

REVERSE AUCTION BIDDING – MULTIPLE GROUP STUDY

A Thesis

by

XUN ZHOU

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2012

Major Subject: Construction Management

Reverse Auction Bidding – Multiple Group Study

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Approved by:

Co-Chairs of Committee,	John M. Nichols
	Nancy L. Holland
Committee Member,	Sarah Deyong
Head of Department,	Joseph P. Horlen

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ABSTRACT

Reverse Auction Bidding – Multiple Group Study.

(August 2012)

Xun Zhou, B. Eng., Chongqing University

Co-Chairs of Committee, John M. Nichols
Nancy L. Holland

Reverse Auction Bidding is a recently developed auction method. In this form of bidding process, the roles of the bidders and the owner are interchanged in terms of the form of the economic transaction. The owner's objective is to drive the unit rates down and the bidder's objective is to maintain an acceptable profit level. A study into Reverse Auction Bidding commenced at Texas A&M University in 2004 and continues to this time, with this the eighteenth study in the series. This study is the second multi-group study in the research. In this study, a multiple group comparison was made between different numbers of bidders, with Games One, Two and Three having three, four and ten bidders respectively. All participants were faculty and students from the Department of Construction Science. The critical requirement for the participants is that they should have no prior experience using the Reverse Auction Bidding system. The eighteen studies have concentrated on new players, with future studies planned for repeat participants. A number of the recent case studies have shown personality has an impact on the performance of the bidders. However, this work was not controlled for

personality, as the research objective was to determine the impact of a different number of bidders in a game. The Keirsey Temperament Sorter test was completed by all participants, so that the results could be understood in terms of personality impact on the level of return to each participant. The results showed the number of bidders has a significant impact on the individual returns confirming the earlier work on varying the number of bidders. An increase in the number of bidders was shown to lead to a more competitive economic environment, which given usual economic circumstances lead to a reduction in the number of firms interested in bidding, for the self-evident economic reasons. This work points to the need to investigate a bidding group size of five or six, which is likely to be the self-constrained upper limit in a real economic system. Some interesting observations on the personality types suggest that further work is required in this area.

DEDICATION

To all my family members, my friends and teachers

ACKNOWLEDGEMENTS

I would like to thank my Committee Co-Chairs Dr. John Nichols, Co-Chair Dr. Nancy Holland and Committee Member, Sarah Deyong. They gave me a lot of help and support in writing this paper. Also, as a teaching assistant for Dr. Nichols and Dr. Holland, I really want to thank them for supporting me and giving me instructions in my work.

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NOMENCLATURE

RAB	Reverse Auction Bidding
KTS	Keirseey Temperament Sorter Test
ASP	Application Service Provider
SQL	Sequential Query Language
TAMU	Texas A & M University

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CHAPTER I

INTRODUCTION

Background to the Study

Reverse Auction Bidding, henceforth RAB, is a reasonably new purchase method used in a procurement process. The method has been adopted by a number of owners and government agencies, with the implicit aim of increasing competition between bidders, hence forcing the lowest possible bid for a service (van Vleet, 2004). The ethics of this system are not considered further in this study (Gregory, 2006). The traditional bidding method is called the sealed bids, which is held at a specified time and a specified place (Little, Fowler, Coulson, Onions, & Friedrichsen, 1973). The OED (Little et al., 1973) defines a bid as '*the offer of a price*'. As Guhya (2010) noted in his statistical study of the first work by van Vleet (2004):

The traditional form of obtaining a bid is to request a price from one or more entities, such as a builder, contractor or company, with the bid due at a specific time and place. This system of bidding is considered by most to be free of collusive influences. Alternative forms of bidding have been developed over the centuries; some suffer from the need for a subjective judgment about the ability of the bidder to perform the work, although prequalification may [help]

This thesis follows the style of *Adult Education Quarterly*.

Within a free market, a competent bidder should be aware of the average expenditure required to gain a sale; as an example noted by Guhya (2010) in consulting engineering the amount of eight percent of the fee is generally considered reasonable for recovering the costs of preparing bids (Nichols, 2009). In bid shopping, as by Guhya (2010) noted, the second entity does not have to cover the cost of preparing multiple bids to obtain work, which is clearly and often perceived as economically unfair and distorts the market in an unfair manner. The essence of competition is fairness (Hartford, 2005).

Reverse Auction Bid Systems were developed specifically for the internet as the perceived distance between bidder and purchaser is decreasing allowing people to facilitate purchase of goods away from the local entities. In this system, the concept of the 'traditional market' has been broken down, often when the purchaser and seller cannot meet in the same place or it is difficult to meet in a common place. As Guhya (2010) further noted, Reverse Auction Bidding systems are considered by some people as being an alternative form of bid shopping. Nichols (2009) considers Reverse Auction Bidding Systems, when operated by an independent entity of the purchaser, represents an electronic equivalent of a free market. Further work on this type of statistical study of online auctions is now commonplace in the literature (Puro, Teich, Wallenius, & Wallenius, 2011).

A Reverse Auction Bidding System is a multiplayer game, with two sub-games. Guhya documents the theory put forward by Nichols that (Guhya, 2010; Nichols, 2010) the first sub-game, designated α game, is between the bidders and the second is the game between the bidding group and the purchaser, designated the ω game.

