The Extent of the Winner's Curse in the 1994 – 1995 FCC Spectrum Allocation Auctions

Leonard Chung Jen Lee

Senior, Electrical and Computer Engineering, Economics

Carnegie Mellon University

Advised by: **Stephen Spear**

Professor of Economics, Graduate School of Industrial Administration

Carnegie Mellon University

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Abstract

This paper seeks to examine the extent of the winner's curse in the spectrum allocation auctions organized by the Federal Communications Commission (FCC) between 1994 and 1995. The amount of electromagnetic spectrum is limited and the government bestowed upon the FCC the task of designing an auction that would efficiently allocate the spectrum licenses to the firms best able to use them, while at the same time seeking to raise a significant amount of revenue. The winner's curse is a phenomenon frequently observed in common value auctions whereby the winning bidder over-estimates the true value of the item and thus pays too much. In this thesis, we conduct an empirical examination of whether the design of the FCC's auctions enabled bidders to avoid the winner's curse.

Introduction

The radio spectrum is valuable, not just to the firms that make use of it, but also to the consumers who enjoy the ever increasing array of services that use it. Technology is continually intertwining itself into our lives at an exponential rate. This has been going on for some time and it is obvious that the available resources associated with the technology become more precious as we begin to use them up. The Federal Communications Commission (FCC) through an act of Congress, was given the task of holding a competitive auction to efficiently allocate and sell off licenses enabling access to the electromagnetic spectrum. Previous methods of allocation had been tried and tested before and it was decided that an auction method would be the best way to ensure that the valuable licenses would get into the hands of the firms best able to make use of them. However considering that the radio spectrum licenses are common value goods, a phenomenon called the winner's curse appears in the auctions. In addition to making sure that the licenses were allocated efficiently, the FCC was also concerned with reducing the effect of the winner's curse – to prevent the bidders from overestimating the value of the licenses and end up paying too much for the licenses, resulting in degraded services to the public.

This paper seeks to draw some insights from an empirical examination of the FCC's broadband PCS auction held from December 5, 1994 till March 13, 1995 and many theories, results and comments from previous research will be referenced. Much work has been done concerning the spectrum auctions. Cramton (1995, 1997, 1998), McMillan (1994, 1995, 1996), Milgrom (2000), Chakravorti et al (1995) and McAfee (1996, 1997) just to name a few, have conducted research into the design of the FCC's auctions, the theory behind it as well as the overall efficiency of the spectrum allocations. Access to their work has proved invaluable.

We start out with a historical summary of spectrum use and regulation. It will be useful in understanding the importance of allocating the spectrum. We will then examine what the winner's curse is, and suggested methods of countering or reducing its effects. This is followed by a short discussion of issues that were considered while designing the auction and the final auction format chosen by the FCC. We then end with an analysis of the data pertaining to firms participating in the auctions.

Historical Background

Initially the radio was seen as a wireless telegraph – it was used where physically connecting telegraph lines was difficult and as a point-to-point, rather than broadcast medium. In the early twentieth century various government agencies started setting up and using radio systems as a means of transmitting information across a large area, thus realizing the first broadcast potential of radio. These radio systems were generally used for weather or ship-navigation purposes and there was little coordination among these agencies. Frequency assignments were not official. At this time, the amount of radio spectrum being used was not enough to generate a need for government regulation of ownership and use.

From 1911 to 1927, the Commerce Department's Bureau of Navigation became responsible for regulating the use of radio. The major responsibility of the bureau was to ensure that large ocean vessels had radio communications systems installed. Radio equipment inspection on naval vessels remained as the primary task of the bureau for the next ten years until 1922 when broadcasting became more common. However even as early as 1914, the government had realized that leaving the spectrum unregulated would be a critical mistake, and the Bureau of Navigation took on the additional task of regulating and enforcing radio operating licenses. Amateur radio broadcasting had begun spreading quickly through the United States and the government started compiling a list of the radio stations to keep track of the official frequency use.

By 1927, radio use was undergoing explosive growth and the situation was becoming increasingly chaotic. The Federal Radio Commission was then established through the Radio Act of 1927 in Congress as a new federal body solely dedicated to the regulation of the airwaves. It would be responsible for ensuring fair and efficient use of this new communication medium as well as the allocation of licenses across the United States.

The Communications Act of 1934

The Communications Act of 1934 was approved by congress on June 19, 1934 and combined the Federal Radio Commission, the Interstate Commerce Commission and the Postmaster General together to form the Federal Communications Commission (FCC). Overseeing everything concerning broadcast and communications, this new agency was to regulate and enforce fair use of all wire and radio services within the United States of

America. Soon after passage of the act, the spectrum bandwidth was allocated for free to several firms. Despite the act making it unlawful to create a monopoly, the allocation resulted in a consensual monopoly of the frequencies by the large conglomerates existing at that time.

The Amendment of 1993

In August of 1993, Congress passed an amendment to the Communications Act of 1934, which directed the FCC to efficiently "provide for the reallocation and auction of a portion of the electromagnetic spectrum." A competitive bidding process was recommended for allocating the spectrum to firms. It was believed that this process would provide for a more economically efficient allocation of the scarce spectrum resource and eliminate or reduce the existence of monopolies. By not giving away the spectrum for free, the auction process would also generate significant revenue for the government which could be used to benefit the public through provision of government services, tax cuts, or retirement of the public debt.

Comparative Hearing Method

The use of an auction was considered novel in many ways. Prior to this, a "beauty contest" or more formally, an administrative process was the common method of distributing spectrum licenses. This allocation method involved comparative hearings between firms vying for the licenses and these hearings typically took a significant amount of time, ranging from one to several years. Despite this drawback, many countries in Asia and Europe used this method in the past. Currently while there has been talk of switching to an auction method, there is still a significant number using the administrative process.

The advantage associated with this method is that the government is free to choose the recipients of the licenses on its own and subject to its own standards, rather than leave the allocation to independent and perhaps unpredictable market forces. In this way, the government would be able to ensure that the licensees would be technologically capable to make use of the spectrum. In addition, the government would be able to define the licensing criteria in accordance with future telecommunication or legislative policies. A technocratic government in favor of a certain technology would be able to ensure that the company best able to provide such a service would be given preference in allocation.

