that when making their investment decisions firms would not take future price fluctuations into consideration? The problem then becomes deciding what events are reasonable to expect and which are unanticipated. The problem of determining predictable and unpredictable events is even more difficult with 3G licences. It is precisely this variation in the market that determines the licences' common value.

Beyond determining what is an unanticipated event there may be a more fundamental problem with valuing the ex-post returns to these assets. Even if we waited until the end of the licence period and calculated the profit made by the winning firms it will not provide a guide to whether the auction suffered from a winner's curse. As with any investment decision that has an uncertain return, a firm should use the expected return to evaluate the investment decision. The expected return would depend on the size of return in any particular state of the world and the probability of this state of the world occurring. Of course it is entirely possible for an investment to return less than the expected return without the estimated expected return being incorrect. Likewise, a firm may make a large profit from holding a licence, which does not mean that the estimation of the expected return was incorrect, just that a positive state of the world has occurred. The winner's curse exists not because a particular negative state of the world exists. Rather it occurs because the administration process awards the licence to the firm with the highest estimated value. It is the fact that an auction is being used, meaning those with the highest estimated value win the licence, and not necessarily the fact that the item's value is particularly difficult to estimate that causes a winner's curse to be present. The returns on the investment decision that is being undertaken have a very high variance and so the inability of the firm to avoid the winner's curse will be exacerbated.

If it is accepted that the only information that we can derive from the ex post returns is the particular state of the world that has occurred, then examining the value of a single licence at the end of the licence period would in no way reveal if the licence winners suffered a winner's curse. Nor would examining the licence winner's performance over any period since the licences were administered. It is true that calculating the ex post returns does provide information on whether the firm made a profit and which state of the world occurred, but neither of these identify a winner's curse.

Although it is not possible to use ex post returns to identify a winner's curse in an individual auction, it is possible to use ex post returns when examining a series of assets that have been auctioned, where the states of the world that affect the value of the asset are uncorrelated. For instance, taking the Capen, Clapp and Campbell study, it is acceptable to take ex post returns for oil drilling rights for a number of different tracts and aggregate them, as long as it is assumed that the estimate of the value of a tract is based on geological factors and not on the price paid for previous tracts, which could force prices upwards. If the amount of oil in each tract is independent of the amount of oil in all other tracts, then we should have as many positive states of the world as negative. In this case a positive state of the world occurs when a tract contains a large amount of oil relative to what is expected and vice versa. An aggregation of the sales should show if, on average, the price paid by winning bidders for a tract of land was too high. The aggregation process would allow the researcher to draw conclusions about any systematic overpayment brought about by a winner's curse.

Although this aggregation process may be used for auction of tracts of land, the aggregation of ex post returns cannot be used for the auction of 3G licences. If the market for 3G services is strong, then all licence holders will do well, due to the common value being determined by the state of the 3G market and technological developments. If the market is weak or there are technological difficulties, all licence holders will do badly. As such, no aggregation effect is possible and ex-post returns cannot return information on the winner's curse. All licence holders will face the same state of the world in all cases. There may be some differences from country to country but these differences will only be minor when compared to the industry trends.

5.6: Other attempts to identify a winner's curse.

Two papers have attempted to test for the winner's curse, both examining the UK 3G auction. Instead of only estimating the revenues from 3G services, Basili and Fontini

(2003) used an option pricing approach in an attempt to value the licences. They found that the revenue extracted by the government was slightly less than the true value of the licences. Given the nature of these licences and indeed the nature of an investment in the high tech sector using an options based approach is clearly better than a simple summation of revenue and costs. However, the authors do not make it clear why they believe their valuation should be anymore accurate than that of the licence winning firms. Even if we are happy with Basili and Fontini's calculation of the option value of these licences, and accept that it gives us an accurate estimate of the licence value, it does not tell us the whole story. Their results suggest that there was not a version 1 winner's curse. However, they cannot use this method to tell if there is a version 2 winner's curse.

Cable et al. (2002) employed an event study methodology to determine whether too much was paid for the licences. An event study compares the stock market valuation of the licences with the winning firm's valuations. A negative stock market reaction would suggest that winning firms overpaid for the licences they won. It could be argued that the use of an event study is no better than the Basili/Fontini approach. Why, after all, would the equity market's estimate of licence value be any more accurate than that of the winning firms? The market valuation will be the aggregation of a large number of individual estimations. As long as these valuations are unbiased, the actual value of the licence will be the same as the market valuation. That is, the correct valuation at the time of bidding. If we are happy to assume semi-strong market efficiency, then any abnormal return will reflect a differential in the true valuation of the licences and the fee the firm paid. The advantage of using the equity markets in this way is that we can factor out valuation problems associated with the dot.com boom. The market valuation accounts for all expectations of future revenue at that time. If it emerged in the future that the 3G technology was overvalued because of misconception about this technology, in essence a particularly negative state of the world arose, and it would have also been overvalued by the markets at the time the licence was sold. Any negative reaction will then be brought about by overpayment of that over valuation. At a more fundamental level, if shareholders, as the owners of a company, consider the firm to be worth less as a result of buying a licence, they have been cursed. Before the licences were bought the market would have a belief over their correct valuation or at least the fee that a firm should pay for them. Any deviation away from this valuation either positive or negative would bring about a returns reaction. The market reaction will not only pick up a version 1 winner's curse but also a version 2. The market will react negatively if they believe the firm will not receive adequate returns for their investment. The UK study found that there was a short-term negative market reaction to the 3G licence winners but there were not consistent negative abnormal returns for the winners or negative for the losers and as such they conclude that no winner's curse exists and so no regulatory response was necessary.

5.7: Does a winner's curse matter?

The discussion thus far has focussed on the correct definition of a winner's curse and the problems posed in attempting to identify it. Given that standard economic theory would tell us that a firm will price according to their marginal costs, sunk fixed costs will have no impact on the post-administration industry. However there have been two suggested consequences of overpayment and a winner's curse. The first is a direct result of overpayment and is caused by the industry no longer being able to support as many operators which bring about firm exit from the industry. This would then impact on the aim to increase the amount of competition in the industry. The second indirect effect is that there will be a social cost associated with a regulatory relaxation brought about by a firm undergoing financial distress and the regulator being obliged to take action.

Gruber (2001, 2005) developed a model to determine the equilibrium number of firms in the post-administration market. In his model there were three factors that affected the number of licences that could be sustained. The prevailing technology determined how efficiently spectrum could be used. If a high level of technological efficiency was available then a greater number of firms were able to operate and be sustained in the market given a certain amount of spectrum. The second factor was the regulatory stance, primarily this was considered to be the amount of spectrum that was made available but also whether a particular technical standard was imposed. The third factor was endogenous sunk costs through licence fees. The higher the licence fees the lower the number of firms the industry can maintain. Although the number of licences is determined exogenously of the industry by the regulator, the size of the licence fee is determined endogenously by the firms bidding for them. If the licence fees are so high that there are negative profits in the industry and some firms have to leave then Gruber believes these to be "excessive" licence fees. If the fixed costs in the industry – in which he includes licence fees and network roll-out cost – are large enough that negative profit will be made, and then firms will exit the industry. Firms will continue to leave the industry until those firms that remain are profitable. If the government decides to reallocate these licences then there will be no additional profit for the firms that did not leave the industry. In this case Gruber argues that firms winning the reallocated licences will pay less for them making them more profitable when they enter the industry. Firms will hence leave and enter the industry until they all have paid low enough licence fees to be able to make a profit.

Gruber's analysis is limited in a number of respects. It does not give a convincing reason why the size of the licence fee should cause firms to exit from the industry. He claims that a firm will exit if it is not able to cover its fixed costs including the sunk costs of the licences and network setup. He suggests that this will come about by the firm becoming bankrupt. However, as long the firm can cover its variable cost it will be better for it to stay open. Gruber does not identify why he believes this will not be the case. Secondly there is no indication of time scale for entry and exit. At what stage of network development will it become apparent that fixed costs will not be met? This is particularly important given the possibility for additional value associated with follow-on options that may be present with this type of technology. Given that excess fees were paid, due to over optimism, how will the firm's behaviour be affected by future expectation over economic conditions? An argument can be made that high sunk will affect the firm's other costs due to capital market inefficiencies. Once licence winning firms have been burdened with a large debt they will find it affects their ability to borrow for future investment. Worthington (1995) found evidence of these types of inefficiencies affecting firms' investments decisions when sunk costs are involved.

Using industry level data in the US he finds that gaining external financing for projects is more difficult when the investments have a high sunk element. This point will be considered in more detail in Chapter 9.

In his studies, Gruber gives an example of how national operators may be disadvantaged when firms operate across countries. He then goes on to class those countries with high licence fees as low profit countries and those with low licence fees as high profit countries. Gruber does not consider the importance of other regulatory levers or the ability of these levers to change in response to changing market conditions. If these regulatory decisions impose costs on the operating firms then it is too simplistic to just look at licence fees. Apart from the number of firms operating, the licensing procedure also determines a number of other regulatory levers. It is possible that rather than allowing firm exit the regulator may seek to adjust these levers. An example of this sort of behaviour would be relaxing the licence coverage obligations in the early stages. All licences placed conditions on the licence with the range of these conditions being seen in chapter 2. One example is the winning firms' obligation to cover a percentage of the population or country within a certain amount of time. Changing these conditions will change the value of the country in terms of Gruber's high/low profit countries.

An alternative view of the costs associated with a winner's curse, and in particular with regulatory behaviour was developed by Swann and Tether (2003). They discussed how a winner's curse can affect a post-administration environment. In particular how a winner's curse can cause higher prices in the post-administration industry or can result in some other social costs. Indeed their argument is not only that this comes about due to a winner's curse but in contrast to standard microeconomic theory where our profit maximising firm is only concerned with marginal cost, that any lump sum sunk cost will affect the post-administration market. They claim that this may occur if a firm that has suffered a winner's curse is able to recoup costs by not meeting all the usual regulatory requirements that they would otherwise be expected to meet. This is particularly an issue with the development of 3G services which, as was shown in Chapter 3 and will be discussed in more detail in Chapter 8, experienced a considerable amount of post-administration turmoil. In the post-administration market there were a large number of regulatory requirements and regulatory interventions. They show that when a resolute regulator is operating the firm will engage in standard profit maximising behaviour and the winner's curse will have no effect. However if the regulator is 'soft' then they place a greater value on the profitability of the firm when determining regulatory action. As the licence fee increases, the minimum regulatory requirement decreases. This then has two possible consequences; if the regulatory requirement has an effect on fixed costs but not on marginal costs then the only effect with be the loss of consumer surplus from the regulatory requirement not being met. However, if the fixed costs or the regulatory requirement has an effect on marginal costs then a change in minimum regulatory requirement will have an effect beyond the initial loss in consumer surplus. A reduction in the minimum regulatory requirement comes about when fixed costs are high. So when fixed costs are high marginal, cost of production will be low. A low marginal cost leads to a lower profit maximising prices and a higher output. In contrast, low fixed costs leads to a stricter regulatory requirement, higher marginal costs, higher prices and a lower output. Again, Swann and Tether find a similar result if the minimum regulatory standard is not reduced but the chance of prosecution or the fine incurred for failure to meet the minimum requirement is reduced.

Such a situation can seriously undermine the claim that auctions provide the most efficient means of administering spectrum licences. If regulators are willing to ease their regulatory stance in response to perceived difficulties in the 3G market then this may impose a social cost on the market. Swann and Tether (2003) give an overview of the potential social cost caused by the winner's curse. They find that if the regulator is not resolute in their regulatory stance then companies have the ability to pass on the cost of the winner's curse to consumers. They stress that this does not mean that the regulator should not help troubled companies by easing regulation, rather that the assumption that using an auction maximizes efficiency should be questioned. From a licence pricing perspective, if the regulator is more likely to ease regulation then there is a danger that the bidders are more likely to overbid as they are no longer concerned about the winner's cure. They believe that regulatory truncation provides a form of winner's curse insurance.

Closely link to the proposal of Swann and Tether is the argument put forward by Bennett (2000) and Bennett and Canoy (2000). They show a specific relationship between prices and the up front sunk costs again as a result of the regulatory approach. They link this work back to labour economics and the work on shirking from Shaprio and Stiglitz (1984). In this case they believe that the firm's probability of being caught colluding (shirking) is decreased when they have incurred high sunk costs due to the regulator not having information on the firm's costs and having to assessing collusion on the rate of return basis. The higher the licence fee the greater the prices would have to be for the regulator to believe that collusion is taking place. They conclude that higher licence costs will lead to more aggressive collusion and higher prices for the consumers. Bennett particularly identifies termination charges as an area where this type of collusion could take place.[2]

Although both the proposals from Swann and Tether, Gruber and Bennett are situated in the context of a winner's curse, none of them actually require a winner's curse to occur. All of them only refer to an increase in the size of the licence fees which does not necessarily mean a winner's curse is present. Given the way that the winner's curse has been defined it this chapter, does one need to be present for there to be the type of impact discussed in the previous section. A winner's curse does not mean the licence winning firms will be making a loss and just because the firms appear to be profitable does not mean they have not suffered a winner's curse. Does the existence of a winner's curse then require a regulatory response, or should a regulatory response come about after an unpredictable adverse common payoff shock which has brought about firm distress?

Although it may be tempting for a regulator, where the distress is brought about by adverse payoff shocks the regulator should not take corrective action. These shocks are

[2] See chapter 8 for a discussion of termination charging.

not the responsibility of the regulator; instead they are part of the risk associated with the project for the firm. However, if overpayment for a licence was brought about by a winner's curse, then it was caused by the way that the administration process was constituted and performed. This is not to say that the bidding firms were not responsible for their bids. Rather the way the administrations were designed allowed overpayment to occur. In this case it could be argued that a regulator or government should take corrective action to rectify a situation that they have created. This then requires the source of the financial distress to be determined, whether it be due to a winner's curse or an unpredictable negative common payoff shock. As I have discussed the best method for doing this is through an event study. However a UK event study in isolation can only provide part of the overall picture. Using an event study on this type of event produces a number of specific problems, some of which were not addressed by Cable et al. The next chapter will outline the use of event study methodology and how an event study can be performed on a 3G administration procedure. Chapter 7 presents the results of event studies on the German and Swedish administration procedures. This event study improves on the Cable et al. study. By performing a comparative study between auction and beauty contest procedures a clearer picture should be gained as to the relative performance of winners and losers in differing administration procedures. This study will also account for clustering and non-parametric tests which were not performed in the Cable et al. study. These results read in conjunction with the UK event study provide clearer insights into the existence of a winner's curse. The following chapter will discuss the methodology behind event studies and the justification for their use. It will also pick up on some of the particular problems that are presented by using an event study to examine an event such as a licence administration. Chapter 7 will then discuss why the German and Swedish administrations are particularly suited to use an event study to search for a winner's curse and report the results of the event study on these two administrations.

Chapter 6: Event Study Methodology

For over seventy years event studies have been carried out to examine a wide variety of different events. These have ranged from the analysis of mergers and acquisitions to the changes in the regulatory environment that a firm faces. The basic method that underlies the event study is to model the normal returns of a firm that has been affected by a particular event, and then, by examining the actual equity returns, test for any abnormal returns after the particular event. The first known event study was carried out by Dolley (1933), however the methodology remained somewhat primitive until Ball and Brown (1968) developed the methodology that is still widely used today. Strong (1992) and MacKinlay (1997) give relatively up to date outlines of the procedure for carrying out an event study. However, the circumstances in which the event study is used will have an important effect on how it should be carried out and how the results can be interpreted.

The issues and criticisms that surround event studies are wide ranging. The central concept that allows the use of event study to analyse real world events is the assumption of market efficiency. In order to draw any meaningful conclusion from the estimated abnormal returns the assumption that markets accurately adjust prices to account for all available information must be accepted. In recent years, this assumption has come under increasing attack from the behavioural finance literature. Section 6.1 will outline the main arguments that have surrounded the efficient market hypothesis. Beyond the broader issue of the efficient market hypothesis there are specific concerns that must be addressed with event studies. A key aspect of the event study is to model a securities' normal returns, however, a large number of alternative models have been used in order to model these returns. The estimation of these models can be problematic, particularly since the introduction of daily returns data, due to non-normality in the form of skewness and excess kurtosis. Even once abnormal returns have been estimated the nature of the event will influence the use of test procedures. When the thin trading problem exists or events are clustered, traditional test techniques may be misspecified. This has led to an array of possible non-parametric tests to overcome this. Sections 6.2, 6.3 and 6.4 will address these problems and the methods proposed to overcome them. Even if we are happy with the underlying methodology of an event study, analysing the effect on an auction procedure presents additional problems from that of an earnings or merger announcement. This chapter will end with a discussion of the exact specification of event study and test procedures that will be used to analyse the 3G administration procedures. Section 6.4 will address those problems particularly associated with this event study and section 6.5 will describe how the event study will be carried out.

6.1: Efficient Markets and Event studies.

The use of event studies to analyse real world events relies on the assumption of at least semi-strong market efficiency. The level of information that is required to make abnormal returns determines the level of market efficiency that is present. The consequence of semi-strong market efficiency is that, given all publicly available information, it is not possible for an investor to make abnormal returns. If markets are semi-strong then they will also be weak-form efficient. Weak-form efficiency reduces the amount of information required to make abnormal returns. Meaning it is not possible for an investor to make abnormal returns given information on past price movements. The consequence of this assumption is that equity prices follow a random walk. A stricter form of market efficiency is strong-form efficiency. Strong form efficiency would mean that no abnormal returns could be made given all publicly and privately available information. If markets are strong-form efficient then insiders would not be able to make abnormal returns. As insider trading is an illegal activity there is a clear attempt to impose strong form efficiency on markets. However, it is perhaps unrealistic to assume that insiders will not be able to make some abnormal returns even if they are behaving legally. Only assuming semi-strong markets is necessary for event study methodology to be valid.

The consequences of accepting semi-strong market efficiency are twofold. When new information is released the markets react instantaneously, and prices will move to their new and correct value. The release of bad news would lead to a decrease in the price of the equity and good news would lead to an increase in price of the equity. This in turn would lead to temporary negative or positive abnormal returns. The size of the abnormal returns can then give an indication of the magnitude of the event's effect.

6.1.1: Foundation of Efficient Market Hypothesis

The efficient market hypothesis can be justified from three possible theoretical foundations. The first of these justifications is that all investors are rational and so will value assets according to the NPV of the assets and their particular attitude towards risk. These rational investors will then respond to information as it is released and price equities correctly. Although this assumption would be convenient it may be problematic when seen in the context of the previous chapter. It would be contradictory to assume that all investors could value a 3G licence correctly when in the previous chapter it was suggested that a bidding firm would struggle to do the same.

However, it is possible to still have efficient markets even if all investors are not assumed to be rational. If, instead, it is assumed that those investors that are irrational behave in a random and unbiased way, then the trades of the irrational investors will cancel each other out. There will be as many overvaluations as undervaluations. With these misvaluations cancelling each other out the price of equities should move to their correct values. The over and under valuation of securities must be unbiased and uncorrelated or the dealings will not cancel each other out. In the presence of some form of bandwagon effect the misvaluation of equities will no longer be uncorrelated.

This justification for the existence of market efficiency is quite closely related to the concept of the winner's curse. However, market efficiency brings about the correct valuation of an asset whereas an auction with a winner's curse overvalues the asset. In a market there are a large number of investors estimating the value of equities that have a common but uncertain value. A piece of news will change the value of the equity, also by an uncertain amount. When a piece of news is released some investors will overvalue it and some will undervalue it. As long as the valuations are conditionally independent and identically distributed, then the net effect will be prices moving to their correct level. This is unlike a winner's curse, where the bidder with the highest estimate will win the item and so will overpay for it.

Even if the assumption that over and under pricing are uncorrelated is relaxed, the Efficient Market Hypothesis can still be argued to hold. If it is assumed that some investors do not pursue rational investment strategies and that these strategies are correlated, market efficiency can still be brought about as long as there are sufficient rational investors to perform arbitrage. Let us assume that, through correlated buying behaviour by irrational investors, a security becomes overpriced. The rational investors would sell this security and purchase other securities that were not overpriced. Rational investors engaged in this behaviour will bring the price of the overpriced security down until it is at its correct level. With rational investors acting in this way prices should only be able to move a short distance from their correct value. Those rational investors engaged in arbitrage will compete to earn the abnormal returns from the arbitrage process so prices should move to their correct value quickly.

If this argument is taken to its logical conclusion, then not only will arbitrage keep prices at the correct level but irrational investors will be driven from the market. The irrational investors will make abnormal losses by buying overpriced and selling underpriced securities. As the irrational investor continues to lose money they will eventually be driven from the market. Only rational investors can remain in the market. These were the justifications for the Efficient Market Hypothesis developed by Friedman (1953) and Fama (1965). The efficient market hypothesis was well supported by a range of early empirical literature. Weak form efficiency was supported by early work from Fama (1965), which found that markets follow a random walk. Keown and Pinkerton (1981) find that securities respond to takeover announcements by jumping when the public announcement is made and then remaining constant suggesting a correct and fast price adjustment. Further support was provided by examining the performance of professional investment managers. If markets are efficient then investment mangers should not be able to perform any better than a passive strategy. Jensen (1968) found that mutual fund managers that engaged in active portfolio management performed no better than the market and tended to underperform. Malkiel (1995) carried out a similar study, with more recent data, and supported Jensen's results. Malkiel also found that there was a considerable survivor bias and that actual fund manager performance was even worse than Jensen's original results suggested.

6.1.2: Challenges to the Efficient Market Hypothesis

The assumption that markets react efficiently to new information has been challenged on a number of levels. A more realistic assumption is that the markets will not react perfectly and instantaneously. However, this does not necessarily invalidate the use of event studies to analyse real world events. There are two possibilities for market behaviour that would affect the way that the abnormal returns are interpreted. The markets may react slowly to the information that has been released leading to a slower change in prices and in turn positive or negative abnormal returns. This may then present a longer period of time where abnormal returns are present as the market adjusts. An alternative is that markets do react instantaneously but overreact to the new information and then over a period correct for this overreaction. If the information was positive then this would lead to an instantaneous jump in the price, followed by a period where the price would decrease, ending at a point above the original price. This will be reflected by an instantaneous positive abnormal return, followed by a period of negative abnormal returns.

Exactly how long this period of adjustment takes and how fast 'instantaneous' can be considered to be is an empirical matter. It may be the case that even with a delay all the adjustment occurs within one day, and so using daily analysis would capture the correct level of abnormal returns. The delay or adjustment may go on for a number of days and an event study will need to account for this. In practical event studies, it may be unrealistic to assume that we can identify the exact day that information is released. Although there are quite tight conditions on releasing information to the market, it is likely that information will be anticipated or leaked beforehand.

6.1.3: Behavioural Finance

A more fundamental challenge to the assumptions behind market efficiency came from the field of behavioural finance. This field of finance identifies market behaviour that appeared not to conform to market efficiency and then put forward psychological and sociological explanations for these observations. An example of this behaviour is investors being caught in a "bandwagon effect". The bandwagon effect occurs when investors are drawn in to stock prices rising, or conversely a panic, at the sight of prices falling. Other effects that seem to deviate from market efficiency are the so called January and Day of the Week effects. The January effect was the observation by Rozeff and Kinney (1976) that average returns in January were consistently higher than average returns in any other month between 1904 and 1974. Similarly, French (1980) and Gibbons and Hess (1981) find that the day of the week can affect the returns received on a security, with Mondays producing consistently lower returns than any other day of the week. Another example is the existence of return reversal. This is simply that investors will over-react to a particular piece of information. Although each of these examples would appear to contradict the efficient market hypothesis, they are all to a greater or lesser degree explainable. Malkiel (2003) provides an argument against these identified inefficiencies and behavioural explanation. The Seasonal and day of the week effects do not appear to be consistent between periods after 1974. Indeed it would appear to a certain extent that once these patterns were identified they ceased to exist as investors altered their behaviour to take account of them. In addition to this, the potential gains from these effects are so small as to be of no consequence once the level of transaction costs are accounted for, leading to no potential net profit from these investments.[1] Indeed, this can be said for almost all examples of anomalies that have been identified within the market. Again, for return reversal, the empirical evidence is not consistent over time. Fama (1998) found that return anomalies were highly sensitive to methodology and when different models or statistical techniques were used the anomaly would disappear. The main criticism of the use of these anomalies to contradict the efficient market hypothesis is that although researchers are able to spot patterns in returns ex post these do not last into the future. As such investors would not be able to make to make abnormal returns from these perceived anomalies.

Another argument against market efficiency is the observation of market bubbles and sudden decreases in market value. Malkiel (2003) recounts the case of the 1987 US market crash. The fact that the US market dropped in value by a third, over a small amount of time, without a fundamental change in the economy has been blamed on psychological factors. In particular the drop had been brought about by a bandwagon

[1] This relative transaction cost was shown to dominate the potential returns in Keim (1989)

effect. Although there is no one event that could be identified as causing the drop in equity prices, it can be explained by the culmination of a number of events. For instance, events such as a proposed new mergers tax and government intervention in the exchange rate markets could interact to make a multi-event super-event. These unexplained events may be a result of an ill-defined event period rather than evidence of market inefficiencies. Whilst not undermining the use of event studies, these dangers should reinforce in the researcher's mind the need to carefully identify the correct event period and any possible confounding factors. This is especially the case when dealing with the European licence administration which could itself be considered to be some form of multi-event super-event.

6.1.4: Unanticipated Events and Confounding Effects.

For an event to be analysed using an event study it must be unanticipated and have an identifiable event date. Identifying an event date when dealing with a procedure that develops over a period of time is particularly challenging. Added to this, other events, within the event window, that may impact of the equities returns must be checked for, and taken into account. The ability of a study to isolate an event from confounding effects that surround it is potentially one of the greatest challenges and potential weaknesses of the event study methodology. How to exactly identify confounding factors is uncertain. It is reasonable to expect events such as earnings announcements or merger announcements to produce an effect, but other less obvious events may also convey information to the markets. The problem of confounding effects becomes particularly acute as the event window gets longer. To identify all possible confounding effects may be impossible; it is advisable to perform at least a superficial check for other potentially important events around the period in question. The hope is that the effect of the event under investigation will be of such a magnitude that it will dwarf the effect of any confounding events. If an event is worthy of examination it would be expected that it would be larger than any other potential confounding effect. However, particular caution needs to be taken when examining an extended post-event window.

6.2: Modeling Normal Returns.

The central purpose of the event study is to measure the abnormal returns on a stock. To do this the normal return of a security must be modelled and, once this is done, the abnormal returns for the particular security estimated. There is however some debate over the best method for estimating these normal returns. The models for measuring normal performance can broadly be split into two categories; those based on statistical assumption and those based on economic theory.

6.2.1: Statistical Models

Two of the most commonly used statistical models are the constant mean return model (CMRM) and the Market Model (MM). The CMRM estimates the return on the security by the mean return on the security over a period of time. The expected returns for the security are constant and only vary across firms.

$$E(\tilde{R}_{jt}) = k_j \qquad \textbf{(6.1)}$$

This is where $\tilde{R}_{jt}$ is the estimated and hence expected returns on security j at time t and k_j is the mean return of the security. Abnormal returns can be calculated as:

$$\hat{u}_{jt} = R_{jt} - k_j \qquad \textbf{(6.2)}$$

Despite being one of the simplest models, when it was tested by Brown and Warner (1980, 1985) it was found that it returned similar results to more complicated models. A more advanced, although still relatively simple statistical model is the Market Model proposed by Markowitz (1959), which models the returns of a security against the return to a market portfolio. In practice a stock index such as the FTSE 100 would be used for the market portfolio. The MM is considered to be an improvement over the CMRM as it accounts for variance in the market returns. In the MM the variance of the abnormal return is reduced by removing the part of the securities return that is due to the market's return. The market model estimates normal returns through:

$$\tilde{R}_{jt} = \alpha_j + \beta_j R_{mt} + \tilde{u}_{jt} \quad \textbf{(6.3)}$$

R_{mt} is the return to the market portfolio at time t and $\tilde{u}_{jt}$ is the error term. The abnormal returns can then be calculated as:

$$\hat{u}_{jt} = R_{jt} - (\hat{\alpha}_j + \hat{\beta}_j R_{mt}) \quad \textbf{(6.4)}$$

A simplification of both of these models would be the market adjusted return model (MARM). This model is similar to the market model, but with restrictions placed on the coefficients. The constant is assumed to be zero and the coefficient on market return set at one. The expected return to any security is equal to the expected return on the market. So normal returns are estimated as:

$$E(\tilde{R}_j) = E(\tilde{R}_m) \quad \textbf{(6.5)}$$

And the abnormal returns are then:

$$\tilde{u}_{jt} = R_{jt} - R_{mt} \quad \textbf{(6.6)}$$

There is the distinct possibility that the restrictions placed on the MARM are false and the MARM is usually only used when no security data is available so it is not possible to estimate normal returns. Unless there is a very good reason for assuming that the expected returns on the security should equal the expected returns to the market the MARM should not be used. An example of when the MARM might be used would be for estimating returns when studying initial public offerings.

6.2.2: Economic Models

Other models based on economic theory can be considered to be restrictions on the statistical models. One of these is the Capital Asset Pricing Model (CAPM) developed by Sharp (1964) and Linter (1965). This model, which determines a security's expected return by its covariance with the market, was widely used after its conception. In recent years, questions have been raised over the validity of the model's assumptions and the empirical support for CAPM has been mixed at best. Particular criticisms have come from Fama and French (1992, 1996) who found parametric models performed considerably better than CAPM when estimating returns. Using the CAPM model would involve estimating the expected return on a particular security using the return on a risk-free security (usually the returns on Treasury Bills) and β_j the systematic risk of our security relative to the market index.

$$\tilde{R}_{jt} = R_{ft} + \beta_j (R_{mt} - R_{ft}) + \tilde{u}_{jt} \qquad \textbf{(6.7)}$$

The predicted abnormal returns can be calculated from:

$$\hat{u}_{jt} = R_{jt} - (1 - \hat{\beta}_j) R_{ft} - \hat{\beta}_j R_{mt} \qquad \textbf{(6.8)}$$

A later model is the Arbitrage Pricing Theory (APT) suggested by Ross (1976) which uses a multifactor model when modelling a security's expected returns. It has been found that these models have little improvement over the much more convenient MM as demonstrated by Brown and Weinstein (1985). Although the APT does eliminate biases produced by the CAPM model, the statistical models also take account of these biases. The statistical models are therefore more widely used. Of these statistical models, the MM is the model that is most popular and widely used in modern event studies.

More recent empirical evidence has added support to the use of MM in event studies. Cable and Holland (1999) tested CAPM, MM, MAR and MARM. They found that, using a sample of 30 UK companies, both the CAPM and the MM performed well. The MAR was rejected against the MM in all cases and MARM was rejected in more than one in three cases. Although the CAPM and MM performed well the MM dominated the CAPM in only a small number of cases. The model that will be used to estimate normal returns in this study will be the market model. This is due to the model's strong performance when compared to other more complex models, its ease of use, and the absence of overly restrictive assumptions.

6.2.3: Returns Data

The data for daily returns was collected from Datastream and defined so that R_{jt} the return to asset j at time t can be written as

$$R_{jt} = \frac{P_{jt} + D_{jt} - P_{jt-1}}{P_{jt-1}} \quad \textbf{(6.9)}$$

Where P_{jt} is the price of security j at time period t, D_{jt} is dividends paid over time period t, both of these are adjusted for any capital change. Then P_{jt-1} is the price of the security at time period t-1[2]

6.3: Estimating the Normal Returns Model

On top of the issues identified in the previous section with regards to choosing the correct model for predicting normal returns, estimating the normal returns using Ordinary Least Squares (OLS) presents its own difficulties. It has been found, in general, that estimates of the market model using OLS suffer from non-normality. Chan and Lakonishik (1992) and Mills et al. (1996) identify this non-normality in the case of excess kurtosis. Brown and Warner, (1985), Chan and Lakonishik, (1992), Campbell and Wasley, (1993), Draper and Paudyal, (1995) identify it due to skewness. The consequence of this non-normality is that the regression results may produce incorrect estimates of beta and consequently incorrect estimation of abnormal returns and cumulative abnormal returns. Also, the test statistics that are obtained will not be reliable. Mills et al. (1996) found that using OLS to estimate the market model was particularly unreliable in the presence of outliers.

To account for possibility of non-normality being present when using OLS to estimate abnormal returns, a range of robust estimation techniques have been suggested. Cable and Holland (2000) find that for portfolios of a size greater than 60, non-normality was no longer a problem. With an event study on the German and Swedish 3G administrations, as Cable et al. (2002) point out in their event study of the UK 3G auction, the model will be run with, at best, very small portfolios and in many cases single companies. This will mean the aggregation effect noted by Cable and Holland will not take place. To attempt to overcome this potential problem Cable et al. use robust and median estimation techniques and found that there was little

[2] Definition of R_{jt} is taken from the Datastream glossary.

deviation across estimation techniques, so OLS was an adequate estimation technique.

Despite Cable et al.'s findings that OLS was adequate, this study will employ three methods for the estimation of the model. In addition to Ordinary Least Squares, two robust-to-outlier methods will be used to account for the risk that the assumption of normality is violated.[3] When using OLS, there can be problems when sampling from a heavy tailed distribution. To overcome these potential problems the first alternative estimation technique is a 'Robust' estimator, using a method suggested by Beaton and Tukey (1974) that applies differential weights to outlier observations. The regression is run using iteratively reweighted least squares. Once the regression has been run the Cook's D statistics are calculated for each observation. Any observation with a D statistic greater than 1 is excluded. Each observation is then given a weighting depending on the scaled residuals. These scaled residuals are based on the median absolute deviation about the median residual divided by a constant according to the Huber (1964) method. The regression is run again with these weights, the results are stored and weights are recalculated and the regression run again. This is done until the maximum change in weight drops below some tolerance level. Using the result from the Huber iterations the process is performed again but using biweights. These biweights are calculated by giving all non-zero residuals a downweighting and attaching a value of zero to very large non-zero residuals. The reason that two weighting systems are used is that Huber weights may have problems converging in the presence of extreme outliers and biweights may not converge to single solution.

The second method is a median regression estimate. This involves the coefficients being estimated by minimising the absolute deviation from the median rather than the sum of the squares of the residuals, as in OLS. So it finds a regression coefficient that minimises the function:

$$\sum_{i=1}^{n} |y - xb| \qquad \textbf{(6.10)}$$

[3] See Chan and Lakonishok (1992) and Mills et al. (1996) in the case of kurtosis, and Chan and Lakonishok (1992) and Campbell and Wasley (1993) in the case of skewness.

The median estimator may still be distorted in the case of serve outliers; however it is preferable to OLS where the data are skewed. All of these regressions estimates will be carried out using STATA.

6.4: Event Specific Problems

Before we consider the usual matters concerning an event study there are some event specific issues that need to be considered. Due to the nature of an administration procedure, and in particular the 3G procedures, carrying out an event study can be troublesome. Cable et al. identify a number of issues that must be addressed when using an event study to analyse the results of an auction. The event in question, an auction, will not be a surprise as it lasted for some time with the outcome becoming more certain as time went on. This led to the market forming expectations of the event over time and making it difficult to determine the exact date of the event. Further to this, a problem was identified with respect to the companies involved in the auction being trans-national. Due to the participants being listed on different markets, the reactions of the markets on which these companies had their primary listings are needed.

These problems mean that it is particularly important to make a careful choice of estimation and event windows. The long drawn out nature of these administration procedures would allow expectations to form. The estimation window needs to be in a period that was not affected by the administration procedures. The event window needs to take account of the expectations being formed. With an open ascending auction there is the potential to have multiple dates as each firm drops out. A closed auction or beauty contest will not suffer so badly from this problem although it is still possible that expectations of the identity of the winners will form as the result announcement draws closer.

An additional factor that could impact on an event study is the prevailing industrial climate during the European administration procedure. The administration occurred whilst the telecommunications bubble was at its peak and bursting. The changing industrial climate needs to be accounted for as a confounding factor when analysing abnormal returns. However this is not the only problem that changing market conditions caused. Due to the turbulence in the telecommunications sector and concerns about the size of the spectrum licence fees, there was a great amount of flux in the organisational structure of the industry. This led to the formation of consortia. Thus, it is sometimes difficult to identify the ownership of the company that is bidding. For instance, E-plus was originally owned by the Dutch company KPN. Before the start of the German auction, a consortium was set up between Hutchison and KPN with support from NTT DoCoMo.[4] This consortium was E-plus Hutchison. However, by a day after the auction the company was again solely owned by KPN, with NTT DoCoMo owning a 15% stake in KPN mobile. Due to worries about the size of licence fees and experience in previous auctions, many companies who originally applied to be involved in the auction withdrew before it began. A final added complication of the German auction was that a second auction took place where additional spectrum was allocated. One of the winning firms from the first process did not receiving any additional spectrum. Although the Swedish beauty contest only had one allocation date, the formation of consortia became more extreme. The 10 consortia applying were made up of over 30 different companies. Some of these issues will be addressed in more detail in the next chapter.

The problem of the telecommunication bubble will be overcome, as with CHH, by comparing a portfolio of winning and losing firms to try and account for any sectoral factors. All companies that were approved by the German regulator on June 1st will be included in the analysis, even if those firms dropped out before the bidding process began[5]. When a company drops out of a consortium, after the auction has finished, that company will be considered a loser. The event date for these losing

[4] Both Hutchison and NTT DoCoMo had originally planned, and been approved, to bid independently. NTT DoCoMo is worthy of special consideration; as they were approved by the regulator, they must be included in the analysis. When they dropped out, they joined the E-plus Hutchison consortium but only as a very minor part owner of a part owner. As such, they should not be considered losers as they are still involved. But it is difficult to consider them as winners in the same sense as the other winners. Indeed it would be comparable to considering Vodafone a double winner because they have a small share in France Telecom. As such, NTT DoCoMo will be included as a winner but should be treated with care.

[5] With exception to Vivendi, in this case it was impossible to get a reliable estimation due to the fact that the company made its intention to not bid clear during the estimation period.

companies will be taken as their withdrawal date.[6] Results will also be examined for the second auction, however they will be given less weight. The second auction only existed to administer additional spectrum. It has no effect on who the winners are, and the prices paid for this additional spectrum were negligible when compared to the main auction. As such, when the end of the German auction is referred to it will mean the end of the first stage, as this is when it has become clear who can be considered a winner. However, it will be worth examining the AR for the day of the announcement of the winners of the second auction to assess if there was any effect of not gaining extra spectrum.

6.5: Conducting an event study

The procedure for conducting an event study can be split into three distinct sections. These consist of defining the estimation window, defining the event window and defining the post event window. Mackinlay (1997) gives an account of this process and denoted the estimation window as between time T_0 and T_1, the event window between T_1 and T_2 which contains $\tau = 0$, the actual event day[7], then the post-event window is between T_2 and T_3. The AR on the day of the event can then be used to observe the effect of the event on the market value of the firm; this is assuming that the event is exogenous of a change in the value of the firm, which in this case it clearly is. If the AR is negative for a licence winning firm in a particular administration then we may say that we have a winner's curse. The ARs of the losing firms on the day they withdrew from the auction will also be examined, if there was a general negative feeling of the market to the auction then the expectation would be of a positive AR for these firms. These ARs and those of the winning companies will then be used to show an overall wealth effect by multiplying the AR by the firm's market capitalisation. Although this number can only give an indication of the level of over or underpayment and does not in itself identify a winner's curse.

The one day AR on it own is not enough to provide a clear conclusion on the existence of a winner's curse. MacKinlay states that "The abnormal return

[6] This only happened in two instances that of Hutchinson and E-on.
[7] In the case of this event study $\tau = 0$ is the day the auction ends.

observations must be aggregated in order to draw overall inferences for the event of interest"(MacKinlay, 1997, p160). This will be especially true if we wish to check for a delay or overreaction. We shall calculate the cumulative abnormal returns where $CAR_i(\tau_1,\tau_2)$ is the cumulative abnormal return between τ_1 and τ_2 for company i. We can then use the standardized cumulative abnormal returns (SCAR) as a test statistic where

$$\widehat{SCAR}_i(\tau_1\tau_2) = \frac{\widehat{CAR}_i(\tau_1, \tau_2)}{\hat{\sigma}_i(\tau_1, \tau_2)} \qquad \textbf{(6.11)}$$

Where

$$\hat{\sigma} = (1/(L_1 - 2) * \text{Cumulative}(AR^2) \qquad \textbf{(6.12)}$$

This will give us a test that follows a t distribution with $L_1 - 2$ (where L_1 is the number of trading days in the estimation period) degrees of freedom and we have a null that the CAR is not significantly different from zero[8]. The CAR will be obtained for each firm and from this the effect of the event over the 30 day post-administration period as well as the entire event period can be judged.

Due to the nature of the event and the fact that only a small number of firms are available, it will not be possible to undertake the usual method of aggregation across securities and through time. However, an alternative method of aggregation is to create portfolios. This method, used by Cable et al., creates portfolios of the winning and losing companies, weighted by market capitalisation. These portfolios should then be able to account for sectoral factors. These portfolios will show if there is any clear disadvantage from being a winner. This will be done by comparing the CAR for each of the portfolios over the entire event period. Although these portfolios will provide a way to analyse the abnormal returns there are still two important issues that require us to be cautious in our interpretation.

[8] Within an event study such as where we shall be looking at CARs over a minimum of 31 days we would expect the test always to reject the null, as such the result of this t-test will be of limited value.

6.6: The Thin Trading Problem and Clustering.

When using daily returns a potential problem can exist if thin trading is present. This can be a particular issue when dealing with securities of different size companies and across countries. For instance, historically Nasdaq stocks were much less frequently traded than stocks NYSE. The problem was first identified as daily returns data became available by Scholes and Williams (1977). Thinly traded stocks may suffer from non-normal distributions due to a potentially large number of zeroes and large outliers. Brown and Warner (1985) used returns data from NYSE and the more thinly traded ASE to test for the effect of thin trading. They find that thin trading has no effect. Also, return variance is likely to differ between the estimation period and the event period. Various alternative tests have been suggested to overcome the problem of thin trading. These tests are non-parametric so are still valid when non-normality is present.

For cross-sectional data, Boehmer et al. (1991) developed a test to overcome increases in return variation. The test allows the abnormal returns variance to be different between the estimation and event windows. Cowan, Nayar and Singh (1990) and Sanger and Peterson (1990) develop the generalised sign test, which is a variation on the sign test. The generalised sign test accounts for asymmetries in the returns distribution. Corrado (1989) outlines the uses of the rank test as opposed to other non-parametric tests. The rank test does not suffer as much as other non-parametric tests from event-date excess returns variance. The rank test was found to perform well by Campbell and Wasley (1993) but Cowan (1992) finds it is misspecified when using Nasdaq data. In particular the rank test is not as powerful as the generalised sign test as the size of the event window becomes greater.

In order to draw a conclusion from the aggregated CARs we must be cautious of the clustering of events. If the events overlap then there will be covariances between each CAR. If this is the case then the assumptions that underlie the standard parametric tests will be violated. The covariance between the abnormal returns will not be zero. Clearly the events for those firms involved with an auction or a beauty contest will be clustered. The event date for those firms involved will be the same for all the firms involved. To take account of this clustering MacKinlay suggests creating portfolios of the affected securities and then analysing the results at a security level. The existence of event clustering does pose problems for non-parametric tests. When event clustering is present, Cowan reports that rejection rates are higher than when compared to random dates. The issues of thin trading and clustering were only superficially considered in the CHH study. They did not report any non-parametric test relying only on the SCAR test and the analysis of the plots of the CAR. Due to its noted better performance, this study includes results of a generalised sign test for each of the firms this study. The sign test for the cumulative average abnormal return (CAAR) is:

$$CAAR_{D_1,D_d} = \frac{1}{n}\sum_{j=1}^{n} CAR_{j,(D_1,D_d)} \quad \textbf{(6.13)}$$

With the null hypothesis

H_0: $CAAR_{D1,Dd} <= 0$

H_A: $CAAR_{D1,Dd} > 0$

The sign test compares the number of stocks with positive cumulative abnormal returns in the event window with what would be expected without abnormal performance. This is based on the fraction of positive returns in the estimation period.

$$\hat{p} = \frac{1}{n}\sum_{j=1}^{n} \frac{1}{L_1}\sum_{t=E_1}^{E_{L_1}} S_{jt} \quad \textbf{(6.14)}$$

Where

$$S_{jt} = \begin{cases} 1 \text{ if } \mathrm{AR}_{jt} > 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(6.15)}$$

W is the number of stock in the event window for which $CAAR_{D1,Dd}$ is positive. The test statistic is then:

$$Z_G = \frac{w - n\hat{p}}{\left[n\hat{p}(1-\hat{p})\right]^{\frac{1}{2}}} \qquad \textbf{(6.16)}$$

The test uses the normal approximation to the binomial distribution with parameter $\hat{p}$. A full description of the generalised sign test and its benefits can be found in Cowan (1992).

This chapter has outlined the justification and methodology behind the use of event studies to analyse real world events. Particular attention has been given to the problems that are associated with use an event study to analyse the results of licence administration procedures. The next chapter will begin with a discussion of particular aspects of the German and Swedish procedures that make them suitable for analysis. It will then go on to report the findings of the comparative event studies and how these results are informative in the search for a winner's curse.