The α game is classified as a multi-player game; however the ω game reduces in reality to a two-player game, with only one effective player able to make moves. The reduction of the ω game to an equivalent two player game can be viewed as maximizing the return to the bidding group, designated λ player, at the expense of the purchaser, designated ν player. This game theory was developed based on the results of four player games; this study looks at a ten player game to determine if the game concepts can be maintained in the analysis.

Several case studies have been completed for a simple Reverse Auction Bidding scenario developed by van Vleet (2004). The purpose of this research is to complete a second trial of multiplayer games with other than four players as occurred in the third study by Gregory (2006).

Research Objectives

The research objectives are:

1. Complete RAB games using three, four and ten participants.
2. Compare the results between these games and to the previously collected results.
3. Complete a statistical study of the results using the methods developed by Guhya (2010) for the analysis of the first case study by van Vleet (2004).
4. Determine if evidence of the ω game exists and does it represent some form of tacit collusion.

Hypothesis

The hypothesis to be tested to provide the results required to meet the research objectives are:

1. As the number of bidders increase, the average profits for the bidder will decrease.
2. As the number of bidders increase, the average price for each job will decrease.
3. The key findings from earlier research on:
 - a. the use of bank loans;
 - b. bidding patterns with time;
 - c. personality type performance;
 - d. observed statistic results on participant's returns will be observed in the results.

Limitations and Delimitations

The participants of this study are limited to the students or faculty in the Department of Construction Science. No industry professionals are used in this study. The participants will be randomly selected from the Department of Construction Science; none of them has any experience on RAB before.

The types of personality won't be controlled for in the study participant selection as has occurred in a number of the studies. Economic and all the other conditions that may have an adverse effect on the bidding process are assumed steady throughout the period of this study game.

Significance of the Study

This research will help the further understanding of Reverse Auction Bidding, continuing a long running study at TAMU.

CHAPTER II

LITERATURE REVIEW

Introduction

This thesis documents the twentieth study on Reverse Auction Bidding at TAMU undertaken in the Construction Science Department. This literature review looks at the prior work and the research by others into online auction systems to establish the key elements of interest to understanding the work.

Definitions

This research is a continuation of previous Reverse Auction Bidding studies. Previous definitions established by others (Gregory, 2006; Guhya, 2010; van Vleet, 2004) are included in this list from necessity. The definitions are now considered to have entered the lexicon of Reverse Auction Bidding studies at TAMU and are repeated verbatim here as not all studies are readily available outside of TAMU. The necessary definitions are:

- λ player: This represents the bidder group, treated as a single entity for the purpose of game analysis.
- λ_i player: The i^{th} bidder in the bidding group.
- ν player: This represents the purchaser.

- α game: The postulated sub-game played between bidders in seeking economic advantage over the remaining bidders. This game almost always disadvantages the ν player, but the ν player created the system and so is responsible for the ν player's economic losses as a result.
- ω game: The postulated sub-game played within the Reverse Auction Bidding game between the purchaser and the bidders. In terms of this analysis, it is deemed to effectively reduce to a two-player game, with competition implications for all players. The ν player in reality sees only the average of all won bids.
- τ : Bid time allowed for each round of play in the game.
- δ : Period between bid time τ that represents the work time in the game.
- B_j : i^{th} bid
- B_ν : Accepted bid for each job.
- K : This variable is a fixed dollar sum, representing the ν player's base price, although in this game K is a vector of costs.
- Γ : This variable is a fixed dollar sum, representing the ν player's maximum incremental price above K .

- Ξ : This variable is normally defined by the set of numbers $\{\Xi | 0 < \Xi \leq 1\}$, although negative values of Ξ are permitted by the Reverse Auction Bidding system. Ξ is used to normalize the profit data. A negative Ξ_j represents a loss on direct costs to the λ_j player who makes this type of bid, and enough of these bids will lead to a bankrupt player. This type of play is discouraged as the assumption in the game is steady state economic conditions in the outside economy. Future studies may look at a failing market, but that is beyond this study.
- Aggressive Bidder: Willing to accept calculated risk of greater than average loss in pursuit of greater than average returns, first defined by Chouhan (2009).
- Bid: A single entry into the game that represents a legally acceptable offer to complete the work assuming the bidder has been prequalified.
- Bidder: An entity that submits a bid. In this game, there are usually three to ten bidders, and each is an individual, rather than a company. In van Vleet's (2004) study, none of the bidders had prior experience, which is not true for Chouhan's (2009) study.

- Bid Efficiency:** It is the ratio of the total number of jobs won to the total number of bids. This is one of the postulated metrics for determining success in the α game.
- Case Study:** ‘Designed to study intensely one set (or unit) of something; for e.g. programs, cities, counties, worksites-as a distinct whole, with the goal of understanding the set as a distinct whole in its particular context. A case study reveals the process and outcome at certain sites and the way in which these interrelate. Case studies are conducted primarily using qualitative techniques, but do not exclude quantitative data.’ (van Vleet, 2004)
- Collusion:** ‘A secret agreement between two or more parties for a fraudulent, illegal or deceitful purpose (van Vleet, 2004).’ Or as defined by the OED as ‘secret agreement or understanding for the purpose of trickery or fraud,’ is generally considered to be reprehensible and is usually illegal in a free market system, because of the economic distortions introduced into the market.
- Dutch Auction:** ‘It is a type of auction where the auctioneer begins with a high asking price which is lowered until some participant is willing to accept the auctioneer's price, or a

predetermined reserve price (the seller's minimum acceptable price) is reached.' (van Vleet, 2004).