However this freedom of choice can be turned around and used as an equally strong argument against the administrative process; licensees might be chosen not for their ability to bring a service to market, but instead for reasons due to political influence or financial size. In this case, industry incumbents would most likely turn out as the winners. A smaller, more innovative firm with an emerging technology would be at a major disadvantage, not having the resources or influence to be recognized as a potential service provider. Furthermore, despite the existence of criterion for judging, firms would have little knowledge as to how the various qualities were weighted. The propagation of technology to the public would thus be delayed since the administrative processes would take a long time, and because the winning firms having paid almost nothing for the licenses would have little incentive to innovate or rapidly diffuse the new services through the licensed areas.

Lottery Method

Allocation by lottery had been used earlier as well, though with limited success. While this process was extremely fast, by definition it was assured that the allocation was purely random and thus unpredictable – the government had little control over the process aside from the setting of initial minimum participation standards. This loss of control meant that there was no way to guarantee that any allocation was efficient – firms in the best position to make use of the spectrum had the same probability of winning as a firm with absolutely no knowledge of communications technology. This coupled with the fact that the winners paid almost nothing for the licenses, had the tendency to attract speculators hoping to gain by arbitrage through secondary markets.

First-Come-First-Served Method

Allocation on a first-come-first-served basis worked as its name implied, assigning the licenses to the first available qualified firms. This aspect of its design led to fast allocation, however like the lottery method, licenses ended up in the hands of random firms and not always in the hands of the ones best able to use the bandwidth.

Proposal for an Auction Allocation Method

In contrast, an auction allocation method aimed to improve upon the flaws of the previous three allocation methods while maintaining goals that the FCC set out to achieve. It could determine spectrum allocation as quickly as the lottery and first-come-first-served methods. Furthermore, the auction could be designed to accommodate all sorts of prerequisite criteria as well as government policy targets. Most important of all, the price-competition would make sure that the licenses would go to the right firms – the highest bidders would be firms who saw the most value in the bandwidth and who believed themselves capable of realizing its potential.

Electromagnetic Spectrum Rights

Before considering the auction design, let us first discuss some qualities of the good in question – a radio spectrum license. What does it mean when the government gives away, sells or auctions off a morsel of the electromagnetic spectrum? Spectrum licenses give a firm the right for to make use of a certain range of frequency in order to directly or indirectly provide a service to the public. By distributing licenses instead of allowing for casual, unregulated use, the government is able to allocate a range of spectrum for public benefit, while maintaining the ability to hold back enough radio bandwidth for military use, research and other purposes with a limited audience or user-base. This right to the airwaves is certainly not final – licenses last for a pre-stipulated time period and need to be renewed upon expiration. In this way, spectrum can easily be re-allocated for new purposes should the need arise.

There are critics who argue that the spectrum is a public good and should thus be given away for free or close to nothing. McMillan (1995) gives a counter-argument that the spectrum does in fact have a price – be it a directly or indirectly derived value to a firm or the government, based on the social costs from interference of adding new spectrum users. Add the exponential growth of technology to the equation and it can be observed that the value of this public good has increased tremendously along with the potential of services to be provided to the public. Whatever the case, leaving the bandwidth unregulated ends up with the limited spectrum being “overcrowded” and inefficiently used. Problems such as congestion, frequency interference and bandwidth misuse then become commonplace and hard to control.

Some Basic Auction Theory

To understand the issues at stake in the design of the FCC’s spectrum auction, it is useful to consider a fundamental result from auction theory, the William Vickrey’s (1961) revenue equivalence theorem. Under certain conditions, any auction format will allocate a good to the bidder who values it the most and will yield the same expected revenue to the seller. Such an auction is considered efficient. However several strong assumptions have to be made:

1. The auction involves a single, indivisible object.
2. Bidders are symmetric in the sense that their individual valuations of the good are drawn from a common, known distribution.
3. Bidders are risk neutral.
4. Bidders have independent private values (IPV). They only know and care for their own valuations of the good. They have no knowledge of how much the other bidders value the good.
5. The seller does not know any of the bidder valuations.

Provided that all of the above assumptions are satisfied and that the good clears at the market price among rational bidders, the auction will produce "the same average expected price and hence the same average expected gains to the buyers and sellers, respectively." (Vickrey 1961)

One important implication is that the type of good to be auctioned will play a significant role in deciding the auction format. If the good is a private value object, then the choice of auction format ceases to matter – the allocation will be efficient and the good will go to the bidder who values it the most. However if the good is a common value object i.e. bidder valuations are correlated, then the format and design of the auction will matter greatly in achieving efficiency.

One reason why an auction may cease to be efficient when using a common value object instead of a private value object is due to the effect of the winner's curse. Consider a simple English auction with only one common value item for sale. There are multiple buyers but only one seller. It is an ascending price, oral outcry auction and the item will go to the highest bidder. All buyers will have a certain valuation for the item and will only bid as close as possible to that valuation without going over that valuation. Taking into consideration that the item has a common value, it can be expected that most buyers will have some similar level of knowledge about what the item is worth. Thus most bids can be expected to be reasonably close. Knowing that the winning bid has to be higher than all other bids, there is thus a significant probability that the winning bid will be an overestimation of the item's value – the winning bid has to be higher than the average bid. In order to want to pay a significantly higher amount for the item, the buyer will want to believe or see sufficient value. In order to win, a bidder is “required” to overestimate, but if he overestimates, he will have paid too much, more than what the object is actually worth.

Is Spectrum Bandwidth a Common Value Item?

Spectrum licenses are not perfectly common value goods in the classical sense, though the value of a license will clearly be correlated across firms. To see why, consider a market environment in which firms have perfect information about their costs and market opportunities. In such a perfect market environment, firms will seek to cost minimize, while maximizing production efficiency and taking optimal advantage of all market opportunities. In such a case, spectrum will be considered a common value good since only the firms able to make efficient use of spectrum will bid for it, and the profits available to bidding firms from winning the right to use spectrum will be the same. However, in a real-world situation, we know that firms are not perfect. Firms will be different – some are less efficient than others and cost structures are not identical. This leads to the firms having different valuations of the spectrum license. For firms in the same industry however, we can still expect the firms to have correlated but not perfect valuations of the spectrum licenses. Some firms will be in a better position to make better use of the spectrum. Since firms’ valuations of the right to use spectrum are correlated, the independent private values assumption of Vickrey’s revenue equivalence theorem is violated, and the winner’s curse emerges and becomes a potential problem.