Chapter 7: A Comparative Event Study: Germany and Sweden

7.1:Introduction

The previous two chapters have outlined the importance of the winner's curse, how it can exist and the selected method for identifying it. Chapter 5 discussed the existence of the winner's curse and where it has been identified before, whilst Chapter 6 detailed the event study methodology that this chapter will use to search for a winner's curse. The aim of this chapter is to extend the event study methodology to perform a comparative analysis on two procedures in the European administration. The comparison of an auction and a beauty contest should enable a more thorough assessment as to the existence of a winner's curse. If a winner's curse is present in some of the European licence auctions, then those firms that won a licence through a beauty contest and only paid a nominal fee should experience a 'winner's bounty'. A winner's bounty should be present as long as a 3G licence held some value above the nominal fee that they were required to pay.

The two administration procedures that will be considered in this chapter are those used in Germany and Sweden. The German authority used a simultaneous ascending auction which raised many billions of Euros. Sweden used the alternative option of a 'beauty contest'. The Swedish beauty contest involved participating bidders submitting proposals outlining their suitability to run 3G services, but only a very small upfront charge was levied upon the winning participants.[1] There was also a charge of 0.15 per cent of yearly revenue. As this charge was dependent on the size of revenue, it in effect insured against a less favourable 3G market. Within the range of administrations in Europe, the Swedish and German administrations are particularly appropriate for comparison. Although Sweden and Germany are not homogenous in terms of size of population, industrial focus etc, there are nevertheless a number of similarities that make them suitable for this study. Both administration processes were relatively successful at

[1] Germany and Sweden raised €45.85bn and €42800 respectively.

attracting bidding applicants, with 10 initial applicants in the Swedish beauty contest and 12 in the German auction. This was probably down to the importance of both countries for building a regional network. It would be very difficult to operate as a Nordic or central European operator without holding licences in these countries. There were only a small number of administrations that were this successful at attracting entry. A large number of entrants are important for an event study as it ensures that the final result is uncertain. It also signals that the licence administration was an important event and so will be less affected by confounding factors.

Using an event study when dealing with the administration of licences in multiple countries in a process like the 3G licence administration, poses a particular problem for event identification. It may not be appropriate to consider each process individually but rather to see the German and Swedish administration procedures as two in a series of sequential European licence awards. This would be equivalent to treating the European process as one long event made up of many micro-events. The market reaction then occurs over the entire period with different micro-events providing information as time goes on. Although the German auction occurred at a relatively early stage in the European procedure, by the time of the Swedish beauty contest much of the stock market reaction may have already occurred.

To understand fully the market's reaction to 3G auctions would then require monitoring stock market reaction for the entire European administration process. The length of the European administration and the number of confounding factors would make an event study of this type impossible. To examine abnormal returns over the entire period would be a fruitless task and no conclusion could realistically be drawn from it. Although the German and Swedish administration procedures are part of a wider European process both had enough of a regional impact to be worth looking at as events individually. They were significant micro-events within a broad encompassing event. Importantly for the purpose of this comparative study, there was a considerable difference in licence fees. It may be fair to assume that the Swedish licence would be worth less than a German licence due to the smaller potential market (in terms of population coverage), alternatively one could take the view that the smaller number of licence holders in the Swedish post-administration market will make these licences more valuable. Although both of these factors should be considered, neither would account for such a large variation in prices. When comparing the two procedures the only conclusion that could be reached is that the German winners overpaid, the Swedish winners underpaid or some combination of the two occurred. A final area which makes the two countries particularly suitable for comparison is in post-administration distress. In both countries there were considerable difficulties in meeting roll-out conditions and there was eventual return of licences and withdrawal of some firms. An automatic conclusion from this is that some licence winners must have overpaid for their licences. A particular area of interest will be the reaction to those firms that won licences but eventually handed them back.

Through examining two procedures, one auction and another beauty contest, a clearer picture of the market reaction to winning a 3G licence should be provided. Firstly, there would be an expectation that the winners in the Swedish beauty contest will perform relatively better than the losers when compared to the German auction. This is because of the differential between the prices of the licences brought about by the beauty contests selling licences below 'market value'. However, there are other factors that may have negatively affected the winners of the Swedish beauty contests. Due to the high licence fees that had gone before and the uncertainty surrounding the development of 3G services, there may have been a general negative reaction to any company that obtained a licence. Although the beauty contest does not require price bidding, there is a form of bidding process in the proposal submitted by the firms. It is worth noting that the winners of the Swedish licences were those companies that offered the best coverage and rollout commitments.[2] If these were considered to be excessively strict and costly, then there may be a negative response to the winning bidders. The results from the Cable et al. (2002) study can also be compared to these results to take the analysis further. Again, this would be with the expectation that the winners of the UK auction would

[2] Each of the winning firms guaranteed 99.98 per cent coverage by 31 December 2003, although due to network sharing rules they had the option of building just 30 per cent of this.

perform relatively worse when compared with the winners of the Swedish beauty contest.

This chapter will first review the outcomes of the German auction and the Swedish beauty contest and discuss the particular aspects of the German and Swedish procedures that make them particularly useful for assess the winner's curse. In particular, how the German and Swedish markets developed post-administration. Section 7.3 discusses the form and period that the market data is taken from. Section 7.4 reports the results of the German and Swedish event studies with references to the Cable et al. UK study. Finally, Section 7.5 concludes this section with a discussion of whether the winner's curse has been identified and what effect this may have on the post-administration market.

7.2: The Swedish and German Procedures and Post-administration difficulties

Germany and Sweden are two countries that personify the way in which European countries favoured different methods of licence administration. Despite their similarities in terms of GDP per capita and mobile penetrations, their chosen methods of administration could not have brought about more divergent outcomes. Sweden administered four licences through a strict and tightly controlled beauty contest whilst only charging s nominal fee. In contrast, Germany used an auction procedure that went as far as giving the bidders the ability to control the number of licence holders and the quantity of spectrum in each licence, whilst raising billions of Euros in the process.

The technical aspects of the Swedish and German procedures have been outlined in Chapter 2. Sweden was well placed to take advantage of the new 3G technology with a relatively high GDP and one of the highest mobile penetration rates in Europe, standing at 58% in 2000.[3] Bjuggren (2003) identifies the Swedish decision to use a beauty contest and charge a nominal fee as motivated by a desire to avoid overly indebting the firms that won licences and encouraging development in the industry. The Swedish had laid out a goal of becoming international leader in IT development; the development of 3G services was considered a key goal in achieving this aim. The use of a beauty contest

[3] International Telecommunications Union (2003)

came about despite opposition from some sections of the Swedish parliament (the Bourgeoisie parties) that favoured an auction due to its revenue raising potential.

The desire for speedy network development extended not only to the relatively strict roll-out conditions that were laid out in the licences, but also the way the applications were judged. In addition to the first stage, where applicants were judged on whether they were suitable candidates from such criteria as their technical, commercial and financial feasibility, there was a second more detailed stage. If an applicant succeeded in achieving the minimum standard from the first stage they would then go through to phase 2 of the procedure where there proposals were ranked according to the commitments each applicant laid down for itself. The criteria in the first stage were so strict that only five out of the ten applicants were considered in the second stage. Of the five that dropped out in the first stage, one was the incumbent and former state monopolist, Telia.[4] Telia failed to move beyond the first stage due to it committing to build fewer antenna than the PTS considered necessary to achieve the required signal strength. Although four licences were finally administered the original number that the PTS had planned to administer was five. The number of licences was reduced to four as the Swedish market was considered not able to sustain five network operators.

The focus for the Swedish beauty contest was speed of roll-out and fast development of services. Despite these goals there were initial delays with the roll-out of services as a number of the firms that failed to win licences challenged the decision in the Swedish courts. These appeals were rejected and the licences were administered according to the PTS's original judgement. The focus of fast market development meant winners of licences in the Swedish procedure should be advantaged in two ways when compared to winners of the German auction. Firstly, they received their licences for a much lower fee. Secondly, the number of licences administered in Sweden was two fewer than in Germany, making the opportunity for profit potentially greater. This had to be weighed against the relatively smaller market that Sweden offered. This of course assumes a

[4] Although the assessment was performed in two stages the results were announced on one date even if the applicant had not progressed to the second stage.

direct relationship between market structure and performance. These two benefits would support the idea that winners of licences should gain a winner's bounty rather than a winner's curse. One important set of factors to account for when considering a winner's bounty in the Swedish procedure are the roll-out conditions. Due to their severity and the conditions that some licence winners placed upon themselves, the value of the licence may have been diminished if investors believed that these conditions were unattainable. However, this still should not have brought about a negative market reaction. Even if licence conditions were tight, the licence can be considered an option to roll-out 3G services. If in the post-administration market the roll-out conditions were found to be unattainable, the licence could be handed back with the loss of only a nominal fee or the licence conditions renegotiated.

Given the desire in Sweden for a speedy development of 3G services it may seem somewhat surprising the difficulties that they faced post-administration. Chapter 2 recounts the struggle faced by some of the operators and the eventual withdrawal of Orange from the Swedish market leaving them with one less operator than was desired. However, this type of behaviour supports the supposition that the licences, to an extent, were treated as options to roll-out 3G services; an option that, as became apparent, Orange did not wish to exercise.

Germany, as opposed to Sweden, raised a considerable amount of revenue from their licences through an auction mechanism (again technical details of this auction can be found in Chapter 3). The German authorities sought to administer the licences to those that valued them the most in the hope that the licences would then be used most efficiently. This led to a considerable amount of revenue being raised. Chapter 2 provides certain evidence that this behaviour negatively affected the development of 3G services in Germany. Referring back to Table 2.1, of the six licences that were administered two were eventually returned. The most critical events in the German post-administration market were the withdrawal of MobilCom and Group 3G. In July 2002, Group 3G shut its network of retail outlets but claimed that it would continue to develop its 3G network. By October of the same year Group 3G declared itself bankrupt and recommended that its customers switch to T-Mobil (T-Mobil paid €50,000 for this recommendation). At the time, Group 3G stated they may still seek to exercise their rights over the licence. However, given that they would not achieve any of the stated roll-out conditions it seemed unlikely that the regulator would allow them to do this. In November of 2002, MobilCom took a €9.9bn write-off on its 3G licence, €7.1bn of which was taken by consortium member France Telecom. In June of 2003, MobilCom sold its existing 3G infrastructure to E-Plus for €20 million. At this point it became clear that MobilCom was withdrawing from the German market and with the first rollout commitment approaching MobilCom returned its licence to RegTP. Although MobilCom requested compensation for the return of the licence, perhaps unsurprisingly RegTP found no grounds for this to be granted. This left the German market with four instead of the original six operators and no new entrants when compared to the 2G market. This was until Telefonica, one of the former owners of Group 3G, bought back into the Germany market by acquiring O2 for €24bn. This gave Telefonica a licence in both Germany and the UK.

These events occurred despite Germany only requiring licence winners to attain around a quarter of the coverage that was required in the Swedish licence. A superficial reading of the failure of these two licence winners would suggest that, as they were forced to hand back their licences without any recompense, then they must have suffered a winner's curse. It is clear that they must have paid too much for the licence. However, taking the definition of a winner's curse as it was laid out in Chapter 5; it would appear that this is not necessarily the case. As was discussed, the behaviour in the post-administration market cannot tell us if a winner's curse was present. The licence winners may have just suffered some unanticipated adverse payoff shock or simply that a particular negative state of the world occurred. It is entirely possible that at the time the winning firms bought the licence they valued them correctly. The results of the event study should indicate whether the markets believed that the winners of these German licences did value them correctly. It will be particularly interesting to see if there was any specific negative reaction to those licence winners that eventually returned their licences. This would mean that some licence winners suffered a winner's curse whilst others did not. Despite the sums that Germany raised and its lower emphasis on market development, Germany still managed to get four 3G networks established – one more than did Sweden.

7.3: Data Description

The estimation period is taken as one calendar year before the start of the event period. This gives an event period of 276 trading days. For consistency the estimation period for both event studies will be the same. The event period is taken as 30 days before the date of the event. The German event is assumed to start when the auction begins, on the 31st July 2000 and ends on the 17th August 2000. This entire 18 day period is considered to be the event date. As the Swedish beauty contest was announced and not run over a number of days, its event date is a single day on the 16th December 2000. However, as this was a Saturday the next possible day for the markets to react was 18th December 2000, so this will be taken as the event date. As with the German study, the Swedish event period will be assumed to start 30 days before the event date. The event period will end 30 days after the event date. For the German study this is 30 days after the end of the first auction.[5]

In the previous chapter, the need to consider carefully the results of some firms was identified. A particular example was the results for NTT DoCoMo due to its changing status during the event. All the firms that took part in the German auction were included in the event study apart from Vivendi. It was not possible to get a consistent estimation period for Vivendi because the firm announced its intention not to bid during the estimation period.

Although data could be obtained for the majority of firms in the German administration this was not the case for the Swedish event study. There were particular issues with firm data being available during the estimation period in the Swedish beauty contest. As the administrations across Europe went on it became more common for consortia to form

[5] Where the firm is listed on a non-European market the event date may be different due to the markets being closed at the time of the announcement.

and bid for licences. By the time of the Swedish beauty contest occurred, over 30 firms made up the 10 bidding consortia. Some of these firms were new start-ups and so did not exist during the estimation period and were certainly not listed on any stock market; even some firms that were established prior to the 3G administration were not listed companies. So consistent estimators were not available and these firms could not be included. Of those firms that took part in the Swedish beauty contest 12 were included in the analysis, split equally between winners and losers. Unfortunately Telia, which would have been of particular interest due to its position in the Swedish market and the fact it did not win a licence, was one of the firms for which it was not possible to get a consistent estimation period. Many of these firms that were involved in bidding were only small contributors to their consortium. However, the size of a firm would not necessarily preclude them from the event study. It would be desirable to weight the firms involved in each consortium by the size of their share in the bidding unit but this was so often ill defined and changeable that it is not possible.

7.4: Empirical Results.

7.4.1: German Results

The results for the German event study can be found in Table 7.1, Table 7.2 and Table 7.3 which contain the results for the winners of the auction using OLS, Median and Robust estimation techniques respectively. Column 1 has the one day AR on the day of the auction result. Column 2 the CAR for 30 days after the end of auction date. Column 3 is the CAR t-ratio and column 4 is the one day AR for the result of the second stage auction. Table 7.4, Table 7.5 and Table 7.6 contain the results for the losers; columns 1, 2 and 3 are the same as in the previous 3 tables. Columns 4, 5 and 6 contain the one day ARs for the date the firm withdrew, the 30 day CAR from the withdrawal date and the t-ratio for this CAR. Table 7.7, Table 7.8 and Table 7.9 show the calculation of the wealth effects for the one day AR at the end of the auction or the withdrawal date depending on the firm. Table 7.10, Table 7.11 and Table 7.12 contain the weighted portfolio of the winning firms. Column 4 is the calculation of the weighted portfolio for the end of auction plus 30 day CAR and column 6 is the calculation of the weighted portfolio for the 30 days before the start to 30 days after the end of the auction CAR. This table also includes the results of the sign test on the CARs. Table 7.13, Table 7.14 and Table 7.15 are the same as the previous three tables but for the losing firms.

Appendix B contains the plots of the CARs. Figure 7.3 to Figure 7.18 show the plots of the CARs for each winning and losing firm for the 30 day before the auction to 30 days after its end. On each chart, the CARs using each estimation technique are shown. Figure 7.1 shows the CAR for the winning and losing portfolio from 30 days before the start of the auction to 30 days after its end. Each estimation technique is plotted on the chart. Figure 7.2 shows the CARs for the winning and losing portfolios form the start of the auction to 30 days after its end. For comparison, the plotted CAR from the Cable et al. study is shown in Figure 7.33.

7.4.1.1 : German Winners

Of the 11 winning firms, 8 had negative one day abnormal returns (ARs) and 3 had positive one day ARs. The 3 firms with positive one day ARs are Deutsche Telecom, MobilCom and NTT DoCoMo. The CARs for the end of the auction to 30 days after its end are all negative apart from NTT DoCoMo for all the estimation methods and BT for the OLS estimation results. The T-ratios in all cases were highly significant. This was consistent across all the estimation techniques with only a small variation across techniques. After the results of the second stage auction were announced all but two firms had negative one day ARs. Of the two firms with positive ARs, BT did not win extra spectrum, the other firm was NTT DoCoMo. Table 7.7 to Table 7.9 give the average one day wealth effect across all the winners which varies between -€1647.51 m and -€1490.94m across the different estimation techniques. This figure has been slightly distorted by the large negative wealth effect for Vodafone. The largest positive wealth effect was achieved by Deutsche Telecom with between €4134.61m and €4179.98m the largest negative wealth effect was Vodafone with between -€11396.1m and -€11519m depending on the estimation technique. Of the firms that were involved in bidding units that eventually returned their licences (Telefonica and Sonera for Group 3G and France

Telecom and MobilCom for MobilCom) there are mixed results. Apart from MobilCom, all experienced a negative one day AR. However, when the progression of the ARs is observed in the CAR plots, all the firms that eventually hand back their licences perform badly. Despite their poor performance they do not appear to have been cursed to a greater extent than any other winner. As was stated previously, Deutsche Telecom was the firm with the lowest CAR at the end of the event period.

From the graphs, in Figure 7.3 to Figure 7.11 we can see the development of each firms CAR over the entire event period. Of these plots one of the most interesting is Deutsche Telekom (Figure 7.4). From this plot we can see that although Deutsche Telekom has a positive one day AR on the date of the auction this is followed by a sharp decline in the following days. After this immediate period Deutsche Telecom's CAR increases and levels off for the remainder of the period. There is also an interesting period around 10 days before the start of the auction, here Deutsche Telekom suffers a sharp decline in its CAR. It is primarily this pre-administration period that causes Deutsche Telekom to have the lowest CAR at the end of the period. The fact that Deutsch Telekom had such deterioration pre-auction could have been due to the assumption that, as the largest incumbent, it would have had to win a licence. Therefore the competition that emerged as present in the auction was immediately received as a negative signal by the markets. Vodafone in Figure 7.11 follows a similar pattern but without such a large pre-administration fall in CAR. Vodafone experiences a decline during the auction procedure and, once it is over, a sharp decline followed by a slight increase. Post auction, Vodafone and Deutsche Telekom follow a similar path. Of the other winners France Telecom, KPN, MobilCom and Sonera all experience sharp declines of their CARs in the days immediately after the end of the auction. Only British Telecom and NTT DoCoMo did not experience a large fall at any time in the post-auction period.

7.4.1.2 : German Losers

Of the 7 losing companies included, 4 have positive ARs on the day of the result. However, there would be no reason to expect any useful information to come from this one day AR as the majority of bidders would have already dropped out of the auction by this point. Of more interest for the losing firms are the abnormal returns for the day of withdrawal from the competition. All but 2 firms have negative 1 day ARs for their withdrawal date. The two firms that have positive ARs are American based which may reflect the relative unimportance of the German market to them. Taking the losing firms' CARs from the end of the auction until 30 days after its end, the results show that the losing firms perform considerably better than the winning companies with 4 out of 7 registering a positive CAR. However, taking the 30 day CARs from the date of withdrawal all but 2 have negative CARs. Taking the average wealth effect for the losers also seems to suggest that they fared considerable better than the winners. The losers' average wealth effect is over €2500m higher than the winners. However the size of this wealth effect is slightly distorted by large positive wealth effects for the two American firms, SBC and MCI WorldCom. Even if these companies are not included, the losing firms' wealth effect still outperforms the wealth effect seen for the winning firms. This result immediately suggests the possibility of a winner's curse.

The CAR plots for the losers can be found between Figure 7.12 to Figure 7.18 and give a clearer indication of the evolution in each firms' performance. The withdrawal, where it is within the event period, is also shown on the diagrams. Of these losing firms, only SwissCom (Figure 7.17) experience a decline in CAR after the end of the auction and a sharp decline after the withdrawal announcement. Debitel (Figure 7.12), although experiencing a small decline after withdrawal, saw a large positive increase in CAR as the auction approached its end. This increase was maintained after the end of the auction. One of the most interesting plots is that of E-On (Figure 7.13), which was the final bidder to drop out from the auction. The end of the auction saw very little reaction in E-ON's CAR. This strongly suggests that the markets attached no penalty for not winning a licence. The remaining losers' CARs do not produce a consistent pattern. Of the two American firms, SBC experienced a gradual increase in CAR post-action and MCI WorldCom saw a short-run gradual increase followed by a sharp decline. Also the plot does not show an instant decline followed by a slow upwards adjustment but rather a series of negative ARs over a number of days. It is likely that this was the reaction to the winning firms and the latter increase in the CAR was brought about by other confounding factors.

7.4.1.3 : German Portfolios

Table 7.13, Table 7.14 and Table 7.15 contain the constructed portfolios of aggregated CARs for the winners and losers. As would be expected with the results from the individual CARs, all the portfolios have negative CARs at the end of the 30 days pre-auction to 30 day post auction and the end of auction plus 30 day period. The portfolio of losers, has a positive 30 day pre-auction to 30 day post auction CAR in all cases, and positive CARs in the end of auction plus 30 day period in all but the OLS case. The OLS reports a small negative value for the CAR. The sign tests for the plus 30 day CARs support the idea that winners performed badly. For both event periods and across each estimation method the null that the CAR is equal or greater than zero is rejected. For the losers, in no case can we reject the null that the CARs are equal or greater than zero. The evolution of CARs over these periods can be more clearly seen in Figure 7.1 and Figure 7.2. The 30 day pre to 30 day post auction plot in Figure 7.1 show an instant divergence between the portfolios of winners and losers. This difference is consistent across all estimation methods, with OLS giving the lowest CARs for both winners and losers. The difference between portfolios remains relatively constant until the start of the auction period. At this point both sets of portfolios begin to decline and continue to do so throughout the auction procedure. At the end of the auction procedure there is another divergence as the winning portfolios sharply decline whilst the losing portfolios level off. This can be seen more clearly in Figure 7.2. Figure 7.2 shows the portfolios' behaviour from the start of the auction procedure. During the auction procedure, both sets of portfolios decline but neither is particularly worse than the other by the end of the auction. However, once the auction had ended and the winners are announced, there is a sharp decline in the winner's portfolio. This divergence is greatest 5 to 8 days after the auction has ended. The portfolios reconverge slowly and meet around 20 days after the end of the auction. This result presents a clear and stark negative market reaction for the winning firms.

An interesting comparison will be made here with results from the Cable et al. study. The portfolios remain quite close until the end of the 30 day period when there is again a slight divergence. This pattern closely resembles the behaviour of the portfolios in the Cable et al. study. The 30 days pre-auction to 30 day after its end for the UK study (OLS results) can be seen in Figure 7.33. After the start of the auction the UK results follow a very similar pattern to the German results. Both have declining CARs during the auctions and, like the German results, after the end of the auction there is a divergence between the portfolio of winners and the portfolio of losers. The winners' portfolio performs relatively worse than the losers' portfolio for a period of around 20 days after the end of the auction. This similarity with the German results does seem stark. Although, unlike the German results, in the UK event study the winners' portfolio does not perform consistently worse than the losers' portfolio pre-auction. However, once the results are taken from the end of the auction procedure, there is clear evidence of a short-term negative response to the winners. A cautionary note does need to be struck concerning the behaviour after this 20 day period. In both the UK and German event studies the winners' CAR plot rejoins the losers CAR plot. It could be argued that this demonstrates an overreaction by the market followed by a slow correction. Referring back to the previous chapter, this was discussed as one of the potential consequences of market inefficiencies. Although this is a possibility it would seem that the negative returns lasted for too long a period. Given the evidence of the speed of market reaction discussed in the last chapter, if this type of market correction was to take place it would be expected to occur over a much smaller number of days.

7.4.2: Sweden

The Swedish results are arranged in much the same way as the German Results. The results for Sweden can be found between Table 7.16 and Table 7.30 which contain the abnormal returns for the winning and losing firms and the portfolios of both. There was no second stage in the Swedish procedure and so there is only one event date reported for the winners. Unlike the German auction the event date is only one day so there is no period between the start of the procedure. The event period still begins 30 days before the event date and end 30 days after it, but as the event date is shorter, the event period will also be shorter. Due to the result of the procedure coming from an announcement on one day, there are no additional withdrawal events for the losers. The charts for the Swedish event study can be found from Figure 7.19 onwards. Starting with the two portfolio CARs for 30 days post administration and 30 days pre to 30 days post event date in Figure 7.19 and Figure 7.20 respectively. The CARs for each individual firm are shown between Figure 7.21 and Figure 7.32.

7.4.2.1 : Swedish Winners

The winners' results are shown in Table 7.16 and Table 7.18, of the 6 companies included, 4 had negative one day ARs and 2 positive. This was consistent across all estimation methods used. The two firms with positive ARs were Vodafone and France Telecom. The 30 day CARs for the winners shows only one firm with a positive CAR (Tele 2). The positive 30 day CAR of Tele 2 was in fact very large when compared to the negative CARs of the other firms. However, perhaps more importantly, all the 30 day CARs for the Swedish winners seem small when compared to the CARs experienced in the German auction. The average wealth effect is heavily influenced by the size of the positive effects for Vodafone and France Telecom. This means, despite only two firms having positive one day ARs, the average wealth effect is around €1500 m across the estimation techniques. The plots of the 30 day CARs support the supposition that the effect of winning a licence in this case in only very small. Most of the firms experienced very little action in their CAR over this period. An exception to this is Tele 2 (Figure 7.25), who experience quite a sharp decline in CAR in the period 30 days pre-administration to just over 10 days before the administration. After this point the CAR increases until the date of the administration. Post administration the CAR is relatively flat for around 14 days but then increases quite considerably. Europolitan (Figure 7.21) experience a period of positive CARs post-administration but by the end of the 30 day post-administration this CAR was relatively neutral. One firm of particular interest is France Telecom (Figure 7.22), as the only licence winner to hand back their licence through its Orange subsidiary. It has already been noted that France Telecom was one of only two firms that experienced a positive AR. There is also very little movement of the firm's CAR, although it does end in slightly negative territory. There would appear to be very little impact to France Telecom winning a licence and certainly no response that would suggest negative market feeling. This is not to say that the firms were wrong to hand back their licence but rather at the time the licences were administered the markets did not believe that these bidders had overvalued the licences more than any other bidder.

7.4.2.2 : Swedish Losers

The losing applicants' results can be found between Table 7.19 and Table 7.21. The losing applicants follow a relatively similar pattern to the winners. Across the losers, 4 out of the 6 firms had negative one day ARs. This was consistent across firms in all estimation techniques apart from OLS where Nomura also had a positive one day AR. Four out of the six firms have negative CARs at the end of the plus 30 day period; this result is consistent across all estimation techniques. Although the losers experienced the same number of firms with negative and positive one day ARs as the winners, there is a considerable difference in average wealth effect. As can be seen in Tables 6.22 to 6.24, across the different estimation techniques the average wealth effect varied between -€2062 million and -€2770 million. The size of this negative result is brought about by the large negative wealth effects for Deutsche Telecom and BT. Unlike the winners, the losers with positive one day ARs had only small positive ARs and had relatively small market capitalisation. Both of these factors gave relatively minor weighting to their positive wealth effect. The losers' 30 day to 30 day CAR plots can be seen between Figure 7.28 and Figure 7.32. The majority of these plots are relatively static. However two present results of particular interest. Both British Telecom (Figure 7.29) and Sonera (Figure 7.31) experience a decline in their CARs in the 10 to 15 day period after the event date. This would seem to suggest at least some negative reaction to these two firms not winning licences.

7.4.2.3 : Swedish Portfolio

The constructed portfolio CARs for the event date plus 30 days and 30 days pre-event to 30 days post-event can be found between Table 7.25 and Table 7.27 for the winners and Table 7.28 to Table 7.30 for the losers. The results are negative across each period and for all estimation techniques for both the winners and the losers apart from the 30 day pre to 30 day post period for the winners using the robust estimation technique. However, in all cases these are relatively small negative numbers. Unlike the German results the sign tests produce mixed outcomes. The null of the CAR being equal or greater than zero is rejected for the winners' event +30 portfolio but is accepted for the 30 day pre event to 30 day post-event period. This is primarily brought about by a stronger performance by Vodafone with its larger portfolio weighting. Likewise the losers outperform the winners in all cases apart from the one robust regression result. Although these results are informative a more accurate reflection of market reaction can be seen in evolution of CARs over this period.

The results of the winner and loser portfolio CAR plots can be seen in Appendix B, Figure 7.19 and Figure 7.20. Both these plots show the CARs over the 30 days pre-event to 30 days post-event. In the 30 days pre-event the winner and loser plots follow a relatively similar pattern until about 15 days before the event. At this point there is a slight divergence as the relative position of the losers disintegrates. There is a slight reconvergence before the event but by the time of the event announcement the losers portfolio was performing slightly worse than the winners. After the event announcement both sets of firms' CARs deteriorated although the losers performed considerable worse than the winners. This continued until 10 to 15 days after the auction when the two portfolios reconverge. This can be seen more clearly in Figure 7.20 where only the post-event period is shown. When taken from the event onwards there is very little movement in the winners' portfolio ending slightly negative. The losers' portfolio has a clear negative reaction over a 10 to 15 day period after the event. However, just as with the winners in the German and UK studies this reaction only occurs for a short period of time. These results remain relatively consistent across the three estimation techniques. When comparing the Swedish portfolio results with the individual CARs it would appear that the majority of action in the loser portfolio is being driven by the abnormal returns from British Telecom and Sonera.

7.5: Conclusion

The last three chapters have been primarily concerned with examining whether there was evidence that, in some of the European administrations, licence winners paid too much for their licences. The use of auctions in the administration process was put forward as a reason why this excess debt was incurred, through a so-called winner's curse. In Chapter 5 the case was made for the existence of the winner's curse in some auctions and why the 3G auctions had particular characteristics that made them susceptible. An important point was made in this chapter over the nature and identification of a winner's curse. Crucially, the argument was made that in these particular auctions a winner's curse could not be identified by examining post-administration returns or post-administration behaviour. This led to the conclusion that the only possible way to search for a winner's curse in the 3G auctions would be to examine the market response to each firm's security price through an event study. The methodology for this event study was laid out in Chapter 6.

This chapter has sought to identify a winner's curse in the German auction through a comparative event study of the German and Swedish procedures. In addition, a further confirmation of a winner's curse was sought by a comparison with the Cable et al. event study in the UK. Taking the German result by itself, we may share the early Cable et al. conclusion that there does appear to be a short-run winner's curse. The winner's portfolio performed worse than the losers' portfolio for around a 15 day period after the end of the auction. The results of the sign test also support this conclusion. Although only a short-run winner's curse can be identified this does not mean that it can be ignored. Indeed identifying anything more than a short-term effect is extremely difficult due to the increasing number of confounding effects that will impact on the firms' returns as time goes on.

The Swedish beauty contest results provide mixed support for the existence of a winner's curse. The performance of the winners' ARs and the winners' portfolio show no sign of the expected winner's bounty. However, there was not the sharp decline in the winning portfolios that was seen in the UK and German auctions. So it would appear that initially, the winners in Sweden were not penalised in the same way as those in the UK and German auctions. It is also the case that the losers in the Swedish auction did no better, and at some points worse, than the winners. The losers' portfolio initially followed a more negative path than the winners' portfolio. This would lead to the conclusion that the losers were worse off for not winning but the winner's did not experience a particular gain from being a licence holder. The results from the Swedish event study may suggest that there was a general negative feeling emerging towards the 3G technology. This negative feeling may have been brought about by the high expected roll out costs of the 3G technology, the high levels of debt already incurred in previous administration processes or simply that there would not be the anticipated market for 3G services. However, this negative sentiment was not large enough to make winning a licence for a small fee a negative event.

One alternative explanation for the market reacting is this way is through endogeneity in the process. Instead of the market determining the value of a licence independently, the post-administration claims by the licence winners that they overpaid impacted on the value that the market placed on these licences. The proposition is then that the 'talk' of the licence winners acted as news to the market. Although this is a possibility, whether this actually happened is questionable. Firstly, even if the winners were complaining over licence fees a rational market would still come to its own valuation. This will be particularly the case if they saw this complaints process as an attempt to bring about regulatory easing or a refund. Secondly, although these complaints did occur, they were not that prevelant during the event period under investigation.

The combined results suggest that the use of an auction in the German administration procedure brought about a short-term negative cumulative abnormal effect for the winners. In other words the markets believed that the winners overpaid and suffered a winner's curse. The presence of a winner's curse may call into question the use of auctions as a method of administering licences. The primary concern of this section has been the identification of a winner's curse and not the effect that overpayment has had on the post-administration industry environment, whether this be through a change in regulatory approach or alteration in investment approach. The perceived efficiency of using auctions may be called into doubt if a winner's curse facilitates the need for licence renegotiation, regulatory easing, or industry instability. The following chapters will make a closer examination of the post-administration industry framework and consider how overpayment has impacted on the industry, particularly in attaining the goals of a competitive and stable industry. In particular, whether in contradiction of standard economic theory, a one off lump sum, like an auction fee, could be responsible for a change in the post-administration environment.

Table 7.1: German OLS Abnormal Returns (winners)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR on day of 2nd Phase
Winners				
BT	-0.010	-0.043	-962.6	0.025
MobileCom	0.018	-0.261	-2442.4	-0.070
D-Telecom	0.020	-0.067	-918.8	-0.014
France Tele	-0.019	-0.034	-662.6	-0.041
KPN	-0.016	-0.340	-2607.1	-0.066
Sonera	-0.032	-0.365	-2368.1	-0.057
Telefonica	-0.027	-0.096	-3221.9	-0.041
Vodafone	-0.038	-0.077	-1148.2	-0.015
NTT DoCoMo	0.002	0.108	2159.6	0.002

Table 7.2: German Median Abnormal Returns (winners)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR on day of 2nd Phase
Winners				
BT	-0.008	0.002	44.0	0.026
MobileCom	0.018	-0.246	-2302.9	-0.070
D-Telecom	0.020	-0.059	-802.3	-0.014
France Tele	-0.018	-0.017	-302.7	-0.040
KPN	-0.014	-0.281	-2233.1	-0.063
Sonera	-0.031	-0.349	-2287.7	-0.056
Telefonica	-0.028	-0.091	-2853.5	-0.042
Vodafone	-0.037	-0.050	-740.2	-0.014
NTT DoCoMo	0.005	0.179	3493.7	0.005

Table 7.3: German Robust Abnormal Returns (winners)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR on day of 2nd Phase
Winners				
BT	-0.009	-0.014	-329.0	0.025
MobileCom	0.020	-0.178	-1725.5	-0.068
D-Telecom	0.021	-0.054	-742.5	-0.013
France Tele	-0.018	-0.009	-167.8	-0.040
KPN	-0.013	-0.290	-2277.6	-0.063
Sonera	-0.031	-0.348	-2282.4	-0.056
Telefonica	-0.027	-0.078	-2563.3	-0.041
Vodafone	-0.038	-0.067	-1022.8	-0.016
NTT DoCoMo	0.004	0.172	3364.7	0.004

Table 7.4: German OLS Abnormal Returns (losers)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR Withdrawal	(5) CAR (withdraw +30 days)	(6) Car T-ratio)
Losers						
DBL	0.131	0.142	749.0	-0.015	0.109	563.1
SwissCom	0.020	-0.168	-4863.3	-0.007	-0.211	-5539.0
Hutchison	-0.028	-0.021	-931.5	-0.028	-0.021	-931.5
SBC	-0.058	0.226	3573.4	0.044	-0.011	-131.7
TDC	0.010	-0.049	-598.5	-0.001	-0.252	-7530.9
MCI Worldcom	-0.005	-0.097	-1102.0	0.030	-0.190	-1131.9
E-ON	-0.028	0.010	285.3	-0.028	0.010	285.3

Table 7.5: German Median Abnormal Returns (losers)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR Withdrawal	(5) CAR (withdraw +30 days)	(6) Car T-ratio)
Losers						
DBL	0.131	0.150	812.1	-0.014	0.114	606.7
SwissCom	0.021	-0.128	-3886.2	-0.005	-0.168	-4711.6
Hutchison	-0.027	0.006	266.2	-0.027	0.006	266.2
SBC	-0.057	0.252	3915.1	0.045	-0.010	-122.6
TDC	0.006	-0.056	-688.6	-0.001	-0.248	-7401.3
MCI Worldcom	-0.004	-0.083	-943.3	0.030	-0.175	-1049.3
E-ON	-0.028	0.011	316.8	-0.028	0.011	316.8

Table 7.6: German Robust Abnormal Returns (losers)

	(1) AR (17/08/00)	(2) CAR (17/08/00 +30days)	(3) Car T-ratio	(4) AR Withdrawal	(5) CAR (withdraw +30 days)	(6) Car T-ratio)
Losers						
DBL	0.132	0.182	967.4	-0.013	0.147	769.1
SwissCom	0.022	-0.119	-3642.9	-0.005	-0.160	-4516.2
Hutchison	-0.028	-0.015	-681.2	-0.028	-0.015	-681.2
SBC	-0.057	0.279	4189.9	0.046	-0.009	-114.1
TDC	0.008	-0.041	-511.4	-0.001	-0.240	-7333.4
MCI Worldcom	-0.004	-0.077	-873.5	0.030	-0.169	-1014.2
E-ON	-0.027	0.035	979.8	-0.027	0.035	979.8

Table 7.7: German OLS Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
BT	-0.010	63050.040	101617.7	-1002.11
MobileCom	0.018	7508.000	7508	134.8654
D-Telecom	0.020	202983.400	202983.3	4134.616
France Tele	-0.019	160352.200	160352.2	-3061.49
KPN	-0.016	46303.840	46303.83	-763.74
Sonera	-0.032	40113.130	40113.13	-1264.43
Telefonica	-0.027	72155.880	72155.87	-1948.21
Vodafone	-0.038	187690.600	302500.9	-11519
Ntt DoCoMo	0.002	26621264.000	269405.3	461.9648
Average Winners				-1647.51
Losers				
DBL	-0.015	2870.250	2870.251	-43.6062
SwissCom	-0.007	43615.110	27746	-204.141
Hutchison	-0.028	383703.100	53105.56	-1489.72
SBC	0.044	148612.500	159594.2	7065.446
TDC	-0.001	122299.900	16380.71	-17.5659
MCI Worldcom	0.030	107859.600	115829.8	3468.585
E-ON	-0.028	27653.880	27653.89	-772.143
Average Losers				1143.837

Table 7.8: German Median Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
BT	-0.008	63050.040	101617.7	-851.508
MobileCom	0.018	7508.000	7508	134.8106
D-Telecom	0.020	202983.400	202983.3	4147.152
France Tele	-0.018	160352.200	160352.2	-2928.49
KPN	-0.014	46303.840	46303.83	-644.851
Sonera	-0.031	40113.130	40113.13	-1245.99
Telefonica	-0.028	72155.880	72155.87	-2050.12
Vodafone	-0.037	187690.600	302500.9	-11280.3
Ntt DoCoMo	0.005	26621264.000	269405.3	1300.897
Average Winners				-1490.94
Losers				
DBL	-0.014	2870.250	2870.251	-39.4528
SwissCom	-0.005	43615.110	27746	-147.862
Hutchison	-0.027	383703.100	53105.56	-1450.82
SBC	0.045	148612.500	159594.2	7210.512
TDC	-0.001	122299.900	16380.71	-16.4039
MCI Worldcom	0.030	107859.600	115829.8	3463.36
E-ON	-0.028	27653.880	27653.89	-774.08
Average Losers				1177.893

Table 7.9: German Robust Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
BT	-0.009	63050.040	101617.7	-901.877
MobileCom	0.020	7508.000	7508	151.5772
D-Telecom	0.021	202983.400	202983.3	4179.984
France Tele	-0.018	160352.200	160352.2	-2887.09
KPN	-0.013	46303.840	46303.83	-615.739
Sonera	-0.031	40113.130	40113.13	-1245.83
Telefonica	-0.027	72155.880	72155.87	-1964.23
Vodafone	-0.038	187690.600	302500.9	-11396.1
Ntt DoCoMo	0.004	26621264.000	269405.3	954.7695
Average Winners				-1524.95
Losers				
DBL	-0.013	2870.250	2870.251	-37.9023
SwissCom	-0.005	43615.110	27746	-149.353
Hutchison	-0.028	383703.100	53105.56	-1488.46
SBC	0.046	148612.500	159594.2	7337.503
TDC	-0.001	122299.900	16380.71	-11.4463
MCI Worldcom	0.030	107859.600	115829.8	3514.035
E-ON	-0.027	27653.880	27653.89	-750.379
Average Losers				1201.999

Table 7.10: German OLS Portfolio of Winners

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR Start +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Winners						
BT	101617.7	0.084	-0.043	-0.004	-0.180	-0.015
MobileCom	7508	0.006	-0.261	-0.002	-0.321	-0.002
D-Telecom	202983.3	0.169	-0.067	-0.011	-0.462	-0.078
France Tele	160352.2	0.133	-0.034	-0.005	-0.189	-0.025
KPN	46303.83	0.038	-0.340	-0.013	-0.837	-0.032
Sonera	40113.13	0.033	-0.365	-0.012	-0.260	-0.009
Telefonica	72155.87	0.060	-0.096	-0.006	-0.078	-0.005
Vodafone	302500.9	0.251	-0.077	-0.019	-0.266	-0.067
Ntt DoCoMo	269405.3	0.224	0.108	0.024	0.015	0.003
Total	1202940	1.000		-0.047		-0.229
Sign Test			2.193**		2.193**	

Table 7.11: German Median Portfolio of Winners

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR Start +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Winners						
BT	101617.7	0.084	0.0019	0.0002	-0.078	-0.007
MobileCom	7508	0.006	-0.2461	-0.0015	-0.263	-0.002
D-Telecom	202983.3	0.169	-0.0588	-0.0099	-0.435	-0.073
France Tele	160352.2	0.133	-0.0167	-0.0022	-0.145	-0.019
KPN	46303.83	0.038	-0.2814	-0.0108	-0.686	-0.026
Sonera	40113.13	0.033	-0.3494	-0.0116	-0.224	-0.007
Telefonica	72155.87	0.060	-0.0908	-0.0054	-0.056	-0.003
Vodafone	302500.9	0.251	-0.0498	-0.0125	-0.196	-0.049
Ntt DoCoMo	269405.3	0.224	0.1790	0.0401	0.160	0.036
Total	1202940	1.000		-0.014		-0.152
Sign Test			1.729*		2.396**	

Table 7.12: German Robust Portfolio of Winners

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR End +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Winners						
BT	101617.7	0.084	-0.014	-0.001	-0.119	-0.010
MobileCom	7508	0.006	-0.178	-0.001	-0.103	-0.001
D-Telecom	202983.3	0.169	-0.054	-0.009	-0.425	-0.072
France Tele	160352.2	0.133	-0.009	-0.001	-0.128	-0.017
KPN	46303.83	0.038	-0.290	-0.011	-0.692	-0.027
Sonera	40113.13	0.033	-0.348	-0.012	-0.222	-0.007
Telefonica	72155.87	0.060	-0.078	-0.005	-0.030	-0.002
Vodafone	302500.9	0.251	-0.067	-0.017	-0.250	-0.063
Ntt DoCoMo	269405.3	0.224	0.172	0.039	0.139	0.031
Total	1202940	1.000		-0.019		-0.167
Sign Test			2.357***		2.357***	

Table 7.13: German OLS Portfolio of Losers

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR Start +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Losers						
DBL	2870.251	0.007	0.142	0.001	0.073	0.001
SwissCom	27746	0.069	-0.168	-0.012	-0.341	-0.023
Hutchison	53105.56	0.132	-0.021	-0.003	0.003	0.000
SBC	159594.2	0.396	0.226	0.089	0.122	0.048
TDC	16380.71	0.041	-0.049	-0.002	-0.429	-0.017
MCI Worldcom	115829.8	0.287	-0.097	-0.028	-0.163	-0.047
E-ON	27653.89	0.069	0.010	0.001	0.054	0.004
Total	403180.4	1.000		0.047		-0.035
Sign Test			0.225		-0.533	

Table 7.14: German Median Portfolio of Losers

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR Start +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Losers						
DBL	2870.251	0.007	0.1501	0.0011	0.219	0.002
SwissCom	27746	0.069	-0.1276	-0.0088	-0.232	-0.016
Hutchison	53105.56	0.132	0.0059	0.0008	0.073	0.010
SBC	159594.2	0.396	0.2521	0.0998	0.186	0.074
TDC	16380.71	0.041	-0.0555	-0.0023	-0.410	-0.017
MCI Worldcom	115829.8	0.287	-0.0834	-0.0240	-0.130	-0.037
E-ON	27653.89	0.069	0.0112	0.0008	0.062	0.004
Total	403180.4	1.000		0.067		0.019
Sign Test			0.356		-0.39953	

Table 7.15: German Robust Portfolio of Losers

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR End +30days	(4) Portfolio effect (2)*(3)	(5) CAR - 30days to +30days	(6) Portfolio Effect (2)*(5)
Losers						
DBL	2870.251	0.007	0.182	0.001	0.193	0.001
SwissCom	27746	0.069	-0.119	-0.008	-0.217	-0.015
Hutchison	53105.56	0.132	-0.015	-0.002	0.025	0.003
SBC	159594.2	0.396	0.279	0.111	0.249	0.099
TDC	16380.71	0.041	-0.041	-0.002	-0.395	-0.016
MCI Worldcom	115829.8	0.287	-0.077	-0.022	-0.115	-0.033
E-ON	27653.89	0.069	0.035	0.002	0.113	0.008
Total	403180.4	1.000		0.080		0.047
Sign Test			0.400		-0.35642	