Economic Winner: 'An individual who generated the highest average returns.'
 Panchal (2007) coined this term to indicate a more successful player in the α game. An economic winner makes no direct difference to the ω game for the ν player where the ν player has an objective of minimizing the average bid for the game. The ν player sees the average price for purchases and a distribution of prices.

Economic Loser: 'An individual who generated the lowest average returns.'
 Panchal (2007) coined this term to indicate a less successful player in the α game. An economic loser makes no direct difference to the ω game for the ν player where the ν player has an objective of minimizing the average bid for the game.

Efficiency: The ration of the output to the input of any system.

Game: a series of jobs for the construction of a reinforced concrete floor slab, each game lasts approximately 8 to 10 weeks in game play time, with each round of the game modelling a week and occurring in a 20 minute period, with 15 minutes of bid time and 5 minutes of build time.

- Game theory:** A formal analysis of conflict and cooperation among intelligent and rational decision makers.
- Herfindahl Index:** ‘a measure of the size of firms in relationship to the industry and an indicator of the amount of competition among them. It is defined as the sum of the squares of the market shares of each individual firm. As such, it can range from 0 to 10,000, moving from a very large amount of very small firms to a single monopolistic producer. Decreases in the Herfindahl index generally indicate a loss of pricing power and an increase in competition, whereas increases imply the opposite. The Department of Justice considers Herfindahl indices between 1000 and 1800 to be moderately concentrated and indices above 1800 to be concentrated. As the market concentration increases, competition and efficiency decrease and the chances of collusion and monopoly increase.’ (van Vleet, 2004).
- Job:** A work unit, in this case a reinforced concrete slab for a home builder, taking 5 working days to construct.
- Loan amount:** It is a bank loan or a guarantee taken by the bidder with the purpose of increasing the bidders’ job capacity. The cost is \$500 per job.

Loss:	negative return applied to a business undertaking after all operating expenses have been met.
Lump Sum offer:	A tender submitted for a lump sum amount in the game assumed to be for a fixed price.
Pre-Qualified:	The process of declaring competent or capable or to certify in advance. The purpose of pre – qualified is to maintain the economic competition.
Profit:	The return received on a business undertaking after all operating expenses have been met.
Profit Efficiency:	It is the ratio of the profit made to the number of jobs won. This is one of the postulated metrics for determining success in the α game.
Purchaser:	Either an owner or owner’s representative who organizes the bid or tender document.
RAB:	It is a single or multiple-item, open, descending-price auction. The initiator specifies the opening bid price and bid decrement. Each bidder submits a successively lower bid. At the end of the auction, the bidder with lowest bid value is being considered as a winner (van Vleet, 2004).
Second Bidder Issue:	‘It has been postulated that the lowest bidder in Reverse Auction Bidding is seeking to undercut the second bidder by the smallest quantifiable fragment, if the bidder

understands the principles of tacit collusion.’ (Chaudhari, 2009). The hypothesis forms the basis for future research.

Sealed Bidding: ‘In this type of auction, all bidders simultaneously submit bids in such a way that no bidder knows the bid of any other participant. The highest/lowest bidder is awarded the contract at an agreed price, all other things being equal.’ (van Vleet, 2004).

Sherman Antitrust Act: ‘The act, based on the constitutional power of Congress to regulate interstate commerce, declared illegal every contract, combination (in the form of trust or otherwise), or conspiracy in restraint of interstate and foreign trade.’ According to Nichols (2010), the problem is tacit collusion does not fit within the meanings of the act, thus leading to the debate about the legality of RAB between contractors who consider it illegal or unethical and economists who accept the converse.

Tacit Collusion: ‘Seemingly independent, but parallel actions among competing firms (mostly oligopolistic firms) in an industry that achieve higher prices and profits, much as if guided by an explicit collusion agreement. Also termed implicit collusion, the distinguishing feature of tacit collusion is the lack of any explicit agreement. The key is that each firm

seems to be acting independently, perhaps each responding to the same market conditions, but the end result is the same as an explicit agreement. This should be contrasted with explicit or overt collusion that does involve a formal, explicit agreement. Tacit collusion is observed in Reverse Auction Bidding, and is potentially related to the Second Bidder Issue.’ (Chouhan, 2009). Nichols (2010) postulates that the α game has been observed and misunderstood as tacit collusion, in reality it can be viewed potentially reviewed as an aggressive player seeking a better than average return from the profit distribution resulting from the α game.

Traditional bidding: ‘In this type of auction all bidders simultaneously submit bids in such a way that no bidder knows the bid of any other participant. The highest/lowest bidder is assumed to be awarded at the price submitted provided no other contracts opened on the decision process.’ (Chaudhari, 2009)

Winners Curse: Problem faced by uninformed bidders or poor game players. For example, in an initial public offering uninformed participants are likely to purchase larger

allotments of issues that informed participants know are overpriced.