Now knowing that the spectrum licenses are close to being common value goods, what does it mean to have paid too much in the context of the spectrum auctions? The winning firm obviously bids the most and thus ends up paying the most for the license. Offering the most and having offered too much are very separate things. Having the highest bid is a prerequisite of winning. The firm will have paid too much for a license if the profits it can generate from marketing communications services using the purchased spectrum are not sufficient to provide as high a return on the investment in the spectrum license as the firm's shareholders could have made by putting their money into some other investment. In this case, the winner's curse effect is that the firm is unable to fully realize the potential of its service to the public. The consequences of this can take the form of payment default, faulty telecommunication services or bankruptcy. In extreme cases, the firm may even by taken over by a rival or professional raider.

The Winner's Curse

The occurrence of the winner's curse was examined in the context of U.S. government auctions of offshore oil leases by Capen, Clap and Campbell (1971), three petroleum engineers proposing strategies in oil lease bidding. They had observed that companies taking part in the sealed bid competitive auctions had often been unable to get the returns they expected from the leased areas. They realized that it was due neither to technological factors involving oil field estimations nor financial factors involving cost estimates. This failure to get the expected returns was in fact a failure of the bid estimation process. The winning companies had simply paid too much for the oil leases – they had overestimated the true value of the lease. What we have seen earlier is that this overestimation is integral to winning the bid. If a player does not overestimate, he does not win!

It is this overestimation that we try to observe for in looking for the winner's curse effects. Capen, Clap and Campbell (1971) report that the history of oil tract auctions was strongly characterized by significantly lower than expected rates of return on the initial company investments. The true rates of return were only observable some time after the auctions had completed and the winner bidder had begin the process of drilling. However there were a number of telltale signs that would have warned the companies much earlier.

An examination by Capen, Clap and Campbell of the 1969 Alaska North Slope Sale reveals an alarming lack of correlation among bids – it is not too much to assume that the auction involved companies with common access to some basic level of information and having similar cost structures. In this way, one would expect that in a sealed-bed auction, the bids would be reasonably close. However comparing winning bids to second-highest bids revealed a large variance in perceived value: the average second highest bid was 41% of the winning bid. One might reason that the winning company might have had significantly better technology or was in some way more efficient, thus making it obvious that the company would want to bid more. A study of two oil companies, Humble and Atlantic Richfield, who were equal partners in exploration and development reveals bid ratios that ranged from 0.03 to 17 – on one tract, Humble offered a bid that was 33 times smaller than that of Atlantic Richfield while on another tract Humble offered a bid that was 17 times larger!

Capen, Clap and Campbell suggest a simple strategy captured by the following rules:

- Bid lower if you have less information than others.
- Bid lower if you are uncertain about your valuation of the object at auction.
- Bid lower if more bidders show up.

The aim of these rules is to prevent the bids from skyrocketing through the roof. Granted that the lower one bids, the lower the chances of winning the auction; but would it be better then to win the auction and end up with revenue loses caused by an overestimation of the projected returns on investment? If all bidders are aware of the dangers associated with the winner's curse, they will be more cautious in their bid estimations. Then when everyone shaves their bids in unison, they will still hold the same chances of winning the auction, but this time without paying too much.

Studying the winner's curse is difficult. It would be impossible to capture all aspects, all factors that could affect the winner's curse in a theoretical simulation. The other method would be an empirical analysis of historical data pertaining to auctions and the bidders. Thiel (1988) very rightly comments that "a difficulty with empirical work on the winner's curse is that the winner is only cursed relative to the true value of the item at auction, which is every bit as difficult for the econometrician to estimate as it was for the bidders." Indeed, if it is so hard to examine the winner's curse, how will we get any results or be able to draw any conclusions? Our data set will obviously not be perfect, to an extent all conclusions we draw will be merely suggestive of what the bigger picture could be. Nevertheless we will attempt the task of understanding if the firms in question suffered the winner's curse.

Information

From the discussion above, it should be clear that accurate information about the value of an object at auction plays a significant role in reducing the winner's curse. The essential argument is that the better the information we have, the closer we can estimate an item's true value. The better our estimates, the better we can structure our bid. The opposite is true as well; having less information lowers our ability to estimate the true value of the item. As a result the worse off we are, the less we should want or be willing to bid.

Considering a world of rational bidders and common value items, there are rarely situations whereby an item is to be won at all costs, with the goal of maintaining the highest bid with little or no consideration of the true estimate. How badly do we want the item? It is important to realize one thing: if we are sure of the true value of the item, there should be no reason for us to exceed a rational estimation of how much we should pay. We will win unless one of two situations occur:

1. Someone has a higher estimation of the true value. For reasons unbeknownst to us, he knows that the item is worth more than what we think. In short, he has better information.
2. Someone has estimated the true value incorrectly. Due to ignorance or tainted information, he is offering a lot more than the item is worth. He will suffer the winner's curse.

Having information enables a firm to shape its strategy in order to poise itself in the best position possible. Strategy is integral in winning the auction as well as minimizing the probability of the winner's curse. Bierman (1998) notes that the bid itself is not the strategy, instead the strategy is “a bidding function that decides what to bid given the value placed on an object.”

Even if private information is not shared, additional information can be revealed from the observation of bids values during and after the bidding process. In a common value auction, every bidder will be using an estimated value of the item. Each estimate is based upon some level of information that the bidder has. Taken alone, each estimate does little good – the bidder has no way of knowing how close (or how far) his estimate is to the actual true value of the item. However when all bidders interact and an aggregation of the estimates takes place, the equilibrium price becomes a more consistent estimator of the true value as the number of bidders increases. The variance from the true value will go to zero as the number of bidders goes to infinity. In addition, the winning bidder’s estimate can be used as an upper bound for all bidding valuations since by definition, the winning estimate has to be the highest estimate. Milgrom and Weber (1982) discuss this method of aggregating private information in more detail.

The winner’s curse will also affect the seller. At first look, one might think that the winner’s curse affects only the bidders, who after all are the ones in control of the bid estimation process and ultimately how much they choose to bid. The seller’s revenue is entirely decided by the outcome of the auction process. If the bidders overestimate the value of the object at auction, the seller obviously stands to gain a greater amount. In simple or experimental auctions, bidders might not be too concerned with the winner’s curse effect. However, when the stakes are high, the rational bidders will most likely be aware that the winner's curse becomes an important issue. As a result of this, these bidders will know that the risk of overestimating the value of the object is high – they now have a strong incentive to shave their bids. At its extreme, bidders may find it more advantageous to share information and perhaps even collude. It is thus to the advantage of the seller to reduce the winner's curse as much as possible in order to discourage any underbidding or collusion.