Swedish Tables

Table 7.16: Swedish OLS Abnormal Returns (winners)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Winners			
Hutchison	-0.003	-0.054	-5533.9
Europolitan	-0.016	-0.056	-461.3
France Telecom	0.022	-0.048	-776.7
Tele 2	-0.039	0.179	1854.4
Skanska	-0.093	-0.041	-361.2
Vodafone	0.021	-0.114	-2143.9

Table 7.17: Swedish Median Abnormal Returns (winners)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Winners			
Hutchison	-0.002	-0.022	-2377.2
Europolitan	-0.012	-0.037	-307.1
France Telecom	0.024	-0.032	-521.2
Tele 2	-0.029	0.159	1771.7
Skanska	-0.028	-0.016	-529.6
Vodafone	0.024	-0.081	-1501.5

Table 7.18: Swedish Robust Abnormal Returns (winners)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Winners			
Hutchison	-0.002	-0.042	-4360.1
Europolitan	-0.010	-0.029	-240.2
France Telecom	0.024	-0.025	-405.3
Tele 2	-0.036	0.172	1833.9
Skanska	-0.031	-0.003	-100.8
Vodafone	0.020	-0.062	-1249.7

Table 7.19: Swedish OLS Abnormal Returns (losers)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Losers			
Deutche Telecom	-0.049	-0.128	-1338.2
Sonera	-0.034	0.132	496.4
Telefonica	0.001	-0.034	-2182.8
ABB	0.029	-0.053	-1461.6
Nomura	0.025	-0.122	-472.7
BT	-0.025	0.078	1219.0

Table 7.20: Swedish Median Abnormal Returns (losers)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Losers			
Deutche Telecom	-0.048	-0.111	-1176.7
Sonera	-0.033	0.146	551.7
Telefonica	0.000	-0.017	-1066.4
ABB	0.031	-0.010	-292.0
Nomura	-0.003	-0.066	-6367.9
BT	-0.024	0.119	1832.9

Table 7.21: Swedish Robust Abnormal Returns (losers)

	(1) AR (18/12/00)	(2) CAR (18/12/00 +30days)	(3) CAR t-ratios
Losers			
Deutche Telecom	-0.048	-0.108	-1138.2
Sonera	-0.033	0.147	554.0
Telefonica	0.001	-0.010	-650.7
ABB	0.030	-0.033	-921.6
Nomura	-0.063	-0.085	-410.3
BT	-0.027	0.043	681.6

Table 7.22: Swedish OLS Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
Hutchison	-0.003	383703.060	53105.56	-159.317
Europolitan	-0.016	58847.020	7040.168	-112.643
France Telecom	0.022	160352.190	160352.2	3527.748
Tele 2	-0.039	54453.780	6514.583	-254.069
Skanska	-0.093	34991.510	4186.212	-389.318
Vodafone	0.021	187690.630	302501	6352.521
Average Winners				1494.154
Losers				
Deutsche Telecom	-0.049	202983.380	202983.4	-9980.34
Sonera	-0.034	40113.130	40113.13	-1346.46
Telefonica	0.001	72155.880	72155.88	67.52217
ABB	0.029	62850.380	7519.111	219.5006
Nomura	0.002	4848552.000	49067.01	1217.741
BT	-0.025	63050.040	101617.7	-2553.55
Average Losers				-2062.6

Table 7.23: Swedish Median Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
Hutchison	-0.002	383703.060	53105.56	-80.7107
Europolitan	-0.012	58847.020	7040.168	-84.5869
France Telecom	0.024	160352.190	160352.2	3848.754
Tele 2	-0.029	54453.780	6514.583	-191.446
Skanska	-0.028	34991.510	4186.212	-116.076
Vodafone	0.024	187690.630	302501	7148.155
Average Winners				1754.015
Losers				
Deutsche Telecom	-0.048	202983.380	202983.4	-9774.79
Sonera	-0.033	40113.130	40113.13	-1327
Telefonica	0.000	72155.880	72155.88	4.865722
ABB	0.031	62850.380	7519.111	230.7052
Nomura	-0.003	4848552.000	49067.01	-169.256
BT	-0.024	63050.040	101617.7	-2468.7
Average Losers				-2250.7

Table 7.24: Swedish Robust Wealth Effect in Millions (€)

	(1) AR (17/08/00 or Withdrawal)	(2) Market Value 31/05/00	(3) Market Value 31/05/00 (€)	(4) Wealth Effect
Winners				
Hutchison	-0.002	383703.060	53105.56	-114.361
Europolitan	-0.010	58847.020	7040.168	-68.4505
France Telecom	0.024	160352.190	160352.2	3872.177
Tele 2	-0.036	54453.780	6514.583	-231.413
Skanska	-0.031	34991.510	4186.212	-127.729
Vodafone	0.020	187690.630	302501	6077.173
Average Winners				1567.899
Losers				
Deutsche Telecom	-0.048	202983.380	202983.4	-9759.11
Sonera	-0.033	40113.130	40113.13	-1326.15
Telefonica	0.001	72155.880	72155.88	71.39831
ABB	0.030	62850.380	7519.111	225.912
Nomura	-0.063	4848552.000	49067.01	-3083.2
BT	-0.027	63050.040	101617.7	-2749.65
Average Losers				-2770.13

Table 7.25: Swedish OLS Portfolio of Winners

	-1 Market Value	-2 Market Capitalisation Weight	-3 CAR End +30days	-4 Portfolio effect (2)*(3)	-5 CAR -30days to +30days	-6 Portfolio Effect (2)*(5)
Winners						
Hutchison	53105.56	0.100	-0.054	-0.005	-0.088	-0.0088
Europolitan	7040.168	0.013	-0.056	-0.001	-0.060	-0.0008
France Telecom	160352.2	0.300	-0.048	-0.015	-0.068	-0.0203
Tele 2	6514.583	0.012	0.179	0.002	0.080	0.0010
Skanska	4186.212	0.008	-0.041	0.000	0.041	0.0003
Vodafone	302501	0.567	-0.114	-0.064	-0.063	-0.0355
Total	533699.7	1.000		-0.083		-0.064
Sign Test			1.547*		0.730	

Table 7.26: Swedish Median Portfolio of Winners

	-1 Market Value	-2 Market Capitalisation Weight	-3 CAR End +30days	-4 Portfolio effect (2)*(3)	-5 CAR -30days to +30days	-6 Portfolio Effect (2)*(5)
Winners						
Hutchison	53105.56	0.100	-0.022	-0.002	-0.030	-0.003
Europolitan	7040.168	0.013	-0.037	0.000	-0.026	0.000
France Telecom	160352.2	0.300	-0.032	-0.010	-0.043	-0.013
Tele 2	6514.583	0.012	0.159	0.002	0.028	0.000
Skanska	4186.212	0.008	-0.016	0.000	0.020	0.000
Vodafone	302501	0.567	-0.081	-0.046	-0.004	-0.002
Total	533699.7	1.000		-0.057		-0.018
Sign Test			1.605*		-0.028	

Table 7.27: Swedish Robust Portfolio of Winners

	-1 Market Value	-2 Market Capitalisation Weight	-3 CAR End +30days	-4 Portfolio effect (2)*(3)	-5 CAR - 30days to +30days	-6 Portfolio Effect (2)*(5)
Winners						
Hutchison	53105.56	0.100	-0.042	-0.0042	-0.0687	-0.0068
Europolitan	7040.168	0.013	-0.029	-0.0004	-0.0129	-0.0002
France Telecom	160352.2	0.300	-0.025	-0.0075	-0.0284	-0.0085
Tele 2	6514.583	0.012	0.172	0.0021	0.0627	0.0008
Skanska	4186.212	0.008	-0.003	0.0000	0.0497	0.0004
Vodafone	302501	0.567	-0.062	-0.0353	0.0448	0.0254
Total	533699.7	1.000		-0.045		0.011
Sign Test			1.664**		0.031	

Table 7.28: Swedish OLS Portfolio of Losers

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR End +30days	(4) Portfolio effect (2)*(3)	-5 CAR - 30days to +30days	-6 Portfolio Effect (2)*(5)
Losers						
Deutsche Telecom	202983.4	0.422	-0.128	-0.054	-0.062	-0.026
Sonera	40113.13	0.083	0.132	0.011	0.095	0.008
Telefonica	72155.88	0.150	-0.034	-0.005	-0.025	-0.004
ABB	7519.111	0.016	-0.053	-0.001	-0.080	-0.001
Nomura	49067.01	0.102	-0.122	-0.012	-0.187	-0.019
BT	101617.7	0.211	0.078	0.016	-0.026	-0.006
Total	473456.3	1.000		-0.040		-0.042
Sign Test			1.547*		0.730	

Table 7.29: Swedish Median Portfolio of Losers

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR End +30days	(4) Portfolio effect (2)*(3)	-5 CAR - 30days to +30days	-6 Portfolio Effect (2)*(5)
Losers						
Deutsche Telecom	202983.4	0.429	-0.111	-0.048	-0.041	-0.0177
Sonera	40113.13	0.085	0.146	0.012	0.126	0.0106
Telefonica	72155.88	0.152	-0.017	-0.003	-0.014	-0.0022
ABB	7519.111	0.016	-0.010	0.000	0.005	0.0001
Nomura	49067.01	0.104	-0.066	-0.007	-0.138	-0.0143
BT	101617.7	0.215	0.119	0.026	0.058	0.0124
Total	473456.3	1.000		-0.019		-0.011
Sign Test			0.813		-0.003	

Table 7.30: Swedish Robust Portfolio of Winners

	(1) Market Value	(2) Market Capitalisation Weight	(3) CAR End +30days	(4) Portfolio effect (2)*(3)	-5 CAR - 30days to +30days	-6 Portfolio Effect (2)*(5)
Losers						
Deutsche Telecom	202983.4	0.422	-0.108	-0.054	-0.062	-0.026
Sonera	40113.13	0.083	0.147	0.011	0.095	0.008
Telefonica	72155.88	0.150	-0.010	-0.005	-0.025	-0.004
ABB	7519.111	0.016	-0.033	-0.001	-0.080	-0.001
Nomura	49067.01	0.102	-0.046	-0.012	-0.187	-0.019
BT	101617.7	0.211	0.043	0.016	-0.026	-0.006
Total	473456.3	1.000		-0.031		-0.031
Sign Test			0.816		1.633*	

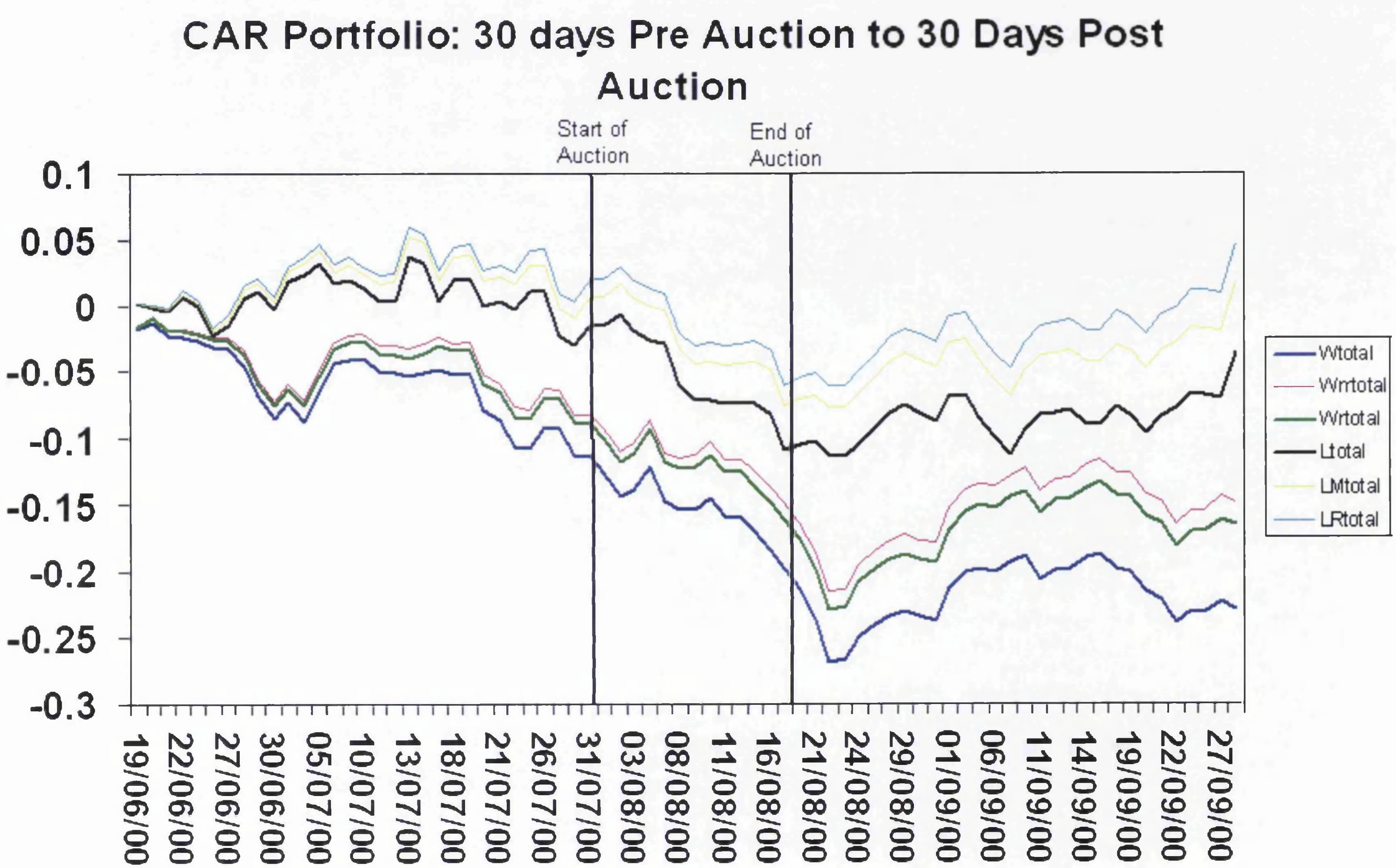

Figure 7.1: German Portfolio 30 day to 30 day.