Background to the Reverse Auction Game Theory

Guhya (2010) documented the game concepts for Reverse Auction bidding suggested by Nichols (2010). The key element is a Reverse Auction Bidding game where the ν player is willing to accept bids of the type shown in equation (1):

$$B_j = K + \Xi_j \Gamma, \quad (1)$$

This development has been shown to provide a stable statistical pattern to the bidding data for four and five player games as shown in *Table 1* for van Vleet's data (Guhya, 2010).

Table 1

Normalized Profit Results

Ξ Range	Number
Less than 0	0
0 to 0.1	3
0.11 to 0.2	35
0.21 to 0.3	13
0.31 to 0.4	4
0.41 to 0.5	5
0.51 to 0.6	2
0.61 to 0.7	7
0.71 to 0.8	2
0.81 to 0.9	1
0.91 to 1.0	1

This first set of normalized results were plotted for van Vleet's results in Figure 1 by Guhya (2010) and are replicated here because of the importance of understanding the strategy used by some bidders.

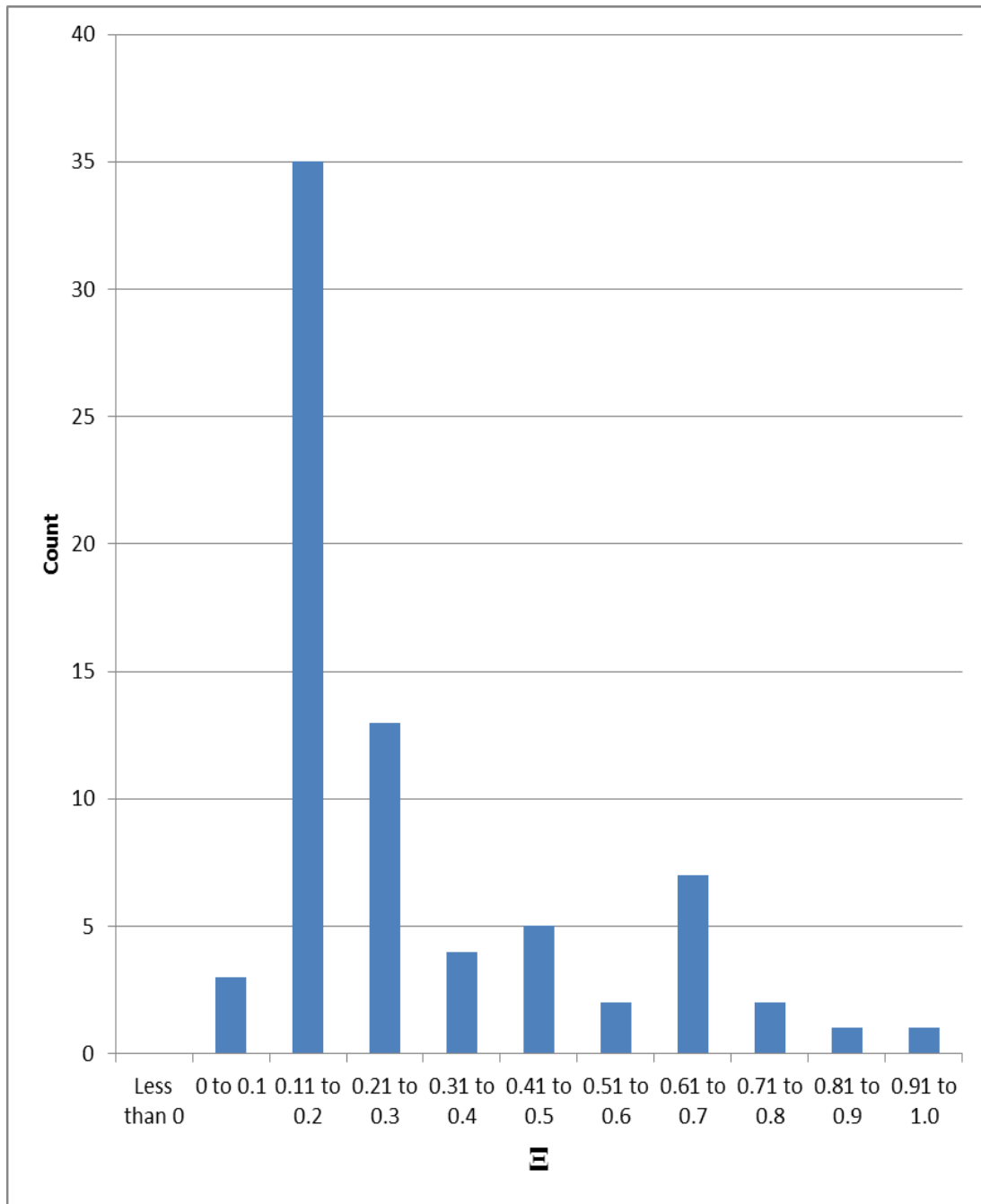


Figure 1. Histogram of the Ξ ; Results Shown in Table 1

Interestingly this result was not found until the eighth study given that it appears to be evident from the earliest result set. The real analysis problem is not the data, but the size and complexity of the data source and the need to work across a number of studies. This work provides an interesting problem in data mining. The problem was to some extent exacerbated by the change from the original Microsoft Access database and ASP system (Kim, 2004) to the SQL Server system developed by Wellington (2006) as a result of the difficulty of managing a ten player game using Access during the study by (Gregory, 2006). Microsoft Access was designed as a single user database system.