The level of information that the seller makes available to the bidders is thus important. Milgrom and Weber (1982) also illustrate that the auction revenue is affected by the auction format and the level of information revealed to bidders. If the seller fully reveals his information to risk averse bidders, they find that the English auction generates the highest average prices. Considering the amount of money and the value of the spectrum licenses at stake, the firms can be considered risk averse – bid estimation techniques will be of utmost importance and no firms will want to unnecessarily pay more than they have to.

Given the clear problems the winner's curse imposes, and the role of information in ameliorating the problem, how should an auction be designed in order to reduce the potential for the curse? While there are no definitive answers to this question (at least that economists have found so far), there are guidelines that are useful. First, making more information available is better. This suggests that an open outcry format is better than a sealed bid format. Second price auctions (in which the highest bid wins but the bidder pays only the second-highest price) reduce the incentive to underbid; in combination with an open outcry format, this structure can significantly reduce the risk of the winner's curse. (A uniform auction, in which some pre-specified number N of high bidders win, each paying the $N+1^{th}$ highest bid has a similar effect.) With these concepts in mind, then, we turn next to an examination of the FCC's spectrum auctions.

The FCC Spectrum Auctions

The Amendment of 1993 was specific in its goals for the auctions. In addition to providing for an efficient allocation of the spectrum bandwidth, the FCC was to see to it that there would be a push for new technologies, a definitive stance against license monopolies and that minority and women-owned firms would have realistic opportunities to own a portion of the spectrum. What was interesting was that the Act also made it clear that revenue was of secondary importance – it was much more important that the licenses be allocated to the firms best able to serve the public good.

Section 309(j) of the Act of 1993 detailed that the licenses to be auctioned were to be used for personal communication services (PCS). Contrary to 50 megahertz set aside for cellular use, PCS technology would have 120 megahertz of bandwidth across the United States. There are two types of PCS: narrowband, which utilizes 12.5 – 50 kilohertz of spectrum in the 900 megahertz band for paging and television applications, and broadband, which utilizes 10 – 30 megahertz of spectrum in the 2 gigahertz range for small, lightweight portable phones, and advanced two-way data communication devices such as wireless computers. These technologies would compete in particular with the existing cellular and mobile communications and the outcome of the auctions was expected to have a strong influence on the advancement of public communications technology.

In addition the spectrum would be allocated in segments across the country. These licensed service areas were divided into 51 regional Major Trading Areas (MTA) and 493 smaller Basic Trading Areas (BTA) to offer a total of 2071 licenses. One benefit was the firms could now pick and choose exactly the areas where they wanted to operate in, rather than let the FCC decide on exact geographic spectrum boundaries.

Auction Goal: Efficient Allocations

The first and primary aim of the auction was to ensure a quick and efficient allocation of the electromagnetic spectrum. Allocation was important because having the wrong firms owning the licenses would cause a delay in providing the next wave of telecommunications service to the public. The best candidates would be the ones in the best position to take advantage of the radio bandwidth – companies who had an interest in making full use of the licensed spectrum and diffusing the technology rapidly and effectively.

However it is difficult to predict or know the identities of such companies. The comparative hearing methods used before had problems – at times it was difficult to clearly draw a line between an efficient firm and one that would further a political agenda. In addition, entrepreneurs and non-incumbents would find it hard to compete with the larger telecommunication giants with even deeper pockets. To a certain extent, the firm with the best lobbyist will end up as the winning, "best" firm.

In contrast the auction method would allocate the spectrum licenses to the firms that offered the most money for them. Assuming that the firms were rational and not prone to market frenzies, the highest valuations would stem presumably from the highest estimated return rates on investment. Sending out the signal that no one firm had an inherent "right" of ownership would spur on competition and ensure that the spectrum licenses would be sold off at market clearing prices. Having interested parties financially bid for a spectrum license would ensure that the winning bidders would be the ones who valued the license the most. After having paid substantially for a license, it would be in the interest of the winning firm to make sure that the bandwidth was made use of as soon as possible.

Who are the firms "best" able to use the spectrum? This is a difficult question to answer. There are countless combinations and possibilities with no one factor being able to tip the scale by itself. Firms who would already have strengths in certain geographic regions, with infrastructure and logistics already in place. Firms with an emerging but potentially wide-reaching technology. Or incumbents who already have a large and loyal subscriber base with perhaps a significant degree of lock-in.

How would we know if licenses had been allocated to the wrong firms? Just like the previous question, it is difficult to come up with a definite answer. However we do know of signs that would signal possible inefficiency. Evidence of a license being sold off in a secondary market would imply a sub-optimal allocation. Such firm to firm reselling of licenses would mean that the licenses had originally fallen in the wrong hands and had to be sold off to other firms. Another sign would be the bankruptcy of a firm that had won a license some time after the auction. It had obviously not been able to make efficient use of the allocated spectrum. In such a case, bankrupt firms may become the targets of takeovers or mergers.

Auction Goal: Rapid Diffusion of Technology

Another high priority was to ensure that the state of technology would not stagnate. The licenses had to be assigned correctly and quickly. As discussed earlier, the auction process was more efficient *and* would take significantly less time than the other allocation methods. Instead of having to wait for a few years to allocate the spectrum licenses, these auctions would rapidly assign the licenses and ensure that companies would be able to set up and provide services much more quickly. In addition, the auction method would provide for a better and more efficient way of allocating the licenses to the right firms. Inefficient allocations on the other hand would necessitate reselling and reallocation of licenses, which would take a significant amount of time, time implying a delay in the rollout of technology.

Innovation was also key – the licenses being auctioned off were to be used for PCS services. PCS technology had the potential to replace many of the current communications technologies like cellular and wireline, as well as innovate with new multimedia applications involving the combined transmission of voice, data and graphics. It was important that there be significant competition for these licenses. Dividing the spectrum and selling multiple licenses would ensure that a large number of firms would be able to take part in the auctions. These firms were expected to come from different industries – companies from cellular, cable, television, wireline, paging and other fields would all compete in the race to become public service providers. With such different backgrounds and technologies, there would be a higher probability of a more diverse set of winning bidders. This diversity would then manifest itself in the form of a wide variety of new and improved services and applications being made available to the public.