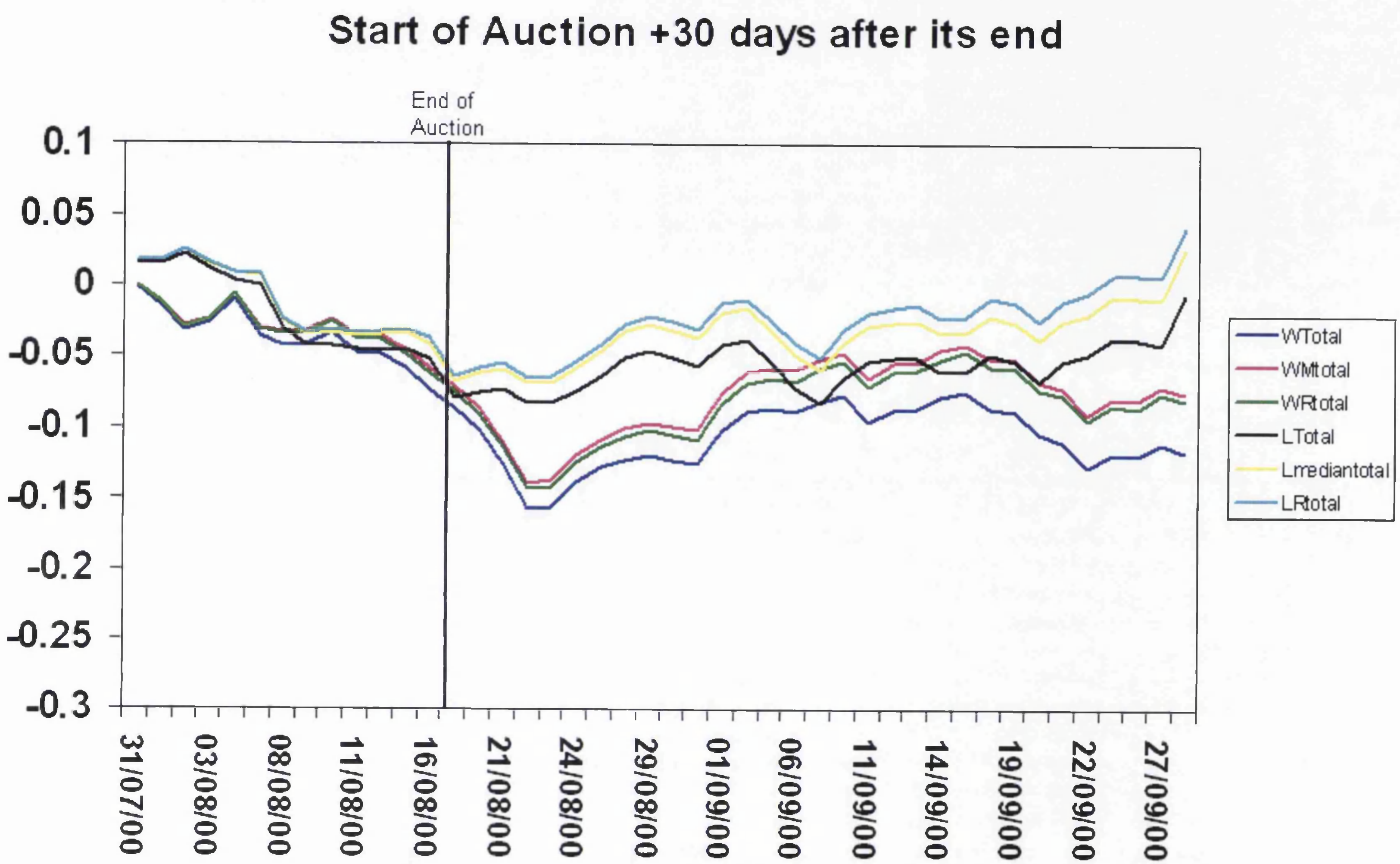

Figure 7.2: German Portfolio 30 day

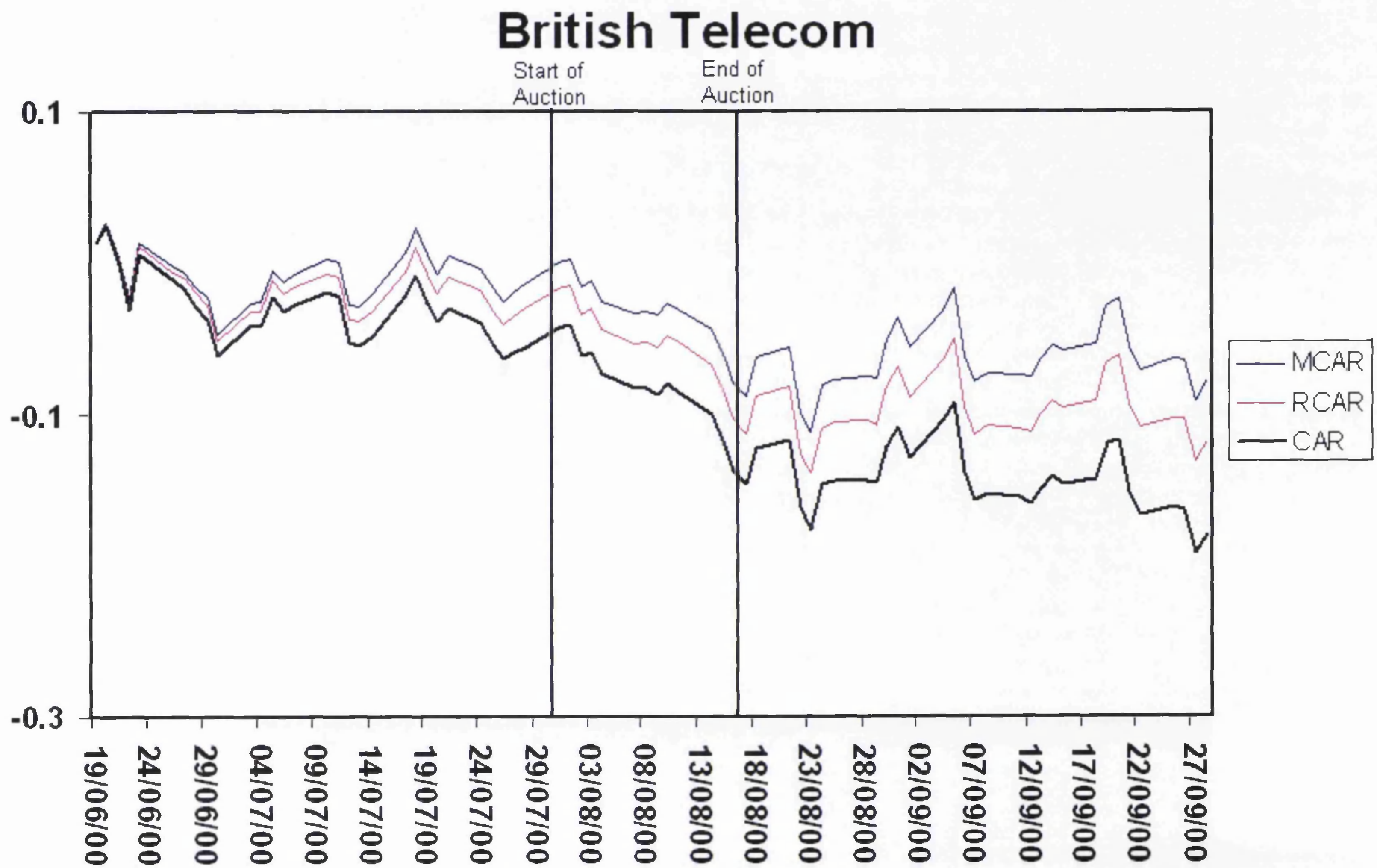

Figure 7.3: German British Telecom

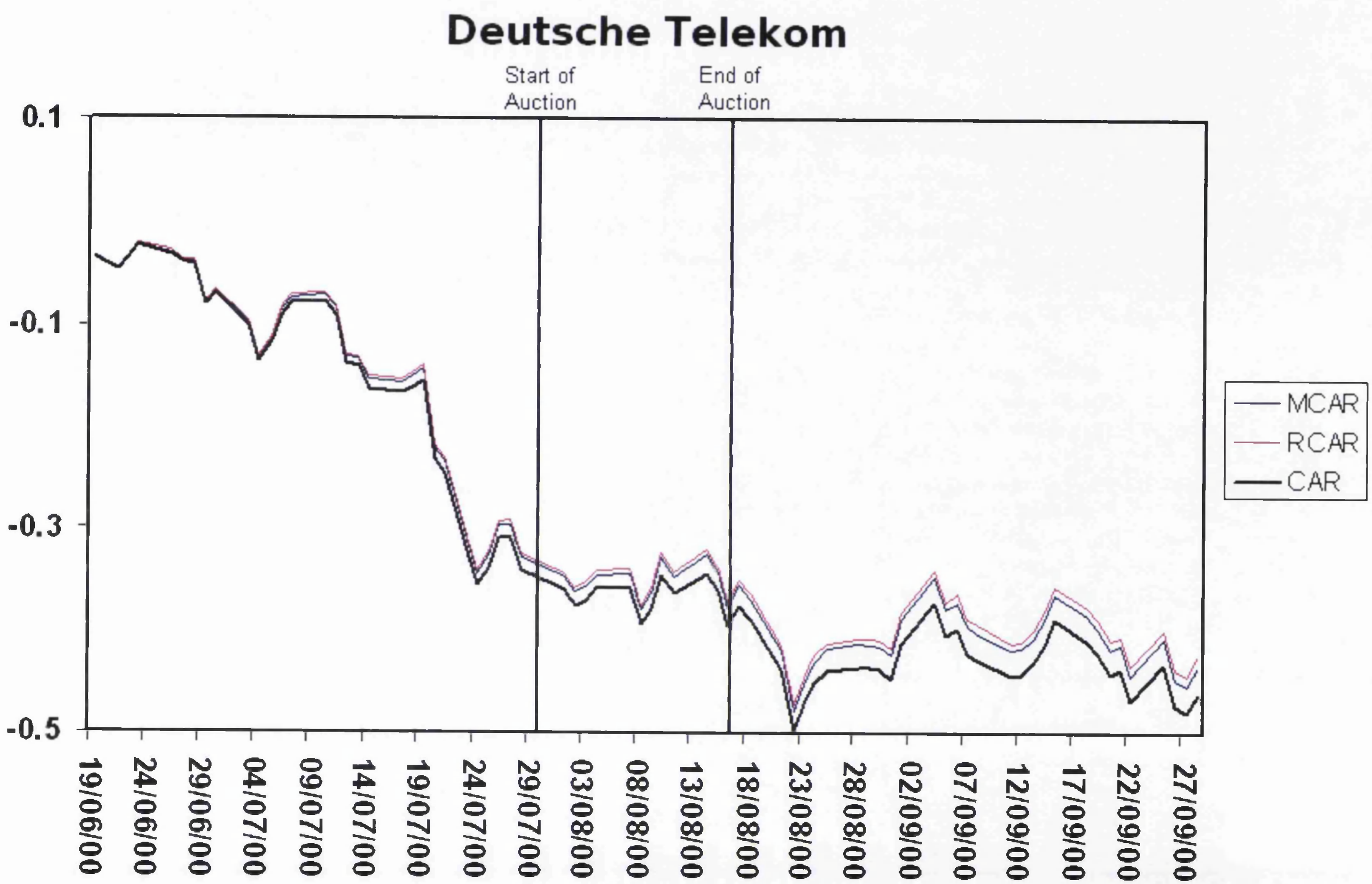

Figure 7.4: German Deutsche Telekom

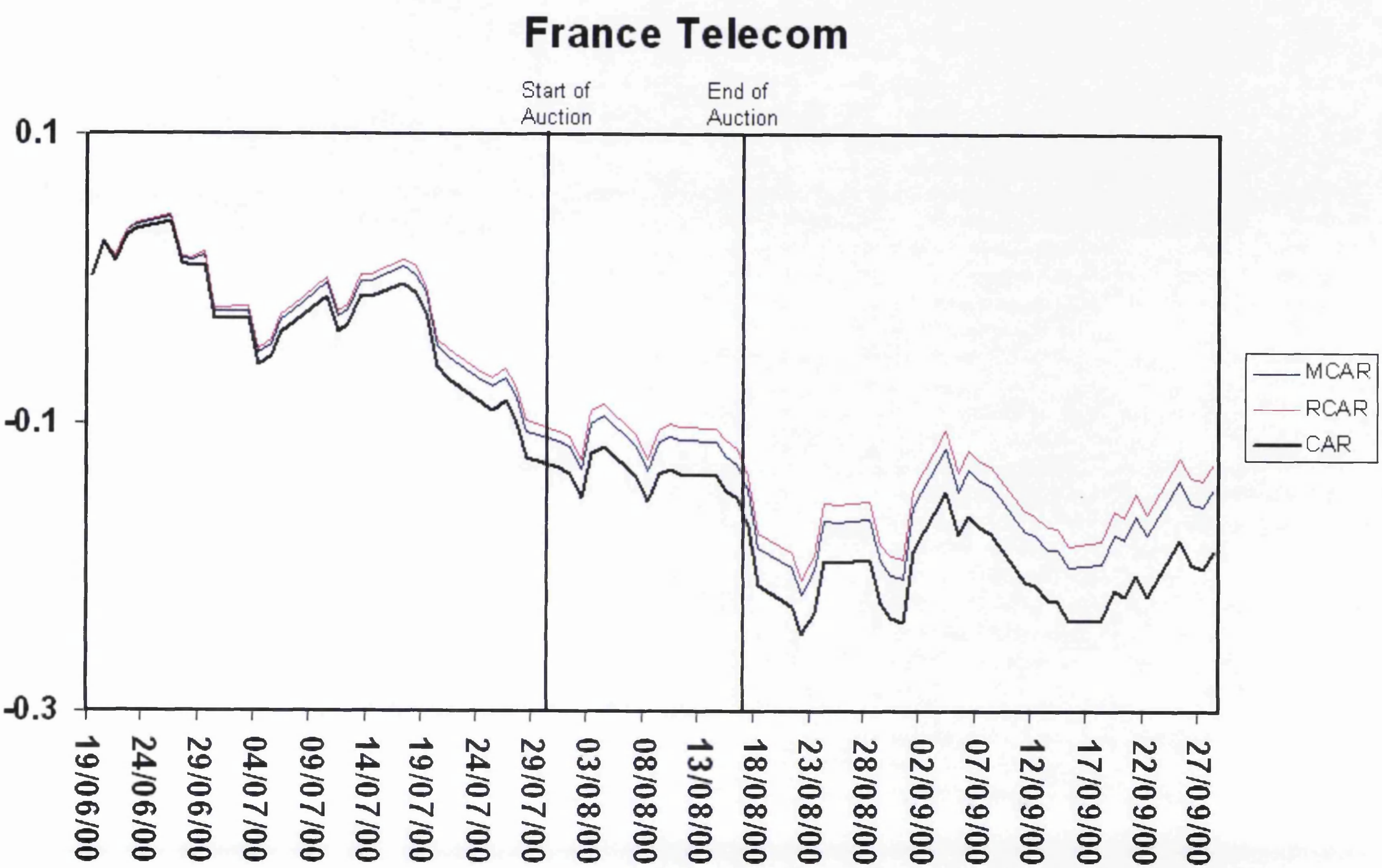

Figure 7.5: German France Telecom

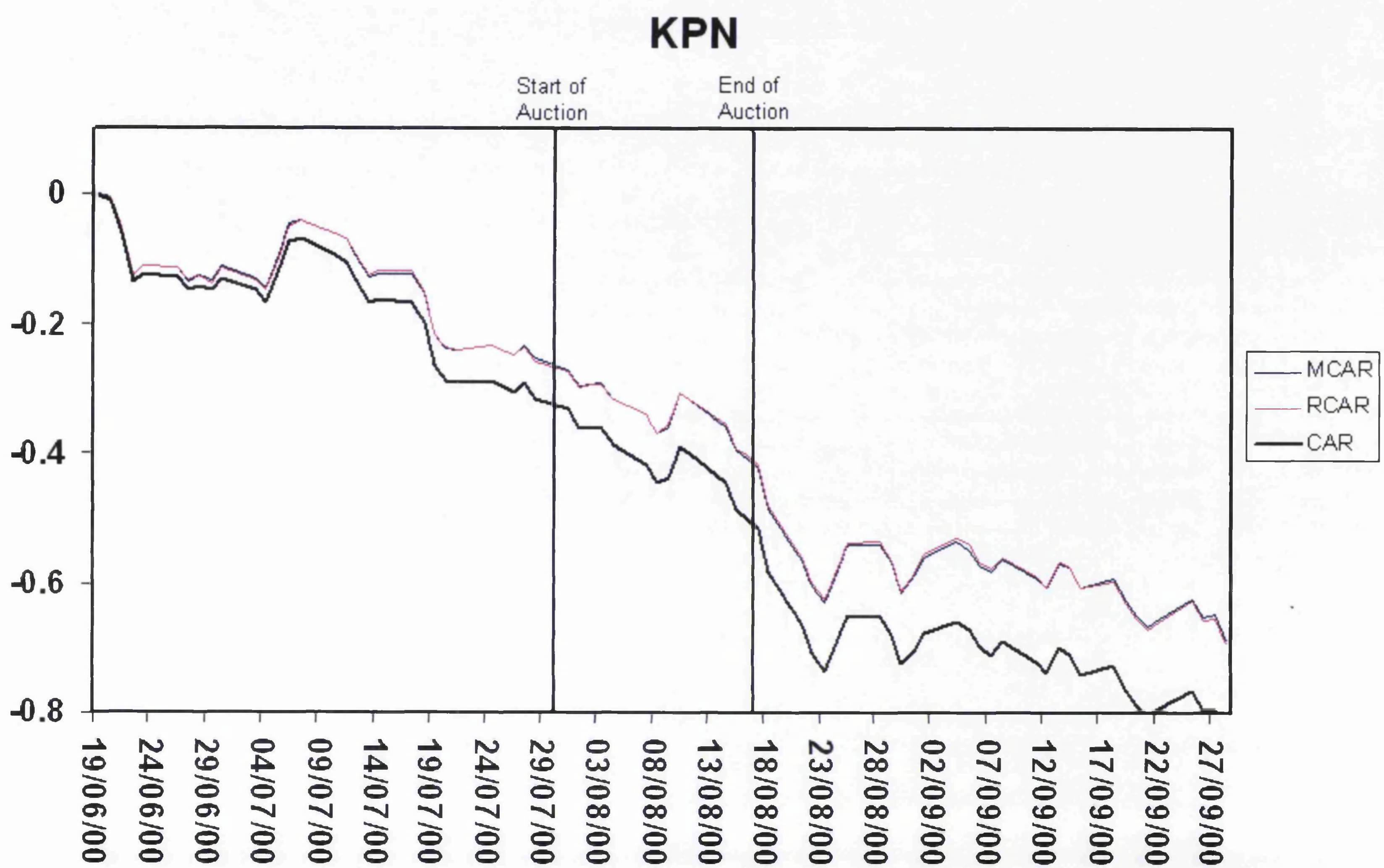

Figure 7.6: German KPN

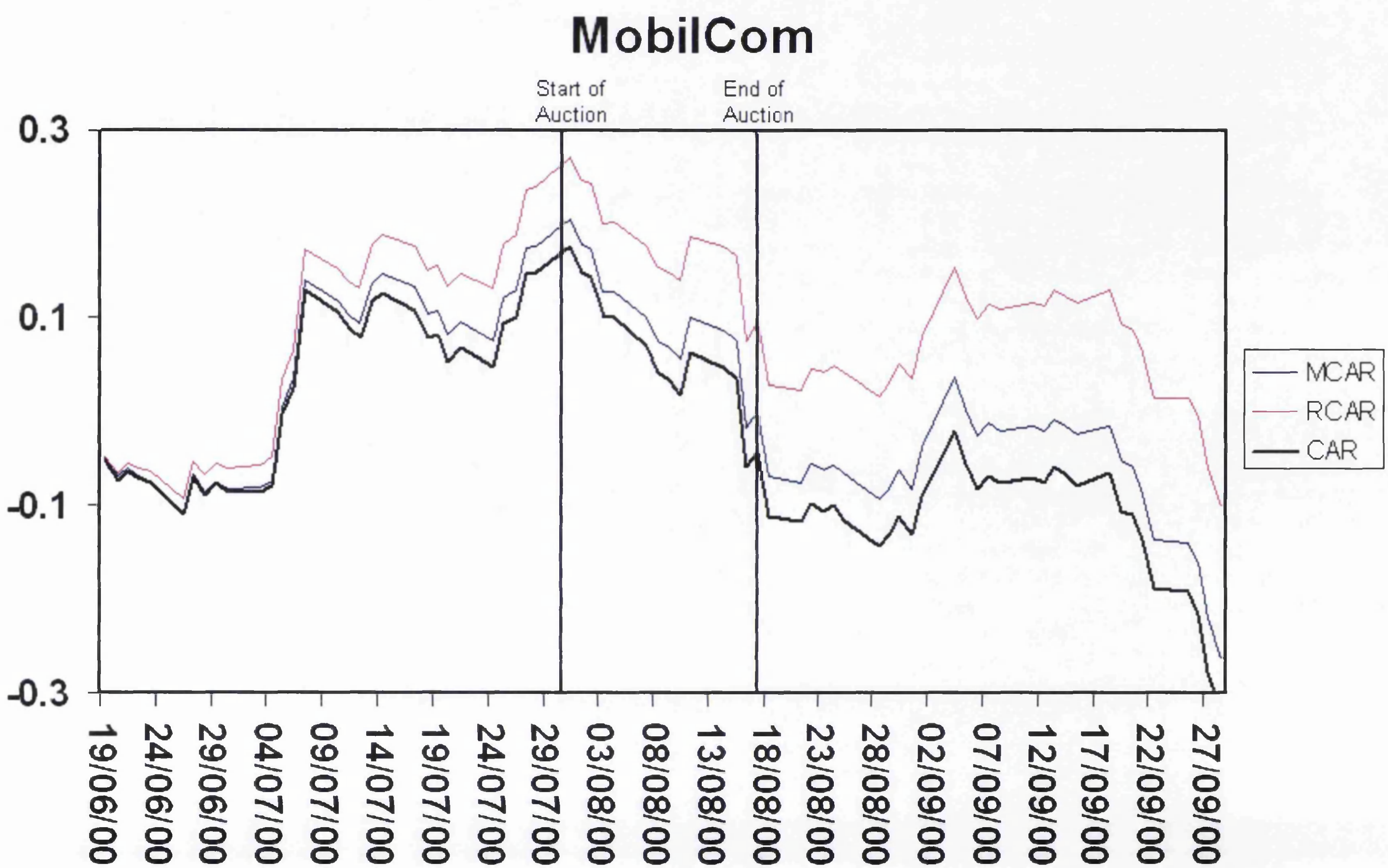

Figure 7.7: German MobilCom

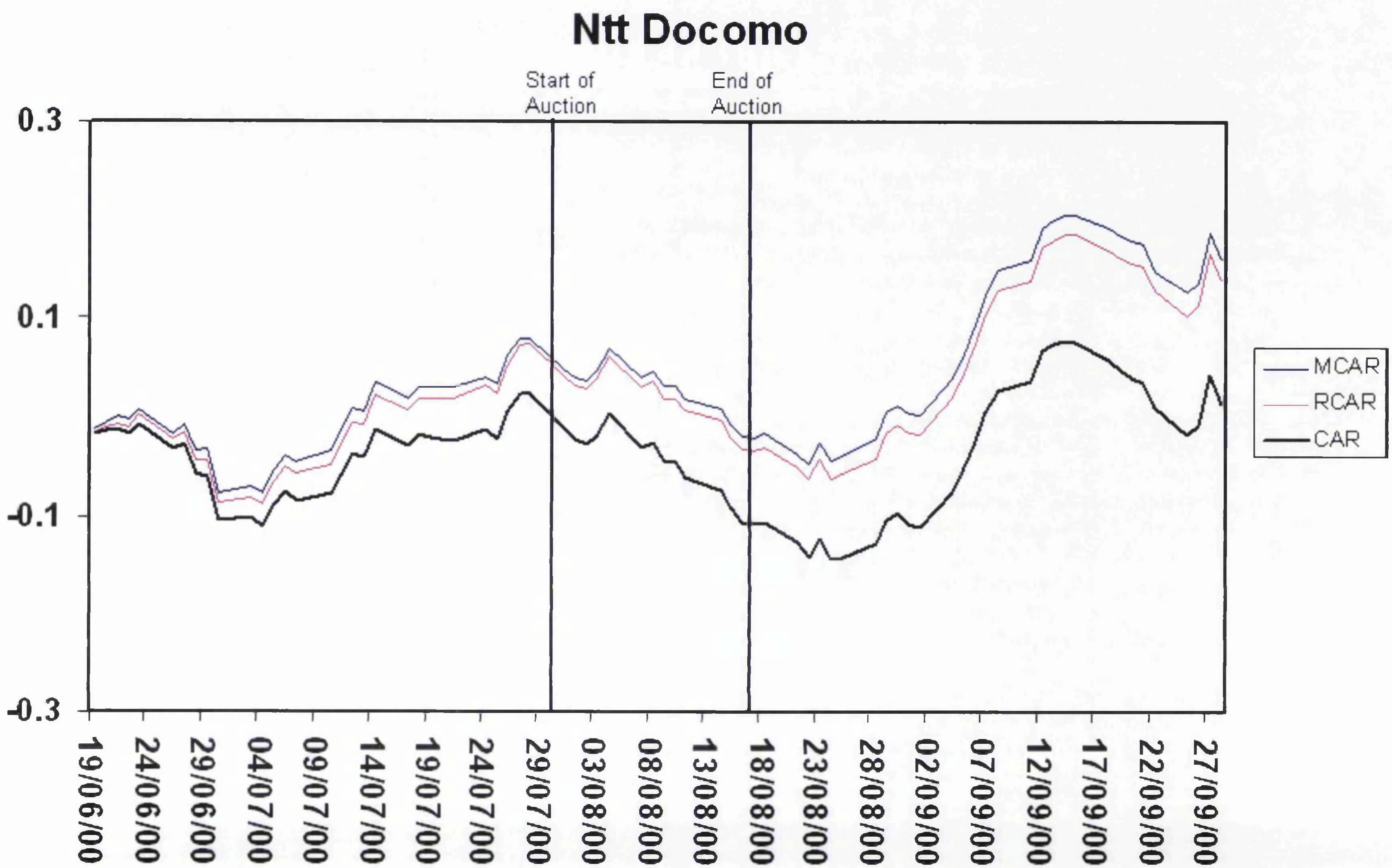

Figure 7.8: German Ntt DoCoMo

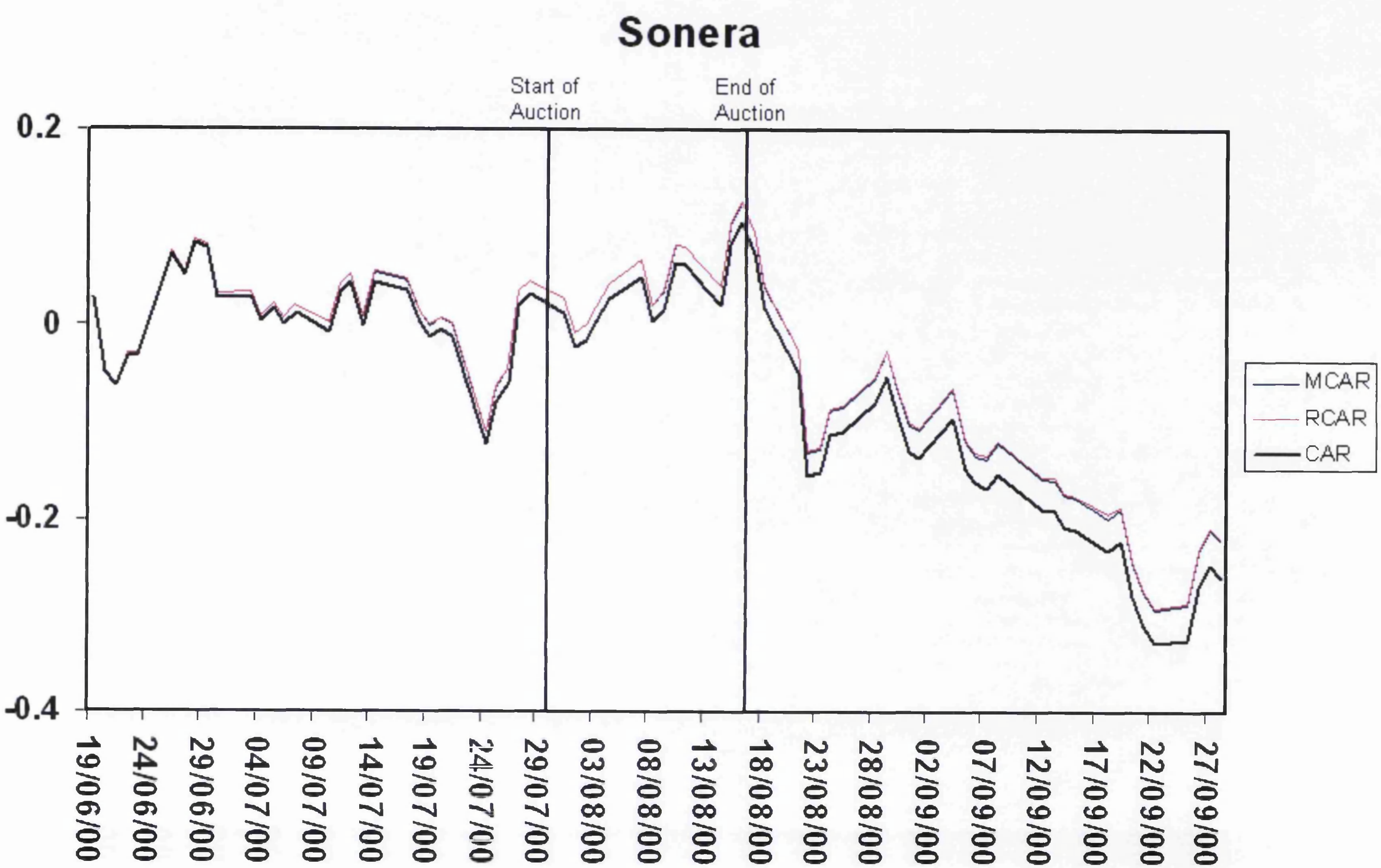

Figure 7.9: German Sonera

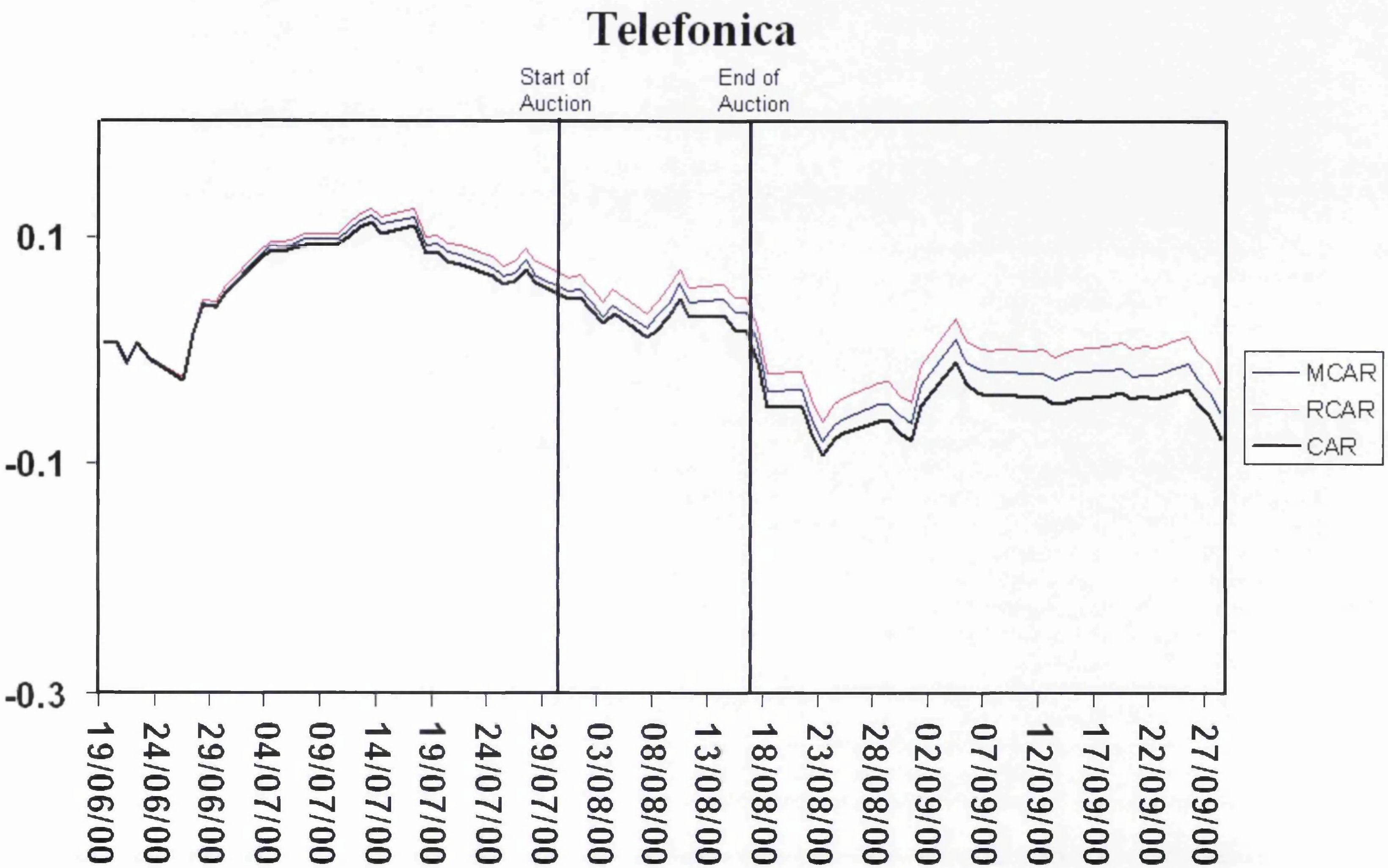

Figure 7.10: German Telefonica

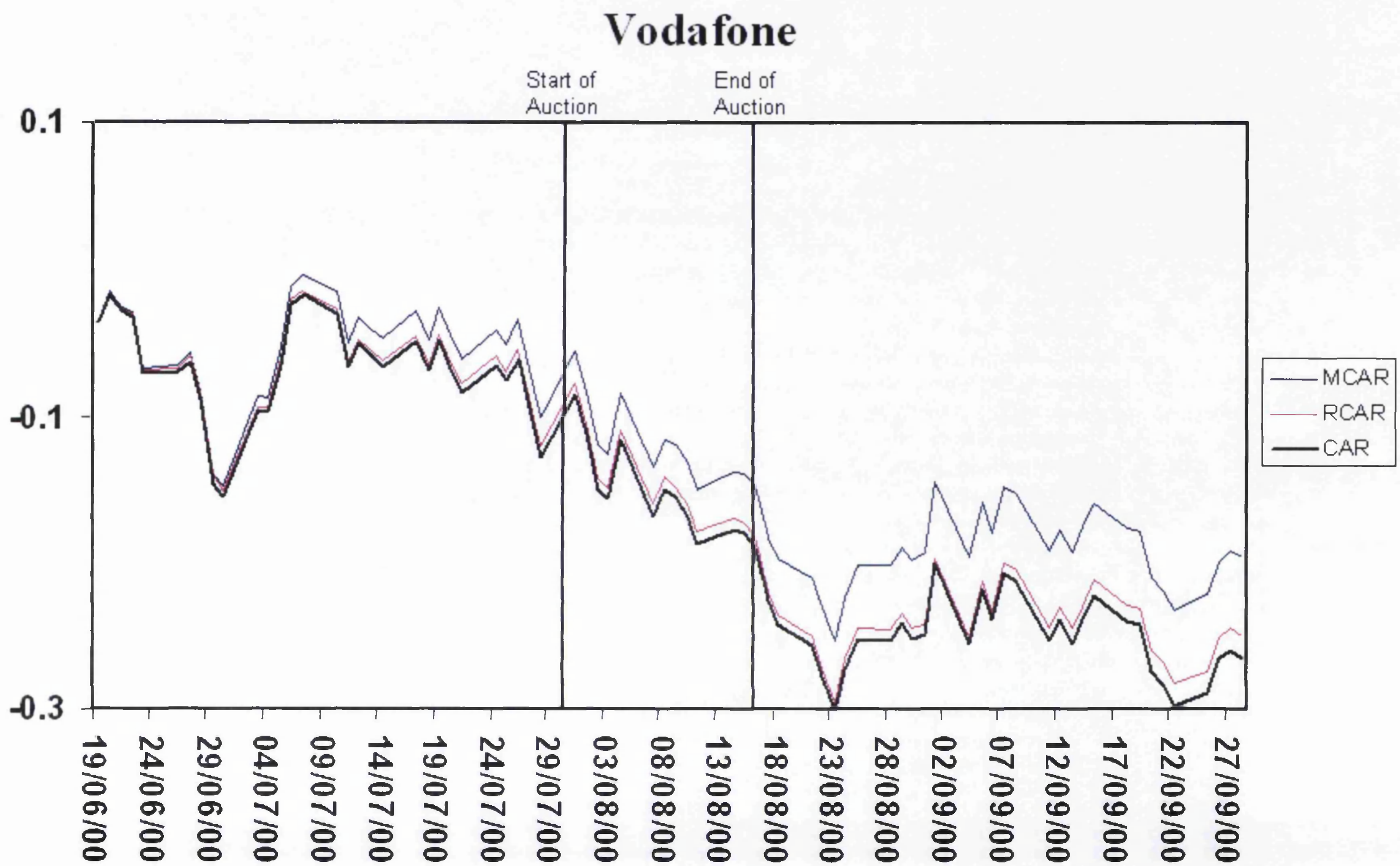

Figure 7.11: German Vodafone

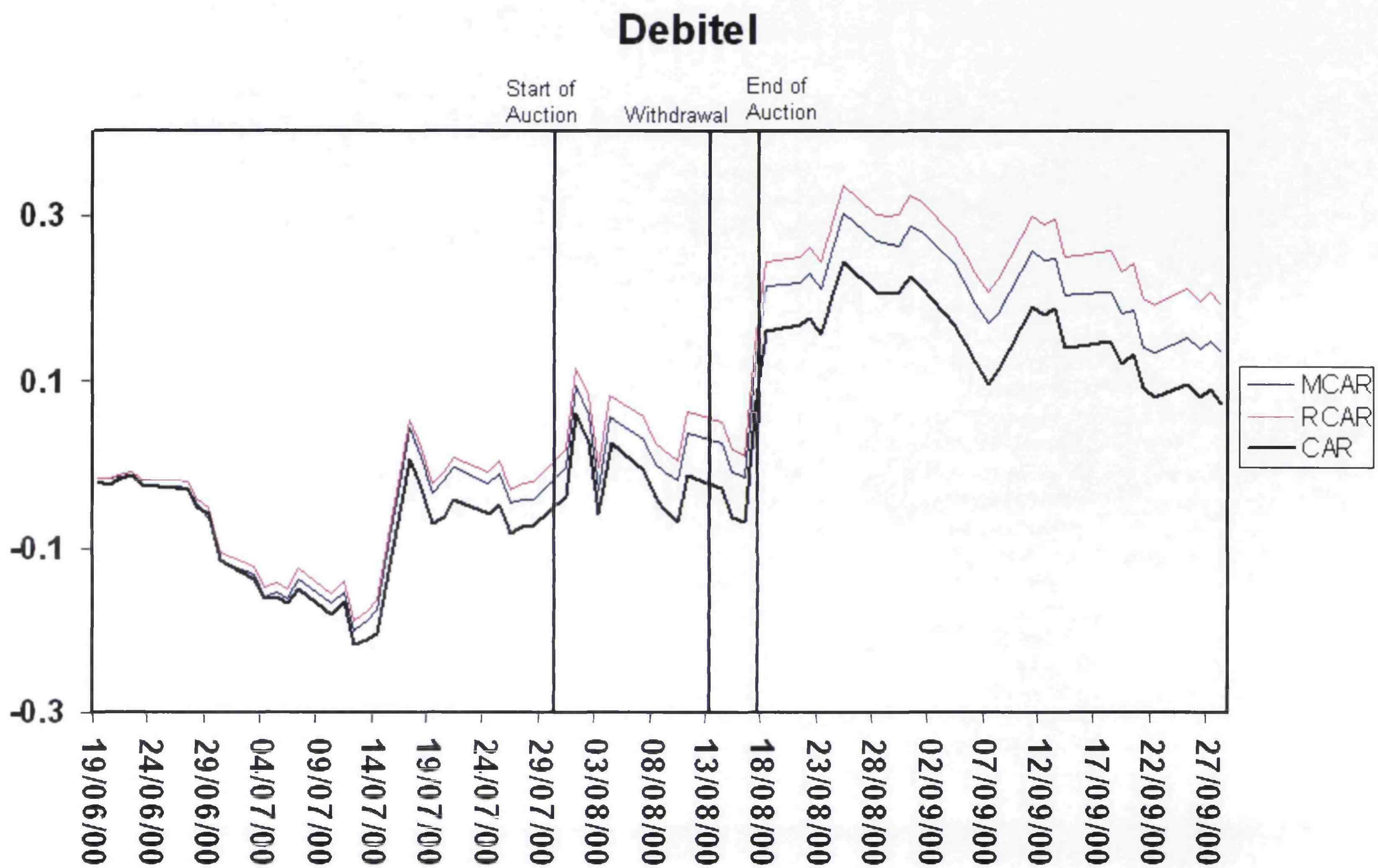

Figure 7.12: German Debitel

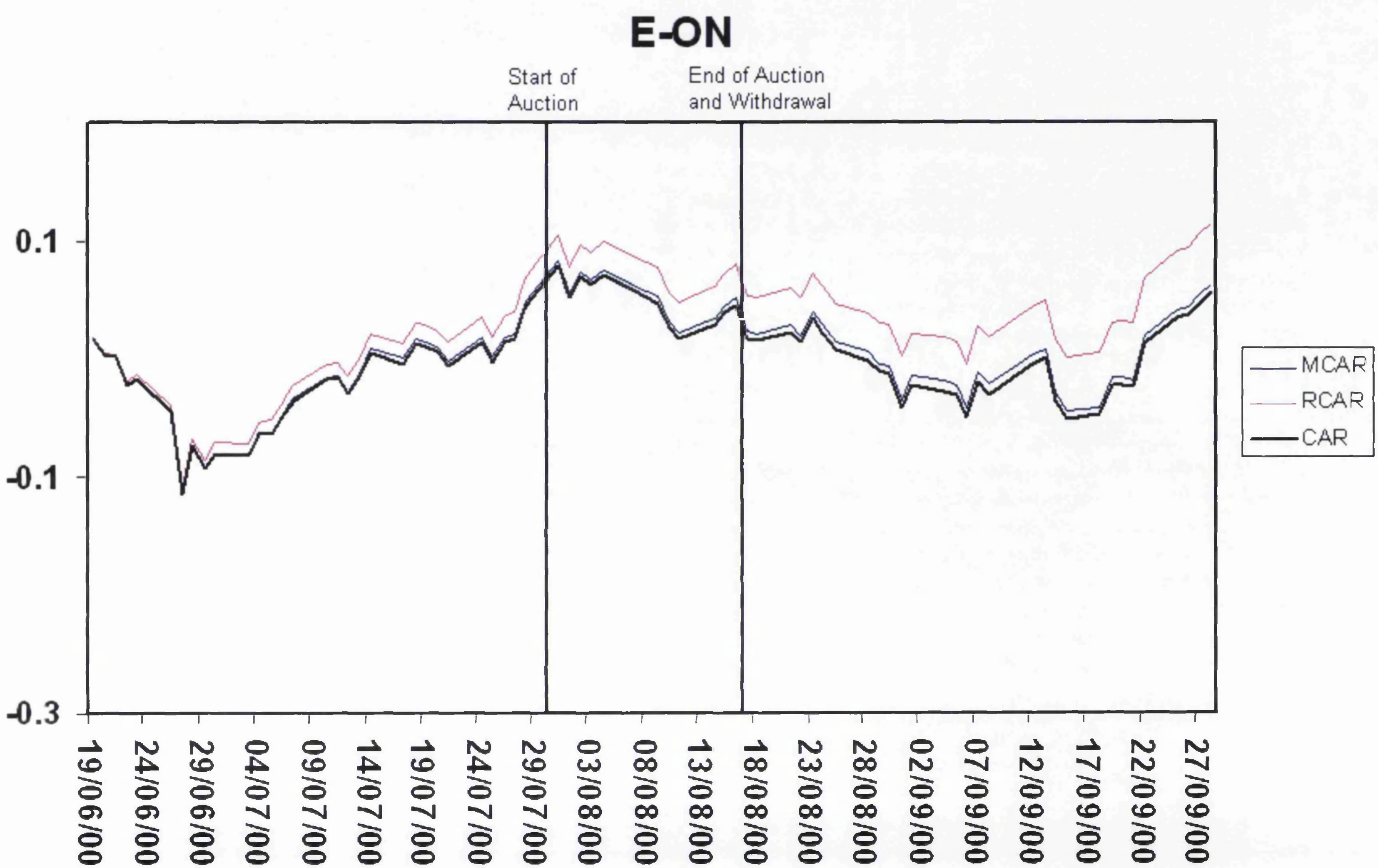

Figure 7.13: German E-On

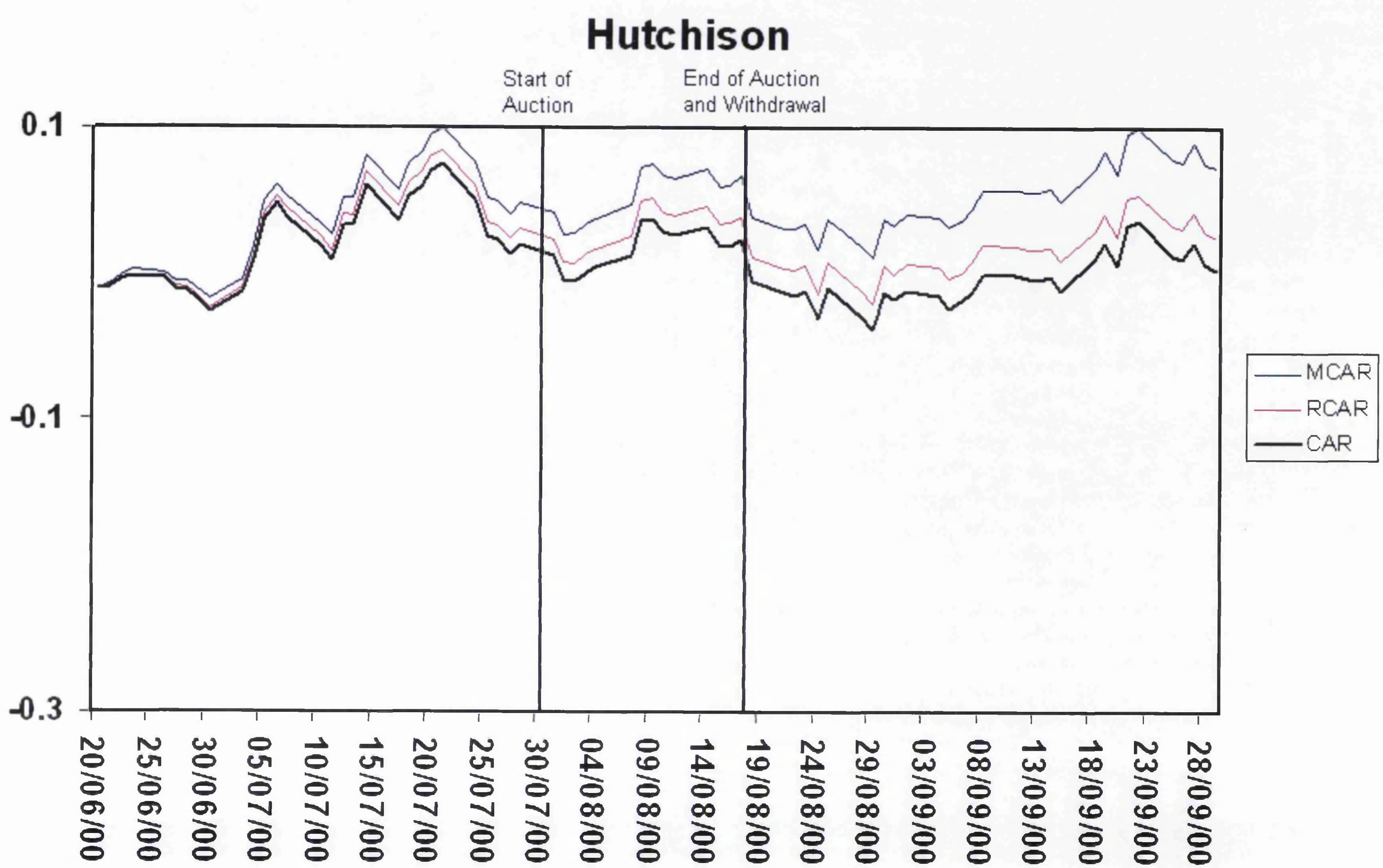

Figure 7.14: German Hutchison

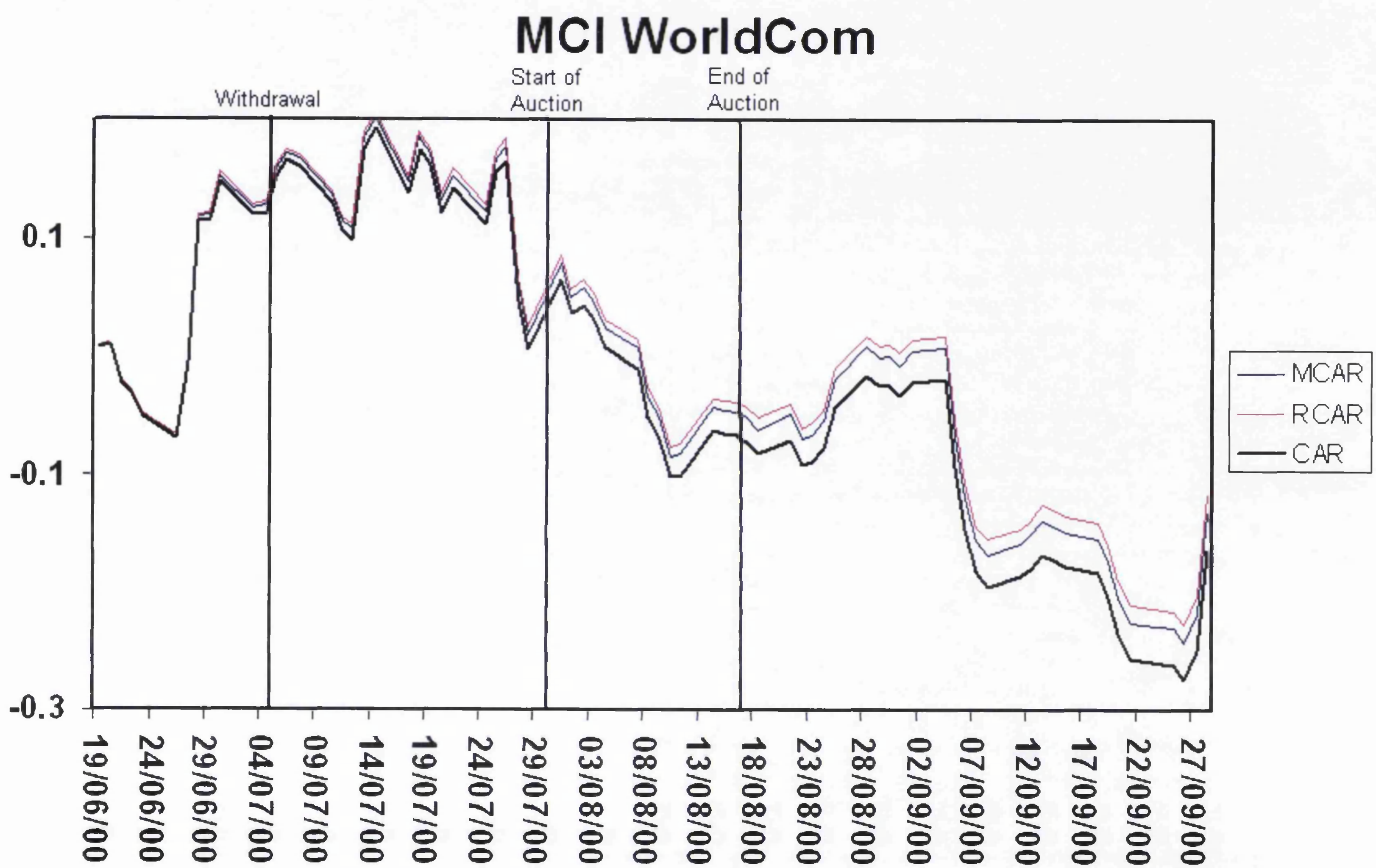

Figure 7.15: German MCI WorldCom

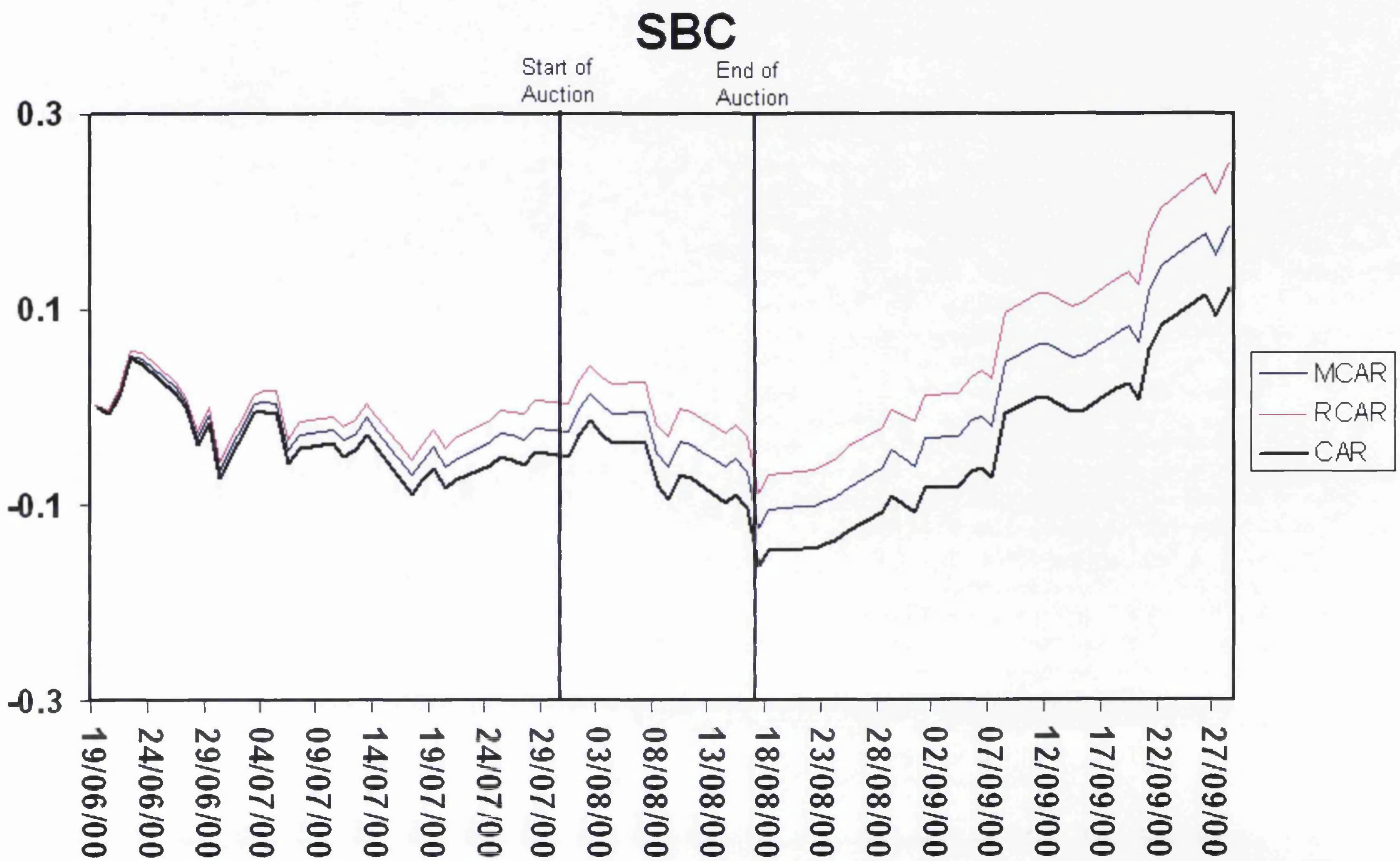

Figure 7.16: German SBC

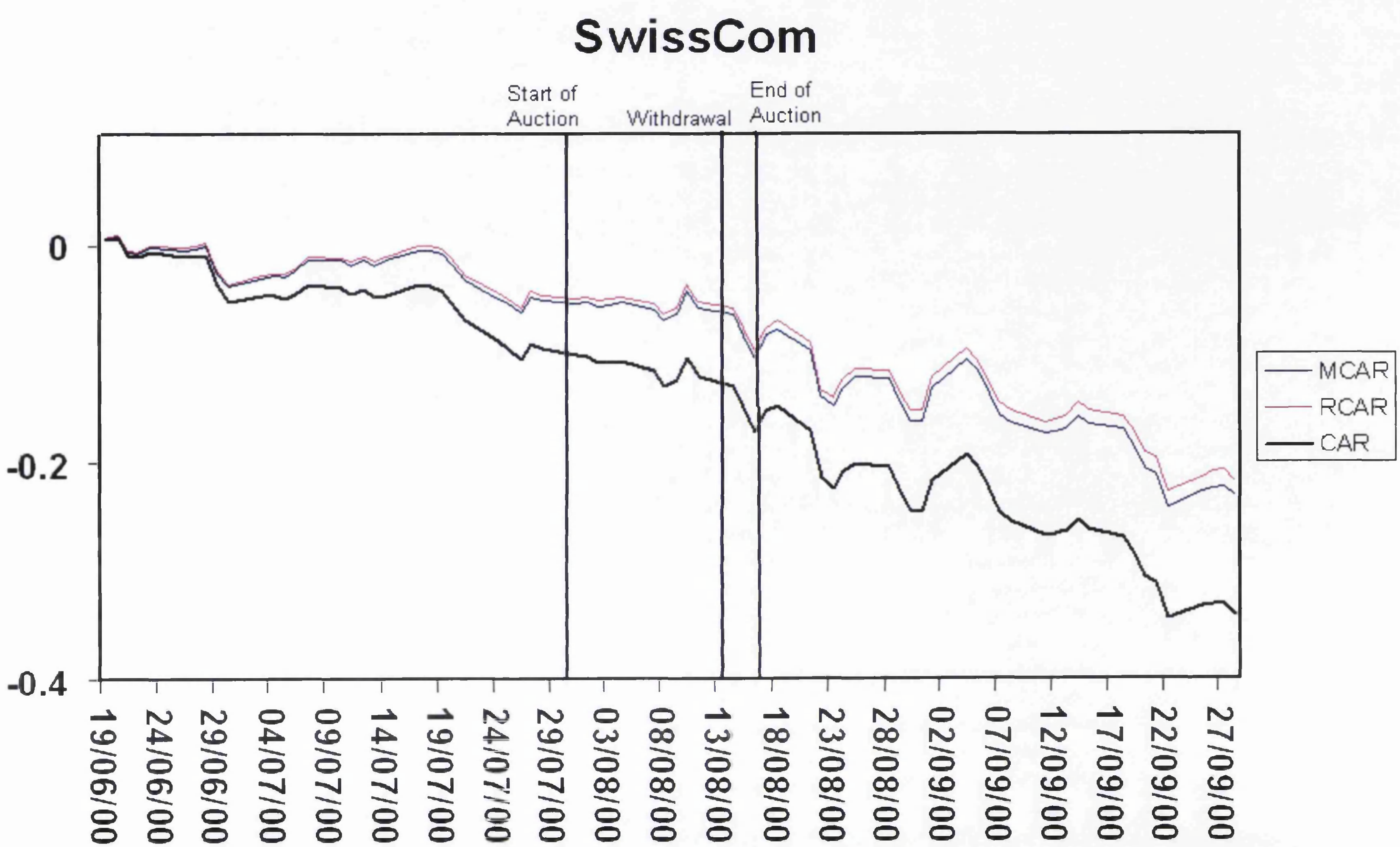

Figure 7.17: German SwissCom

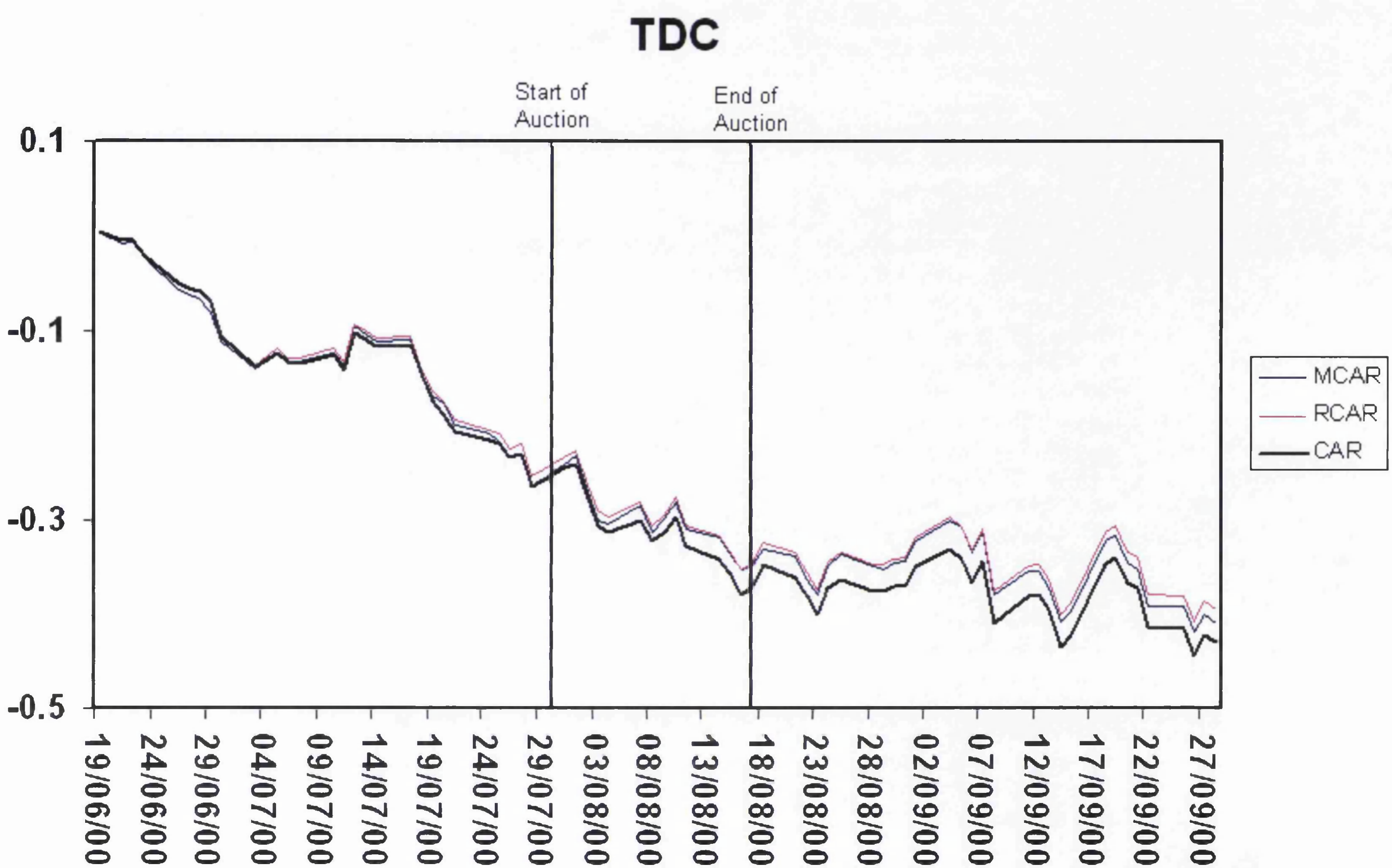

Figure 7.18: German TDC

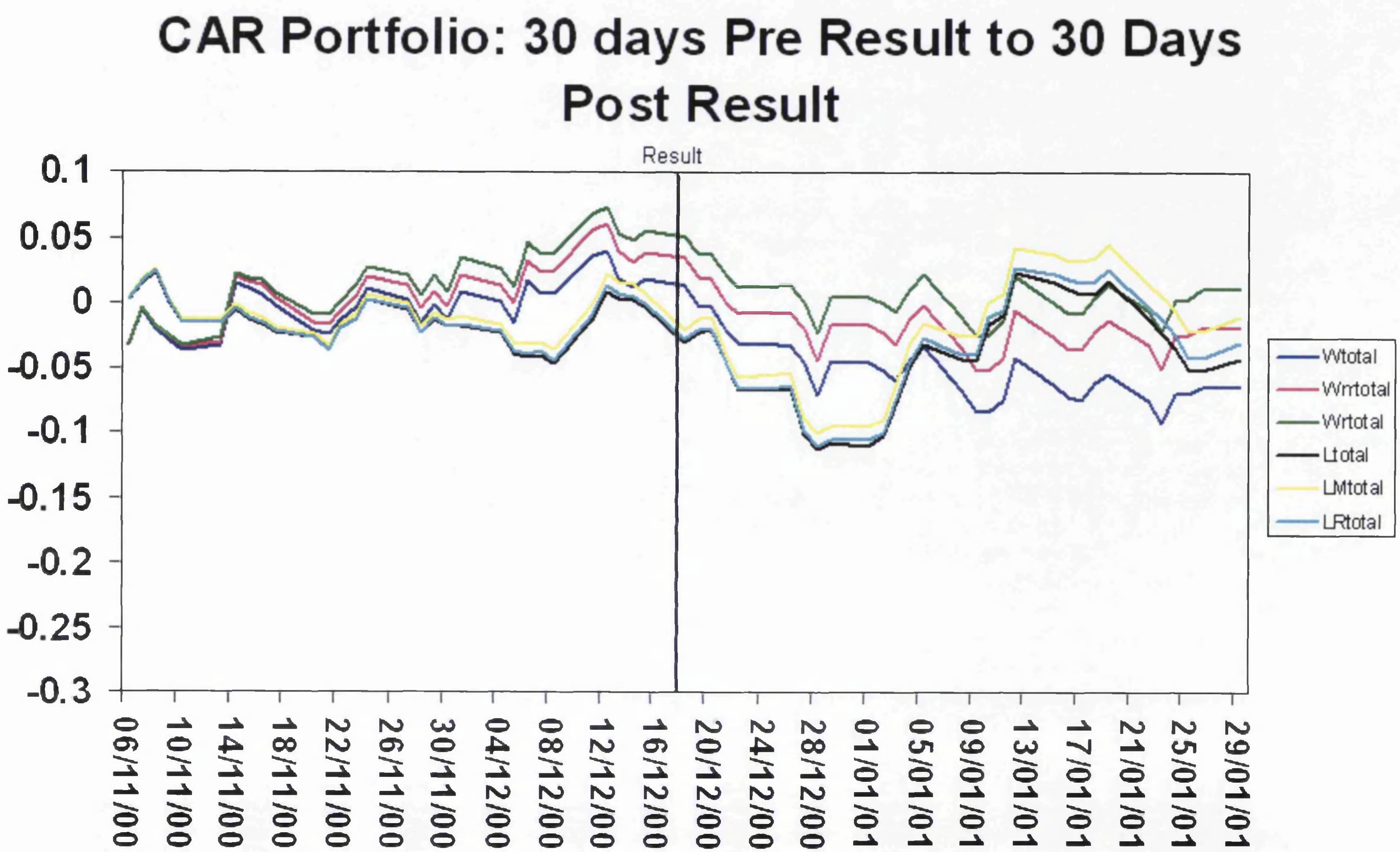

Figure 7.19: Sweden Portfolio 30 days to 30 days

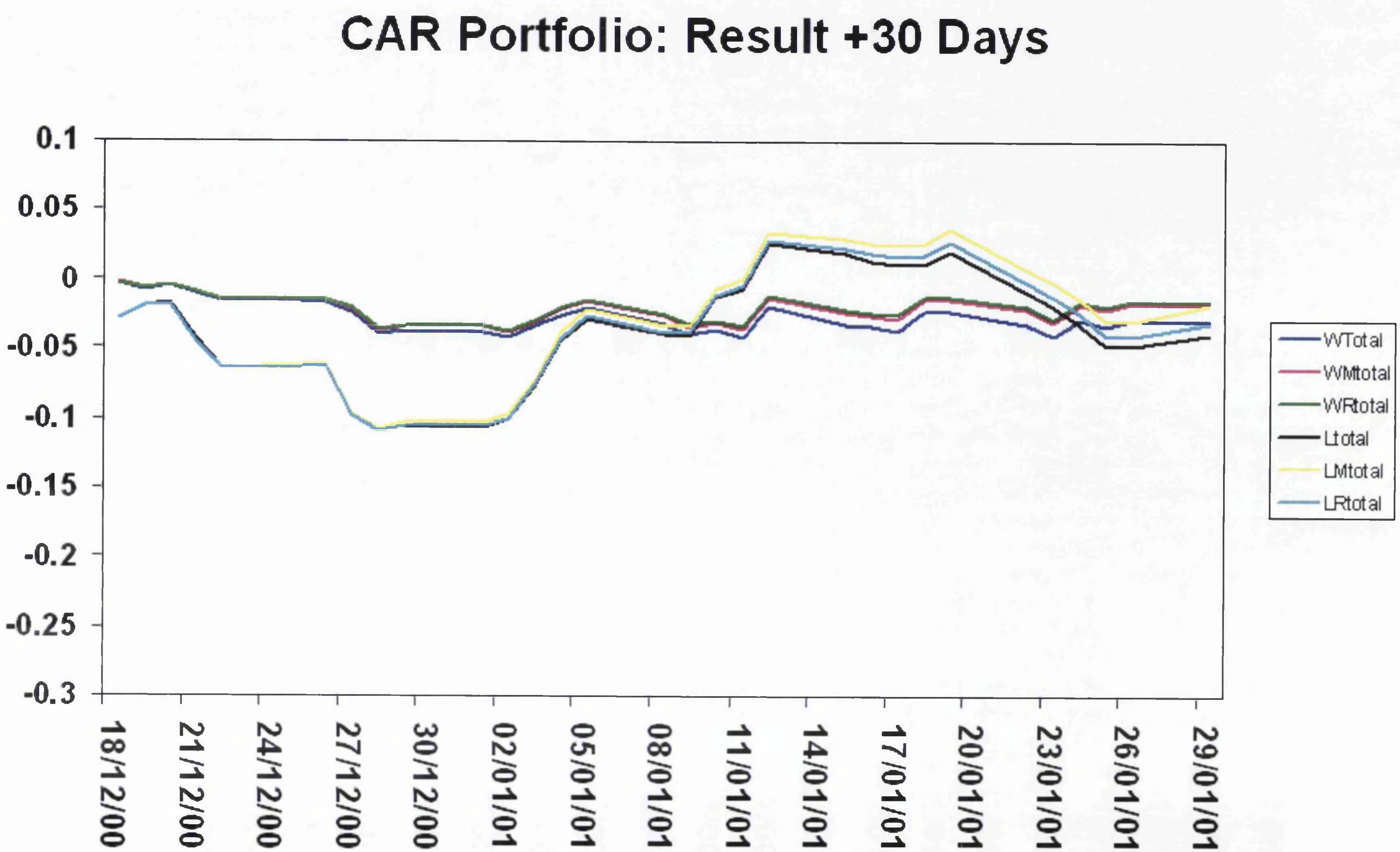

Figure 7.20: Sweden 30 days

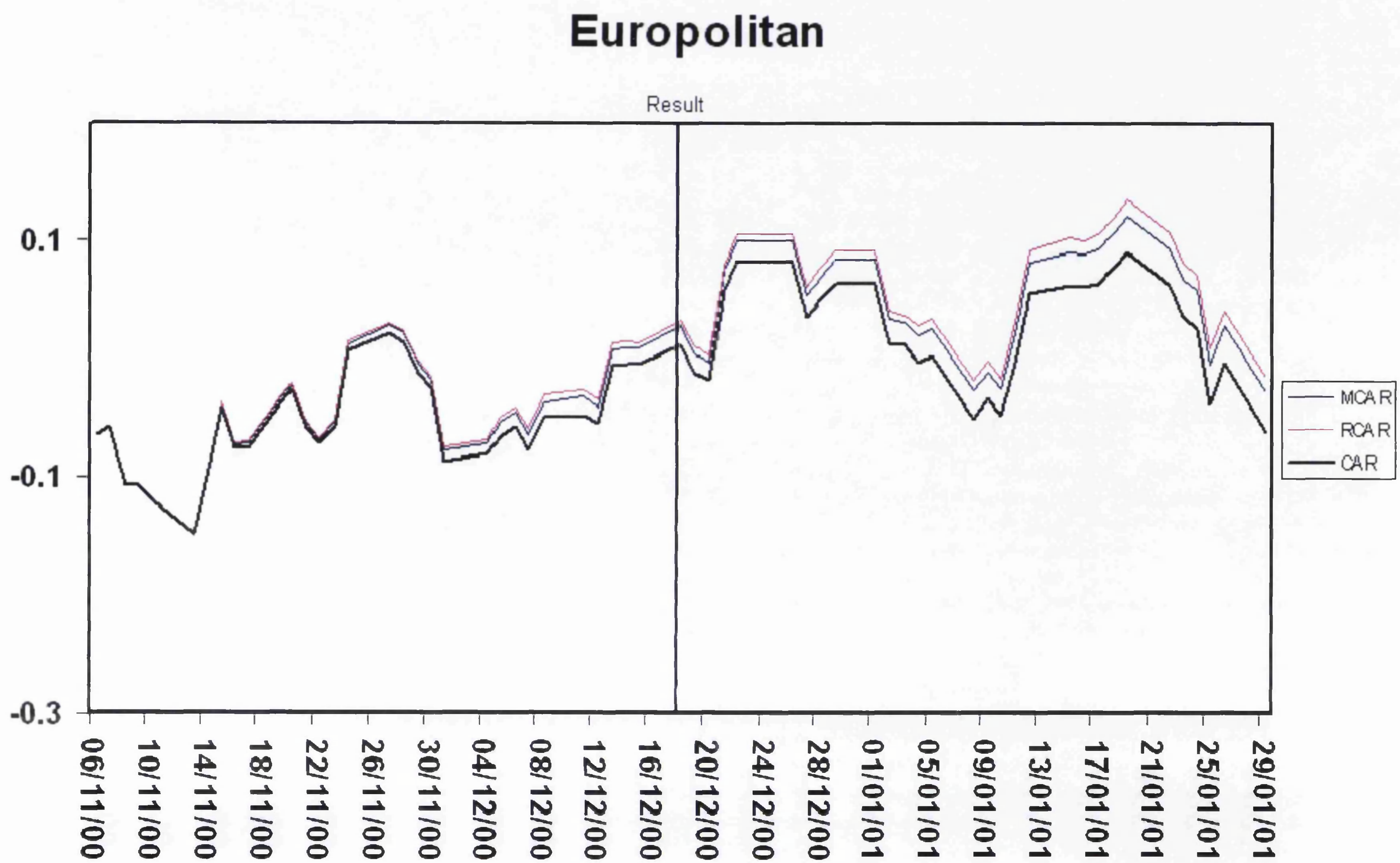

Figure 7.21: Sweden Europolitan

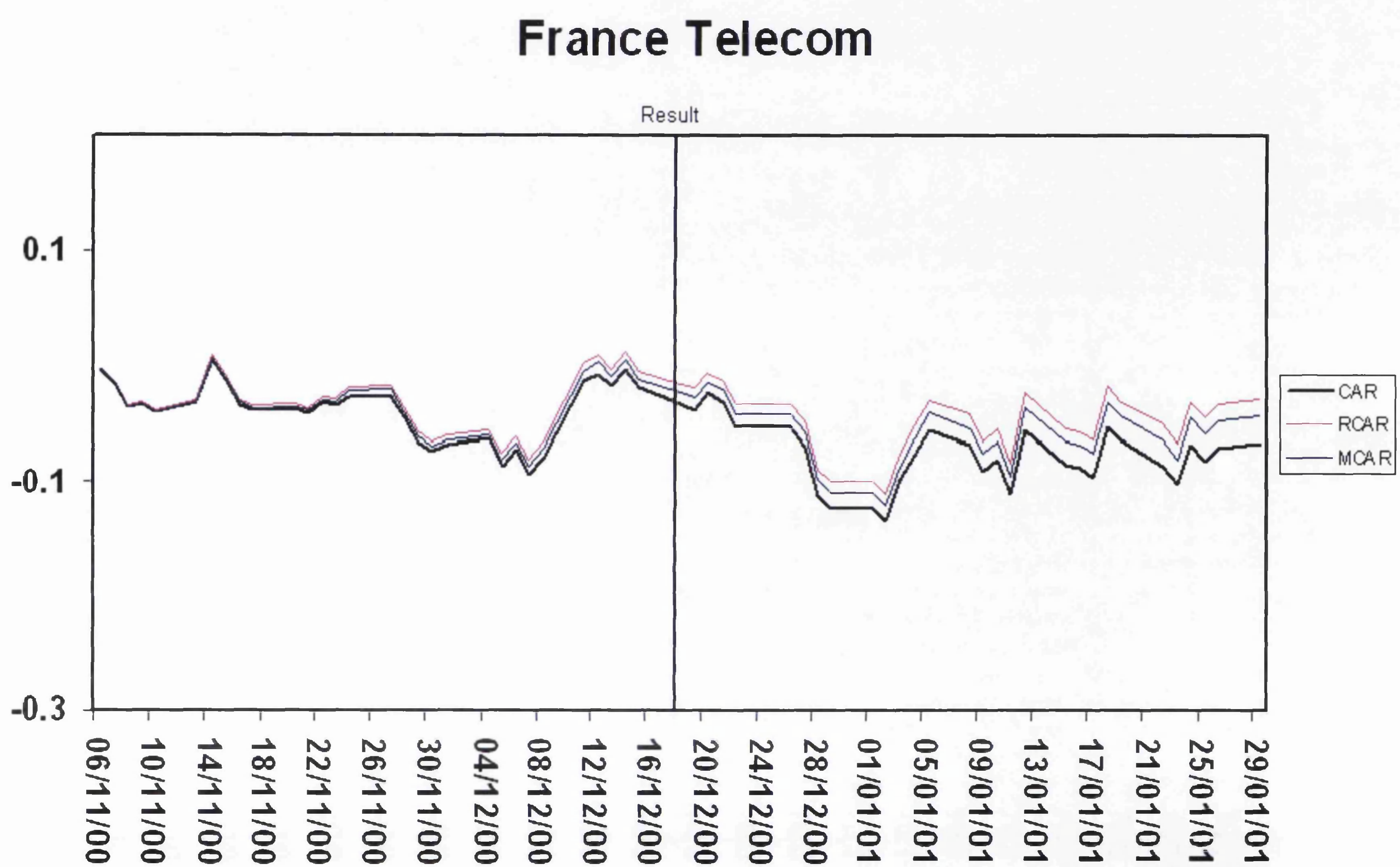

Figure 7.22: Sweden France Telecom

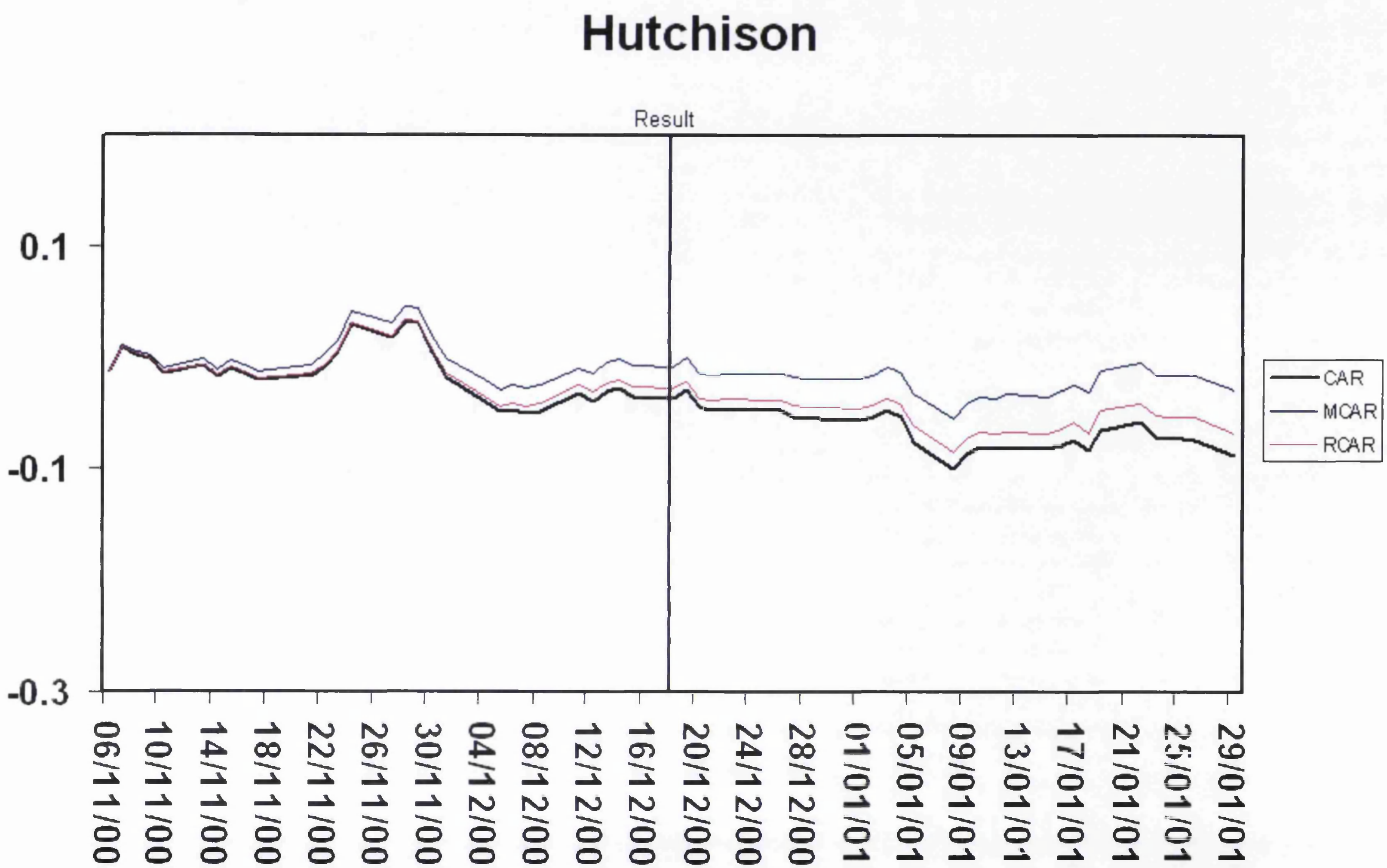

Figure 7.23: Sweden Hutchison

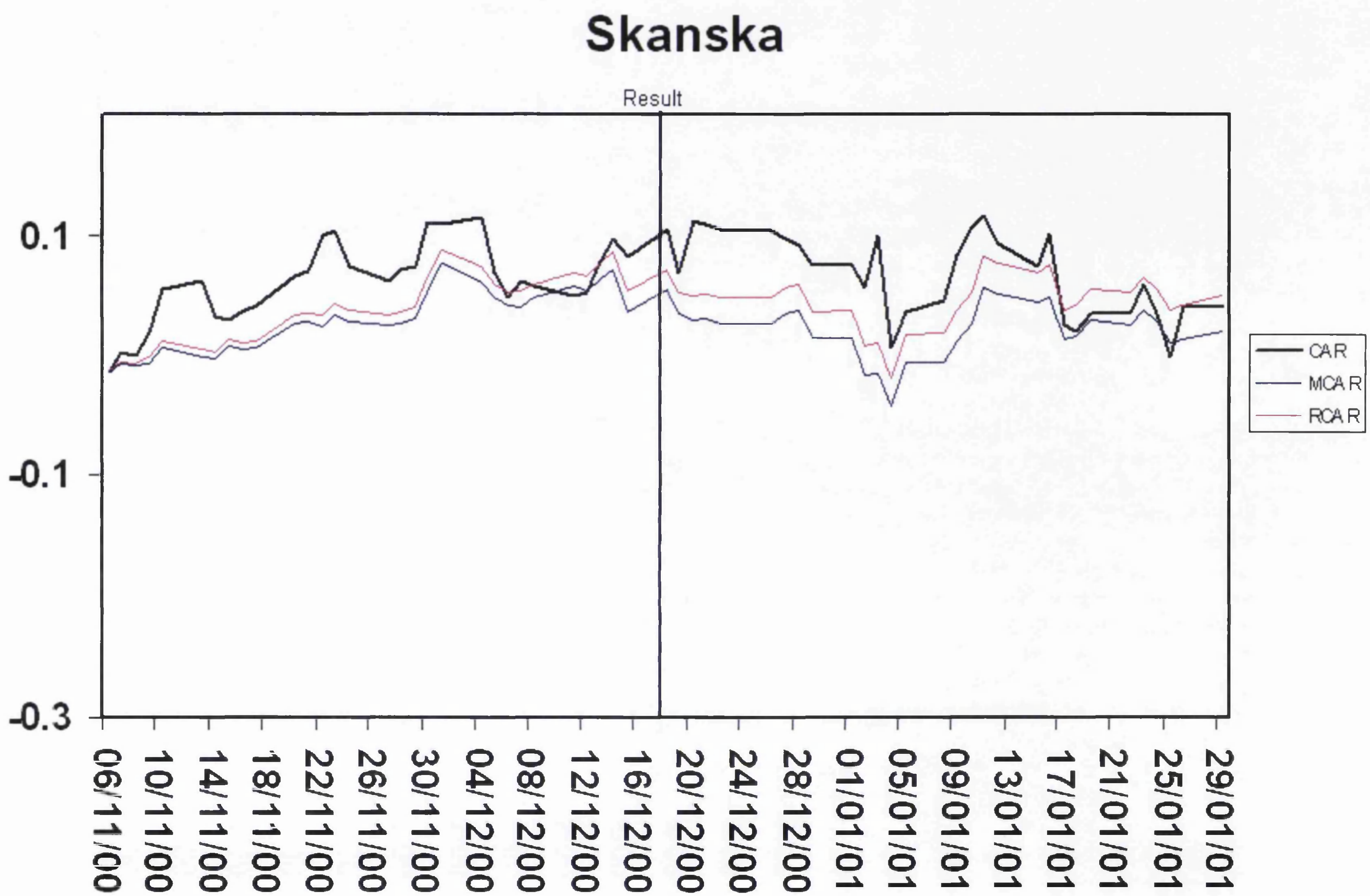

Figure 7.24: Sweden Skanska

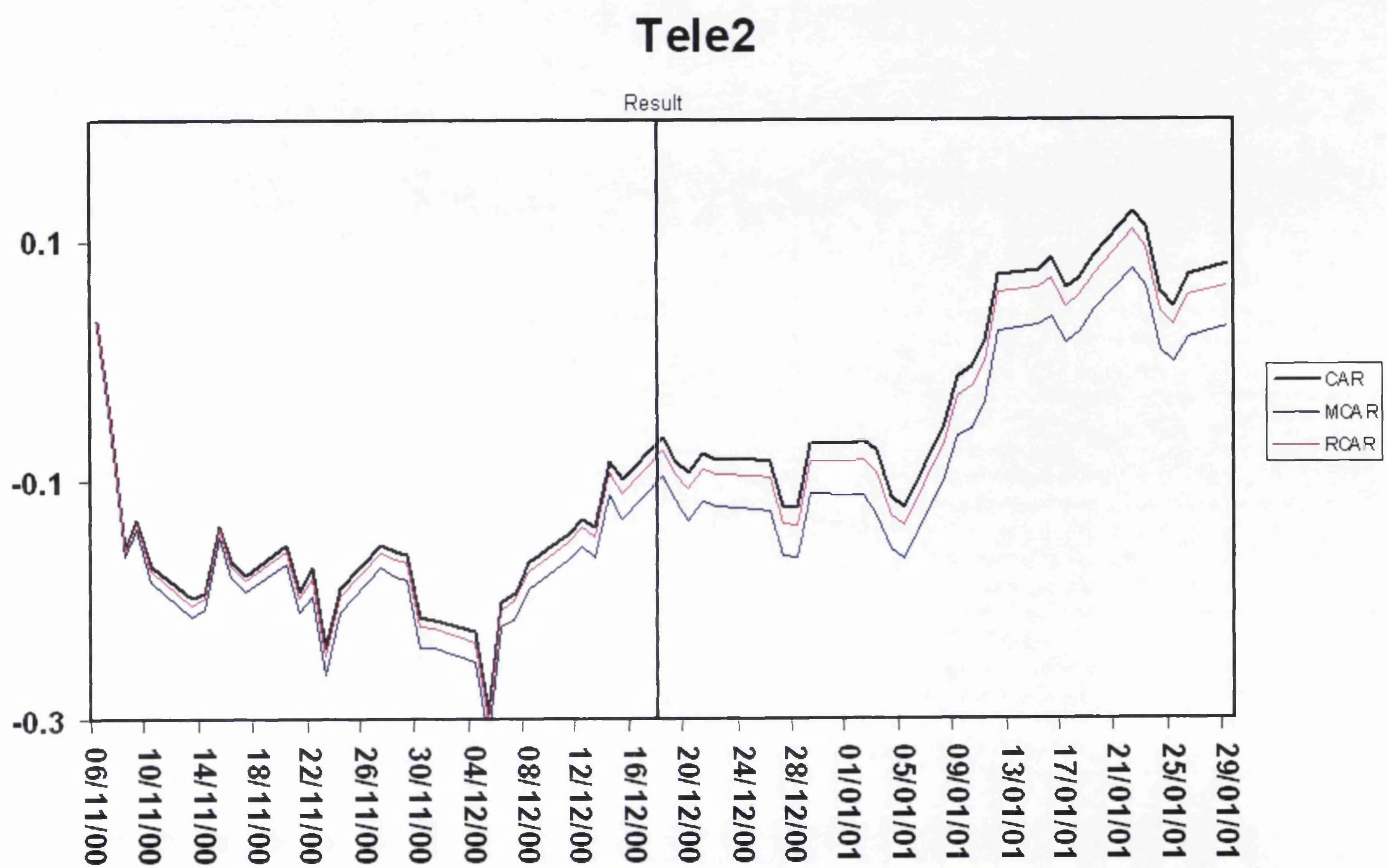

Figure 7.25: Sweden Tele2

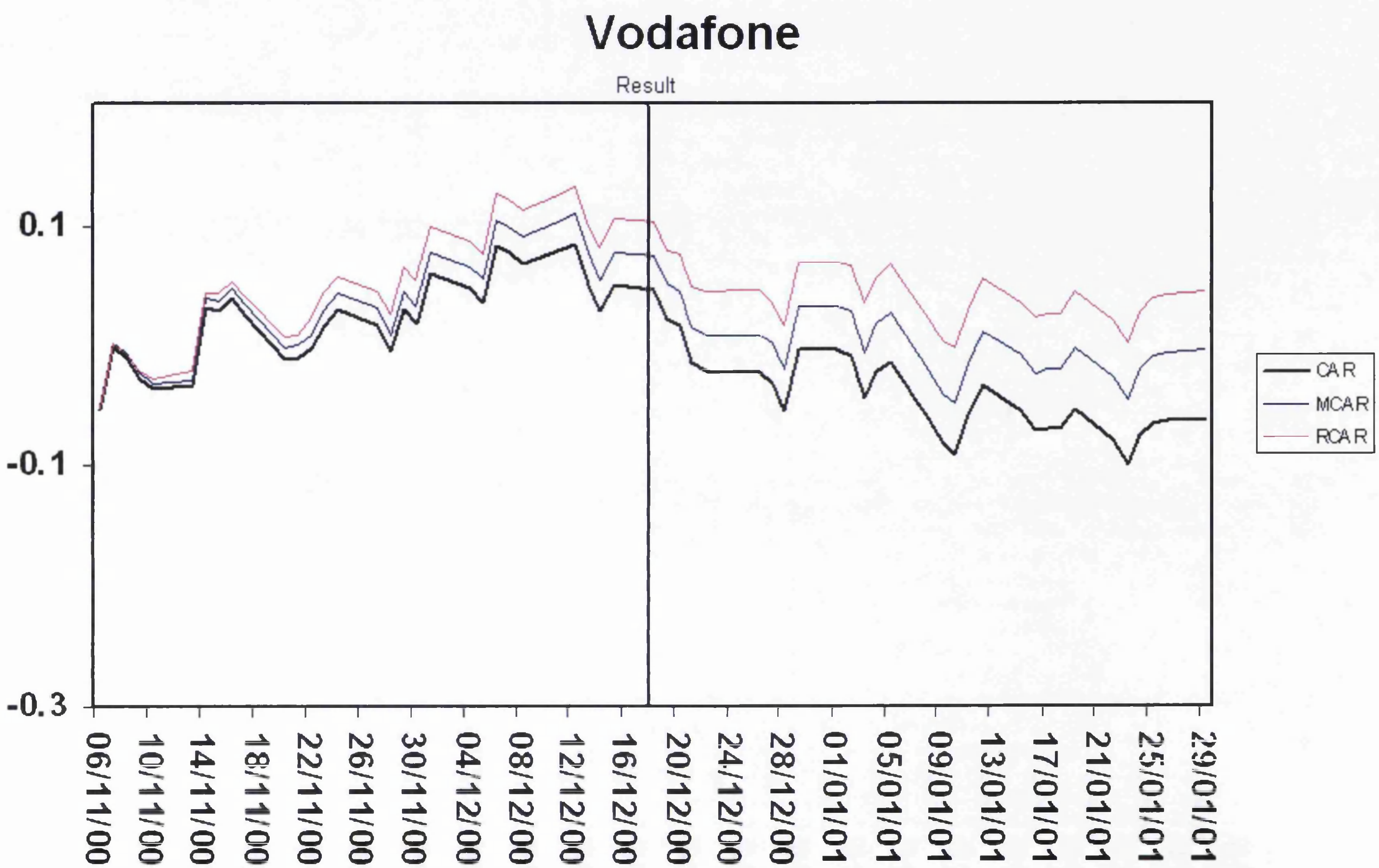

Figure 7.26: Sweden Vodafone

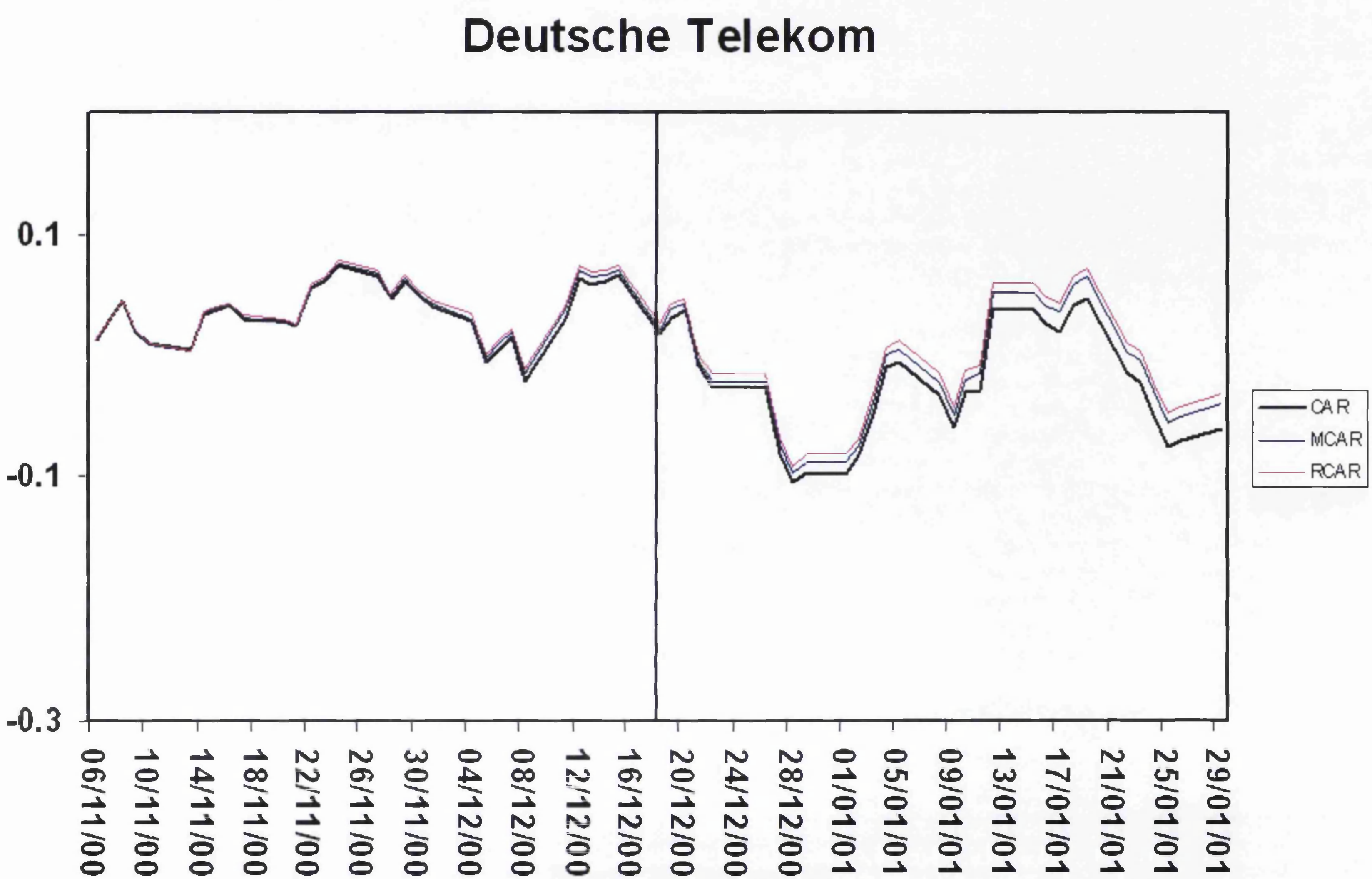

Figure 7.27: Sweden Deutsche Telekom

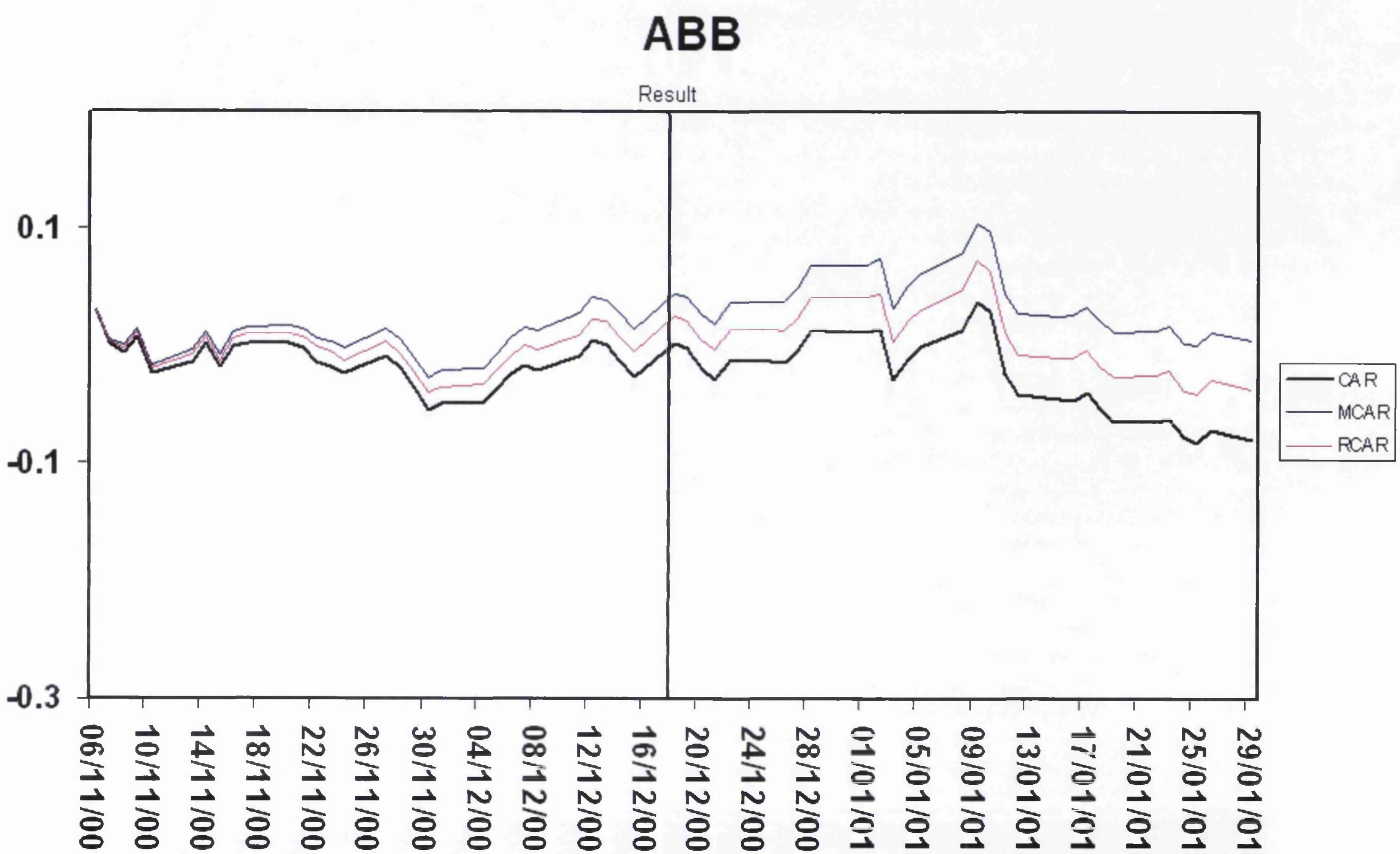

Figure 7.28: Sweden ABB

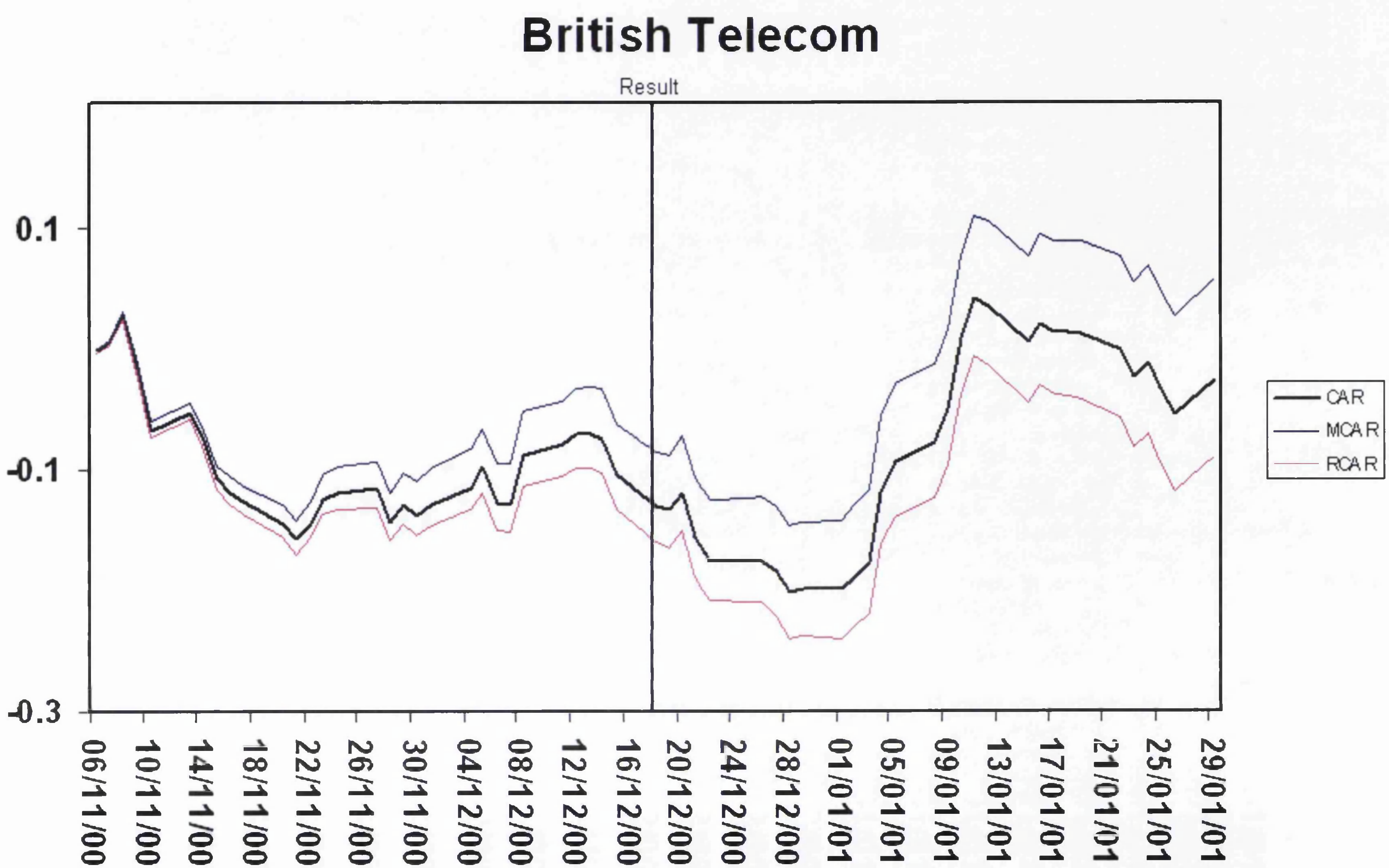

Figure 7.29: Sweden British Telecom