Γ represents the upper limit the ν player is prepared to pay in the game above the nominal minimum bid amount K . A negative Ξ_j represents a loss on direct costs to the λ_j player who makes this type of bid, and enough of these bids will lead to a bankrupt player. The concept of Γ can be attributed to Feigenbaum (Nichols, 2010), who considered there had to be an upper limit everyone was prepared to pay for a service or good, although this is a generally accepted economic theory (Perloff, 2004), the reality is established by negotiation rather than by fiat.

Feigenbaum's concept of a maximum price point is akin to the economic concept of the subcontractor taking all of the profit from the transaction, which clearly puts the purchaser at economic risk (Perloff, 2004). This price point issue was studied as part of a RAB case study using the price of Coca Cola™ as the base product (Gujarathi, 2007). The small study showed a price range from 1 unit to about 3.5 units of cost for the range of available transactions. As Hartford (2005) notes the price can be driven by scarcity or monopoly rent type issues to give two examples. There has been significant discussion

amongst the research team undertaking and directing this study as to the range of prices that would be charged by the bidders for the work. At this stage there is no real resolution to this issue aside from the following comments that seem applicable:

1. The purchaser is silent in the transactions except for two occasions, in one study the purchaser interfered by having one of the bidders drive down the prices to rock bottom, causing serious discussion in the bid group.
2. In this current study one of the bidders was bidding recklessly and was considered a high bankruptcy threat imperilling the purchaser's business model of rapid turnover and high quality. The bidder was removed.

As Guhya (2010) noted the bidding period for each game lasts for a set time, τ , in this case it is 15 minutes. The total cost for ν player is shown in equation (2):

$$B_\nu = \sum_{j=1}^n B_j, \quad (2)$$

This total cost is based on the accepted lower bid for each job, where the λ player submitted a valid bid. Each λ_i player then has a unique set of bids and a unique set of jobs, with a total return to the λ_i player defined by a simple summation.

The interesting issue is that Reverse Auction Bidding exposes the bidding strategy for the bidders to the purchaser, giving both sides an incredible amount of high quality economic data on the current state of the game market, provided there are no outside influences, and aside from the two mentioned earlier there have been none. It is instructive to consider the games that have been completed to this time, refer Table 2.

Table 2

Previous RAB Studies at TAMU

Study Number	Name	Date	Number Participants	Comments
1	Van Vleet	July 2004	Five	First Study to establish system, no controls on price
2	Shankar	July 2005	Five	Duplicated Van Vleet's study
3	Gregory	December 2006	Three, Six, Ten	Multigame study
4	Gujarathi	November 2007	Four	Coke Study included and first four player game
5	Panchal	November 2007	Four	Standard Study
6	Chouhan	August 2009	Four	Bidder's personality studied
7	Chaudhari	December 2009	Four	Owners Interference
8	Machado	November 2009	Four	Personality Study
9	Petersen	May 2010	Four	Poor economic performer types studied
10	Guhya	May 2010	Five	Statistical Analysis of First Case Study
11	Saigonkar	May 2010	Four	Personality
12	Billing	August 2010	-	Graph Theory Study
13	Gupta	August 2010	Four	Study Guardians
14	Patel	August 2010	Four	Study personality
15	Somani	August 2010	Four	Study Guardians
16	Plumber	August 2010	Four	Personality Type
17	Bhalerao	August 2011	Four	Statistical Study of the Fourth Case Study data
18	This study	August 2012	Three, four and ten	Repeat Study 3

The key stages represented in the research in are:

1. development of the web site and understanding the bidding strategies of the bidders was up to and including Study Three (Gregory, 2006; Shankar, 2005; van Vleet, 2004);
2. Study Four, (Gujarathi, 2007), looked at fixing an upper limit to the price as suggested by Feigenbaum (Dagostino & Feigenbaum, 2003; Nichols, 2010), using Coca Cola™ sales price as a guide, which is line with accepted microeconomic theory (Perloff, 2004);
3. Study Five as a four bidder study (Panchal, 2007) continued the development of the process;
4. Study Six, (Chouhan, 2009), was the first work to look at the impact of personality using the Keirsey Temperament Sorter Test;
5. Study Seven, (Chaudhari, 2009), showed that owners interference in the process caused disruption in the results and significant disquiet in the bidders. The old adage, *if looks like a duck and smells like a duck then it is a duck* applies to this scenario as the bidders quickly perceived the interference;
6. Study Set Eight, Nine, Eleven and Thirteen to Sixteen, (Gupta, 2010; Machado, 2009; Patel, 2010; Petersen, 2011; Plumber, 2010; Saigaonkar, 2010; Somani, 2010);
7. Study Ten, (Guhya, 2010), was a through statistical analysis of the first case study. The work established a number of the standard techniques now used in the analysis of the RAB results;

8. Study Twelve, (Billing, 2010), looked at the use of graph theory to understand the bidding process (Behzad & Chartrand, 1998);
9. Study Seventeen, (Bhalerao, 2011), completed a study similar to Guhya (2010) to confirm this earlier work;
10. Study Eighteen, this study is designed to replicate the work by Gregory (2006).