Auction Goal: Anti-Monopoly

It was important that there not be an excessive aggregation of nationwide licenses. Allowing the existence of monopolies would only decrease the level of competition possibly resulting in delayed services and technologies. Lower levels of competition would also mean higher prices being charged to the public. Instead of regional monopoly licenses, the geographic segmentation into smaller areas would aide in making it harder for any one firm to monopolize over a large region. Firms interested in providing a service to larger areas would then have to bid on the individual licenses that made up that area.

Auction Goal: Opportunities for Minority and Women-Owned Firms

The communications industry has long been dominated by large firms and monopolies. With such a large amount of spectrum to be auctioned off, sending it back into the hands of the incumbents and industry giants would be a mistake. These spectrum licenses represented an excellent entrepreneurial opportunity for firms owned by minorities and women, who would not have otherwise had a chance to participate and own a portion of the spectrum. In order to further this goal, almost a third of the licenses were set aside for small businesses.

Auction Goal: Treasury Revenue

Taxes have been the main source of government revenue. In addition to an efficient license allocation, the FCC wanted to raise significant revenue for the U.S. Treasury. If the amount raised was substantial enough, the government would have less of a need to raise or introduce new taxes. Ensuring fervent competition among the firms was thus in the interest of the government.

Auction Design

In addition to the aforementioned goals, there are several other things that should be considered when designing the auctions. In order for the spectrum auctions to be fully efficient, several conditions should be satisfied:

- The right spectrum licenses should go to the right firms. The firms most capable of realizing the true value of the license should be the winners.
- No one should suffer the winner’s curse. These winners should not have had to bid too much.
- The government makes the highest possible revenue from the auctions. Every firm pays its maximum willingness to pay and the full social surplus is realized.

Vickrey's (1961) revenue equivalence theorem can be used as a test for the efficiency of an auction as well as help us decide how to better design the spectrum auctions. We can use the theorem and its initial conditions as a basis for identifying factors and possible solutions. If all the assumptions hold, we can safely state that our auction is efficient. However, if we cannot maintain any of the assumptions, the theorem cannot hold and inefficiency can result.

Chakravorti et al. (1995) use Vickrey's theorem in their study of the auctions involving broadband PCS (Auction #4, which will be discuss later in more detail) as a benchmark case for comparison and discover the following facts when recalling some of the assumptions:

Symmetric Bidders (2)

Coming from different industries as well as different geographic regions, there is a high probability that firms will not have valuations from a common distribution – some firms will have better information about the service demand or different cost structures and technology efficiencies. The bidders are asymmetric, rather than symmetric. Drawing valuations from different distributions means that the expected seller revenue will be different across the different distributions – the bidder with the highest valuation will not always be the winner of the auction, merely the one who makes the highest bid!

Independent Private Values (4)

We discussed earlier that we are dealing with a common value good. As such, bidder valuations are correlated. Bidders will make bid estimations based on information such as their technology levels, future projections about the industry structure and projected user demand. The information will not be perfect but is strongly correlated enough to violate the assumption of independent private values. As a result, the winner's curse can emerge. Chakravorti et al. (1995) also mention two factors that reinforce the winner's curse. The first is that the variance of the bids will increase as the number of bidders increase. This then increases the likelihood of the winner overbidding. The second is that bidder uncertainty about their valuations also increases the variance of the bids. Once again, there will be an increased likelihood of a higher estimate due to the higher variance – there is a higher probability of overbidding.

Having seen already that two of Vickrey's assumptions will be violated, we can see that there is a need to carefully design the auction – the format of the auction will be important in deciding the correct license allocations. The auction design will obviously affect both the seller and the buyers. As referenced earlier, Milgrom and Weber (1982) develop an auction model of competitive bidding and show that when the revenue equivalence theorem breaks down, some auction formats have the ability to generate more revenue than others. From the view of the buyers, different auction formats and rules will present the bidders with different possible outcomes depending on their strengths and abilities. Different strategies will be needed to win in different formats.

What is especially important is that there is now a very real threat of the winner's curse – because the spectrum licenses are common value goods, the phenomenon of the winner's curse can emerge and become a serious issue. We have seen that the effects of the winner's curse can be reduced when more information is given. In light of this, the auction format should maximize the amount of information available to the bidders to enable them to make better bid estimations.

Final Auction Design

After much consideration and consulting with economic theorists, consultants and firms, the FCC decided upon the auction format proposed by Preston McAfee, Paul Milgrom and Robert Wilson. The most obvious traits were that it was:

- Ascending Bid
- Simultaneous
- Multiple-Round

The ascending bid aspect would allocate the license off to the highest bidder. Bidding continues while current bids are contested and ends when no more bids are called. The auction would be simultaneous in that multiple licenses would be auctioned off at the same time. Having divided the licenses into geographical segments, these licenses at a particular frequency would be offered simultaneously and firms could bid on all the licenses that made up an aggregation that they were interested in. The major advantage of this is that there would be no uncertainty associated with purchasing half of a license aggregation now, only to lose the other equally important half to another bidder in a later auction. Keeping in mind that the spectrum licenses were extremely valuable goods, and that a lot of money was at stake, the auction would consist of multiple rounds, in order to give the bidders time to plan and estimate bids.

In addition, an open auction design was chosen in favor of a sealed bid in order to reveal more information. However unlike the traditional open-outcry auction, the FCC's auction would be made open in the following sense: since it would take multiple rounds before an equilibrium price would be found, bids during each round would be submitted as sealed bids, and then revealed at the end of each round. The FCC (1994) felt that the proposed design would provide enough flexibility and information to let firms achieve "efficient aggregations across spectrum bands." Chakravorti et al (1995) comment on the design, saying that "the proposed mechanism is cleverly designed to maximize the amount of information about the value of the licenses that is transmitted through the bidding process, thus ameliorating the winner's curse."

There would also be opportunities for entrepreneurs, minority and women-owned firms. While the auctions would hand the license off to the highest bidder, the smaller businesses would not be able to financially compete with the industry giants. In order to equalize the game, small firms could be designated and given discounts on licenses. This way, they would be able to compete at the same level with the other firms knowing that they would only need to pay a certain percentage of the final winning bid.