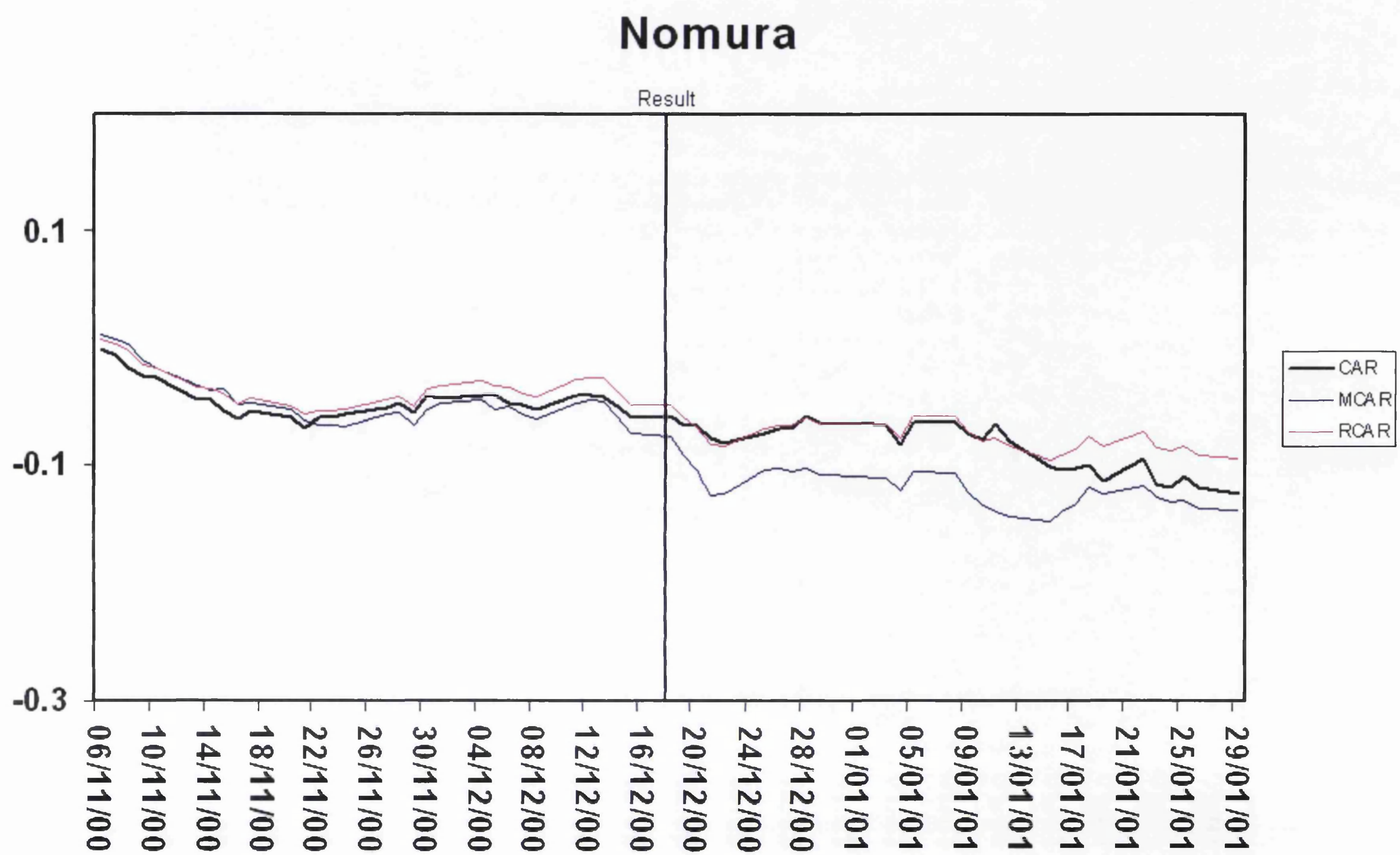

Figure 7.30: Sweden Nomura

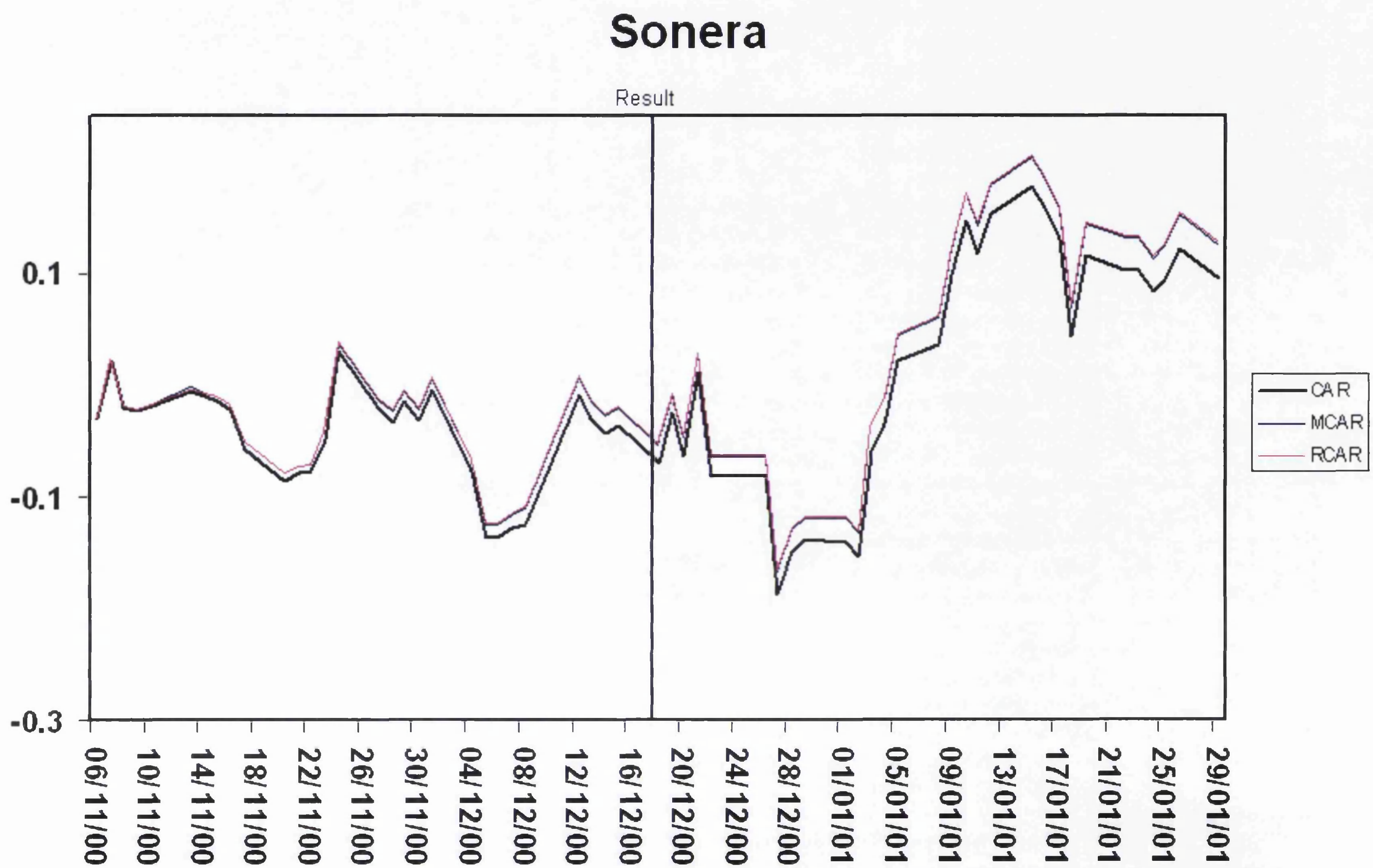

Figure 7.31: Sweden Sonera

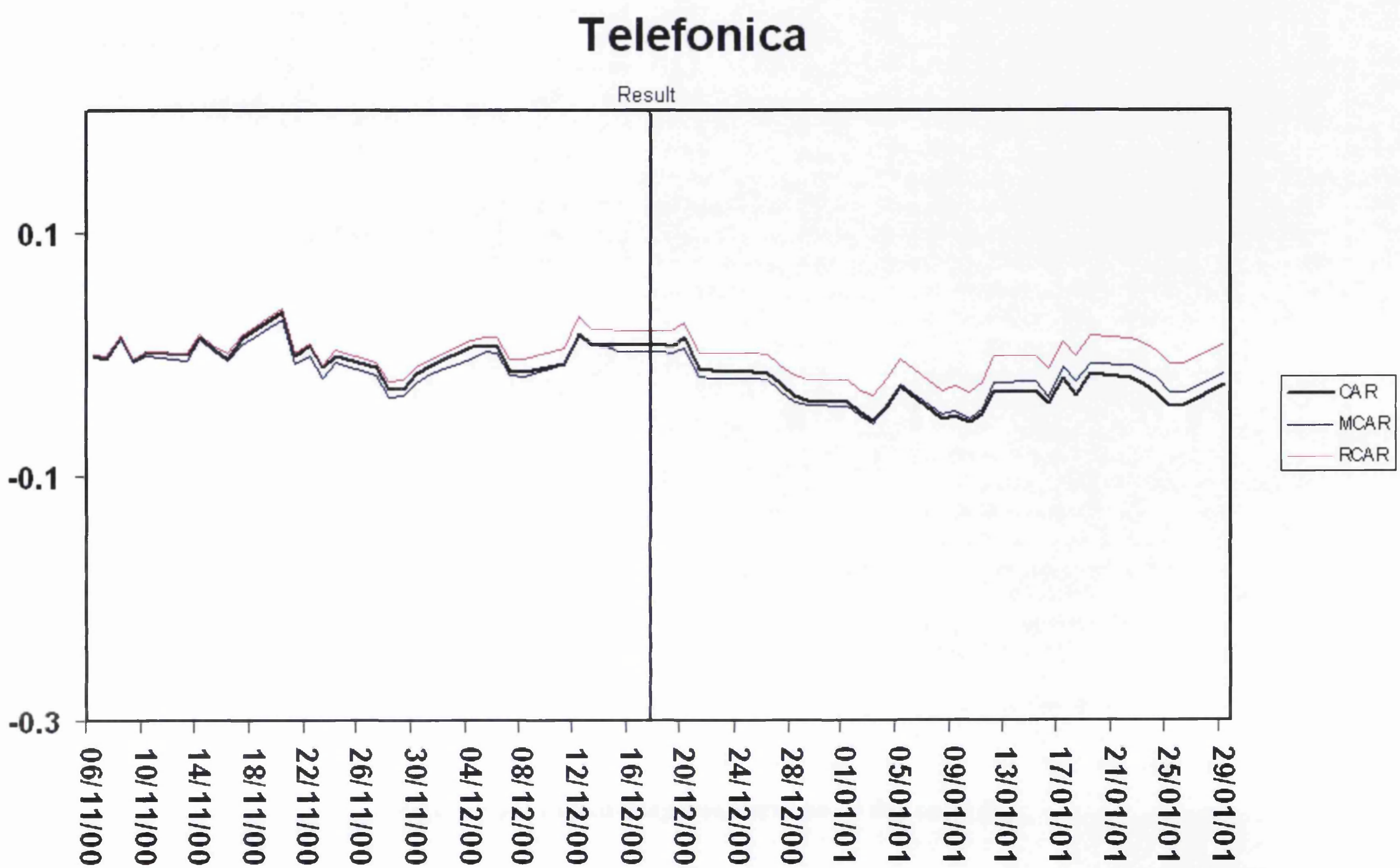

Figure 7.32: Sweden Telefonica

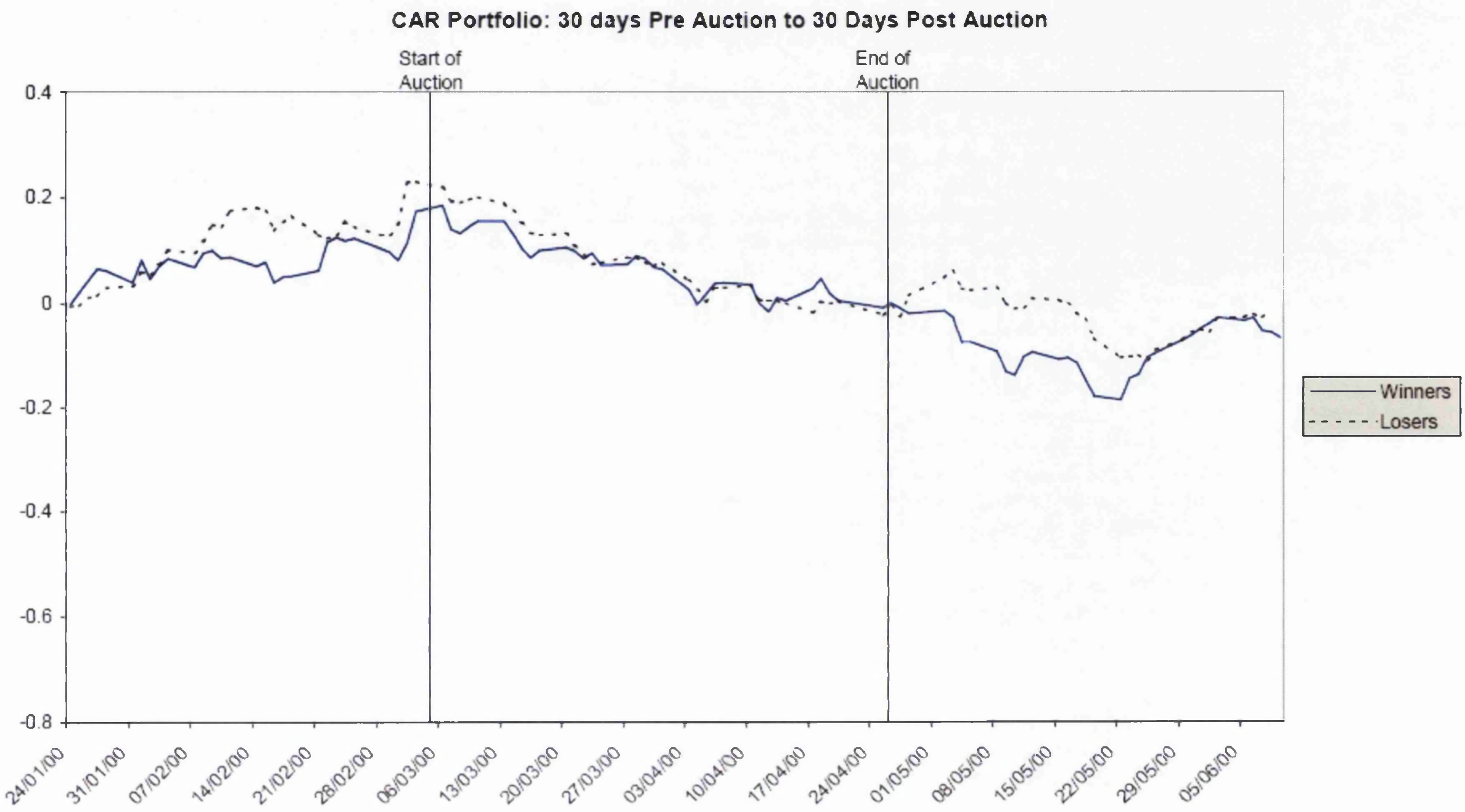

Figure 7.33: United Kingdom Portfolio 30 day to 30 day

Part 3

Chapter 8: A Review of Regulation in the European Mobile Telecommunication Market

"Advanced wireless access platforms such as 3G are an essential building block to achieve the goals of the Information Society, in terms of satisfying consumer demand, increasing productivity, ensuring competitiveness and creating jobs."(European Commission, 2002a, p4)

The previous two sections of this thesis have focussed on why different prices were paid for 3G licences and whether some auctions caused too much to be paid. The first broad conclusion that can be taken from these two sections is that much of the difference in licence fees was brought about by factors outside of the control of the National Regulatory Authority (NRA). The second is that there is evidence that overpayment occurred for these licences in some administration procedures. Thus far the consequence of overpayment has only been superficially explored. The primary argument has been with regards to the effect that overpayment has had through a change in regulatory stance. This argument will be expanded in the next two chapters. To facilitate a discussion of regulatory easing, mobile telecommunication regulation must first be placed in the context of general telecommunication regulation. This chapter will lay out in more detail the way regulation has been carried out in the telecommunication section, with a particular focus on regulation in Europe and the UK. This will lead on to a consideration of the evidence of regulatory easing in response to the distress faced by some licence holding firms. Chapter 9 will then go on to attempt to explain the behaviour of the regulator and the firm in terms of a bargaining framework.