Historical Use

Reverse Auction bidding, as a new variant of Dutch auction, has become a widely used tool in the construction industry. Some purchasers are starting to use this bidding system as a common purchasing method. Usually a purchaser or surrogate company will create a website that can handle RAB jobs, such as that developed by W. Kim (2004) for van Vleet (2004). The information to bid on a job is either posted on the website or sent to prequalified bidders.

All qualified bidders must bid through this website, and each bidder can see the current lowest price. A bidder can lower their bid according to the current lowest bid within a specified timing system, since the lowest price can win the bid in the end.

Some assert that reverse auctions bidding largely reduces the cost and the cycle time for the purchasers. For example, General Electric Inc., one of the largest electronic companies in the world, has stated a reduction of 520% in procurement cost due to this method (Presutti Jr, 2003). This type of statement cannot of course be proven (Hartford, 2005) as the reduction would have occurred most likely in a hard bid environment.

Recent research results collected from thirty individual companies, by Schoenherr and Mabert (2007), have suggested to some that myths about the reverse auction process may be false, as follows:

1. Lowering the price of the bid is not the most important objective in the reverse auctions;
2. Either commodity item or non-commodity items can be bid in the reverse auctions;
3. Reverse auctions may harm the buyer – supplier relationship, but a lot of methods can be used to prevent this happening;
4. Though the first time bidding may generate higher profits, it doesn't mean profits will disappear in the following bidding process;
5. Even though there is a decline in the usage of reverse auction, for the long run, it is still a very promising method.

According to Beall, Carter, Carter, Gerne, Hendrick, Jap. (2003) it is:

” an online, real-time dynamic auction between a buying organization and a group of pre-qualified suppliers who compete against each other to win the business to supply goods or services [...]. These suppliers compete by bidding against each other online over the Internet using specialized software by submitting successively lower bids during a scheduled time period. This time period is usually only about an hour, but multiple, brief extensions are usually allowed if bidders are still active at the end of the initial time period”

The graph shown in Figure 2 can better explain the main common myths about reverse auction now.

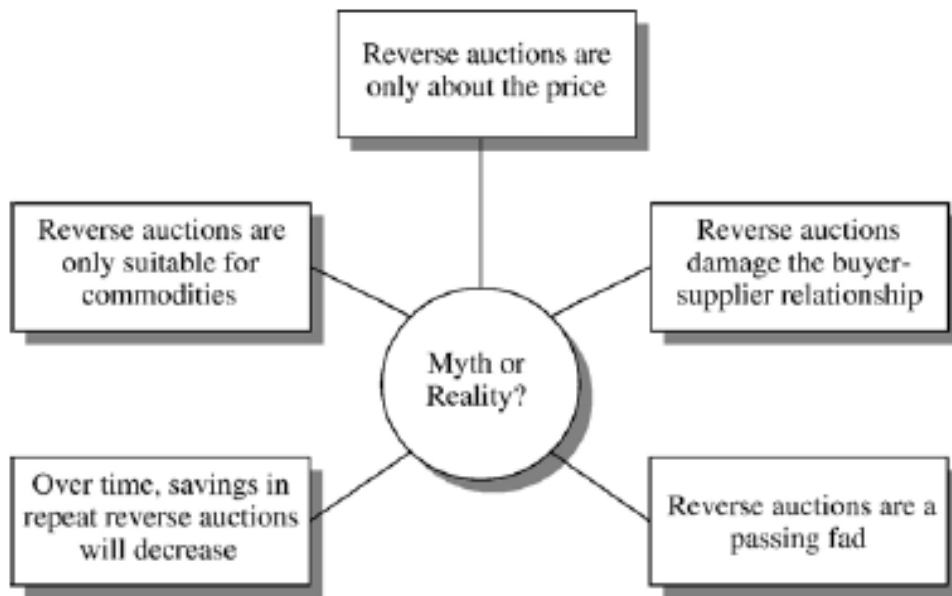


Figure 2. Common Myths Associated with Online Reverse Auctions after Schoenherr and Mabert (2007)

Kaufmann and Carter (2004) provided a very specific and detailed literature review in their paper on RAB systems. As with all new systems it will take a while for the economic studies to catch up with the practical reality. The perception is that costs are reduced, the reality according to the TAMU work is that this is not always true (Guhya, 2010).

Although there are a number of people holding negative opinions against Reverse Auction Bidding systems, the positive aspects of Reverse Auction Bidding systems cannot be neglected (Caniëls & van Raaij, 2009). The biggest factor shown in recent result is:

1. that suppliers from developing economies tend to accept Reverse Auction Bidding systems more than those from mature economies.
2. Also, “*firms that aim to compete on prices are very positive on [Reverse Auction Bidding systems].*”
3. different individuals may have different opinions on Reverse Auction Bidding systems,
 - a. *sales people and tenured managers are opposed to this kind of method;*
 - b. *Sales people live on revenue and margin;*
 - c. *managers are rewarded on market share.*
4. *Reverse Auction Bidding systems may reduce the connection between the buyers and suppliers to some extent (Caniëls & van Raaij, 2009).*

Ray, Jenamani, and Mohapatra (2011) have proposed “*a novel multiple attribute relationship-preserving reverse auction mechanism for a limited supplier base*”, which can help create a healthy competition environment. Wagner and Schwab (2004) in considering the issues that have impact on the Reverse Auction Bidding systems, divided them into three categories:

1. Core problems of the auction, for example, the goods or services that is going to be auctioned, suppliers etc;
2. Characteristics of the auction process, like the auction type, rules, period, etc;
3. preparation and conduction of the auction.