Auction Analysis

There have been several methods of analysis when seeking empirical proof or suggestive evidence of the winner's curse. Capen, Clap and Campbell (1971) examined ratios of winning to second-highest bids as well as post auction reports of lower than expected returns on investment in oil tract auctions. Thiel (1988) utilizes the theory of order statistics to estimate bids in the highway construction industry.

Cramton (1998) examines the efficiency of the spectrum auctions and finds credible evidence of success in that there were many positive signs suggesting an efficient allocation of licenses. The FCC raised a substantial amount of money and spectrum aggregations made sense. More importantly, the prices that the licenses were sold off for were noticeably close. This would mean that a significant amount of information was revealed during the auction and market prices were effectively generated. However Cramton does note that the characteristics of spectrum licenses do lend complexity to the design of the auctions as well as the benchmarks for measuring efficiency.

We analyzed the fourth spectrum auction held by the FCC from December 5, 1994 till March 13, 1995. This auction allocated the A & B spectrum blocks for broadband communications. There were several reasons for analyzing this auction. This auction was important because it was the first auction to offer broadband PCS licenses, which enabled the use of PCS technology, a potential replacement for cellular technologies as well as a frontrunner of other more innovative implementations. Many of the participants in the auction were publicly listed companies – we had more access to information regarding these firms – annual reports, historical stock prices, media news. This allowed for a more thorough examination of how the firms did after the auction. Another reason was that since this auction involved many "big" players, it was almost certain that they would have observed the earlier auctions whether or not they participated in them, in order to gather as much information as possible and learn about optimal bidder behavior and strategies. It is assumed that this being the fourth auction, a sufficient amount of learning would have taken place for the bidders to be aware of and thus try to avoid the effect of the winner's curse.

99 licenses were offered; 2 in each of the 51 Major Trading Areas across the nation to gain a net revenue of $7,736,020,384. 18 out of 30 qualified bidders became winning bidders. Due to insufficient data on stock prices, 10 out of the 18 winning bidders were examined:

1. AT&T Wireless PCS
2. Ameritech Wireless Communications
3. BellSouth
4. Centennial Cellular Corporation
5. General Communications Incorporated (GCI)
6. GTE Macro Communications
7. Pacific Telesis Mobile Services
8. PCS PrimeCo L.P.
9. Powertel PCS Partners
10. SouthWestern Bell

Note that PCS PrimeCo was a bidding consortium formed by 4 firms with equal shares of 25% each; these firms were Bell Atlantic, Nynex, US West and Airtouch Communications. A weighted portfolio was used to examine how this consortium did.

We chose to track the stock price in order to find suggestive evidence of the winner's curse. The stock price of a publicly listed company is a reasonably good indicator of the current public confidence in the company. If a company is believed to be doing well, its stock price remains stable or can increase. If a company is believed to be in financial trouble, the stock price usually starts to follow a downward trend. However there are obviously many things that can affect a companies stock price. In light of this, we tried our best to account for the more significant events. The NASDAQ is a good indicator of the state of technology companies and these companies generally follow its trend line whether or not they actually make up the index. It was important that we take out any general upwards or downwards behavior due to aggregate market influence. Another important event was the occurrence of a stock split. At times, companies would issue these stock splits and the price would be altered accordingly. Therefore a dummy variable had to be used whenever this happened to account for the seemingly drastic fall in price.

The simplest regression model thus used the daily bid/ask average as the dependent variable, the NASDAQ as an independent variable to detrend the information and a dummy variable corresponding to whether or not the auction had taken place. At times additional dummy variables were used to indicate the occurrence of stock splits before or after the auctions. Regressions were done at a 95% level of confidence.

All data a period of 6 months before and after the auction was removed to clear any increased price variance and instability due to possible shocks related to the auction. At the maximum duration, data used was from September 1, 1993 – September 2, 1994, and from June 13, 1995 – December 31, 1999.

The main variable we observed was the auction dummy variable, which would indicate of how well the firm was doing as a result of having participated in the auctions. The null hypothesis was the situation where participating in the auction had no consequence or effect whatsoever on the firm. Our examination of the values for the auction dummy variable showed that out of 10 firms, there was statistical evidence that 5 firms were better off as a result of the auction and 4 were worse off. For one firm, there was not enough evidence to reject the null hypothesis – participating in the auction had not made the PCS PrimeCo consortium any better or worse off. A summary of the outcome due to participation is displayed in table 1a and a summary of values for the auction dummy variable for all the firms are listed in table 1b along with the associated values displaying confidence. Refer to the appendix for tables displaying the full regression results for all independent and dummy variables.

Table 1a

Summary of Outcome as a Result of Auction Participation, Broadband PCS Auction

Positive Influence	No Influence	Negative Influence
Ameritech BellSouth GCI GTE SBC	PCS PrimeCo	ATT Centen Pactel PowerTel

Table 1b

Auction Dummy Variables for Winners, Broadband PCS Auction

Firm	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
AT&T	-8.341848122	0.922943479	-9.038308753	5.14639E-19
Ameritech	6.737356293	0.468167251	14.3909175	8.90465E-44
BellSouth	3.904053344	0.931237731	4.192327278	2.93409E-05
Centennial	-12.34763399	0.527190804	-23.42156559	1.1472E-102
GCI	1.835898136	0.113029054	16.24270995	1.70606E-54
GTE	2.368055689	0.324368598	7.300508447	4.78457E-13
Pacific Telesis	-9.436802736	0.330770174	-28.52978741	1.1348E-119
PCS PrimeCo	-0.015681482	0.429610113	-0.036501659	0.970888397
PowerTel	-3.546447191	0.98096565	-3.615261342	0.000311588
SouthWestern Bell	8.506165279	0.464017234	18.33157188	1.86791E-67

For Ameritech Wireless Communications, BellSouth, GCI, GTE Macro Communications and Southwestern Bell, we were able to observe a generally positive trend associated with the auction dummy variables. This would suggest that these firms had estimated the license valuations correctly and made efficient use of the spectrum.

There was insufficient evidence for the consortium PCS PrimeCo to imply that participation in the auction had any effect of the winner's curse. The value of the auction dummy variable associated with was close to zero and the p-value was much too high and the t-statistic was much too low for us to reject our null hypothesis case.