8.1: The Focus of this Chapter

One of the themes alluded to a number of times in this thesis is that a winner's curse, or a perceived winner's curse, can change the regulatory position of the NRA. Regulation is not just being used to achieve economic efficiency but also to achieve certain political goals. The quote that opens this chapter is an example of how this type of technological development should be seen in a wider political context. How exactly this manifests itself will depend on those factors that the NRA considers important when they are deciding on regulatory intervention. When buying a licence the regulatory stance is part of the worth of a market and hence affects the value of the licence. A change in regulatory stance will, in effect, change the value of the licence to the winning bidder if the regulator is willing to change their stance. In the case of 3G licences the price that is paid for a licence can change the value of the licence. In this case the NRA is providing a form of winner's curse insurance. If a winner's curse is thought to have occurred the NRA will seek to bail the firms out and provide them with a more favourable regulatory environment. This may be through giving a refund on the licence fee or by making the market worth more. Those firms that have paid out large sums for licence fees are able to affect the state of the world that they face. They can do this through influencing the regulatory framework that they face. Once a bidder has acquired a licence the licence holder and the regulator engage in a bargaining process over the regulatory framework that the firm will face. The regulator will then seek to balance regulation that they perceive will improve efficiency in the market with other political goals.

In order to examine whether this is a realistic proposition, this chapter will explore the way mobile telecommunication regulation has been carried out in Europe and the UK. This chapter will be split into three broad sections. The first section outlines why and how regulation is carried out in the mobile telecommunications sector. The second section considers the evidence of regulatory easing in terms of explicit statements made by regulating authorities and inferences drawn from some regulatory decisions that have been made post licence administration. These regulatory actions are considered at a European level and the national level for the UK. The final section considers why this type of regulatory easing could come about and sets this in terms of a bargain between the regulated firm and the regulator. The concept of a bargaining mechanism will be formalised in Chapter 9.

The first part of this chapter consists of Sections 8.2 to 8.5 and will set the context of regulatory decisions. Section 8.2 contains a discussion around the broad motivations for telecommunication regulation and areas of the telecommunication industry that have had regulation imposed on them. Sections 8.4 and 8.5 will examine some specific regulatory issues and how they have been dealt with in the EU. Section 8.4 deals with issues directly linked to licensing and Section 8.5 with those outside of licensing. The second part of this chapter includes Sections 8.6 and 8.7. Section 8.6 will consider the evidence of regulatory easing at the European level. Section 8.7, considers evidence of regulatory easing in the UK. The chapter will end with a discussion in Section 8.8 of the problems associated with ex ante regulation of mobile telecommunication through the laying down of conditions in licensing agreements.

8.2: Why Regulate the Telecommunication Industry?

8.2.1: General Principles

Within the utility industry, Rossi (2005) identifies three potentially overlapping schools of thought that motivate regulation. The neoclassical motivation is to correct for market failures in order to improve market efficiency and potentially social welfare (Posner, 1974). The public interest approach is concerned with forcing private markets to enhance social welfare and in turn to benefit consumers (Mitnick, 1998). The public choice theory states that to varying degrees the regulatory authority, or the type of regulation, is dictated by the firms that are supposed to be regulated. This has broadly been termed the "capture" theory, whereby a regulator starts out with public interest goals but is captured by the firms it is seeking to regulate (Stigler, 1971 and Mashaw, 1997). How these concepts of regulation can be seen in the mobile telecommunication sector shall be discussed as we continue through this chapter.

The broad principles that surround regulation of the mobile sector are similar to any market. The regulator would seek to promote competition leading to an efficiently priced product and correct for any potential market failures. There may also be some particular politically desirable goals; for instance in network industries there is often a desire for universal access to the particular network. In addition to this, the regulator may seek to protect consumers from 'excessive' pricing and ensure the provision of a quality service. However, there is the potential for a strong political impact on how these issues are prioritised. All of these goals would be conditional on the formation of a sustainable industry that promotes investment and development. If there is no industry then there is no way that the other goals can be fulfilled.

These regulatory goals can be seen to emerge from the public interest and efficiency theories of regulation, discussed above. The majority of regulatory decisions that follow can be seen in the context of these goals. However, it is possible that these goals may interfere with each other. For instance, pricing controls that aid consumers may adversely affect the sustainability of the industry. These interactions between potentially conflicting goals that affect different stakeholders in the market can lead to complexities in the decision making process. The final regulatory measure will only come about after these interactions between the regulator, firm and stakeholder have taken place and will be determined by the relative political weights placed on different outcomes.

The way that the regulator balances these different goals becomes important for the post-administration mobile market. It is in the context of the interactions between regulator, firm and consumer that post-administration regulatory easing may take place. A regulator, in its attempt to carry out action that they believe would be in the public interest, may make decisions which would appear more in line with regulatory capture. Regulatory easing is not necessarily brought about by the regulator being beholden to the firms, as in public choice theory. If the stability of the market is at risk then it will be in the public interest to adjust the regulatory stance to support the firms in the industry. As Priest (1992) suggests, the focus of this chapter and the next is not to attempt to derive explicit motivation for a particular regulatory decision in isolation but rather consider the mechanism by which a decision, or series of decisions, comes about in the broader regulatory framework.

If a regulator does behave in a way that supports struggling firms, there may be a concern that the industry will be affected by a regulatory moral hazard. There is no need for the firms to maintain a stable industry if the regulator will bail them out. The firm then may engage in high risk behaviour in the belief that any down side risk will be covered by the regulator. This is dependent on the firm believing that a high political weight is placed on the failure of a particular firm or industry. A regulatory moral hazard can be linked back to the winner's curse. If the firm has a belief that the regulator places a high value on the development of 3G services, which regulatory authorities at a number of levels did,[1] then the firm may suppose that a regulator will adjust its stance to allow protection from a winner's curse.

8.2.2: Market Failures in the Mobile Telecommunication Industry

The last section gave a broad description of the main motivations for regulations. This section will look at more specific motivations for regulation in the telecommunications industry and the remedies that have been identified to deal with them. Before going on to consider how regulatory interactions are taking place we need to examine the structure and justification for regulation in the mobile sector. Taking the neoclassical approach, there are three clear areas of market failure that can be identified in the mobile telecommunication market. The first of these is the existence and abuse of monopoly power or significant market power (SMP). How this monopoly power may come about, how' it is abused by the firm with power, and how market definitions affect the understanding of significant market power will be discussed at a later stage.

The second perceived market failure comes through network externalities.[2] The telecommunications industry provides a perfect example of network externalities. The more people that are connected to a telecommunication network the more people the existing users can communicate with. Each additional user that joins the communications network will increase the value of the network to existing users. Albon and York (2006) identifies network externalities within the mobile telecommunication market. Mobile user externalities exist when additional subscribers to the network add value to the current subscribers. Fixed-line mobile network externalities exist when fixed line users gain from more mobile subscribers as this gives them additional users to call. Finally, fixed to mobile call-receipt externalities occur as a mobile subscriber

[1] The quote at the start of this chapter is one of many examples.
[2] See Shy (2001) for a discussion of network industries.

places a value on the call they are receiving. Although they place a value on the call, the mobile user is unable to affect the volume of calls that they receive.

The third market failure comes from the transactional incapacities that exist within the mobile market. Transactional incapacities are caused when one party to a transaction has made the contract so complex that a person of reasonable intelligence would not be able to make a well-informed decision about the transaction they were undertaking. These transactional incapacities can occur in the mobile telecommunication due to customer ignorance of some mobile charges. This is the case for both the user of the mobile phone as well as a third party caller. This customer ignorance over their contractual fees is particularly a problem when considering roaming and terminations charges. When a user makes a call to a mobile phone they have no way of knowing which network provides the termination on that network and therefore no way of knowing how much they will pay for the service. This is a clear case of a transactional incapacity. Gans and King (2000) find that this type of customer ignorance can cause monopoly level prices for call termination. This topic will be discussed further in Section 8.3.

8.2.3: Methods for Regulating the Mobile Telecommunication Sector

The way regulatory control is applied to the mobile telecommunication can be split into the following three broad categories. The first of these is the number of network operators and the structure of the industry. The regulatory primarily controls this through pre-entry regulation where the quantity of radio frequency, the number of licences on offer and technology to be used is decided. Linked to these issues are the ownership and control rules and the licensing procedures and conditions. The majority of these considerations are determined at the initial licensing level, although they can often be changed at a later stage. An example of a regulatory issue that evolved was the approach taken towards Mobile Virtual Network Operators (MVNOs), as discussed in Section 8.4.3. The decisions taken in this broad industry structure area can impact on the level of competition in the industry and potentially the degree of SMP. A particular danger with this type of regulation is the possibility of delay if there is political disagreement over the structure of industry, where the radio frequency is sourced from, and how it is administered. There is also the possibility that the regulator can choose an inferior technological standard.

The second regulatory lever is based around controls against "abusive" pricing, at both the retail and wholesale level. Market failures associated with pricing have been focused in two areas. As mentioned previously, these have been termination charges at the national level and roaming charges at the international level. Both of these issues have been seen where MNOs are able to exert significant market power at the wholesale level, which links back to the previous point on industry structure. In some cases SMP has been found not because of industry structure but rather because of the nature of mobile telecommunication. The abuse of SMP is exacerbated by the inability of consumers to obtain accurate information on pricing.[3]

The final regulatory issue revolves around quantity and quality of service. Primarily these focus on the obligation to interconnect between other networks, mobile networks and fixed line networks and the obligation to provide a universal service. The obligation to provide universal service links back to the second issue regarding the licensing conditions and pricing. Usually there would not be an absolute universal service obligation rather a set minimum roll-out commitment and there may be the option to roam on other national networks. Chapter 3 contained a detailed discussion of these licensing roll-out conditions and the problems that licence holders experienced when trying to meet them.

8.3: Telecommunications regulation in practice.

8.3.1: Mobile Telecommunication Development and Institutions

Historically a hands-off approach has been taken within the mobile telecommunication sector. In the early stages of mobile development few people owned mobile devices and they were seen as luxury goods, as such regulation of the industry was not considered to be necessary. It was also thought that there was adequate competition in the sector from

[3] For an overview of the way pricing regulation is applied to Telecommunication Regulation see Sappington (2002).

fixed line networks. The Mobile telecommunication sector was originally seen as an extension of the state-owned fixed network operator. Often this meant that the firm was under a degree of direct political control. As mobile technology improved and switched from analogue to digital systems it became clear that there would be room for additional operators. With new technology giving greater usability and the sector increasing in value, additional spectrum was allocated for use with mobile telecommunications. The growth in the mobile telecommunication market has been so rapid that in some developed countries the number of fixed line telephones has been dwarfed by their mobile counterparts.[4] Across Europe additional operators were being licensed, however access to the market was and is still restricted by the licensing procedure. The licensing of new spectrum for mobile telecommunications, which has often been slow to respond to changes in technology and market structure, has led to most mobile telecommunication markets operating with only a small number of firms as network operators. Where liberalisation was occurring, one of the first priorities of any regulation was to prevent the incumbent firms using market power to restrict competition. A particular example of this is the duopoly policy adopted in the UK market. An additional complication occurred because the body that administered spectrum was not always the same as the authority that dealt with the post-administration regulatory environment. This means that motivations of those administering spectrum may be different from those regulating the post-administration market.

8.3.2: Recent Developments in European Regulation

Much of the early regulation emanating at the European level was concerned with the liberalisation of telecommunication networks and how to apply competition policy alongside sector specific regulation. The development of a European regulatory framework must be seen in the broader political context of European economic and political integration. Indeed the Maastricht treaty changed the status of the telecommunication sector by listing it as a Trans-European Network.

[4] See Hausman (2002) for a discussion of the development of mobile telecommunication.

In the year 2000, a review was undertaken to amend the 1998 framework (European Commission, 1999, 2000a). The new framework was due to come into effect by 2003, however it was felt that greater progress was required on local loop unbundling which led to European Commission (2000b). The final framework had three key focuses. These three areas are the authorisation of new operators both in terms of licence administration and interconnection, the definitions of universal usage rights and consumer rights, and how to identify and deal with significant market power.

April 2002 saw the introduction of the EU's "New Regulatory Framework". This was based on antitrust law and moved EU regulation away from ex ante regulation to ex post anti-trust regulation. The Framework was based on three key principles. The principles were the promotion of competition, the development of the internal market and the promotion of the interests of the citizens of the European Union The Framework consisted of Directive 2002/21/EC the Framework Directive, Directive 2002/19/EC the Access and Interconnection Directive, Directive 2002/20/EC the Authorisation Directive, Directive 2002/22/EC the Universal Service Directive, Directive 2002/58/EC Privacy and Electronic Communications Directive and the Radio Spectrum Decision. Broadly, these directives deal with interconnection between communications networks, the availability of communication access, the protection of data and a common internal and external radio spectrum policy. Crucially the Framework outlines how NRAs should treat market power. The NRA is obliged to make an assessment of competition in a particular market. If the market is considered to be sufficiently uncompetitive and significant market power is present, then the NRA must take rectifying action. The new regulatory framework also moved the assessment of market power away from the old definition of significant market power, which was considered to be present when a firm had greater than 25 percent market share to more 'market dominance' based criteria. This new definition meant that market power would require a market share of around 40-50 percent (Gruber, 2005, p56). In addition to this, firms could have positions of joint market dominance, meaning that an investigation could be launched if there was evidence of collusion between firms. So a firm was considered to have market power if "either individually or jointly with others, it enjoys a position equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers."(Gruber 2005, p57). NRAs were thus obliged to look for joint as well as individual market power. Markets that have been identified as potentially requiring regulation are voice call termination, the wholesale market for international roaming and call origination from mobile networks.

8.4: Specific Mobile Telecommunication Regulation

The previous three sections have focused on the broad motivations for regulation in the telecommunication sector, the international institutions that interact to bring about regulatory control, and the approach that has been taken to communication regulation across the EU. The following section will examine some specific issues that have arisen in mobile telecommunication regulation. It will begin with a discussion of those issues that were in some way, although not exclusively, linked to licensing. The section will then consider those regulatory issues that were dealt with primarily outside of the licensing process. The section ends with a discussion of EU regulatory support for mobile telecommunication companies.

8.4.1: Market Entry and Licensing Conditions

Considerable barriers to entry exist for firms in the mobile telecommunications industry. Each firm will require one of a limited number of licences to operate. These licences determine how much spectrum each operator receives and on what terms they must operate. This barrier to entry, as will be discussed later, may infer market power on incumbent network operators. The NRA or government has complete control over the number of firms that operate as MNOs within the industry. The NRA has the ability to ensure market entry, as in the UK 3G case, when a licence was set aside for an entrant. This type of policy will only ensure entry if the market is able to sustain an additional licence holder. However the decision over the number of licences to offer does not necessarily correspond with the number that can be sustained by the market.

In Chapters 3 and 4 the way the 3G licence fees differed across countries was discussed. However, just as the size of licence fees differed across countries so did the payment schedules. In a number of countries the payment schedules were relaxed. Most of the licences allowed for a certain degree of payment by instalment, spreading the payments over a period of time. Because these payments were spread out it presented the possibility that the fees could be delayed or reduced. Where the whole licence fee was made as an upfront payment there is the possibility for a refund or some form of tax break. Although this is a possibility, there may be issues of legality surrounding both these suggestions. Those firms that did not win auctions for these licences could easily argue that they would have bid differently given the different licensing conditions.

Problems arising from excessive licence fees were not exclusive to the European UMTS auctions. The US 1995 PCS C block and F block spectrum auctions experienced significant post-administration difficulties. Many of the owners of C block licences were not able to pay the interest payments on their financing deal. This was such a concern that the Wireless Telecommunications Bureau suspended the licence holders' obligation for repayment. The FCC decided not to forgive the debt of licence winners as this would undermine the FCC in future auctions. The result of this decision was a number of bankruptcies of licence owning firms. Once these bankruptcies took place the licences became embroiled within the bankruptcy proceedings effectively freezing the development of infrastructure on the spectrum that they were issued on. By January 2000, of the almost 1000 licences that had been awarded in the F and C block auctions only 25 licence holders were offering services. Due to the government financing agreements that had been put in place, the government directly lost revenue. Those companies that filed for bankruptcy still owed the government over $8bn (Cramton, 1998).

The success and failures of the European licence administration procedures have been discussed in the previous six chapters. Perhaps one of the most interesting aspects of the whole procedure was the attempt by a large number of national governments to increase competition at the network level. The results from Tables 1.1 and 1.2 have already shown the attempts to administer more licences than there were incumbents and, in many cases, the failure of this policy as licence holders either left the national market or, as will be discussed, began establishing joint networks.

8.4.2: Spectrum Trading

How to manage the radio frequencies that mobile telecommunications, as well as many other services, require has come under increasing scrutiny. Most developed economies have historically opted for a 'command and control' approach to spectrum management. The regulating authority decides how much spectrum a particular industry will receive and determines which companies will be able to use it.[5] Once usage guidelines for a particular piece of spectrum have been identified they are fixed for a period of time. Both the spectrum that was used for GSM and UMTS in Europe was decided and administered on a command and control basis. The advantage of having this harmonised spectrum is the certainty it provides for infrastructure and network investment, and the economies of scale provided by a common EU standard. Cave (2002) compares the success of the European GSM standard against the relative poor performance in the USA which had a fragmented communications base. Having said this, there was a certain amount of flexibility for the NRA with spectrum management. As Cave discusses, both the UMTS and GSM spectrum could be used for areas other than mobile telecommunication as long as sufficient spectrum is available for the service that is required.

Administering and controlling radio frequency, by command and control, has been criticised for a number of reasons. The amount of time it takes to make the decision over what to use the spectrum for, and then to administer it, can take a number of years. A current example of problematic spectrum management is the imposition of a standard for mobile television. In July 2007, the EU made a decision to back the DVB-H standard for mobile television. For some countries this decision is of no concern. Italy has already begun offering mobile television using that particular standard. However, in the UK it is possible that delays will occur in offering mobile television using this standard. The allocated frequency band falls within the UHF band. These frequencies are currently

[5] It should be noted that in some cases international guidelines are laid down for where on the radio spectrum an industry should operate.

being used for analogue terrestrial Television. Some of this spectrum will not be available until 2012 when the full digital switch over (DSO) has occurred. It will also impact upon companies such as Virgin UK, which are already offering mobile television through the Digital Audio Broadcasting (DAB-IP) technology. Companies such as these may be forced to switch the standard they are using.

If there is a strict command and control approach in place then those who 'own' spectrum may not be able to put it to its most profitable use because of the restrictions placed by the NRA. Spectrum must be used in the blocks that it was assigned in. There may be no option to sell or lease off small parts of spectrum that are not being utilised. To actually carry out spectrum trading in this command and control environment would be extremely difficult. Farquhar and Fitzgerald (2003) look at the system for administering and controlling spectrum in the US. They identify those areas that would need to be reformed in order to create an efficiently operating market for spectrum. These include the elimination of usage restrictions on all newly administered spectrum, and spectrum that has already been administered. It also requires the removal of preapproval to use spectrum for a particular service. Instead of usage restrictions, emissions criteria and power limitations would be put in place to prevent interference. Also, where the NRA sets a usage/power limit that a company considers to be overly restrictive, they should be allowed to contact potentially affected parties and buy out their protection rights. This is, of course, if an agreement can be reached. This idea could be taken further to allow, not only the trading of spectrum, but also the trading of emission rights between those companies that may interfere with each other. This focus on power limits as well as blocks of spectrum could also be considered at the administration phase. Instead of the current system of offering particular blocks of spectrum, the administering authority could offer several licences for the same block of spectrum but with different power outputs. This then gives the bidders the opportunity to either bid for all power usage and get the complete licence or, if technologically able to, bid for only part of the power usage. Although some of these recommendations are particular to the US market they could equally be applied to the European market. Although technically possible it may not necessarily be politically desirable to have this level of freedom in spectrum usage. In general and given the current technological constraints, a system of spectrum property rights is preferred to a commons approach where spectrum use is open to all. Indeed Crocioni (2008), when examining those factors that can bring about an efficiently operating secondary market for spectrum, identifies that spectrum rights that do not enforce usage restrictions but rather have interference restriction, incentivises the development of more spectrally efficient technology. This applies to the type of technology that is used on the transmission and reception side.

The ability to buy and sell radio spectrum was in some cases laid out in the licence conditions. Unfortunately, in the majority of cases it was not clearly defined whether the licence holders had the right to sell on the spectrum in these licences or indeed to buy additional segments of spectrum. This is despite the fact that as early as 1998 the UK government were looking into a secondary market for spectrum trading.[6] The lack of explicit decision-making around spectrum management made it an area in which a lax regulatory stance could be taken. If all radio frequencies were traded it is likely that there would be an increase in the amount of spectrum available for telecommunication networks. This is due to the relative value of spectrum in the mobile telecommunication sector when compared to other uses. In addition to this being able to trade spectrum in a secondary market would correct for any inefficiencies in the original administration procedure.

We may expect spectrum to shift from other uses to mobile telecommunications. Taking the total market for spectrum, the formation of a secondary market is not a simple task. The exact nature of this market is not clear. This is partly to do with the multi-dimensional nature of radio spectrum; it has a particular bandwidth over a particular geographic location and usually over a set amount of time. Radio spectrum is usually put aside for a particular task and this is often in accordance with some international agreement. In some cases radio spectrum may be used in units smaller than the size of a

[6] Managing spectrum through market forces. Radiocommunication Agency of the Department of Trade and Industry (1998)

country. In different parts of the country it may have different uses. If we think in terms of mobile telecommunication there may be technological restrictions on the radio spectrum that can be used and the size of units it can be sold in. However, the spectrum market reforms and technological changes may make these problems obsolete.

The situation can be simplified by only considering the option of 3G licence holders being able to sell spectrum, either between themselves or to others, rather than an entire market for trading spectrum. If spectrum trading is allowed then the number of mobile operators is potentially no longer fixed.[7] It has been argued that incumbent operators will be averse to spectrum trading (Valletti, 2001).[8] However, what is to stop operators gaining significant market power by buying up all additional spectrum? In the early stages of network development spectrum trading may be considered beneficially as some spectrum owners would not be able to utilise all of their spectrum.

At a European level there is an interest in changing the way radio spectrum is treated. This is laid out in the Review of the EU Regulatory Framework for Electronic Communications Networks and Services. This document moves the EU away from exclusive usage rights. They no-longer merely wish to prevent interference and maintain standards. Mobile telecommunication standardisation and harmonisation occurs at an international rather than European level, meaning spectrum trading within this industry may pose additional difficulties. These may only be short-term problems as new technologies improve efficient use of spectrum. The technological improvements will not only improve the efficient use of existing spectrum but also open up additional spectrum that can be used for the mobile telecommunications sector. Cave and Crowther (2006) give an overview of the development of European spectrum liberalisation since the introduction of the competition directive in 2002. They find that although the EU has moved towards a market based approach there still needs to be further work to harmonise the level of liberalisation across member states.

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[7] This to a certain extent is dependent on technological constraints and the amount of spectrum each needed.

[8] Valletti (2001).

8.4.3: Mobile Virtual Network Operators (MVNOs)

There is a certain amount of confusion over the exact definition of MVNOs and there is no clear consensus of opinion surrounding them (Landgrebe, 2002). Mobile Network Operators are those companies that own a network and have acquired a licence over a certain amount of spectrum. Any company that does not have ownership over spectrum cannot be considered to be an MNO. If we take the most stringent definition of an MVNO it would be a company that has ownership and control over its own network infrastructure and only buys access to the MNOs spectrum. This type of MVNO may be considered to be spectrum trading light. Although the MVNO does not own the rights to the spectrum they are free to operate on it. There is a question over the amount of network infrastructure that an MVNO must own to qualify as an MVNO. Some classifications state that an MVNO must have at least a network of switching stations, others that they do not necessarily require any infrastructure at all to be classed as an MVNO. It is generally agreed that at an absolute minimum the MVNOs must have control over SIM cards. With this level of control, the MVNO would be responsible for the information held on subscribers and the subscribers' ability to connect to a network.

If the company does not control the SIM card then it must be some form of Service Provider (SP). These companies can vary in the amount of control they have over the services they sell, in general they are heavily reliant on the MNOs. The SP would buy wholesale subscriptions and then control billing and have some limited control over other services and special offers. These SPs do provide competition for the MNOs' retail outlets but as they are in effect franchises of the MNO there is no addition to competition at the network level. There is very little scope for the SP to adjust call packages or pricing as these are largely controlled by the MNO. In contrast to this, an MVNO should have a large amount of control over pricing and package content and thus provide greater competition at the network level. Dippon and Banerjee (2006) argued that an MVNO does not necessarily need any network infrastructure as long as they have a strong brand identity, usually built up in the non-telecommunication sector. The MVNOs must then provide a well branded product that differentiates itself from the

MNO brand. If the MVNO operates in other industries it will offer bundles of products alongside mobile services. An example of this would be Virgin Mobile UK which offers TV, Broadband and Mobile telecommunications in a single bundle. It is these types of services that allow MVNOs to reach markets that MNOs have been unable to penetrate. In the short and medium term MNOs find a use for their spectrum through the wholesale market that they cannot use in the retail market. This has to be weighed against the potential cost to an MNO brought about by erosion of their market share, downward pressure on the average revenue per user (ARPU) and, as more spectrum becomes utilised, network congestion. The number of MVNOs would appear to be increasing across Europe. In 2007 the European Commission classed 290 firms as MVNO/service providers, an increase of 76 firms on the previous year; this compares to a constant 79 MNOs (European Commission, 2007, p41).

A further area of contention for MVNOs is network roaming. It is often the case that MNOs have roaming agreements among themselves. This is in order to achieve greater network coverage or may be part of the licensing agreement. This will also often be the case cross-nationally. If an MVNO obtains the rights to use a certain amount of spectrum from an MNO this does not mean they have the right to roam on the other networks that the MNO may roam on. Indeed, Gabathuler and Sauter (2004) report on restrictions of MVNOs being able to roam on other networks in Germany This may mean other MNOs have the ability to limit the coverage of MVNOs (this would be the case where roaming agreements have been extensively used). At this point the only companies that could be considered close to a pure MVNO would be Tele 2 in Denmark and Germany and Sense in Sweden and Denmark.

A question remains as to whether there is a need for regulation to enable MVNOs to operate. For this to be justified the MNOs would need to have market power and be abusing it. Dippon and Banerjee (2006) argue that in developed economies there is sufficient competition between mobile networks to allow the market to form naturally. Indeed they identify the ability of MVNOs to access markets that the MNO would struggle to access, thus not be cannibalising subscribers from the MNO's network, as a as a reason why the MNO would be happy to sell to the MVNO at the wholesale level. This has been the view of the majority of countries in the EU leaving this part of their wholesale access networks unregulated.[9]

The access of MVNOs to MNO networks falls within the realm of the New Regulatory Framework, specifically the "access and call origination on public mobile telephone access". If MNOs were considered to have SMP in this area then an MNO could be forced to open their networks up to all MVNOs. In general, NRAs found little evidence of SMP in this section of the market. A discussion of the UK analysis can be found at a later point. Only Slovenia and Spain identified SMP and suggested action which was eventually approved by the EC. The fact that the number of MVNOs, in some form or another, have been growing so substantially would seem to support this analysis.

8.4.4: Network Sharing

A similar issue to that of MVNO is the volume and depth of MNO network sharing. The volume of network sharing is in terms of the number of MNOs that can share a base station and the percentage of population that can be shared. The depth of sharing is in terms of the level of infrastructure that the MNOs can share at. Again, the way that network sharing could take place was often not clearly laid out in the licensing conditions and so was left to the post-administration discussion. The sharing of infrastructure involved those companies that owned licences, and so owned radio spectrum, coordinating their activities in order to save costs in the provision of mobile networks. Infrastructure sharing can be broadly split into three categories. The MNOs can either share actual network infrastructure, each operate a segment of a network on geographic grounds or have one operator building a network and the other MNOs piggyback on it.

The main form of infrastructure sharing would include the sharing of sites, masts and other network infrastructure, but still with two identifiable networks. This type of network sharing is usually split into two types. Either the Radio Access Network (RAN)

[9] See Dippon & Banerjee (2006).

level which includes the masts, power supplies, base stations (Node Bs) and Radio Network controllers, which control the Node Bs which link to the core network. The core network would be the next level of network sharing.[10]

The alternative form of network sharing would be for the geographical segmentation of a country. Each network operator would build their own network at the infrastructure level but in different geographic segment. Each operator then agrees that all the other operators that are part of the agreement can use their geographic segment. The option is particularly attractive when the MNOs are committed to strict roll-out conditions within a limited time-frame. A slight variation on this model would be for all operators to set up networks in core areas while splitting up less profitable areas such as rural zones. This type of network sharing is essentially a national roaming agreement. If left unchecked there is a danger that this type of behaviour could cause a country to have a fragmented series of small linked networks rather then any national networks.

The final most complicated version is where a considerable amount of infrastructure is shared. This extreme would involve a single company operating a network infrastructure on behalf of several licence holders. We then have a single network company "Necto" and the licence owners becoming service companies "Servcos". The Servcos then rent space on the Necto's infrastructure whilst using their own spectrum.[11]

Infrastructure sharing makes it considerably easier and cheaper for licence owners to meet their roll-out obligations. They are able to share parts of their infrastructure and in some cases they will not have to develop network in certain areas. As a side issue, network sharing is considered desirable as it reduces the environmental impact of each licence owner building separate physical infrastructure. The network sharing agreement between O2 and T-mobile, which was the first to go before the EC for approval, was an important precedent. They planned to share network up to but not including the Node B

[10] See Oftel (2001a)
[11] See Oftel (2001a) for a discussion of the competition issues associated with Servcos and Nectos.

level. This would mean that they were not sharing at the core network level. More detail of these agreements will be discussed in Section 8.6

8.5: Non-licence regulatory issues

8.5.1: Competition and Concerns over Significant Market power

The previous section has dealt with those regulatory issues that were in some way linked to the 3G licensing. This section will focus on those regulatory issues that have arisen outside of the licensing process. Although not directly linked to 3G licensing, these regulatory decisions still allowed for regulatory easing within the 3G sector. The two most widely used forms of non-licence regulatory controls are pricing controls and interconnection controls. These would include controls against abusive retail pricing and international pricing. This may come in the form of mobile to mobile (M2M) or fixed line to mobile (F2M) tariff regulation. A key concept behind phone networks is that they are able to interconnect. There is an obligation for EU telecoms networks to interconnect.[12] The interconnection between two networks is a commercial agreement of which termination charges are a part. Further to the obligation to connect NRAs should also assess if any operators have significant market power (SMP) within this market.

The determination of market power that is in line with the New Regulatory Framework was discussed in detail in Section 8.3.2. If there is evidence of SMP then the NRA are obliged to take corrective action. When assessing SMP NRAs have been given a relatively free hand; this can be seen in the analysis of SMP within the UK market as discussed later in Section 8.7. The European Commission laid out guidance for what would constitute significant market power.[13] These included the size of the operator, control of infrastructure, vertical integration, existing retail network among other. These guidelines were built upon by the European Regulators' Group which suggested taking into account pricing behaviour including perceived excessive pricing behaviour, the potential for market entry and barriers to switching within an industry.

[12] see Gual (2003) p38, p47 (access directive) (European Commission (2003a)

[13] Commission Guidelines on market analysis and assessment of significant market power under the Community regulatory framework for electronic communications networks and services.

One particular area where MNOs are considered to have market power is the pricing of interconnection charges. When a user makes a call their network provides originating access and the receiving network is said to provide terminating access. The Calling Party Pays (CPP) principle means that the fixed subscriber that calls a mobile subscriber will pay the cost of the call termination. This is as opposed to Mobile Party Pays (MPP) where the mobile subscriber pays the call termination charge. Most of the world operates a CPP system. A notable exception is that of the USA which operates a MPP system. The individual making the call may not know the network that the mobile owner is a subscriber on. If they do not know the price they are paying for the call then they have no ability to respond to pricing incentives and change their calling behaviour. The caller also has no choice over which operator terminates the call. As the users do not respond to changes in price the operators do not then have any incentive to lower their prices. As such it is suggested that mobile termination rates will not be constrained by competitive forces. The issues that surround call termination and market power were discussed in Section 8.2.2. Although there may be intense competition at the wholesale level and between mobile operators in other areas, as the cost of a call from a fixed line is hidden there is no incentive to compete in this area. So a high termination charge will not influence the number of subscribers to a particular network. An exception to this would be so called closed user groups as will be discussed in the next section. It was thought to be a particular problem with the F2M mobile charges. Fixed network operators have their termination charges regulated. As such they do not have bargaining power. As we shall see in the next section there have been a number of approaches put forward to deal with this problem. The conventional wisdom amongst regulators is to impose price caps on these termination charges.

8.5.2: Termination Charges

Mobile termination charges are the charges placed by a mobile operator to terminate a call with one of their subscribers. When a call is made to a mobile the caller will pay a retail fee for their call to be accepted and then the call, to be successful, must be terminated. These termination charges are purchased by the caller's network at the wholesale level. The market for these calls is often seen as a two-sided market. There is the caller and the receiver, the price structure between the two will determine call volumes. We should remember at this stage that the networks operate on a CPP principle so the termination fee will be completely paid for by the caller.

It has generally been accepted that these termination charges are considerably higher than costs and that mobile licence holders are able to exert monopoly power over calls to their networks (Gans and King, 2000). It is ironic that in developing countries mobile operators are receiving unreasonable interconnection payments from the fixed line operators, whereas in most developed countries, where fixed line operators are forced to provide access and restricted their interconnection charges, mobile operators are charging above cost termination charges to the fixed line operators. Armstrong (1997, 2002) discusses the incentives that mobile operators have to push their termination prices towards the monopoly level then cross subsidise to other areas. Armstrong took the example of F2M termination charges with two mobile operators and a regulated M2F charge. Each mobile operator has an incentive to increase their termination charges to the fixed line operator and provide a subsidy to attract a greater number of subscribers. The mobile operators would not be making abnormal profits as all of this extra money from termination charges would go into the subsidisation of subscriptions. However, they would still be making monopoly profits from the termination charging and there would be the deadweight welfare loss associated with this. When Armstrong accounts for internalising network externalities he finds that the level charged by network operators will still be above the level which would be welfare maximising.

With the current technological constraints, the only operator that can terminate a call to a mobile handset is the operator the user subscribes to. This operator has absolute monopoly power over termination on their network. This is the case no matter what the size of the MNO. Indeed Laffont and Tirole (2000) argue that smaller MNOs will have greater market power due to smaller firms facing inelastic demand for their termination services. The wholesale prices that a larger firm charges will have a greater impact on the final price than that of a smaller rival, this is assuming that retail prices are not dependent on where the call terminates. Even if the retail price does depend on the network that is being called it may not matter. If users are ignorant of the termination cost or of which network they are connecting to, then they will still not receive any pricing information. When determining their call demand it is assumed they will use average call prices. So if a network increases their termination rates all networks suffer a decrease in calls. A smaller network will have less impact on this average price and so less impact on demand. As such, termination charges on a smaller network are less price elastic than those on a large network. For this reason it has been suggested that a mobile market with a large number of network operators would actually lead to higher termination charges.

The mobile operators accept, to an extent, that their termination charges were above costs but give a number of reasons for this.[14] The MNOs argue that they charge high termination charges in order to subsidise subscription charges and handsets. They justify this from the positive externalities gained by other mobile users of having additional users to call and by fixed line users who have the option of connecting with mobile users. The argument is that the network externalities that were discussed in Section 8.2.2 are internalised by transferring the excess pricing of termination charges into a subsidy for subscriptions and handsets. Those who will gain through having more users to call, pay some of the costs of these users joining the network. It is then argued that through competitive forces within the industry, operators will select the optimum level of cross subsidy. Albon and York (2006) find that MNOs have "neither the incentive nor the ability"[15] to subsidise at the socially optimal level. Even if we accept that termination charges are used in this way, once an industry becomes mature there should no-longer be a need for this type of subsidy. Everyone who wishes to will have already joined the network. Operators have also claimed that termination charges should not be looked at individually but rather as one within a bundle of mobile phone services that the user buys. As such, each operator should not be considered to have monopoly power as there is plenty of competition for these bundles. Even though it is true that there is

[14] See UK case study for some of the particular excuses that were used to explain termination charging.
[15] page 380.

competition at this level, it does not detract from the SMP that is held by each individual operator.

Crandall and Sidak (2004) identify substitutes to FTM calls as MTM, MTF, FTF and data messages although these vary in how closely they can be considered substitutes. If we consider a fixed line user who wishes to contact a mobile user in a particular instant there are in fact no direct substitutes.[16] No other substitute offers the ability to communicate with a person at that instant wherever they are without connecting to their mobile. If it is accepted that mobile calls have no direct substitutes then it increases the inelasticity of demand for call termination. A mobile user is in a slightly different position as they have the ability to send data messages. Also a distinction needs to be made between MTM calls from a different network and those calls on the same network. An MNO would not wish to increase termination charges on calls made between mobile users on its own network. If they did, it would impact directly on their own customers. This is one of the reasons that it is not unusual to see greatly reduced prices for calls between mobiles on a particular network compared to off-network.

It is possible that termination charges do have an effect on the mobile subscribers' behaviour if they care about the price that the caller is paying. Valletti (2006) identifies some of these "closed user groups" as "families that behave under a single budget constraint, or some business users who provide different sorts of telephony services to their employees."[17] It is also possible however for the mobile operators to circumnavigate these concerns by price discriminating between groups. Families can be placed on so called "friend and family networks" so that calls from certain numbers will incur a smaller charge and business networks can be offered similar discounts. As such these groups do not need to affect the overall price level that is being charged.

The SMP held by each network provides a justification for intervention. In general this intervention has taken the form of caps on the amount that can be charged for

[16] Although it is now possible to send and receive text from fixed line phone if the user has an enabled phone.
[17] Page 72.

termination pricing. As with all regulatory pricing decisions the exact level at which to place the cap is difficult to determine. Valleti and Houpis (2005) report on the use of Long Run Incremental Cost (LRIC) calculations as a bench mark for the price cap with a potential mark-up to account for those externalities already discussed. Determining the mark-up for these externalities may also be problematic. Oftel took the approach of examining Rohlfs-Griffin factor (Rohlfs, 1979 and Griffin, 1982). The Rohlfs-Griffin factor is the ratio of social value to private value when a new subscriber joins a network, or in the case of termination charges, the social and private value of a call being made. The larger the Rohlfs-Griffin factor the greater the charge allowed for network externalities. If the ratio is 2 then none of the network externalities from an additional subscriber is internalised. In this case, the value of the call to the two users is the same and so the social benefit is twice that of the private benefit. This assumes that the benefit to other subscribers does not exceed the private benefit of the new subscriber. At the other extreme the ratio has a value of 1 where the private benefit is equal to the social benefit so there are no externalities.[18] Oftel estimated that these RG factors lie between 1.3 and 1.7 (Oftel, 2001b).

The methods of regulating termination charges across Europe do differ. Depending on the definition of SMP that is used, how important externalities are considered to be and how to adequately determine the correct cost structure for termination.[19] The type of mobile services may also affect the level of regulation with some countries not initially placing any restriction on 3G termination charges. These differences are likely to decrease as the EU's Mobile Service review comes into effect. There have been suggestions that the level of cap may also be affected by other regulatory considerations for instance the level of spectrum fees. For a more detailed discussion on the way SMP was judged and how the appropriate level of termination pricing was determined see the discussion of UK regulation that follows.

[18] It is possible for the Rohlfs-Griffen Factor to be less than 1 if the externality is negative.
[19] For a review of different measures of termination regulation see Valletti and Houpis (2005) p236.

8.5.3: European Roaming Fees

An area that caused particular concern in the EU was the cost of using mobile telecommunication services in an EU country that was not the subscriber's home country, so called international roaming. The EU approaches regulation from two perspectives; an efficiently operating market and further EU integration. On both counts a persistent pricing concern surrounds international roaming fees. Despite the decreasing cost of using mobile phones, and the widespread use of them across Europe, roaming charges have remained high. Fees on cross European calls take two forms. These are an extension of termination pricing. In this case we have both CPP and MPP. Both the calling and the receiving party pay a fee. Sutherland (2001) gives a review of the issues that surround international roaming. International roaming came about with the advent of GSM and was credited as one of the reasons that GSM became so popular in Europe. When a mobile user enters a foreign country their mobile will provide them with a list of possible networks they can connect to. They are able to connect to a particular network if the user's home operator has a roaming agreement with that particular network. Where an operator has networks across Europe these will usually be connected as preferred networks. The preferred network will be held on the SIM card. A user can select an alternative network manually and then their phone will always connect to this network if it is available. Two operators may agree to place each other on their preferred list. If there is no preferred network in range, and the user does not select a network manually, the handset may select a network at random. This selection will be based on the strength of signal at that time. Although not a problem in Europe an issue can arise as SIM cards do not have sufficient memory to hold preferred lists for all possible countries. MNOs have avoided having exclusive roaming agreements as it would limit the potential roaming coverage and it would mean they would get less roaming traffic on their own network. Depending on the type of call they are making the preferred network is not necessarily the cheapest. Also, given both the receiving and the calling party pays, it may be cheaper, rather than answering an incoming call, to wait and return the call from the mobile.

The European Commission became concerned at the level of roaming charges and launched an investigation in 1999.[20] Concerns were raised after an International Telecommunications Users Group (INTUG) survey finding that the difference between international mobile calls on roamed and non-roamed networks was up to 500%.[21] They identified two markets that existed within the broad international roaming market. These are the wholesale and retail markets. The Commission believed there was evidence of at least tacit collusion as operators across countries charged similar prices at both the wholesale and the retail level. Linking back to licensing, the European Commission was concerned with the barriers to entry, particularly in the wholesale market, brought about by a limited number of licences. Even on the retail side they found average prices have been increasing.

Salsas and Koboldt (2002) argued that the problem comes about through the inability of MNOs to direct their subscribers onto a particular network. They conclude that an operator would have little or no increase in demand if they decrease their wholesale price. As such, operators would do better to compete by increasing their network coverage. For the subscriber it is not as simple as knowing how much a particular network will charge. There is a particular problem separating the retail and the wholesale prices. These prices can vary over the course of day and at weekends. This may also vary depending on how many calls an individual makes. For example, a mobile user may find that the billing structure changes when they are roaming. Instead of being billed by the second, they may find they are being billed by the minute. The time of day when they receive discounted calls may be different when they are roaming. In some case this may vary from country to country. For instance in France Saturday morning is still considered to be peak time.[22] Indeed in a number of cases the MNO made it explicit

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[20] European Commission, EC Working Document on the initial findings of the sector inquiry into mobile roaming charges of 13 December 2000 (the EC Working Document), available online at
http://europa.eu.int/comm/competition/antitrust/others/sector_inquiries/roaming/working_document_on_initial_results.pdf.

[21] Sutherland (2001) p9.

[22] Sutherland (2001) p8

that they could not guarantee the price their subscribers would pay when roaming internationally.

With the importance of international roaming growing, the pricing structure has begun to change. Depending on contractual arrangements it is possible to get a flat rate for calls made to the user's home country no matter which network they are roaming on. Or a flat rate from a particular country no matter which network they are roaming on. An alternative option used by Vodafone was to encourage manually selecting a certain network to roam on. This plan known as Eurocall used reciprocal IOT discounts. Networks on the plan would charge each other a special lower tariff and other networks a higher tariff. Even if a MNO is charging a fixed roaming fee this does not mean that a subscriber will necessarily be using the cheapest option for their particular call. This may depend on how charges change throughout the day. However, it may encourage increased competition in roaming fees as these become a greater part of user contracts. Technological changes are making it easier for MNOs to direct traffic onto particular networks. These include SIM cards that allow over the air programming that would allow an MNO to select the network that the user will roam on. This has the potential to allow them to switch to the cheapest networks at any particular time. There is an additional concern with 3G international roaming over whether full data services will actually be available.

8.5.4: Other Regulatory Considerations

Other areas of regulation that 3G licensing has had less impact on surround customer access regulation and universal service performance. Customer access regulation which involves number portability and rules that affect the use of SIM-cards have been relatively set for several years and are unlikely to change. Mobile users in the EU gained the right to hold onto their mobile number due to the EU's Universal Service Directive 2002. This gives the mobile user the right to keep their number even if they switch service providers. Service providers could charge for this service but this charge had to be proportional to any cost incurred. Buehler et al. (2006) outline the benefits of mandatory number portability. They benefit the customer by greatly reducing the cost of switching; this is assuming that having to change a mobile number imposes some cost upon the user. Also, by reallocating the property rights of the number to the mobile user they provide an incentive for customers to invest in 'vanity numbers'. In addition to this, those individuals who wish to contact the mobile user do not have to incur any cost through number search.