To better understand the purchaser’s motivation for using reverse auctions, some research has been completed as follows:

1. Amelinckx, Muylle, and Lievens (2008) created a model to show the sourcing outcome of buying firms and the e-sourcing success.
2. Smeltzer and Carr (2003) interviewed a bunch of purchasing companies and got *“three primary motivations, three perceived risks and four conditions for success.”*
3. Smeltzer and Carr (2003) further concluded that the conditions for successfully using Reverse Auction Bidding systems are:
 - a. *clear and comprehensive specifications of the commodity must be provided;*
 - b. *an attractive bid must be based on a large enough purchase to encourage suppliers to bid;*
 - c. *“the appropriate supply market must exist”;*
 - d. *“the appropriate infrastructure must exist within the buying organization.”*

Importantly, the reasons for using reverse auction by buyers, according to their research, are *“new business, market penetration, cycle time reduction and inventory management”*. *Even though only two parties may well be involved in the final stages of bidding, at least four or five viable, competitive bidders are generally required to begin an auction”* (Smeltzer & Carr, 2003).

These reasons for using RAB makes sense, any reasoning based on price minimization clearly fails to understand the auction process or human nature.

Personality Testing

All the participants were asked to take a test called Keirsey Temperament Sorter (KTS) Test before they start bidding. This test is used to evaluate the personalities of

those bidders who have participated in the RAB game. The sixteen personality types defined by Keirsey are shown in Table 3.

Table 3

KTS Different Personality Types

	Temperament	Role	Role Variant	
Introspective (N)	Idealist (NF)	Mentor (NFJ)	Teacher (ENFJ): <i>Educating</i>	
		<i>Developing</i>	Counselor (INFJ): <i>Guiding</i>	
	<i>Diplomatic</i>	Advocate (NFP)	Champion (ENFP): <i>Motivating</i>	
		<i>Mediating</i>	Healer (INFP): <i>Conciliating</i>	
	<i>Rational (NT)</i>	Coordinator (NTJ)	Field marshal (ENTJ): <i>Mobilizing</i>	
		<i>Arranging</i>	Mastermind (INTJ): <i>Entailing</i>	
		<i>Strategic</i>	Engineer (NTP)	Inventor (ENTP): <i>Devising</i>
			<i>Constructing</i>	Architect (INTP): <i>Designing</i>
	Observant (S)	Guardian (SJ)	Administrator (STJ)	Supervisor (ESTJ): <i>Enforcing</i>
			<i>Regulating</i>	Inspector (ISTJ): <i>Certifying</i>
<i>Logistical</i>		Conservator (SFJ)	Provider (ESFJ): <i>Supplying</i>	
		<i>Supporting</i>	Protector (ISFJ): <i>Securing</i>	
<i>Artisan (SP)</i>		Operator (STP)	Promoter (ESTP): <i>Persuading</i>	
		<i>Expediting</i>	Crafter (ISTP): <i>Instrumenting</i>	
	<i>Tactical</i>	Entertainer (SFP)	Performer (ESFP): <i>Demonstrating</i>	
		<i>Improvising</i>	Composer (ISFP): <i>Synthesizing</i>	

Table 4 provides a descriptive meaning of each letter, which in combination describes the characteristics of each unique personality.

Table 4

Summary of Individual Components of the Different Personality Types

Letter	Name	Meaning
E	Extraversion	Feel motivated by interaction with people. Tend to enjoy a wide circle of acquaintances, and <i>gain</i> energy in social situations
N	Intuition	More abstract than concrete. Focus attention on the big picture rather than the details, and on future possibilities rather than immediate realities
F	Feeling	Value personal considerations above objective criteria. When making decisions, often give more weight to social implications than to logic
J	Judgment	Plan activities and make decisions early. Derive a sense of control through predictability
I	Introversion	Quiet and reserved. Generally prefer interacting with a few close friends rather than a wide circle of acquaintances, and <i>expend</i> energy in social situations
P	Perception	Withhold judgment and delay important decisions, preferring to "keep their options open" should circumstances change
T	Thinking	Value objective criteria above personal preference. When making decisions, generally give more weight to logic than to social considerations
S	Sensing	More concrete than abstract. Focus attention on the details rather than the big picture, and on immediate realities rather than future possibilities

The results define four main personality types as noted by (Guhya, 2010):

- i. Idealist (NF).
- ii. Rational (NT).
- iii. Guardian (SJ).

iv. Artisan (SP).

Berens and Cooper (2001) summarize the key elements to the four primary personalities as:

- i. Artisans are known to be observant and practical. They have notable skill set in crafting, performing and composing with their highest strength being tactical variation.
- ii. Guardians excel at facilitating, checking and organizing and are more concerned with responsibility and duty. They are observant and supportive in their nature.
- iii. Idealists seek their own unique identity and are prominent in their diplomatic intelligence. They are introspective and cooperative and place a high skill importance in inspiring, clarifying and individualizing.
- iv. Rational are introspective and pragmatic. They personality type is excel in logical investigation, conceptualizing and coordinating. They are deeply concerned with their own knowledge, have a good potency in strategic intelligence and seek self-control.