What is more interesting however, is that there was statistically significant evidence that 4 out of the 10 firms examined were worse off. The regressions for AT&T Wireless PCS, Centennial Cellular, Pacific Telesis and Powertel PCS gave values for the auction dummy variables ranging from –3.546 to –12.348! The p-values were small enough for us to reject our null hypothesis. It is not too much to accept these negative values as indicators of the winner's curse in action. If only one or two firms had seen negative dummy variable values, we would be able to state that the winner's curse effect was not strongly pronounced and that the auctions were well designed. However, having 40% of our data tell us that things are worse off does suggest that the winner's curse is still very much a problem in the spectrum auctions. The firms did not have sufficient information to correctly estimate their license valuations and as a result, paid too much for the licenses. They might have miscalculated the cost of building the network and infrastructure. Or the information pertaining to estimated subscriber base in the licensed areas was wrong. There are many possible reasons for this. The financial burden of overpayment might then have been experienced during infrastructure construction or during product roll-out as budgets got tighter.

Suffering the effects of the winner's curse does not immediately guarantee that a firm will be bankrupt or out of business – this is an extreme case. In most situations, we would expect that the firm experiences lower than expected earnings due to having spent too much on obtaining the licenses. Depending on the degree by which the earnings estimates were missed, public confidence in the firm would wane and thus lower the listed share price.

As discussed earlier, Cramton (1998) finds sufficient evidence to suggest that the auctions achieved market prices. However saying that a firm pays too much for the license does not mean that it was too expensive in general and that the market price was wrong. Rather, it means that perhaps the license was too expensive for the firm and it should not have bid that high. In a perfect market environment, the market price will approximate the true value of the common value object. Thus the licenses did go at the right prices, except at times to firms that could not have afforded them.

Conclusion

Ensuring efficiency in the spectrum auctions is extremely important because of the potential associated with the spectrum bandwidth. The FCC needed to make sure that the licenses went into the hands of the best firms most able to provide a new generation of communications and technology services. In our examination, we found sufficient evidence indicating that a significant number of the examined firms suffered the winner's curse effects and were experiencing losses as a result. However this does not mean that the auctions were badly designed or inefficient. Nothing in the data suggests this. What is suggested instead is that in some way, for some reason, several firms were unable to estimate the prices of the licenses correctly and ended up paying more than they could afford. The auction was designed well enough to reveal sufficient information to generate market prices and allocate the licenses quickly – the problem was that in some cases, it was just into the wrong hands.

Appendix

Regression Tables: at a 95% Confidence Interval
Data from 3 September 1994 till June 12 1995 was removed to allow for prices to adjust to minor shocks prior to and after the auction.

Except for the NASDAQ independent variable, all other independent variables are dummy variables.

American Telephone & Telegraph (AT&T)

- 3 for 2 stock split on 16 April 1999

Analysis:
Sufficient evidence of a winner's curse effect: Auction negatively affects price.

- Regressions show a value of –8.342 for the auction dummy variable.
- P-value is small.
- Absolute t-value of 9.038 is statistically significant.

Table 2
Regression Results for AT&T

Regression Statistics	
Multiple R	0.421616835
R Square	0.177760755
Adjusted R Square	0.176001327
Standard Error	10.45435111
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	33126.82871	11042.27624	101.0332781	3.27814E-59
Residual	1402	153229.4268	109.293457		
Total	1405	186356.2555			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	45.28087391	0.875244869	51.73509211	0
NASDAQ	0.012809611	0.000770847	16.61758664	9.63421E-57
Auction	-8.341848122	0.922943479	-9.038308753	5.14639E-19
Split (post-auction)	-22.08830289	1.360602823	-16.23420333	1.93086E-54

Ameritech Wireless Communications
Regression data from 1 September 1993 – 8 October 1999
- Stock split on 24 January 1994
- Stock split on 27 January 1998

Analysis:
No evidence of a winner's curse effect: Auction positively affects price.
- Regressions show a value of 6.737 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 14.391 is large enough for evidence to be statistically significant.

Table 3
Regression Results for Ameritech Wireless Communications

Regression Statistics	
Multiple R	0.927883445
R Square	0.860967688
Adjusted R Square	0.860553593
Standard Error	4.551088078
Observations	1348

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	172257.2864	43064.32161	2079.156255	0
Residual	1343	27816.75682	20.71240269		
Total	1347	200074.0433			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	62.29027704	0.572685601	108.7687153	0
NASDAQ	0.025223793	0.000454538	55.49325534	0
Auction	6.737356293	0.468167251	14.3909175	8.90465E-44
Split (pre-auction)	-41.01414678	0.583800094	-70.25375153	0
Split (post-auction)	-25.75425614	0.491645142	-52.38383126	0

BellSouth
Regression data from 1 September 1993 – 31 December 1999
- Stock split on 9 November 1995
- Stock split on 28 December 1998

Analysis:
No evidence of a winner's curse effect: Auction positively affects price.
- Regressions show a value of 3.904 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 4.192 is large enough for evidence to be statistically significant.

Table 4
Regression Results for BellSouth

Regression Statistics	
Multiple R	0.759606511
R Square	0.577002051
Adjusted R Square	0.575794348
Standard Error	7.865169233
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	118220.6585	29555.16462	477.7681993	7.2046E-260
Residual	1401	86667.10277	61.86088706		
Total	1405	204887.7612			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	40.5257183	0.749209247	54.09132159	0
NASDAQ	0.024433566	0.00074915	32.61505908	4.5154E-174
Auction	3.904053344	0.931237731	4.192327278	2.93409E-05
Split (post-auction 1)	-28.74391012	0.883242841	-32.54360952	1.6999E-173
Split (post-auction 2)	-36.53376817	1.104666544	-33.07221385	9.2721E-178

Centennial Cellular Corporation
Regression data from 1 September 1993 – 31 December 1999

Analysis:
Evidence of a winner's curse effect: Auction negatively affects price.
- Regressions show a value of –12.348 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 23.422 is large enough for evidence to be statistically significant.

Table 5
Regression Results for Centennial Cellular Corporation

Regression Statistics	
Multiple R	0.87360351
R Square	0.763183093
Adjusted R Square	0.762845506
Standard Error	6.46450806
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	188949.0312	94474.51562	2260.704045	0
Residual	1403	58631.17984	41.78986446		
Total	1405	247580.2111			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.975270708	0.462408274	10.75947596	5.35388E-26
NASDAQ	0.019536393	0.000296541	65.88093676	0
Auction	-12.34763399	0.527190804	-23.42156559	1.1472E-102

General Communications Incorporated (GCI)
Regression data from 1 September 1993 – 31 December 1999

Analysis:
No evidence of a winner's curse effect: Auction positively affects price.
- Regressions show a value of 1.835 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 16.243 is large enough for evidence to be statistically significant.