Allowing number portability should increase the amount of competition in the market. Ofcom saw the inability to retain a number when switching provider as a significant switching cost (Ofcom, 2006, p4). By allowing number portability, switching costs are reduced and entrant firms are able to compete. Allowing number portability does exacerbate one of the regulatory problems already identified. There is a potential for a problem to occur with number portability and termination charges. In the early development of mobile telecommunication, each network had particular numbers that were assigned to it. This meant that it was possible for a user to identify the network that they are calling from the starting digits of the phone number. Buehler and Haucap (2004) discuss how, once this relationship had broken down, it exacerbated the consumer ignorance problem with regards to pricing. Unless the caller was informed by the mobile user, it was no longer possible to identify which network the caller is calling. Although this is a problem, it is not the sole cause of the market failure around termination charging and the gains from number portability outweigh the loss. The universal service issue has been largely covered with the renegotiation in spectrum licences. The level and coverage of service is usually included as one of the preconditions for holding a licence.

8.6: European Regulatory Easing

So far this chapter has focused on those particular regulatory issues that have been dealt with in the mobile telecommunication sector. The aim is to inform the next section's discussion and to add context to the documentary evidence that both at a European and national level regulators engaged in an easing of regulation. After the administration of 3G licences there was concern over the level of indebtedness and in turn that licence winning firms would not be able to achieve their roll-out commitments. This led the EC to outline its position on regulatory relaxation and licence re-negotiation (European Commission, 2002b). This communication did give a slightly mixed message and was interpreted by some as the Commission taking a hard line with the licence winners. This came from the statement that *"in principle the licensing conditions should not be changed"*. However they go on to place a caveat on this statement saying that licensing conditions can be changed when the market has *"changed unpredictably"*. In essence this sanctioned a wide raft of changes, as it could be easily argued that the market had changed unpredictably. The EC appear to be sanctioning regulatory easing in response to unpredicted negative payoff shocks but not for simple mis-pricing of assets. The communication then went on to suggest some possible changes including extending roll-out periods, treating issues that were not explicitly mentioned in the licensing conditions in a favourable way, and only gave vague concerns around refunds of licences. The only measure they explicitly advised against was the extension of licence periods as it was thought that this would not help the short-term situation. As was discussed in Chapter 4, it was entirely possible that once an operator was in possession of a spectrum licence, once the licence term had ended it would be extended anyway.

The EC's advice would then appear to have placed most of the onus for regulatory easing onto the NRAs. Indeed, the EC's behaviour with regards to roaming charges would suggest that they still prioritised competition in the EU market over helping the 3G licence holders. However, two areas that would appear to give a clear indication of a relaxed approach by the EC can be seen in decisions on the sharing of network infrastructure and the approach of the EC to mobile content owners.

Network infrastructure sharing has already been discussed and the potential savings that it can bring. The first case that the Commission considered was a proposal by O2 and T-mobile that involved sharing network infrastructure in the UK. The Commission had concerns over network sharing under Article 81(1) Treaty of Amsterdam (85(1) Treaty of Rome). The concern was that if the MNOs all incurred a common cost it would feed through to less competition at the retail level (88). There was also a concern that both parties had a similar plan for rolling out their network and this would lead to less overall geographic coverage (89). An issue that attracted particular attention was that network sharing in this agreement would block other operators from the sharing of infrastructure. This was because each operator in the agreement gave the other first refusal on site sharing of new sites. Further to this, if access was allowed by a third party not in the agreement then this would be at a price equal to or greater than the price for those in the agreement. Once this was added to the concerns around national roaming, the EC came to the conclusion that the agreement was in violation of Article 81(1).

However, the EC decided to grant O2 and T-mobile an exemption under Article 81(3). This exemption was granted as network sharing was considered to aid the production process as it increases roll-out speed with higher geographic coverage and better transmission rates. The EC also believed that network sharing would actually increase competition due to the competition with the non-agreement operators. Firms would not seek to minimise costs rather than maximise their network coverage. This ruling also laid down the position for future requests for network sharing agreements. If an NRA wishes to approve a network sharing agreement it must do so within the confines of Article 81(1) and 81(3).

The second instance of support of 3G MNOs came with the EC's approach towards potential 3G content. Clearly with faster transmission speeds a key area of expansion is to provide content that takes advantage of these transmission speeds. An example of the EC forcing content owners to give up some of their content rights came with the decision on the commercial rights of the UEFA Champions League. Petit (2004) reviews how the EC attempted to support 3G MNO through opening up transmission rights. UEFA members allow UEFA to negotiate joint-selling agreements with TV buyers. This was considered a violation of Article 81(1) as it prevents individual clubs taking individual action over their viewing rights. It also prevented TV content being shown on other media. In response to this conclusion, UEFA put forward proposals to unbundle the transmission rights which would crucially include the UMTS market as a single market. The EC explicitly stated that part of their objection to UEFA's behaviour was motivated by a desire to improve MNOs position. The new proposals will provide "*...an impulse for the emerging new media such as UMTS services*" (European Commission, 2003b) This approach to mobile content was continued with the agreement over marketing systems for Bundesliga broadcasting rights (European Commission, 2003c) and the agreement with the FA Premier League and BSkyB over football content rights (European Commission, 2003d). These agreements sought to reduce dramatically the time between a match being shown live, and footage being shown on Mobile phones. The agreements also sought to increase the amount of footage that could be shown on mobile networks. This became a more formalised policy when the EC launched an inquiry into the sale of sports rights to Internet and 3G mobile operators (European Commission, 2004).

8.7: The UK Market

8.7.1: 3G Post-Administration in the UK[23]

The UK mobile telecommunication market post-3G licence administration poses a slightly unusual case study. The regulatory position taken in the licensing differed from that taken in many other countries. One of the most notable differences is the starting position of having relatively light roll-out condition. This meant there was no need to extend the roll-out period as was done in countries such as Spain, Portugal and Belgium. With the first roll-out condition not needing to be met until 2007, and the politically and legally sensitive issue of giving some form of refund not being considered as an option, there was only a limited scope for licence condition easing. Given that there is no requirement for a fast roll-out it could be questioned why any regulatory easing was required. If there was an easing of regulatory stance this would have been due to some implicit desire for a speedier roll-out of 3G infrastructure or a concern over the sustainability of mobile telecommunication market. The only options open to the regulator were changing regulations around spectrum management (in the form of spectrum trading, network sharing and the position of MVNOs) and any controls on pricing.

[23] For a review of the administration of licences in the UK see Chapter 2.

The UK was generally open to allowing operators to share networks, however there were concerns over how it could affect competition at the network level. As with most 3G licences there was no a priori exclusion of network sharing. There were concerns that any infrastructure sharing did not violate the Wireless Telegraphy Act.[24] There was an obligation on NRAs to encourage physical infrastructure sharing from Article 11 of the Interconnection Directive.[25] In addition to this, there were concerns that the balance between encouraging infrastructure sharing but not allowing companies to engage in anti-competitive behaviour was maintained. It was thought that less competition would mean that network coverage and quality would be lower. If infrastructure sharing was to take place it would need to conform with UK Competition Act 1998 Chapter 1 competition prohibitions which "prohibits agreements which have the object or effect of preventing, restricting, or distorting competition and that may affect trade within the UK"[26]

The UK uses a relatively loose definition of MVNOs. An MVNO is considered to be a service provider that has control over SIM cards, billing and their subscriber database. In the early stages of mobile development, retail mobile services had to be offered by service providers. This was the case when there were only two MNOs and it was thought that there needed to be an additional layer of competition. Ofcom's weak form MVNO means that companies like Virgin mobile and Tesco Mobile counts as MVNOs even though they have no physical infrastructure.[27]

Regulation of pricing comes about because of the two issues discussed in Section 8.5 Regulators have a desire to cut termination charges and cross-Europe roaming charges. The current charging was thought to be greater than the "true cost" The problem then becomes identifying whether regulatory changes that are adverse to the MNOs would have been more severe if it had not been for MNO lobbying.

[24] See Ofcom(2001) 3G Mobile Infrastructure Sharing in the UK.
[25] European Parliament (1997a).
[26] Oftel (2001) section 14.
[27] Oftel (1999).

8.7.2: Mobile Network Operators and Market Power.

Before considering possible regulatory interventions, Oftel and then Ofcom attempted to identify significant market power within the mobile market. The European Commission laid out guidance for what would constitute significant market power.[28] This guidance has already been discussed and included the size of the operator, control of infrastructure, vertical integration, the existing retail network, pricing behaviour including perceived excessive pricing behaviour, the potential for market entry and barriers to switching within an industry. As was outlined in Section 8.3.2, this was all brought about by the EU's new regulatory framework. Most of the EU directives were implemented in the UK through the 2003 Communications Act.

Ofcom came to the conclusion that each MNO had SMP. It may seem counter intuitive to say that every operator in the market has SMP, particularly when given the number of operators in the mobile market. Ofcom did this by narrowing the definition of the market they were considering to the termination of voice calls on each particular network. As each MNO has 100% control over the termination charges on their network by definition a licence holding MNO would have SMP. By defining each market in such a way they also inferred greater barriers to entry. At this point in time it is not possible for a MNO to terminate the calls of another network making entry virtually impossible. These findings, added to the fact that Ofcom considered the pricing to be above the cost of call termination, led them to seek corrective action. By contrast when considering the retail side of the mobile telecommunications market Ofcom find MNOs do not have SMP.[29]

The MNOs in the UK lobbied against controls on termination rates. Originally they put forward the argument that MNOs would not raise termination rates as doing so would reduce calls to mobile phones and therefore reduce their profits.[30] This was particularly the case as the number of MNOs had increased. Oftel believed the termination charge

[28] Commission Guidelines on market analysis and assessment of significant market power under the Community regulatory framework for electronic communications networks and services.
[29] Oftel (2003)
[30] Newbery et al. (2000)

could get as high as £0.25 per minute[31]. The MNOs also put forward Ramsey or near Ramsey pricing as an excuse for higher termination charges in order to cover the fixed costs they incurred from building networks.[32] Vodafone was one MNO that argued along these lines, suggesting that calls to a mobile are relatively more price inelastic than other telecommunication services meaning that MNOs are justified in charging higher termination charges. In their response Vodafone stated that "pricing structures are consistent with Ramsey outcomes"[33] When these arguments were rejected by Oftel the MNOs began lobbying on the grounds that termination rates should be greater than the marginal cost to help recover the fixed costs of licences and network roll.[34] Indeed mm02 directly linked the speed of 3G roll-out with price controls. They threatened that if the UK introduced tight control over termination charges they "...would have to cut back on 3G investments [meaning] other markets would be materially ahead of this country."[35] Again these arguments were rejected on the grounds that it was not made clear at what level termination charges were set to recover fixed costs. Without regulation there was nothing to stop mobile firms setting charges too high.

The MNOs appealed the decision to the Competition Commission who agreed with OFTEL. Vodafone and mm02 were ordered to decrease their rates by 15 per cent immediately and then by 15 per cent per year until 2006, bringing them to a target of £0.0563 per minute. T-Mobile and Orange were ordered to decrease their termination rates by 14 per cent and then by 14 per cent every year until 2006 bringing them to a target of £0.0631 per minute. However, it should be noted that these restrictions were not applied to the 3G technology. It was considered that this may damage a developing industry.

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[31] Ofcom (2006) 4.16.

[32] Ramsey pricing or Ramsey-Boiteux pricing is used when it is believed that marginal cost pricing will not cover the regulated firm's costs. The aim of the regulator is then to allow price that maximises social welfare under the condition that the firm does not make a loss. Those services with greater inelasticities of demand should have a larger mark-up over marginal costs than those with lower elasticities. Firms that are engaging in Ramsey pricing will charge prices that are inversely proportional to the elasticities of demand. As such the structure of prices will be the same as it would be for an unregulated monopoly, just not as high (see Armstrong et al. 1999 for a full discussion of Ramsey Pricing under different assumptions).

[33] Oftel (2001b).

[34] See Newbery et al (2001).

[35] Budden (2002).

As time went by Ofcom seemed to take a more relaxed approach to termination pricing. Ofcom carried out a review of termination pricing that took over from the previous arrangement. The new arrangement cuts the termination charge to 5.3 pence per minute (Hutchinson 3G had a cap of 6 pence per minute due to exogenous cost differences between H3G and the other MNOs) by 2010-11. Ofcom were criticised by both the European Commission and national fixed line operators for taking an overly lenient approach to termination charges.[36]

A further area of relaxation came with the reassessment of Vodafone's and BT Cellnet's (now O2) market power in the wholesale mobile access market. An Oftel assessment in 2003 found that under the new regulatory framework the two companies no longer had SMP in this market. This was due to SMP being redefined in the New Regulatory Framework to include the concept of 'dominance'. This led to the removal of the regulatory requirements placed on Vodafone and O2 previously. This actually had only a limited impact on these operators. Both Vodafone and O2 were still required along with the other MNOs to negotiate interconnection contracts between each other under Article 4 of the Access Directive. There were also no mobile IA providers operating at the time.

Although the UK set one of the longest time periods for a roll-out obligation to be met, as the deadline approached there was still the possibility of non-compliance with coverage commitments. Although Ofcom seemed to take a tough line over adherence to roll-out conditions "...Ofcom expected all licensees to meet the rollout obligation included in their licences by the end of 2007.",[37] the actual sanctions that would be taken against a licence holder were not made clear. Ofcom went as far as to virtually rule out revoking a licence "....where a licensee had rolled-out a network to a significant extent and could clearly demonstrate to Ofcom that they have evidence of a clear commitment to remedy the infringement of their rollout licence condition in a timely way, Ofcom is

[36] Parker (2006).
[37] Ofcom(2006) section 3.10.

likely to consider that revocation would be a disproportionate sanction to impose."[38] When the deadline arrived four out of the five licence holders had met the roll-out condition. O2 the subsidiary of Telefonica was the only operator that missed the target. The response of Ofcom was to extend the roll-out condition by another 4 months.

8.8: How the Regulatory Decision is Reached

The question still remains – why would the regulator change its regulatory stance? If it is accepted that the licence fees did impact on the post-administration regulatory position, then the licence winning firms must have the ability to affect the regulatory regime that they are under. It is fair to assume that the regulators have certain goals discussed at the start of this piece. Some of these goals will be motivated by perceived improvements in efficiency and some from political motivations. The operating firms will have an influence over some of these factors. These include the speed of roll-out, quality of service, maintenance of a stable industry. The regulatory decision-making process can then be seen as a bargaining process. The structure of this bargaining mechanism will be explored to a greater extent in the next chapter. The regulator must balance out this desire for a stable market with the perceived improvement in welfare they can obtain from other regulatory levers. The operating firms wish to lobby the regulating authority to provide them with a more favourable regulatory regime. The bargain will then occur as the regulator trades off the speed of network development against other regulatory levers. The MNO offers a faster network roll-out in exchange for an easing of future regulatory stance. This bargain will occur even if the firm does not have any difficulty in achieving their licensing commitments. However, for the regulator to take account of this lobbying activity the operating firms must be able to provide some credible signal to the regulating authority. How exactly this signal manifests itself is a matter for each individual regulatory authority. It may come about through falling stock market prices, revisions in the firm's credit ratings, or identified problems in technological developments, all which were present after the 3G administration procedure.

The proposition that the regulatory regime that a firm faces is not exogenous to it would seem to be well supported. Indeed the very fact that NRAs produce consultation

[38] Ofcom(2006) section 3.13.

documents in order to consult with the industry shows a desire to engage in a bargaining process. Of course it is not only firms in the industry that are being consulted at this stage, consumer groups and other related businesses also lobby. Protecting those firms in the telecommunication industry has occurred since the beginnings of the liberalisation of the industry. As already discussed the level of competition was limited in the early stages of liberalisation in order to protect the incumbent BT. Indeed Armstrong et al. (1999) refers to the early relationship between Oftel and BT as "almost regulation by bargaining"[39].

8.8.1: Industry Lobbying

Duso (2000) examines the lobbying activity within the mobile market in the U.S. In particular how lobbying activity affected regulation and in turn how this impacted on prices. Duso's study only focused on price regulation, however he does find that firms' lobbying activity caused the 'wrong' markets to be regulated, in as much as those markets that would have had a significant decrease in price if regulated were not. Despite this finding Duso does not give a full account of how the regulated firm exerts power over the regulator.

If it is accepted that the regulatory regime can be influenced by the lobbying of firms, assuming they can provide a credible signal of not being able to achieve regulatory aims, then it can be inferred that this will feed back to the auction procedure. The value placed by bidders on a licence will be some function of the possible future states of the world. If a bidder knows that if they suffer a winner's curse, or at least are able to signal that they have overspent, then the state of the world will change as the regulatory regime changes. This will mean that if a licence winner is able to signal that they have overspent, the licence will be worth more. The price paid for the licence will affect the value of the licence. A problem may arise if the bidders do not know if the regulator takes a strong or weak approach to their post administration regulatory regime. In reality it may not be as simple as dividing regulators into strong and weak, instead they may occupy a spectrum of regulatory severity. An added complication in this framework is that we have a regulator with changing motivations. This may be particularly relevant if

[39] p271.

the regulator has little political independence. A regulator's primary motivations may change with the election of a new government. Also there may be different regulatory goals at differing levels of regulatory institution. This can be seen from the EC's criticism of Ofcom's termination charges and the negotiations concerning roaming fees.

8.8.2: Incomplete Contracts

It may be useful to consider the regulatory setup in terms of incomplete contracts. Rossi (2005) gives themes that can be transferred from incomplete contracts to regulatory bargaining. The parties involved are unable to commit to not renegotiating the contract in the future. The political process may lead to ambiguities in law leading some bargaining agents to prefer incomplete contracts to a bad law. Both these points are particularly relevant for a market that is evolving with new technologies that were not originally catered for in the original regulatory contracts. A regulatory decision is only one point in an ongoing discussion. From this view, those conditions laid out in licensing agreements should not be seen as legalistic contracts that need to be enforced, but rather are a starting point, an incomplete contract open to renegotiation. Making a slight alteration to the Hart and Moore (1999) description of an incomplete contract we have a very close approximation to what occurs in a licensing process. Imagine a regulator that requires a licence winning firm to operate a network under certain conditions. The exact nature of how the network will run depends on a state of the world that is yet to be realised. In an ideal world, the parties would write a contingent contract – or possibly with regulation a law – specifying how the network is to be run depending on each state of the world. However, with such a large number of states of the world, to write such a contract would probably be impossible and certainly would be prohibitively expensive. Instead an incomplete contract is written and then renegotiated when the state of the world is realised.

8.9: Conclusion

This chapter has focused on the motivations and methods that have been used to regulate the telecommunications industry. In particular, it has focused on the regulatory interventions that have occurred and that were perceived to be needed to correct certain market failures. The chapter gave background information for a discussion of the ways that regulators have engaged in regulatory easing. A key part of this chapter was the discussion of documentary evidence that regulators engaged in regulatory easing in response to the high 3G licence fees.

The evidence for regulatory easing was considered at a European level and at the national level for the UK. At the European level this evidence consisted of the European Commission's immediate reaction to the licence fees and some key decisions taken post-administration. As discussed in Section 8.6, the Commission left all options open to NRAs if they believed the post-administration market had changed unpredictably. The EC reinforced this support for licence winners firstly by allowing network infrastructure sharing even though they found it in breach of competition rules. The EC then went on to enforce new rules for rights to show European football highlights with the explicit aim of helping 3G licence holders.

Further evidence of regulatory easing is provided in Section 8.7 by examining decisions made post-administration in the UK. This regulatory easing took a number of forms. At the national level network sharing was also allowed. Ofcom did not impose charge controls on the 3G termination rates. Finally, despite having relatively lax roll-out conditions, no action was taken against those operators that did not meet their roll-out commitments.

The next chapter will pick up this discussion of regulatory easing and attempt to identify in more depth why a high licence fee could bring about the behaviour seen in the post-administration market, most notably the delay in the roll-out of 3G services and the relaxation of 3G licensing conditions and post-administration regulatory environment.

Chapter 9: Real Options in Mobile Telecommunications Investment and Post-administration Regulatory Bargaining.

9.1: Introduction

Chapter 8 discussed the development of mobile telecommunication regulation and, in particular, regulatory decisions that took place in the aftermath of the administration of licences to run 3G services. This chapter will seek to explain the rationale behind some of the behaviour by both firm and regulatory in the post-administration market. Exploring this relationship is by its nature difficult to do. There are a number of complex interactions between the regulator, the firm in question and other firms in the industry.

This chapter will focus on a number of areas. It begins in Section 9.2 with a discussion of the motivation for the firm to delay the roll-out of their 3G infrastructure and how the size of licence fees could impact upon this decision. In particular, this section exemplifies how a change in the firm's cost of capital can bring about a change in the value of the firm's option to delay. This relationship will be demonstrated through a number of simulations in Section 9.3. These simulations show that under a number of different assumptions an increasing cost of capital causes an increase in the value of the option to delay. The chapter will then go on to explore how, in the light of the firm's increasing desire to delay investment when their cost of capital increases, the size of the licence fee will impact on a basic Nash bargaining game between the regulator and the firm. This is shown via a Rubinstein bargaining mechanism in Section 9.5. This Rubinstein bargain shows that an increase in the value of the option to delay can increase a firm's bargaining power. The final section applies this principle to a simple two stage Nash bargaining game.

9.2: Infrastructure Investment, the Cost of Capital and Timing Options

9.2.1: UMTS Infrastructure and the Cost of Capital

In order to provide 3G services, a licence owner must undertake a large amount of investment in new base stations and network infrastructure. The existing 2G network infrastructure is on the whole not suitable to run 3G services although there can be some conversion from 2G basestation. With over €100bn spent on licences and another estimated €127.4bn[1] needed to be spent on the provision of 3G services, operating firms face mounting debt. As these costs are fixed and sunk they should have no effect on firm's pricing or investment decision. The size of the licence fees should not, in theory at least, have an effect on the firm's marginal cost or pricing behaviour in the post-administration market. However, this logic will only hold if capital markets are behaving efficiently and firms follow rational investment strategies. If the size of the debt has negatively affected the firm's ability to borrow then this may have a significant impact on the firm's investment decision. Table 9.1 shows the deterioration of some of the licence winning firms' credit ratings over the period that the licences were being administered.

There were other factors apart from 3G licence fees that were negatively impacting on the high-tech sector around this period, however, there is evidence that the size of the 3G licence fees were directly responsible for the downgrading in credit ratings. Almost immediately after the end of the German auction, all the firms that won licences in Germany apart from Vodafone were placed on the S&P's credit watch list. In early September MM02 offered a loan package in order to try and raise funds in the aftermath of their split from BT. The loan package was given a BBB- rating by S&P, which is only one grade above junk status, indicating the decline in these firms' credit ratings. Even Hutchison Whampoa had its S&P rating downgraded from A to A- as a direct consequence of uncertainty surrounding the company's 3G business plan (3GNewsroom 2003). The association between credit ratings and licence fees was explored by Del Monte (2004). The Del Monte study calculated a ratio of each operators' total cost of licences against the 1999 value of their assets. Licence owners with the highest ratio were those that had their credit ratings downgraded by the largest amount. This is put forward as direct evidence that the licence fees increased the licence winners' cost of borrowing.

[1] Estimate from European Commission (2002a) Exhibit 44.

It is not surprising that the size of licence fees had this effect on the winners' credit ratings. High borrowing costs will lead to higher financial gearing ratios. The gearing is a financial ratio that compares the level of owner's funds that are invested in the firm compared to borrowed funds. When firms have to pay large lump sums they may borrow more or sell off some of their assets to pay for it. Either way this will lead to an increase in gearing. The gearing ratio is one factor that is used to determine credit ratings and in turn the cost of borrowing for the firm. This problem will be exacerbated by many telecoms firms attempting to acquire finance at the same time. Investors will wish to diversify across sectors in order to spread risk. This raises the possibility that borrowing will become more expensive for all operators not just those that have deteriorating leverage. Cave and Valletti (2000) discuss the possibility of this occurring. They consider this to be a "genuine but small" risk. However this analysis was made before the process of roll-out had begun. As the process went on there was widespread downgrading of credit ratings. The companies that were particularly badly hit were start-ups which were no-longer able to borrow money.

9.2.2: Cost of Capital and the Firm's Investment Decision

Even if the firm's cost of capital was negatively affected this should still not impact on the firm's investment decision. Basic finance theory would tell us that each project that the firm engages in should be assigned its own discount rate. This discount rate should be determined by the risk associated with that project. The company cost of capital is then the weighted sum of all the costs of capital for the investments that the firm is engaged in. A particular project may have the same discount rate as the company as a whole but that is only due to the risk associated with the project being the same as the company as a whole. If the firm used a single cost of capital for all investment appraisals then some projects will be taken on even though they have returns too low for their actual level of risk and some projects will not be taken on even though their returns are high enough for their level of risk. This would lead to the firm only accepting high risk projects and rejecting low risk. In practice however, there are a number of problems with the assumption that firms will assign different costs of capital to each project. Firstly, it assumes that the firm will be willing and able to compute individual costs of capital for each investment project. When dealing with regulatory interactions it also assumes the regulator will have some method of ascertaining the cost of capital used by the firm.

Although using the appropriate cost of capital is assumed in theory it is by no means certain. The first issue, of whether the firm will attempt to identify individual project cost of capital, places the onus on the firm to determine the correct cost of capital. Clearly this would be a particularly arduous task of which there is no consensus over the best means for determining either the expected return for a project or the risk associated with the project. One way for the firm to determine the correct cost of capital is to identify a listed company or a number of listed companies that shares the same characteristics as the investment project that they are facing. Adjust each company's beta for capital structure giving an asset beta and take an average of these betas. From this, and using CAPM, the cost of equity can be calculated. Alternatively if a single listed firm can be found that shares the characteristics of the investment there is no need for aggregation, this is the so called 'pure player' approach (Grinblat and Titman, 2002). Finding such an undiversified firm for each project would be extremely difficult. In addition to this adequately adjusting for firm leverage can be problematic. It may also be difficult to make an adequate adjustment for the possible growth option. A listed company's beta will also include its prospects for future growth.

Just because it is difficult to calculate costs of capital for each project does not mean that a company would not do it. After all, the serious consequences of using the company's cost of capital for all investments have already been discussed. Despite this, companies do seem to shy away from using investment specific cost of capitals. Surveys of company finance managers over the last 30 years have consistently found that a majority of companies not only fail to use an investment specific cost of capital, but do not even go as far as to use different cost of capitals for different divisions of the firm. A survey by Brigham (1975) found that only 23 percent of firms questioned attempted to evaluate the risk associated with each project while 48 percent used a single cost of capital across the entire firm. Of those firms that did adjust their cost of capital the majority (45 percent) only did so at the divisional level. A more recent study by Bruner et al. (1998)

found similar results when addressing the same question. Of those firms surveyed, 26 percent adjusted their cost of capital for each investment decision while 41 percent did not adjust at all. Further evidence of this type of behaviour was found by Graham and Harvey (2001) in a study of US firms 60 percent used a single company-wide discount rate. Those that do use different discount rates for different divisions often use heuristic approaches such as adjusting the company cost of capital by a set amount depending on which division it is. Both Cooper et al. (1990) and Block (2003) both find that over half of those firms surveyed use subjective approaches to adjust the cost of capital for different projects. Despite financial theory suggesting that only the risk associated with a particular project should be considered when assessing the appropriate cost of capital in reality, due to inefficient investment practices, the company cost of capital is more often used.

Even if the firm is able to calculate a correct cost of capital for a specific investment they will have no interest in sharing this with the regulator. When assessing the investment decision that the firm faces, the regulator will have even less information than the firm over an appropriate level of cost of capital. The regulator will be more inclined than the firm to use a measure that is related to the company cost of capital even if they aspire to a more financially sound measure. Despite the fact that the risk associated with a particular project has not changed the firm will attempt to use its change in cost of capital to bring about a higher cost of capital calculation from the regulator. A recent example of this can be found with Ofcom's treatment of the Openreach[2] section of BT's business.

Given the potential demand for UMTS services and the price operators paid for licences to run them, a question remains as to why any operator would delay rolling out a network and, in some cases, after delaying, decide to abandon 3G development. Even if the licence winning firms had their credit rating lowered, they would still be able to borrow. If the cost of capital is higher it may mean that investment will no happen but

[2] Openreach is a new organisation established out of BT to run Wholesale Line Rental, Local Loop Unbundling and Ethernet services.

why delay? If borrowing became so expensive that a network was no-longer viable then the project should be abandoned immediately. If a network is viable then why not invest now and begin to recover costs. By treating the roll-out of 3G services as a timing option, we can explain why a licence winning firm may delay roll-out and potentially abandon the project. The timing option can be seen as a type of a financial call option. The call option allows the holder, for a specified period of time, to pay the exercise price and receive a certain asset. The proposition is then that the option to delay investment is affected by the size of the licence fee via the cost of capital. Given this framework we can also consider the impact of different regulatory decisions and the effect that high sunk costs, such as licence fees, can have on the decision to delay or abandon. In turn, it will be shown how the introduction of an option to delay will impact on the interaction between the firm and regulator.

9.2.3: Option to Delay in Telecommunications

There has been wide-ranging work carried out on the problem of a firm's investment decision when faced with an irreversible investment and have an option to delay. Given these conditions the net present value rule - that the firm should invest in a project if the NPV of the expected cash flow is equal to or greater than the cost - is no longer valid. For an overview of timing options and the firm's investment decisions, see Pindyck (1991) and later Dixit and Pindyck (1994). Investment decisions and timing have also been used to model investment decisions in multi-firm industries under different conditions.[3] This piece seeks to consider in more detail the relationship between the regulator and the firm within this framework. If the regulator attaches some welfare to the speed of network roll-out, then the regulator may make decisions that will change the firm's investment behaviour. Harmantizis and Tanguturi (2007) take the US case and attempt to calculate the value of an option to defer expansion from 2.5G to 3G under a number of quite stringent assumptions. They calculate that the value of the option to delay is small but considerably greater than the NPV of the project if investment

[3] See Vives (1989), Spence (1979), Sadanand and Sadanand (1996), Ghemawat and Sol (1983).

occurred immediately. Although they consider other factors that can influence the size of the option they do not consider the impact of regulatory behaviour.

This piece takes a similar approach to Alleman and Rappoport (2002). The authors use the concept of timing options to demonstrate potential costs of regulation. In particular they examine the costs placed on broadband and payphone providers of removing the option to delay in the USA. They do acknowledge that companies could engage in lobbying to change the market they face, but they do not engage in a detailed discussion of this. Allenman and Rappoport identify four possible regulatory conditions that can affect the delay option: (1) no constraints on cash flow or the ability to delay, (2) a constraint on cash flow but not on the ability to delay, (3) no constraint on cash flow but no ability to delay, (4) a constraint on both cash flow and the ability to delay. These translate well to the 3G case but we may also include enforcing the cost of investment (the exercise price). In the 3G case the regulator can allow operators to share network infrastructure etc.

We start with the assumption that the 3G licence owner can begin roll-out now or in the next period (Period 1 and Period 2 respectively). This model will be similar to that of Lozano and Rodriguez (2006) and use a finite horizon model with discrete instead of continuous time. The regulator must decide in period 1 which regulatory stance it wishes to take, either strict or lax.

The cost of roll-out is (I) and is assumed to be the same in each period so that $I_1 = I_2$, in options terms this is the exercise price. The discounted cash flow of the project if the firm invest now is (V_1).The net present value of the project assuming immediate investment is:

$$NPV_1 = V_1 - I_1 \tag{9.1}$$

If there was no uncertainty over the level of future demand then as long as $V_1 > I_1$ investment will take place. This is still the approach taken with neoclassical investment theory. However, once we introduce uncertainty over future demand this is no-longer the case.

In this simple delay option example period 2 demand can either be high or low. If demand is low then the cost of roll-out is greater than the value of the project and it will be abandoned. p is the probability of high demand and $1-p$ is the probability of low demand in period in the second period. Vu_2 is the value (in terms of cash flow) of the project if demand is high. Vd_2 is the value of the project if demand is low. It will be assumed that $Vd_2 < I_2$ so investment will not take place. In this case Vu_2 and Vd_2 have been put in terms of demand, it may be better to think in terms of technological ability and perceived potential demand. The uncertainty comes not just from whether people will want to use 3G services but also what services 3G will be able to offer. The present value of the project if investment occurs in the next period can be calculated as:

$$c_t = \frac{(p \times (Vu_2 - I_2)) + ((1-p) \times 0)}{1+r} \tag{9.2}$$

This leads to three possible outcomes. If $c_t > NPV_1$ and in period 2 Vu_2 occurs, then the firm waits until period 2 and then will invest. If $c_t > NPV_1$ and in period 2 Vd_2 occurs then the firm will wait until period 2 and then abandon the project. If $c_t < NPV_1$ then the firm will invest in period 1.

The regulator has the ability to influence I, V_1, Vu_2 and Vd_2. If the regulator wants the firm to begin roll-out in period 1, they can decrease I or increase V_1. However it is unlikely that V_1 could be increased without also increasing Vu_2 and Vd_2. The regulator could decrease the value of c_t without decreasing V_1 by having a fine for delay. This may increase the chance of abandonment if Vu_1 becomes less than I. In this case the timing option is worthless so investment will take place in period 1 or not at all. Let us say that a regulator with a lax stance will decrease I and increase Vu_2 and Vd_2. If the regulator is able to increase Vd_2 to such an extent that it is greater than I then it is probable that the firm will invest in period 1. This would be to ensure that they do not to miss out on the forgone revenue. Strictly speaking the value of c_t is still greater than the NPV due to I remaining the same across periods. So it is still possible that delay would occur even if both Vu_2 and Vd_2 were greater than I. Taking the more realistic assumption that the value of I changes then if both Vu_2 and Vd_2 investment will take place in period 1 as any uncertainty over profitability of the project is removed.

It may be more appropriate to consider the roll-out process as a staged multi-period option procedure, particularly as staged roll-out conditions were used. As roll-out was required in set periods, a discrete rather than continuous model is appropriate. A licence holding firm will continually assess from period to period whether they will roll-out, delay, or abandon. By treating the development as a rolling timing option, the firm will have no reason to abandon. Instead of abandonment they will just delay until the next period. Now we assume that high demand in the next period means demand high enough to bring about immediate investment and low demand means a further delay or abandonment will take place. The regulator must now also decide whether to enforce the roll-out condition or allow an extension. This enforcement may not lead to simply removing the licence but may be a fine. In each period the regulator will come under lobbying pressure to relax their regulatory stance in the next period. If the regulator is known to enforce a roll-out condition then, due to the loss of future options, c_t will be worth less, encouraging investment in period 1.

9.3: Two Examples of Changing the Cost of Capital

Section 9.2 established the position of options to delay in mobile telecommunication infrastructure development and the impact of licence fees on the cost of capital. This section will give an indication through simulations of how these two factors can impact on infrastructure investment. These simulations are used to illustrate the effect of a change in the cost of capital on two simple option formations. In both these examples it is assumed that the regulator has the ability to influence the size of the initial investment. The regulator will then seek to set the investment to a level that would cause immediate investment given different costs of capital. The level of demand in the future is assumed to be uncertain. The first example uses Black-Scholes framework and the second a binomial framework. Each simulation is run over a seven year period with a risk-free rate of 3%. The cost of capital is assumed to change form 7% to 7.5%. Each simulation shows the change in investment required to bring about immediate investment given a change in the cost of capital.

9.3.1: A Black-Scholes Simulation

Using a modified Black-Scholes framework whereby

$$c = Ve^{-yT}N(d_1) - Ie^{-r_f T}N(d_2) \tag{9.3}$$

and

$$d_1 = \frac{\ln(s/I) + (r_f - y + \sigma^2/2)T}{\sigma\sqrt{T}} \tag{9.4}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{9.5}$$

Where c is the value of the option, V is the present value of cash flows of the project, T is the time to expiration I is the investment cost and r_f is the risk free rate. In this simulation the level of I is set so that the firm is indifferent between investing now and delaying investment so that

$$NPV = C \tag{9.6}$$

$$V - I = C \tag{9.7}$$

The correct level of investment can then be calculated iteratively using

$$I = \frac{V - Ve^{-yT}N(d_1)}{1 - e^{-r_f T}N(d_2)} \tag{9.8}$$

The initial starting point equates the NPV of the project and the value of the option to delay. The results of this simulation can be seen in Table 9.2. Both this simulation and the next were calculated using Excel.

By changing the cost of capital we can calculate the level of I that is required for the firm to be indifferent between immediate investment and delay. Note that this is not the level of adjustment that will cause the firm to undertake investment. The simulation says nothing about whether the investment is in the money (if it is not then the investment will not take place). Rather, it shows how much the cost of investment will have to change in order to bring about immediate investment even if the project is not in the money. This then brings about the condition set out in Equation **(9.7)**. This comes about as the NPV of the project decreases by a greater amount than the value of the option to delay. If the value of the project moves out of the money then an even greater adjustment would be needed to cause immediate investment.

9.3.2: A Binomial Simulation

A more complex version of the same concept can be seen by using a binomial model.
In section 9.2.3 a simple model was used that only has two periods. Just as with the Black-Scholes example this simulation will use 7 periods. The model that will be used will follow that suggested by Lozano and Rodriguez (2006). Using a finite time horizon model with discrete periods, Lozano and Rodriguez run simulations to demonstrate how by using option pricing a more accurate level of access pricing can be imposed by a regulator.[4] They demonstrate the difference between an NPV calculation of an access price that would bring about immediate network investment and the option pricing valuation. This simulation will keep the level of access pricing fixed and instead adjust the level of initial investment so that network investment will occur instantly. Unlike the previous Black-Scholes example results will also be shown for three levels of demand volatility (0.15, 0.25 and 0.5).

As with Lozano and Rodriquez D is demand at t = 0, p is the probability of an 'up' state u and $1-p$ is the probability of a 'down' state d. Next period D may increase to uD with a probability p or to dD with a probability of $1-p$. a is the access price set by the regulator, k is the cost of capital and I is the cost of the initial investment.

[4] See Chapter 8 for a discussion of access pricing.

In t periods time D will take the value

$$D_t = Du^j d^{t-j} \tag{9.9}$$

The present value of the future cash flows will then be

$$V_t = D_t \sum_{i=t}^{T} \frac{a}{(1+k)^{i-t}} \sum_{j=0}^{i-t} \frac{i!}{j!(i-j)!} p^j (1-p)^{i-t-j} u^j d^{i-t-j} \tag{9.10}$$

In their model the regulator would traditionally (not taking account of the option cost) set (a) so that the NPV of the future cash flows just covers the investment.

$$I = D \sum_{i=0}^{T} \frac{a_i}{(1+k)^i} \sum_{j=0}^{i} \frac{i!}{j!(i-j)!} p^j (1-p)^{i-j} u^j d^{i-j} \tag{9.11}$$

When the value of waiting is included the regulator must set an access price according to

$$a_t = \frac{I}{u^t D} - \frac{qu+(1-q)d}{1+r} \sum_{i=t+1}^{T} \frac{a_i}{(1+k)^{i-t-1}} \sum_{j=0}^{i-t-1} \frac{i!}{j!(i-j)!} p^j (1-p)^{i-t-1-j} u^j d^{i-t-1-j} \tag{12}$$

where q is the risk neutral probability so that

$$q = \frac{(pu+(1-p)d)(1+r)-(1+k)d}{(u-d)(1+k)} \tag{13}$$

and now taking account of optimal timing the firm will seek to maximise the following

$$W_t = \max\left(\frac{qW_{t+1}^u + (1-q)W_{t+1}^d}{1+r}, V_t - I\right) \tag{14}$$

If we wish for I to be set at a level just high enough to cause immediate investment then

$$\frac{qW_{t+1}^u + (1-q)W_{t+1}^d}{1+r} = V_t - I \tag{15}$$

Lozano and Rodriquez sought to calculate the difference between the access price that would cause immediate investment with or without a value placed on waiting. They come from the position of setting the price of access to a level that will compensate a firm for the lost of the option to delay when they are forced to build a network immediately. Using the same framework I will run a simulation that calculates the level of access price that is needed to just cause instant infrastructure investment and then holding those constant calculate the change in the size of initial investment if there is a change in the cost of capital. Equation (14) can be rearranged so that

$$I = a_t u^t D + u^t D \frac{qu+(1-q)d}{1+r} \sum_{i=t+1}^{T} \frac{a_i}{(1+k)^{i-t-1}} \sum_{j=0}^{i-t-1} \frac{i!}{j!(i-j)!} p^j (1-p)^{i-t-1-j} u^j d^{i-t-1-j} \quad (16)$$

Again an increase in the cost of capital will require a decrease in I for investment to begin immediately. Results for this simulation can be seen in Table 9.3 At any set level of prices, increased demand volatility will cause changes in the cost of capital to have a greater effect of the require change in level of investment..

9.4: UMTS Regulation and Timing Options

The timing option sets up how the firm and regulator interact with regards to roll-out. To understand how a regulator will respond we must consider how they will bring about a change in c, V or I. The revenue that a firm receives given particular market conditions will partly be a function of the regulatory stance. It is clear that allowing higher termination charges and giving operators access to premium content will increase the revenue given any particular market conditions. The regulator can decrease the exercise price through decreasing the cost of roll-out. This may be through allowing site sharing, reducing legal and environmental red tape, or even giving a refund on licence fees if this decreases the cost of borrowing. From the discussion that occurred in Chapter 8 it is clear that a combination of these actions were used.

The action that the regulator takes depends on which policy it wishes to pursue. It may wish to ensure speedy roll-out, minimise the chance of abandonment out of a desire to maintain the number of operators, or both of these options. The regulator will then be balancing the desire for a speedy roll-out of services and preventing abandonment and withdrawal from the market against achieving other regulatory goals. The decision to change the regulatory position will depend on the weighting that the regulator places on speedy roll-out, having a larger number of operators and controlling for perceived market failures. Section 9.5 will outline a more formal approach to the interaction between the firm and regulator.

9.4.1: Regulatory Difficulties with Options

A cautionary note comes from Dixit and Pindyck when they discuss policy intervention in a market such as this. They find that any delay or abandonment is not caused by a market failure and so is socially optimal. Indeed they claim that "a social planner would not want to invest any faster". This will mean that the regulator should make no alteration in its stance to account for uncertainty. These claims do rest on a number of assumptions. The most problematic in this case is that the firms operate in well functioning capital markets. Even if we are happy to accept the assumptions surrounding the firm's behaviour we must then accept that the regulator's primary goals are the correction of market failures. It is difficult to marry this concept with the stated goal of speedy roll-out of 3G services. Dixit and Pindyck's argument focuses on how regulators should behave, what they actually do may be quite different. The regulator may not be attempting to correct for a market failure but rather to undertake a particular political goal. When the regulator decides on its particular regulatory stance it is fair to assume that they will only have partial knowledge of the position they will need to take to prevent delay in period 1 or abandonment in period 2. The licence holding firms will need to be able to send some credible signal to the regulator that the value of the option is greater than the NPV of the project. The exact nature of this signal will depend on the regulator, but may take the form of deteriorating stock prices, credit ratings; all of which occurred in the post-administration market. However, if the regulator believes that this is not the case then they will not change their stance as investment will occur immediately. Even if the believe that the option to delay is worth more than the projects NPV they will not intervene if they attach greater importance to the conditions they would have to relax than the speed of roll-out.

Thus far it has been assumed that the regulator makes a decision in period 1 which is then adhered to in period 2. More realistic is the assumption that the regulator will react to the state of the world as it occurs. Once the network operator has built its network and so undertaken some level of irreversible investment it is in a weaker bargaining position. The regulator will truncate any up side with stricter regulation. If the operator believes that an upside will bring additional ex-post regulation then this decreases the future value of an upside and hence decreases the probability of period 1 investment. This problem was discussed with respect to telecommunication regulation by the Australian inquiry reports by the Production Commission into Telecommunication Competition. They suggested allowing a fair rate of return in the form of a truncation premium which rewards the operator for the risk they face (Lally, 2003). How exactly this premium would be calculated and whether a regulator would be able to commit to it is unclear.

9.4.2: Regulatory Approach to the Cost of Capital

When there is an interaction between a regulator and a firm there will be information asymmetries. The actual level of cost of capital may be less important than the perceived cost of capital that the regulator uses to assess the firm's investment decision. It would be simple to assume that the regulator was perfectly informed over the level of cost of capital faced by the firm and hence, be able to determine the level of regulation that would bring about immediate investment. However it is unlikely that the regulator would have as much information as the firm over the cost of capital they face. If a regulator values immediate investment highly then it may estimate on the side of caution when they determine the cost of capital. Indeed there is a certain amount of evidence for this. In Ofcom's discussion on its decisions around appropriate cost of capital they state that when using CAPM to estimate the cost of capital the estimation of the Equity Risk Premium (ERP) can be difficult as

"...calculation of a forward-looking ERP entails a significant degree of judgement and a wide range of estimates can be derived by commonly-used estimation techniques. As explained in the first and second consultation, Ofcom considers that the downside risk associated with taking too low a value for the ERP (discouraging discretionary investment) is more detrimental to the interests of consumers than taking too high a value (leading to higher prices to customers) and has tended to the higher end of the possible range." (Ofcom, 2005, Section 1.13)

As may be expected, there would appear to be a clear preference here to allow a more generous cost of capital in order to ensure that investment takes place even if this is to the detriment of the price that future the future consumers will pay. Indeed in the same document Ofcom refer to the level of compensation provided to an investing firm for the loss of the option to delay. They take the view that by using an upper estimate of the weighted cost of capital they can account for the value of the option without having to explicitly set a value for it. In essence they use a higher cost of capital when assessing the level of return that a firm should receive.