Table 6
Regression Results for GCI

Regression Statistics	
Multiple R	0.404788296
R Square	0.163853565
Adjusted R Square	0.162661624
Standard Error	1.385982502
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	528.1371495	264.0685748	137.4678773	3.02735E-55
Residual	1403	2695.089337	1.920947496		
Total	1405	3223.226486			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.712445952	0.09913976	47.53336059	1.29E-294
NASDAQ	-0.000366309	6.3578E-05	-5.761575496	1.02279E-08
Auction	1.835898136	0.113029054	16.24270995	1.70606E-54

GTE
Regression data from 1 September 1993 – 31 December 1999

Analysis:
No evidence of a winner's curse effect: Auction positively affects price.
- Regressions show a value of 2.368 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 7.301 is large enough for evidence to be statistically significant.

Table 7
Regression Results for GTE

Regression Statistics	
Multiple R	0.949473925
R Square	0.901500734
Adjusted R Square	0.901360322
Standard Error	3.977465845
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	203143.85	101571.925	6420.380476	0
Residual	1403	22195.78907	15.82023455		
Total	1405	225339.6391			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	21.12765953	0.28450937	74.25997788	0
NASDAQ	0.016806099	0.000182455	92.1109584	0
Auction	2.368055689	0.324368598	7.300508447	4.78457E-13

Pacific Telesis Mobile Services
Regression data from 1 September 1993 – 31 March 1997
- Stock split on 6 April 1994

Analysis:
Evidence of a winner's curse effect: Auction negatively affects price.
- Regressions show a value of –9.437 for the auction dummy variable.
- P-value is small enough.
- Absolute t-value of 28.529 is large enough for evidence to be statistically significant.

Table 8
Regression Results for Pacific Telesis

Regression Statistics	
Multiple R	0.984721165
R Square	0.969675773
Adjusted R Square	0.969546916
Standard Error	1.702060683
Observations	710

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	65402.08383	21800.69461	7525.238203	0
Residual	706	2045.289462	2.897010569		
Total	709	67447.37329			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	34.98770817	0.53204983	65.76020931	2.9671E-303
NASDAQ	0.026133408	0.000665512	39.26812255	1.0091E-179
Auction	-9.436802736	0.330770174	-28.52978741	1.1348E-119
Split (pre-auction)	-22.61271669	0.218542411	-103.4706105	0

PCS PrimeCo

Regression data from 3 December 1993 – 29 June 1999

Consortium formed out of the following with a 25% stake each

- Bell Atlantic
  - Stock split on 30 June 1998
- Nynex
  - Merged with Bell Atlantic in 15 august 1997 (I began using the stock price from Bell Atlantic as a substitute).
- US West
  - Stock split on 1 November 1995.
- Airtouch

Analysis:

Weak evidence of a winner's curse effect: Auction variable does not seem to affect price.

- Regressions show a value of –0.0157 for the auction dummy variable. However evidence is not strong enough to support the hypothesis that the auction negatively affects price.
- P-value of 0.971 too large for the dummy variable to be significant.
- Absolute t-value of 0.0365 is too small.

Table 9

Regression Results for PCS PrimeCo

Regression Statistics	
Multiple R	0.956024617
R Square	0.913983069
Adjusted R Square	0.913626448
Standard Error	3.306700982
Observations	1212

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	140117.1714	28023.43429	2562.8991	
Residual	1206	13186.73129	10.93427138		
Total	1211	153303.9027			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	25.48080777	0.454024635	56.12208192	0
NASDAQ	0.019094459	0.000513139	37.2110539	1.8306E-202
Auction	-0.015681482	0.429610113	-0.036501659	0.970888397
Merger-Bell-Nynex (post-auction)	14.07051522	0.364844262	38.56581202	1.1979E-212
Split-Bell (post-auction)	-15.50697524	0.376773711	-41.1572644	5.1438E-232
Split-US West (post-auction)	-5.138433083	0.384665391	-13.35818923	4.65114E-38

PowerTel PCS Partners
Regression data from 8 February 1994 – 31 December 1999

Analysis:
Sufficient evidence of a winner's curse effect: Auction negatively affects price.
- Regressions show a value of –3.546 for the auction dummy variable.
- P-value of 0.003 is small enough for the evidence to be valid.
- Absolute t-value of 3.615 is large enough for variable to be statistically significant.

Table 10
Regression Results for PowerTel PCS

Regression Statistics	
Multiple R	0.746913212
R Square	0.557879346
Adjusted R Square	0.557194949
Standard Error	9.951845378
Observations	1295

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	161461.5928	80730.79638	815.1396096	1.0456E-229
Residual	1292	127958.6806	99.03922644		
Total	1294	289420.2733			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-3.688100459	0.895998671	-4.116189655	4.096E-05
NASDAQ	0.017194376	0.000456546	37.66189653	4.1748E-210
Auction	-3.546447191	0.98096565	-3.615261342	0.000311588

Southwestern Bell Company (SBC)
Regression data from 1 September 1993 – 31 December 1999
- Stock split on 20 March 1998

Analysis:
No evidence of a winner's curse effect: Auction positively affects price
- Regressions show a value of 8.506 for the auction dummy variable.
- P-value is small enough for it to be valid.
- The absolute t-value of 18.332 is large enough for variable to be statistically significant.

Table 11
Regression Results for Southwestern Bell

Regression Statistics	
Multiple R	0.777654909
R Square	0.604747157
Adjusted R Square	0.603901395
Standard Error	5.561977664
Observations	1406

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	66359.83966	22119.94655	715.0321876	5.9691E-282
Residual	1402	43371.70494	30.93559554		
Total	1405	109731.5446			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	33.1196063	0.471211233	70.2861137	0
NASDAQ	0.011288381	0.000421142	26.80421528	4.0264E-128
Auction	8.506165279	0.464017234	18.33157188	1.86791E-67
Split (post-auction)	-19.68999355	0.554344536	-35.51941483	1.2697E-197

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