In order to demonstrate some of the regulatory implications the models of options to delay have been kept necessarily simple. In reality further complications could be added in a number of areas. The 3G market contains a number of competing firms. We may wish to introduce the concept of a first mover advantage or model the impact of differing industry structures. If there is some advantage from early market entry then this may negate any value from waiting. It has also been assumed that the demand is exogenous of the firm's investment decision. Although this will be true to a degree, as the success of new technologies is always uncertain, a firm building or not building a network is bound to impact on demand in the next period. It may be better, rather than considering the model in discrete time periods, to treat it as a continuous process where the firm must decide at which point to invest. Further complications could be added by the introduction of a time to build effect. Thus far it has been assumed that when investment occurs the investment returns begin to be realised instantaneously. It would be much more realistic to assume that once the decision to invest is made a time lag occurs before revenues begin to be received. Finally, only the option to delay has been explicitly considered here. Like the first mover advantage the option to expand may provide a strategic value to the firm of investing at an early stage. Once investment has occurred it may provide access to other more profitable investments as the market develops. This would be particularly important where the market develops quickly. Another option that would add value to immediate investment is the follow on option. This option has value when the investment that takes place leads to other linked investments that would not be able to take place without the original investment. How valuable both of these options are will depend to a degree on the timeframe of the investments. The follow on option would only take on a significant value over a longer timeframe than either an option to delay or an option to expand. The option to expand takes on greater value when the timeframe for roll-out and the formation of services is greater. It would be difficult for operators to respond to a change in demand if roll-out cannot be performed quickly. It is possible that given their existing infrastructure the value of an option to expand will be worth less to existing operators than new ones. Now that the nature and position of options in mobile telecommunications has been outlined, and the interaction of the regulator and the firm discussed, the following section considers how the option may impact on regulatory bargaining.

9.5: A Simple Model of Regulatory Bargaining

Section 9.5 will discuss how the decision of the firm to invest came be seen in the light of a bargaining scenario. The first stage of this discussion will link the effect of an option to delay on a firms bargaining weight. This will be done through a two stage Nash bargaining solution game where the asymmetric bargaining weights are justified by a Rubenstein type argument (Muthoo, 1999). The supposition is then that once the licence administration has take place the regulator and the licence holding firm engage in a bargaining process over the division of surplus where both are impatient and prefer investment to occur earlier rather than later. This will be picked up in Section 9.5.1 where the discussion will be used to inform the weights that are applied to the licence holder and government in a Nash bargaining game. Preceding that discussion, this section will argue that for the firm this preference for early investment will be reduced when the firm incurs high licence fees through the impact that this will have on the value of the firm's option to delay.

The Rubinstein bargaining is based on the assumption that those taking part in the bargain are impatient. They would prefer to complete the bargain earlier rather than later. In a simple game the surplus to be divided between participants decreases after each period. This concept fits well with the timing of network roll-out, particularly where the regulator desires early roll-out. One of the simplest example of a Rubinstein bargaining model is the dollar game where the two players prefer more dollars to less and prefer the money sooner rather than later. The roll-out of network infrastructure to run 3G services is clearly more complicated than the dollar game but can be seen in a similar way. If it is assumed that the regulator wishes to maximise consumer welfare, and at a broader level, to efficiently use the limited amount of spectrum that is available, they will seek to do this through a number of different policy goals. The regulator has a desire for a speedy roll-out of 3G infrastructure in order to be able to offer 3G services at the earliest point possible. This desire comes from the potential loss of consumer surplus over the period of delay and other politically motivated aims. These factors cause the regulator's preference for earlier rather than later investment by the licence holder. The dollar is then made up of the conditions that are attached to this roll-out. These factors include the level and quality of coverage (in terms of their obligations to cover a certain level of the population or country as part of the roll-out conditions), the prices charged for services and the content that are provided on the network and the punishment placed on the firm if they do not meet this requirement. The consumers and hence the regulator would want the best service at the lowest possible price. This is with the constraint on the regulator that a service must be offered. As such they must ensure that investment occurs at some point so that the network roll-out takes place.

The link between the value of the option and the ability to bargain comes through the bargaining weights for the licence holder. The firm will seek to gain surplus from a decrease in the discussed regulatory levers. Where we have no other strategic considerations, the cost of delay for the firm is the forgone revenue from not investing immediately. The cost of immediate investment will be the loss of the option to delay. The greater the expected revenue from investment in network infrastructure, the more likely that investment will occur immediately. Where there is a great amount of uncertainty, whether it is due to the potential future demand of the success then the value of the option to delay will increase and investment will be less likely. However, this reasoning does not explain why the licence fee would have an impact on the decision and the timing to invest. The desire of the firm to engage in bargaining over its regulatory position, would be used in a regulatory bargaining game whether high licence fees were incurred or not. Indeed the licence winning firm has an option to delay even if it receives the licence fee for free. If it is accepted that the size of the licence fee negatively affects the firm's cost of borrowing then this in turn it will positively affect the value of the option to delay.

In Section 9.3 it was shown that a higher discount rate will cause the value of the option to delay to be greater. If we assume that the cost of investment in each period will be the same and that the size of the potential market will not be affected by late delay, then the only cost of delay to the firm is the foregone revenue. In terms of a bargaining model, the discount factor will be reduced when the value of foregone revenues is high and increased when the value of the option is high. If the value of the option is the same as the forgone revenue the discount factor will be 1. In this case we are assuming that the cost of network investment remains the same in real terms between periods.

More formally, let us say that we have a total surplus of x that the regulator can divide between the firm and consumers. The regulator knows that if they do not provide enough surplus to the firm then they will delay investment until the next period. If delay occurs then there is no surplus provided to either the consumers or the firm. We can also say that the licence winning firm and the regulators have discount factors of δ_f and δ_r respectively. δ_r takes a value between zero and one and is determined by the loss of total surplus between the two time periods. In addition to the loss of total surplus there may also be other unquantifiable political factors which will mean that the regulator has a very strong desire for early roll-out.

If there is no option to delay then the cost of delay for the firm, assuming that once investment occurs output can take place immediately, is only the revenue lost in the period between bargains and δ_f will take a value between 0 and 1 .

$$\delta_f = 1 - \frac{r}{x} \qquad (9.17)$$

where r is the forgone revenue between two periods. If r = 0 then there would be no revenue in the period, and hence no revenue lost. This would leave the firm with a discount factor of 1 and the firm would be indifferent between investment now and in the next period. If r = x then all the revenue for the project is made during the period between bargains and hence all the revenue is lost. In this case the firm has an absolute preference to invest now and so will invest even if offered a fraction of the surplus.

When we include an option to delay with some value then the discount factor becomes;

$$\delta_f = 1 + \frac{c - r}{x} \qquad (9.18)$$

Remembering that c is the value of the timing option. It should be noted that the discount factor no longer has to be less than 1. If the value of the option takes a value so that $0 < c < r$ then the discount factor will be between 0 and 1 but will be greater than with no option to delay. If $c > r$ then the discount factor will be greater than 1 and the value of the investment is increased if investment is delayed. Each side's surplus is then taken as $x\delta_i^t$ where t is the time at which the bargain takes place.

The model also rests upon the assumption that once the agreement over the regulatory stance has been fixed both sides will stick to it. This is realistic to a degree; once the firm has invested in its infrastructure it no longer has any bargaining power. Investment has occurred and as long as the firm can cover its marginal costs there is no motivation to cease the provision of services. The regulator has less of an incentive to keep to the agreement that is made. The temptation for the regulator would be to renege on the agreed division of surplus once investment has occurred and the infrastructure is in place. This form of regulatory truncation has already been discussed in relation to its effect on the value of the option to delay. The regulator would be particularly keen to engage in this truncation if their estimate of surpluses was incorrect. If they believe that the licence holder is experiencing a windfall from the regulatory regime that is in place they may wish to remove part of this. The regulator may be prevented from behaving in this way through legally enforceable contracts. However, as was discussed in the last section, where contractual inefficiencies are present these contracts made be difficult to form.

9.5.1: Nash Bargaining Model

The discussion around Rubenstein discount factors will be used to inform the building of a model to examine the Nash bargaining model. The primary argument is that greater debt will cause a higher cost of capital and in turn increase the value of the option to delay. As was shown in the last section this will in turn improve the licence holder's bargaining position. Due to the complexity that surrounds the 3G administration and post-administration market it is impossible to model all the interactions that occurred during the period under consideration. There is also the added complication of a number of different firms interacting with each other and the regulator. Indeed one of the themes of the last two chapters has been the influence of political and psychological factors in determining the interactions between the regulator and the firm. As such this model will present a simplified version of the possible interaction between the regulator and the firm and the consequences for how the government would approach licence fees.

As with the simple option pricing example, the licence holder's investment decision will occur over two periods. In each period either a positive or negative state of the world occurs. The only negotiation that occurs between the government and the licence holder occurs over the price (P) that will be charged and the level of the investment (I). As has been discussed if a price is negotiated in period 1 then it will also be used in period 2 so that $P_1 = P_2$. Before the first period the sale of a licence occurs. The government can determine the level of revenue it receives by either giving the licence away in a beauty contest or charging a fee through an auction. The government and licence buyer negotiate over the level of investment in period 1. If the licence holder invests, then production occurs in period 1. If the licence holder does not invest in period 1 then the government and licence holder engage in another bargain over investment levels and pricing in period 2. The licence holder then has the opportunity to invest if they have not done so in period 1. If investment takes place in period 2 then so will production. It should be noted that in this model the government is responsible for both revenue raising at the licensing stage and the post-administration regulatory bargaining. As was discussed in the previous section, once an agreement is reached both parties will adhere to it.

Given that the licence holder invests in period 1, the government's payoff in period 1 is $W_1(I_1)$. This welfare is made up of a range of different factors such as consumer surplus, political influences, and network externalities. Potentially this could include any of the social factors that were outlined in the previous chapter. In period 2, the welfare function for the government is $W_2(I_i)$ where i = 1 or 2 depending on whether investment has taken place in period 1 or 2. The welfare function will take a form so that $W'(I) > 0, W''(I) < 0$. The payoff for the government if investment has only occurred in period 2 with a positive state of the world is

$$G_2 = W\left(I_2\right) - P_2 \tag{9.19}$$

If investment occurs in period 1 then the expected payoff for the government is

$$E\left(G_1\right) = p\left[W_1(I_1) + W_2(I_1) - 2P_1\right] \tag{9.20}$$

where p is the probability that the positive state of the world occurs.
For the licence holder the payoff in period 2 is

$$B_2 = P_2 - I_2 \tag{9.21}$$

The expected payoff if investment occurs in the first period is then

$$E\left(B_1\right) = 2pP_1 - I_1 \tag{9.22}$$

Moving on to the Nash bargaining solution threat points,in period 2, if the licence holder and the government do not reach an agreement then both receive a payoff of zero. This is equivalent to a licence holder removing themselves from the market. It is also assumed that the licence can be re-sold at a later date but this is both costly and time consuming. In period 1 the threat point is the expected value of the outcomes in period 2. The bargaining power of the licence holder will be α and the power for the government the bargaining power is $1-\alpha$. As discussed in the previous section, the cost of delay to the licence holder will decrease due to the higher value of the option to delay. As such α is a function of the licence fee L where $\alpha'(L) > 0$.

Taking the usual backwards induction method the bargaining solution for period 2 given that investment did not occur in period 1 is

$$Max_{P_2,I_2}\Omega_2 = (W_2(I_2) - P_2)^{(1-\alpha)}(P_2 - I_2)^{\alpha} \tag{9.23}$$

which leads to the first order conditions

$$I_2 : (1-\alpha)W_2'(I_2)(P_2 - I_2) = \alpha(W_2(I_2) - P_2), \tag{9.24}$$

$$P_2 : (1-\alpha)(P_2 - I_2) = \alpha(W_2(I_2) - P_2). \tag{9.25}$$

Solving Equations **(9.24)** and **(9.25)** gives

$$W_2'(I_2^*) = 1, \tag{9.26}$$

which means that investment is efficient and

$$P_2^* = \alpha W_2(I_2^*) + (1-\alpha)I_2^*. \tag{9.27}$$

One point to note from Equation **(9.28)** is that

$$\frac{dP_2^*}{dL} = \alpha'(L)\left[W_2(I_2^*) - I_2^*\right] > 0, \tag{9.28}$$

This will mean that no matter what the licence fee as long as the investment is worthwhile in the positive state of the world then investment will be efficient. Although the government is keen to have full mobile coverage, they are willing to compromise if it will cost the rest of the country too much.

The bargaining solution for period 1 is

$$Max_{I_1,P_1}\Omega_2 = \left[p\left(W_1(I_1)+W_2(I_1)-2P_1\right)-p\left(W_2(I_2^*)-P_2^*\right)\right]^{(1-\alpha)}\left[p\left(2P_1\right)-I_1-p\left(P_2^*-I_2^*\right)\right]^{\alpha}. \quad (9.29)$$

Leading to the first order conditions of

$$\begin{aligned} I_1 &: (1-\alpha)\left(W_1'(I_1^*)+W_2'(I_1^*)\right)(2pP_1^*-I_1^*-p(P_2^*-I_2^*)) = \\ &\alpha 2p\left(W_1(I_1^*)+W_2\left(I_1^*\right)-2P_1^*-\left(W_2\left(I_2^*\right)-P_2^*\right)\right), \end{aligned} \quad (9.30)$$

$$P_1 : 2p(1-\alpha)(2pP_1^*-I_1^*-p(P_2^*-I_2^*)) = 2\alpha p\left(W_1(I_1^*)+W_2\left(I_1^*\right)-2P_1^*-\left(W_2\left(I_2^*\right)-P_2^*\right)\right). \quad (9.31)$$

Solving Equations **(9.30)** and **(9.31)** gives

$$W_1'(I_1^*)+W_2'(I_1^*)=2p. \quad (9.32)$$

Here, when compared to period 2, efficient investment can be higher due to the longer time period or lower because of the associated future uncertainty of investing immediately.

The price is then given by

$$P_1^* = \frac{(1-\alpha)\left[I_1^*+p\left(P_2^*-I_2^*\right)\right]+\alpha p\left[W_1^*(I_1^*)+W_2^*(I_1^*)-(W_2^*(I_2^*)-P_2^*)\right]}{2p}. \quad (9.33)$$

From Equation **(9.33)** it can be seen how the price will change with the licence price L

$$\frac{dP_1^*}{dL} = \alpha'(L)\left[-I_1^*+p\left(P_2^*-I_2^*\right)+p\left(W_1(I_1^*)+W_2(I_1^*)\right)-p\left(W_2(I_2^*)-P_2^*\right)\right]+p\frac{dP_2^*}{dL}>0 \quad (9.34)$$

From this we can conclude that delay only occurs due to a high level of uncertainty. If the bargaining surplus is positive in the first period then a bargain will be reached. Now looking at the government's ex-ante overall payoff including the licence fee. This payoff will be

$$\Pi\left(I_1^*\right)=W_1\left(I_1^*\right)+W_2\left(I_1^*\right)-2P_1^*+L \quad (9.35)$$

The optimal choice of licence fee is then

$$\frac{d\Pi(I_1^*)}{dL} = -2\frac{dP_1^*}{dL} + 1, \tag{9.36}$$

Equation **(9.36)** provides an interesting conclusion. Depending on the size of dP_1^*/dL the government would opt for either an auction or a beauty contest. When dP_1^*/dL takes a low value, due to the period 1 surplus being low or $\alpha'(L)$ being small then a high licence fee will have a smaller impact on the government's bargaining power. If $\alpha'(L)$ is high or the period 1 surplus is large then beauty contests are better due to the smaller impact they have on bargaining power. Taking the discussion from the Section 5.2 and applying it here; if the mechanism through which the licence fees impact of the option to delay is particularly strong, whether this be through inefficient capital markets or through firms engaging in heuristic investment practices, it will mean that $\alpha'(L)$ will be high and a beauty contest should be more attractive to the government than an auction. As such, governments that perceive a higher external effect are more likely to opt for a beauty contest. This finding links back to the discussion in Chapter 3, that those countries that used beauty contest explicitly citing concerns over market development.

9.6: Conclusion

The previous chapter discussed the evidence of regulatory easing in the post 3G administration. Evidence was presented from both the European and national level. This chapter had demonstrated through a bargaining mechanism why this behaviour may come about. The chapter has focused on three main areas. Firstly, the chapter was interested in how a lump sum licence fee could impact on a firm's investment decision.

Sections 9.1 and 9.2 outlined how inefficient capital markets and heuristic investment approaches could have an effect on the firm's operational cost of capital when the firm pays out a large lump sum fee. The next step was to explore how these changes in the cost of capital would impact on the firm's preferred timing for network infrastructure investment. As was shown in Sections 9.3, 9.4 and 9.5, both theoretically and through simulation, this could be explained through an increase in the value of the firm's option to delay. When the firm's cost of capital increased the value of the option to delay also increased. This relationship is then applied to a bargain between the firm and the regulator. This relationship is examined in the context of a Rubinstein bargain where the increasing value of the option to delay increases the firm's bargaining weight by making delay more attractive for the firm.

The final section applies this concept to a simple two stage bargaing model between the licence holder and the government. The final section shows that where the firm's cost of capital is affected in the way described, it may be better for the government to use a beauty contest instead of an auction to avoid the associated loss in bargaining power. As such, a one-off lump sum licence fee administered using an auction mechanism can have an impact on the post-administration industry.

Table 9.1: Fall in Licence winner credit ratings

Operator	Long Term Rating (Moody)			
	1999	2000	2001	2002
British Telecom	Aa1	A2	Baa1	Baa1
Deutsche Telekom	Aa2	A2	A3	Baa1
France Telecom	Aa2	A1	Baa1	Baa3
KPN	Aa1	Baa1	Baa2	Baa3
Sonera	A2	A2	Baa2	Baa2
Tele Danemark	Aa3	Aa3	A2	A3
Telecom Italia	A3	Baa2	Baa1	Baa1

Source: Del Monte (2004) in Money, Credit and the Role of the State

Table 9.2: Black-Scholes Simulation Results

Cost of (K)	7.1%	7.2%	7.3%	7.4%	7.5%
Investment (I) % change	0.348	0.694	1.037	1.380	1.720

Table 9.3: Binomial Simulation Results

Cost of (K)	7.1%	7.2%	7.3%	7.4%	7.5%
(I) % change 0.15	-0.318	-0.634	-0.948	-1.261	-1.571
(I) %change 0.25	-0.321	-0.639	-0.956	-1.27	-1.582
(I) %change 0.5	-0.331	-0.659	-0.985	-1.31	-1.632

Chapter 10: Conclusion

This thesis has been concerned with an analysis of the administration to run 3G technology across Europe. Controversy surrounded these licences due to the range of fees that different countries raised, as well as due to the post-administration difficulties of many of the operators. During and soon after the administrations the focus was on the success of auction theory and on denials that large lump sum fees would have an impact on the post-administration market. This thesis has challenged some of these ideas and has presented reasons why such behaviour was observed. The thesis began by exploring those factors that were responsible for the differential in licence fees across countries, and examined the issues that affected which bidders won licences. The second part of the thesis focused on using financial market reaction to explore whether there was evidence of overpayment via a winner's curse. The final part of the thesis explored the evidence that 3G licence fees directly brought about regulatory response. In essence, the analysis found that the regulators responded to regulatory distress by providing the licence holders with a more favourable regulatory framework. The previous section ended by seeking to explain how and why this regulatory easing could come about, suggesting that the key motivation for this regulatory easing was some socially desirable goal.

10.1: How Much? Who? Why?

The first section of this thesis focused on what actually happened in the 3G administrations. Chapters 2 and 3 outlined why particular administration types were used and how auctions became the favoured type of administration procedure. Auctions were preferred due to their relative speed, ability to raise revenue and the perceived efficient outcomes associated with auctions. Auctions became even more popular in the European administration after the success of the British and, to a certain extent, the German auctions. Despite the popularity of auctions, some countries still used comparative selection procedures, often with the expressed aim to avoid overpayment and encourage network development. One key insight that chapter 3 provided concerns the difficulty that developed in the post-administration market. This post-administration difficulty manifested itself in two ways: through delays in network development and through the return or revocation of licences. Indeed, as was shown, in a number of cases the same licences were administered and returned several times. It should be noted that these delays and hand-backs occurred across countries that used different administration procedures and was not the reserve of countries that used auction procedures.

Chapter 4 provided the main empirical analysis of the first part of this thesis. Firstly the analysis attempted to identify those factors that affected the size of each bidding unit's bid. As discussed in Chapter 4, it would have been desirable to examine each bidding unit's willingness to pay, but due to the way the auctions are constructed this is not possible. The bidders' observed highest bid was analysed against country-specific, bidder-specific and administration-specific variables. The second part of the analysis examined those factors that affected the bidding units' probability of winning a licence. The analysis also introduced an instrumented observed highest bid into the probit equation.

Certain results of this analysis conformed to expectations over the procedures. Although, unsurprisingly, one of the main determinants was the type of administration used, auction or beauty contest, there were also a number of other factors that determined the size of licences across countries. One critical factor among these was the timing of each administration. This meant that one of the most important determinants of a bidding unit's bid was out of the hands of the administering authority. The main finding of the second part of the analysis is that despite attempts to allow entry into the industry, the main factor in determining the probability of a bidding winning a licence was whether or not they were an incumbent.

10.2: The Identification of a Winner's Curse

After the first part of this thesis addressed those factors that influenced the size of the observed bids and who won licences, the second part focused on whether too much was paid for these licences due to a winner's curse. One of the key discussions from Chapter

5 was the problems associated with identifying a winner's curse, in particular the weakness of using ex post returns data to identify a winner's curse in general and in particular for the 3G administrations. Indeed, an examination of ex post returns could only inform us of which state of the world occurred, rather than whether a winner's curse was present. The argument was made for the examination of the stock market reaction in order to test whether overpayment occurred. This was done through examining the reaction to the winners and losers of the German and Swedish licences administrations through an event study. One key question that was addressed regarded the importance of a winner's curse in terms of regulatory response. Given the definition of a winner's curse provided in Chapter 4, the licence winner could be in financial distress whether they had suffered a winner's curse or not. Indeed, the licence holders could have suffered a winner's curse and still made a considerable profit. The importance of identifying a winner's curse lies in two areas. As Chapter 4 made clear, firstly, a winner's curse makes financial distress more likely and, secondly, the administering authority is partly to blame for the financial distress that occurs.

In order to identify the winner's curse, an event study was employed. The event study analysed the equity returns of each of the firms involved in the German and Swedish procedures. In this event study, the market model was used to estimate the normal returns and three estimation techniques were used to account for any non-normality. Although it may have been preferable to treat the European administration as one larger super-event, with each administration as one event within it, this is not possible due to the length of the event. This is, however, something to be aware of in the interpretation of the results. The results of the event study in Chapter 7 show that the winners in the German auction fare considerably worse than the losers when compared on both the event date and the losers' withdrawal date. Further evidence was provided to support this supposition by the lack of a negative response to the winners of the Swedish administration. The results from the comparative Swedish/German event study suggest that the markets reacted negatively to the winners in the German auction and there was evidence of at least a short-term winner's curse.

10.3: Post-administration Regulation

The final part of this thesis dealt with the regulation of mobile telecommunications, evidence of post-administration regulatory easing, and an explanation of the post-administration behaviour by both the firm and regulator. In order to facilitate this discussion, Chapter 8 has given an overview of the way telecommunication regulation has been carried out at the European level and at the national level in the UK. In both cases, documentary evidence was provided for the proposition that regulators responded to the size of licence fees and the firms' financial distress by easing the regulatory framework the firms faced.

Chapter 9 sought to examine how high licence fees can impact on the firm's investment decision by changing the firm's cost of capital. In particular, it showed that where capital markets are inefficient or where firms engage in heuristic investment practices, a large lump sum fee could impact on the cost of capital that the firm uses to assess its investment strategy. This in turn can affect the value that is placed on the firm's option to delay. It was shown that this could explain the post-administration behaviour of the firm in delaying its roll-out of network infrastructure. The second part of Chapter 9 outlined how the regulator and the firm could interact in a simple two stage Nash bargaining model, informed by the first section on the value of the option to delay and how this could affect Rubinstein bargaining weights. It demonstrated the ways in which the size of the licence fee could bring about delay in network infrastructure investment due to the regulatory firm interaction. A larger licence fee increases the value of the firm's bargaining weight via a change in the firm's cost of capital. When this concept is applied to the simple Nash bargaining model a solution is reached that shows beauty contests may be more attractive to governments than auctions. Indeed the model shows that those countries that perceived a higher external effect will have a preference for beauty contests.

Although this model poses valuable insights, it can only be indicative of the actual relationship between the firm and the regulator. The model assumes only a single firm and regulator. Further, it assumes two time periods and that the same authority is responsible for both administration revenue raising and post-administration regulatory stance. All of these assumptions could be changed and provide scope for further research. Another area of potential future interest is the relationship between the level of regulatory easing and the level of independence of the regulatory authority. This area was touched upon in Chapter 2 with a discussion of the level of interference in the regulator's decisions over the number of licences and the way the licences were administered.

10.4: Lessons learnt from the 3G auctions.

The administration of spectrum has undergone a considerable evolution over the past 30 years. Much of this experience has been a matter of trial and error. Perhaps the most important leap forward was the use of spectrum auctions and the lessons learnt from the FCC administrations. These lessons were primarily focused on ensuring participation, revenue maximisation and efficient allocation. As was discussed in Chapter 2, many of these lessons were adapted for use in the European 3G auctions. Just as lessons were learnt from the FCC auctions, they can also be learnt from the 3G administrations. Some have already been discussed in other literature (Klemperer 2002a). However, these have focused on auction design matters, such as attracting entry or preventing collusion. This thesis has been particularly interested in the impact that overpayment has had on the post-administration market. At a European level, there were clear winners and losers from the allocation of spectrum, and this may require additional coordination when administering spectrum. The results of the empirical analysis show that part of the success for the countries which did well was brought about by luck rather than good judgement. This led to an inequitable distribution of revenue between countries, although in many cases the post-administration distress was not exclusive to the countries that raised the most. If the EU administration is considered to be a sequential administration rather than a series of individual administrations, then one potential option would be to administer licences all at once through a simultaneous European procedure. Although this would improve equity among countries in terms of revenue raised, as it removes the element of luck (particularly in terms of timing), it runs the danger of exacerbating the possibility of a winner's curse. In a sequential process, information about the true value of licences emerged over time. If licences were sold through a simultaneous procedure, this information could not be released. The danger then is that a winner's curse is present in all, not some of the administrations.

It follows from the examinations in this thesis that auctions may no longer be the best way to administer spectrum licences if the administering authority has some social goal to achieve, as was the case with the 3G technology. If handled differently, the licences would end up in the hands of those that valued them the most, and the administering authority would have to accept that it is up to the winning bidder to decide what to do with their licence. Although contracts can be written that oblige the licence-winning firms to meet certain roll-out or quality commitments, it has been shown that in many cases these contracts are not enforced and are open to be rewritten. In this case the regulator takes a 'how would this make me look?' approach. Where there is a desire to achieve a certain policy goal it may be better to administer through a beauty contest procedure and enforce the efficient use of spectrum through some form of administered incentive pricing. However, if that is to be done, it must be done at a European level to stop some countries using auctions and free-riding on those countries that used beauty contests.

N.o	Country	Bidder	Did the Bidder Win	Total Order	Relative Days	Reserve Price	Spectrum Per licence	Number Of Bidders	2G Incumbent	Two or more 2G	Total 2G held	3G won to date
1	Finland	Radiolinja	1	1	1	NA	35	4	1	0	1	0
2	Finland	Sonera	1	1	1	NA	35	4	1	1	1	0
3	Finland	Suomen	1	1	1	NA	35	4	1	1	3	0
4	Finland	Telia Finland	1	1	1	NA	35	4	0	0	0	0
5	Spain	Airtel	1	2	363	NA	35	4	1	1	12	10
6	Spain	Amena	1	2	363	NA	35	4	1	0	1	1
7	Spain	Telefonica	1	2	363	NA	35	4	1	1	1	5
8	Spain	Xfera	1	2	363	NA	35	4	0	1	1	5
9	Spain	Jazzel	0	2	363	NA	35	4	0	0	3	0
10	Spain	Uni2	0	2	363	NA	35	4	0	1	8	0
11	UK	TIW UMTS	1	3	408	3.45	35	13	0	1	0	0
12	UK	Vodafone	1	3	408	2.95	30	13	1	1	12	1
13	UK	BT3G	1	3	408	2.46	25	13	1	1	6	0
14	UK	One2One	1	3	408	2.46	25	13	1	1	3	0
15	UK	Orange	1	3	408	2.46	25	13	1	1	8	0
16	UK	Crescent	0	3	408	2.46	25	13	0	0	0	0
17	UK	3G UK	0	3	408	2.46	25	13	0	1	0	0
18	UK	Spectrumco	0	3	408	2.46	25	13	0	0	0	0
19	UK	Epsilon	0	3	408	2.46	25	13	0	0	0	0
20	UK	One.Tel	0	3	408	2.46	25	13	0	0	0	0
21	UK	Worldcom	0	3	408	2.46	25	13	0	1	0	0
22	UK	Telefonica	0	3	408	2.46	25	13	0	1	1	5
23	UK	NTL Mobile	0	3	408	2.46	25	13	0	1	8	4
24	Netherlands	Libertel	1	4	496	2.86	35	5	1	1	12	2
25	Netherlands	KPN	1	4	496	2.86	35	5	1	1	2	0
26	Netherlands	Dutch Tone	1	4	496	2.58	25	5	1	1	12	1
27	Netherlands	Telfort	1	4	496	2.58	25	5	1	1	6	1
28	Netherlands	3G Blue	1	4	496	2.58	25	5	0	1	3	1
29	Germany	Mannesmann	1	5	521	1.24	25	9	1	1	12	2

30	Germany	Group 3G	1	5	521	1.24	25	9	0	1	1	2
31	Germany	E-Plus 3G	1	5	521	1.24	25	9	1	1	2	1
32	Germany	Moilcom	1	5	521	1.24	25	9	0	1	12	2
33	Germany	Viag Interkom	1	5	521	1.24	20	9	1	1	6	2
34	Germany	T-Mobile	1	5	521	1.24	25	9	1	1	3	2
35	Germany	Debitel	0	5	521	1.24	20	9	0	1	1	0
36	Germany	Talkline	0	5	521	1.24	20	9	0	1	2	2
37	Germany	SFR	0	5	521	1.24	20	9	0	0	1	0
38	Germany	Nets	0	5	521	1.24	20	9	0	0	0	0
39	Italy	Omnitel	1	6	587	36.03	25	8	1	1	12	3
40	Italy	Ipse	1	6	587	36.03	35	8	0	0	1	3
41	Italy	Wind	1	6	587	36.03	25	8	1	0	1	0
42	Italy	Andala	1	6	587	36.03	35	8	0	1	0	1
43	Italy	Telecom Italia	1	6	587	36.03	25	8	1	1	3	0
44	Italy	Blue	0	6	587	36.03	35	8	1	0	1	0
45	Italy	Dix.it	0	6	587	36.03	35	8	0	0	0	0
46	Italy	TU Tlc	0	6	587	36.03	35	8	0	0	0	0
47	Austria	Mobilkom	1	7	598	1.24	25	6	1	1	1	1
48	Austria	Max.mobil	1	7	598	1.24	25	6	1	1	3	3
49	Austria	Mannesmann	1	7	598	1.24	20	6	1	1	12	3
50	Austria	Connect	1	7	598	1.24	20	6	1	0	0	0
51	Austria	Hutchison	1	7	598	1.24	25	6	0	1	0	2
52	Austria	3G Mobile	1	7	598	1.24	20	6	0	1	1	3
53	Norway	Broadband Mobile	1	8	624	NA	35	7	0	1	1	5
54	Norway	NetCom GSM	1	8	624	NA	35	7	1	1	4	2
55	Norway	Telenor	1	8	624	NA	35	7	1	1	4	4
56	Norway	Tele2	1	8	624	NA	35	7	0	1	3	4
57	Norway	Orange Norge	0	8	624	NA	35	7	0	1	8	2
58	Norway	BusinessNet	0	8	624	NA	35	7	0	0	0	0
59	Norway	Orkla	0	8	624	NA	35	7	0	0	0	0
60	Switzerland	Swisscom	1	9	631	4.49	35	9	1	1	12	4

61	Switzerland	dSpeed	1	9	631	4.49	35	9	1	0	2	2
62	Switzerland	Orange	1	9	631	4.49	35	9	1	1	8	3
63	Switzerland	Team 3G	1	9	631	4.49	35	9	0	1	1	4
64	Switzerland	Teldotcom	0	9	631	4.49	35	9	0	0	0	0
65	Switzerland	Cabelcom Management	0	9	631	4.49	35	9	0	0	0	0
66	Switzerland	T-mobile	0	9	631	4.49	35	9	0	1	3	4
67	Switzerland	Telenor Mobile	0	9	631	4.49	35	9	0	1	4	2
68	Switzerland	Hutchison 3G	0	9	631	4.49	35	9	0	1	0	2
69	Sweden	Europolitan	1	10	641	NA	35	9	1	1	12	5
70	Sweden	Hi3G Access	1	10	641	NA	35	9	0	1	0	2
71	Sweden	Orange Sverigne	1	10	641	NA	35	9	0	1	8	4
72	Sweden	Tele2	1	10	641	NA	35	9	1	1	3	2
73	Sweden	Telia	0	10	641	NA	35	9	1	1	4	1
74	Sweden	Tenora Networks	0	10	641	NA	35	9	0	0	0	0
75	Sweden	Broadwave Consortim	0	10	641	NA	35	9	0	0	0	0
76	Sweden	ReachOutMobil e	0	10	641	NA	35	9	0	1	1	5
77	Sweden	Mobility4Swede n	0	10	641	NA	35	9	0	1	3	3
78	Portugal	Oni-Way	1	11	645	NA	35	7	0	1	4	2
79	Portugal	Optimus	1	11	645	NA	35	7	1	1	8	5
80	Portugal	Telecel	1	11	645	NA	35	7	1	1	12	6
81	Portugal	TMN	1	11	645	NA	35	7	1	0	1	0
82	Portugal	MobiJazz	0	11	645	NA	35	7	0	1	1	4
83	Portugal	Vivendi Consortium	0	11	645	NA	35	7	0	1	1	1
84	Portugal	Maxitel Consortium	0	11	645	NA	35	7	0	0	0	0
85	Belgium	Belgacom Mobile	1	12	717	14.78	35	4	1	1	1	7

86	Belgium	KPN Mobile 3G Belgium	1	12	717	14.78	35	4	0	1	2	2
87	Belgium	Mobistar	1	12	717	14.78	35	4	1	1	8	6
88	Belgium	ST3G	0	12	717	14.78	35	4	0	1	1	3
89	France	France Telecom	1	13	807	NA	35	2	1	1	12	8
90	France	SFR	1	13	807	NA	35	2	1	1	6	1
91	Greece	Panafon	1	14	850	13.81	45	4	1	1	12	8
92	Greece	Cosmote	1	14	850	13.81	35	4	1	0	4	3
93	Greece	Stet Hellas	1	14	850	13.81	25	4	1	1	3	1
94	Greece	Infoquest	0	14	850	13.81	25	4	1	0	1	0
95	Luxembourg	EPT	1	16	1163	NA	35	3	1	0	1	0
96	Luxembourg	Orange Sverigne	1	16	1163	NA	35	3	0	1	8	10
97	Luxembourg	Tele2	1	16	1163	NA	35	3	1	1	2	3
98	Ireland	Hutchison	1	17	1197	NA	35	3	0	1	0	4
99	Ireland	O2	1	17	1197	NA	35	3	1	1	6	2
100	Ireland	Vodafone Ireland	1	17	1197	NA	35	3	1	1	12	9
101	France	Bouygues	1	18	1291	NA	35	1	1	0	1	0
102	Luxembourg	LuXcommunicat ions	1	19	1582	NA	35	1	0	0	0	0

N.o	Country	Bidder	Observed Bid (€)	Observed Bid per Block per Capita	N.o Licences	Additional Licences	Method of Administration	GDP per Capita	Population	Mobile Penetration	Internet Penetration	ITU Index
1	Finland	Radiolinja	14000	0.04	4	1	0	26914	5165090	3364	1667	91.5
2	Finland	Sonera	14000	0.04	4	1	0	26914	5165090	3364	1667	91.5
3	Finland	Suomen	14000	0.04	4	1	0	26914	5165090	3364	1667	91.5
4	Finland	Telia Finland	14000	0.04	4	1	0	26914	5165090	3364	1667	91.5
5	Spain	Airtel	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
6	Spain	Amena	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
7	Spain	Telefonica	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
8	Spain	Xfera	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
9	Spain	Jazzel	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
10	Spain	Uni2	75144649	0.27	4	1	0	16448	39418020	12300	2830	85.6
11	UK	TIW UMTS	7195123515	17	5	1	1	26157	59501000	27185	12500	96
12	UK	Vodafone	9786693878	27	5	1	1	26157	59501000	27185	12500	96
13	UK	BT3G	6613238598	22	5	1	1	26157	59501000	27185	12500	96
14	UK	One2One	6569753120	22	5	1	1	26157	59501000	27185	12500	96
15	UK	Orange	6719736993	23	5	1	1	26157	59501000	27185	12500	96
16	UK	Crescent	2985565198	10	5	1	1	26157	59501000	27185	12500	96
17	UK	3G UK	3283727887	8	5	1	1	26157	59501000	27185	12500	96
18	UK	Spectrumco	3446018971	12	5	1	1	26157	59501000	27185	12500	96
19	UK	Epsilon	3400400244	11	5	1	1	26157	59501000	27185	12500	96
20	UK	One.Tel	3578608653	12	5	1	1	26157	59501000	27185	12500	96
21	UK	Worldcom	5206770569	18	5	1	1	26157	59501000	27185	12500	96
22	UK	Telefonica	6019210566	20	5	1	1	26157	59501000	27185	12500	96
23	UK	NTL Mobile	6515437297	22	5	1	1	26157	59501000	27185	12500	96
24	Netherlands	Libertel	713796280	6	5	1	1	27104	1583900	6900	3000	82

25	Netherlands	KPN	711073599	6	5	1	1	27104	1583900	6900	3000	82
26	Netherlands	Dutch Tone	435629007	6	5	1	1	27104	1583900	6900	3000	82
27	Netherlands	Telfort	430002133	5	5	1	1	27104	1583900	6900	3000	82
28	Netherlands	3G Blue	394970300	5	5	1	1	27104	1583900	6900	3000	82
29	Germany	Mannesmann	8484786510	21	6	1	1	27716	82163470	23470	14400	83
30	Germany	Group 3G	8471441792	21	6	1	1	27716	82163470	23470	14400	83
31	Germany	E-Plus 3G	8432123446	21	6	1	1	27716	82163470	23470	14400	83
32	Germany	Moilcom	8431714413	21	6	1	1	27716	82163470	23470	14400	83
33	Germany	Viag Interkom	8445008002	26	6	1	1	27716	82163470	23470	14400	83
34	Germany	T-Mobile	8484786510	21	6	1	1	27716	82163470	23470	14400	83
35	Germany	Debitel	5007592684	15	6	1	1	27716	82163470	23470	14400	83
36	Germany	Talkline	164096141	0	6	1	1	27716	82163470	23470	14400	83
37	Germany	SFR	164096141	0	6	1	1	27716	82163470	23470	14400	83
38	Germany	Nets	164096141	0	6	1	1	27716	82163470	23470	14400	83
39	Italy	Omnitel	2448005702	9	5	1	1	22069	5734260	30296	8200	86
40	Italy	Ipse	3269172171	8	5	1	1	22069	5734260	30296	8200	86
41	Italy	Wind	2427347426	8	5	1	1	22069	5734260	30296	8200	86
42	Italy	Andala	3253678464	8	5	1	1	22069	5734260	30296	8200	86
43	Italy	Telecom Italia	2417018288	8	5	1	1	22069	5734260	30296	8200	86
44	Italy	Blue	2318891477	6	5	1	1	22069	5734260	30296	8200	86
45	Italy	Dix.it	2065827596	5	5	1	1	22069	5734260	30296	8200	86
46	Italy	TU Tlc	2065827596	5	5	1	1	22069	5734260	30296	8200	86
47	Austria	Mobilkom	120636905	3	6	1	1	27523	8176900	4206	1250	85
48	Austria	Max.mobil	119401467	3	6	1	1	27523	8176900	4206	1250	85
49	Austria	Mannesmann	113151603	3	6	1	1	27523	8176900	4206	1250	85
50	Austria	Connect	120055522	4	6	1	1	27523	8176900	4206	1250	85
51	Austria	Hutchison	113587640	3	6	1	1	27523	8176900	4206	1250	85

52	Austria	3G Mobile	117439300	4	6	1	1	27523	8176900	4206	1250	85
53	Norway	Broadband Mobile	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
54	Norway	NetCom GSM	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
55	Norway	Telenor	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
56	Norway	Tele2	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
57	Norway	Orange Norge	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
58	Norway	BusinessNet	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
59	Norway	Orkla	23612292	0.76	4	0	0	37232	4445330	2745	2000	88
60	Switzerland	Swisscom	32094502	1	4	1	1	39281	7144700	2935	1761	90
61	Switzerland	dSpeed	32094502	1	4	1	1	39281	7144700	2935	1761	90
62	Switzerland	Orange	32094502	1	4	1	1	39281	7144700	2935	1761	90
63	Switzerland	Team 3G	32094502	1	4	1	1	39281	7144700	2935	1761	90
64	Switzerland	Teldotcom	32094502	1	4	1	1	39281	7144700	2935	1761	90
65	Switzerland	Cabelcom Management	32094502	1	4	1	1	39281	7144700	2935	1761	90
66	Switzerland	T-mobile	32094502	1	4	1	1	39281	7144700	2935	1761	90
67	Switzerland	Telenor Mobile	32094502	1	4	1	1	39281	7144700	2935	1761	90
68	Switzerland	Hutchison 3G	32094502	1	4	1	1	39281	7144700	2935	1761	90
69	Sweden	Europolitan	5576401	0.09	4	0	0	29160	8861430	5165	3666	86.2
70	Sweden	Hi3G Access	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
71	Sweden	Orange Sverigne	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
72	Sweden	Tele2	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
73	Sweden	Telia	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
74	Sweden	Tenora Networks	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2

75	Sweden	Broadwave Consortim	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
76	Sweden	ReachOutMobile	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
77	Sweden	Mobility4Sweden	5112924	0.08	4	0	0	29160	8861430	5165	3666	86.2
78	Portugal	Oni-Way	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
79	Portugal	Optimus	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
80	Portugal	Telecel	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
81	Portugal	TMN	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
82	Portugal	MobiJazz	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
83	Portugal	Vivendi Consortium	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
84	Portugal	Maxitel Consortium	99759579	1.43	4	0	0	12331	9979450	4671	1000	87.8
85	Belgium	Belgacom Mobile	150200000	2	4	1	1	26444	10152150	3193	1200	87
86	Belgium	KPN Mobile 3G Belgium	150200000	2	4	1	1	26444	10152150	3193	1200	87
87	Belgium	Mobistar	150200000	2	4	1	1	26444	10152150	3193	1200	87
88	Belgium	ST3G	75000000	1	4	1	1	26444	10152150	3193	1200	87
89	France	France Telecom	4950000000	12.06	4	0	0	25401	58620000	5370	5370	82.6
90	France	SFR	4950000000	12.06	4	0	0	25401	58620000	5370	5370	82.6
91	Greece	Panafon	176376199	2	4	1	1	12741	10625710	750	750	86
92	Greece	Cosmote	161411701	2	4	1	1	12741	10625710	750	750	86
93	Greece	Stet Hellas	146735169	3	4	1	1	12741	10625710	750	750	86
94	Greece	Infoquest	146735143	2	4	1	1	12741	10625710	750	750	86
95	Luxembourg	EPT	2784040	0.93	4	1	0	48661	429200	209	75	79
96	Luxembourg	Orange Sverigne	2784040	0.93	4	1	0	48661	429200	209	75	79
97	Luxembourg	Tele2	2784040	0.93	4	1	0	48661	429200	209	75	79

98	Ireland	Hutchison	53400000	2.02	4	1	0	27258	3705070	1655	679	83.6
99	Ireland	O2	116000000	4.47	4	1	0	27258	3705070	1655	679	83.6
100	Ireland	Vodafone Ireland	116000000	4.47	4	1	0	27258	3705070	1655	679	83.6
101	France	Bouygues	1032882834	2.52	2	1	0	25401	58620000	21434	5370	82.6
102	Luxembourg	LuXcommunications	2784040	0.93	1	1	0	48661	429200	209	75	79

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