Panchal (2007) opined that RAB process is heavily influenced by personal behavior and individual characteristics. Chouhan (2009) observed and defined the clear difference among the aggressive and average bidders. Chaudhari (2009) and Saigaonkar (2010) proposed that this may be due to differences in the personality types of the bidders, which has now been studied in some detail as part of the TAMU work. Their results showed that the bidders with Guardians (SJ) personality type are the most

economically effective bidders. However as Petersen (2011) noted in his conclusions as the definition of a Type ξ player:

This research shows that guardians do not perform equally in a game. The definition of a Type ξ player may include guardian as one of the defining elements, but it is not exclusive. Future research is recommended using a larger selection pool to obtain a full set of non-guardians to meet the original objective of the research.

Now more research has been done to get into deeper analysis about the Guardian. Guardian consists of four types of roles – Supervisor, Inspector, Provider and Protector. Some experts suggest that research can be focused on the difference among these four types of personalities, and determine if one of these four types perform best in the game with highest profits and lowest jobs.

van Vleet's RAB Game

Game Introduction

Reverse auction bidding is a new purchasing method in the construction industry. Though it has been somewhat proved effective, efficient and economical in the manufacturing industry, no significant research has been done for the construction industry. In Guhya (2010) research, he considered the RAB game developed by van Vleet could be considered as an algorithm. The algorithmic process is shown in Figure 3.

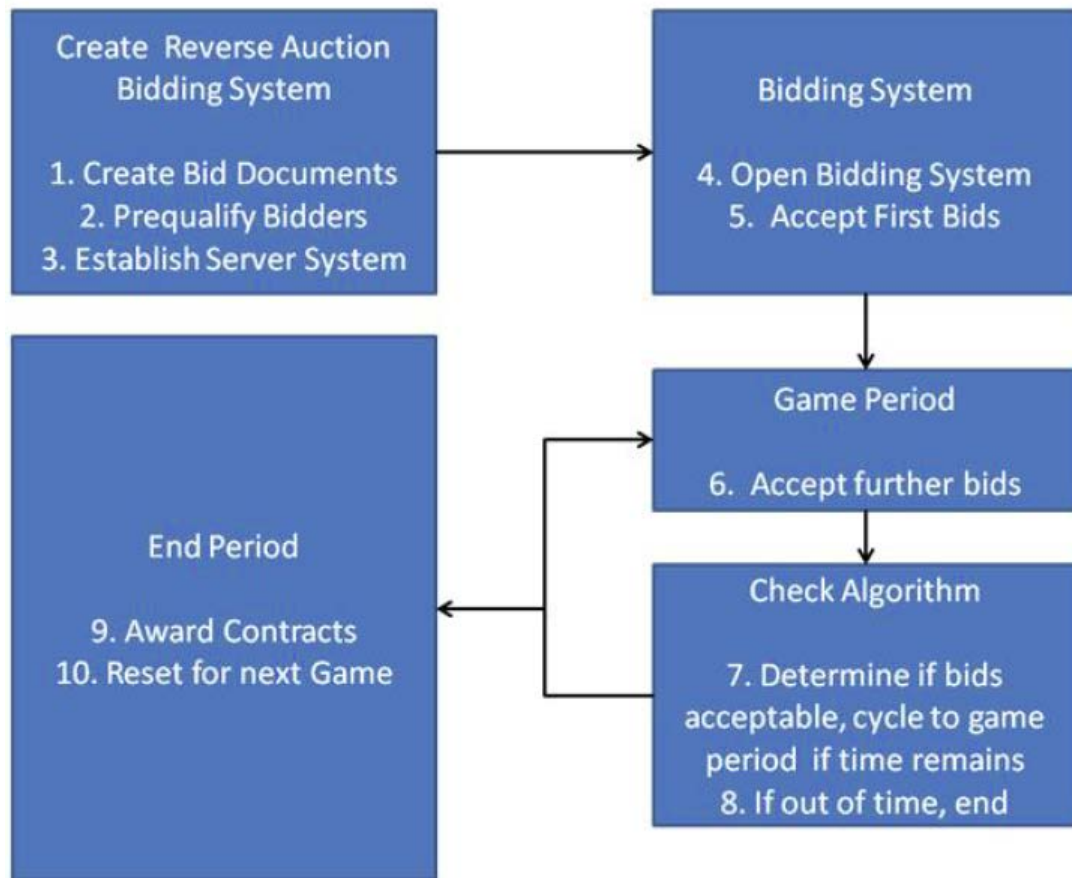


Figure 3. Reverse Auction Bidding General Algorithm after Guhya (2010)

For the research work completed by van Vleet in 2004, a RAB scenario was created. But since van Vleet's professional paper was not published, it is necessary to explain it again. In the scenario van Vleet (2004) created, each participant acts as an independent contractor working for a production home builder. All the contractors need to finish the work so the purchaser can construct a home, and they are going to compete with each other on one particular type of subcontract work, which is a slab construction. In order to simplify the game, van Vleet assumed that the home builder only builds one

type of house, which is not far from the truth for production builders. In this way, each contractor only needs to build one type of slab.

This assumption largely reduces the qualification requirements for each contractor so the final results can better show the efficiency of RAB. The game is assumed to happen in six suburbs in the Greater Houston area. As shown in the Figure 4. (The six suburbs are highlighted with red stars.)

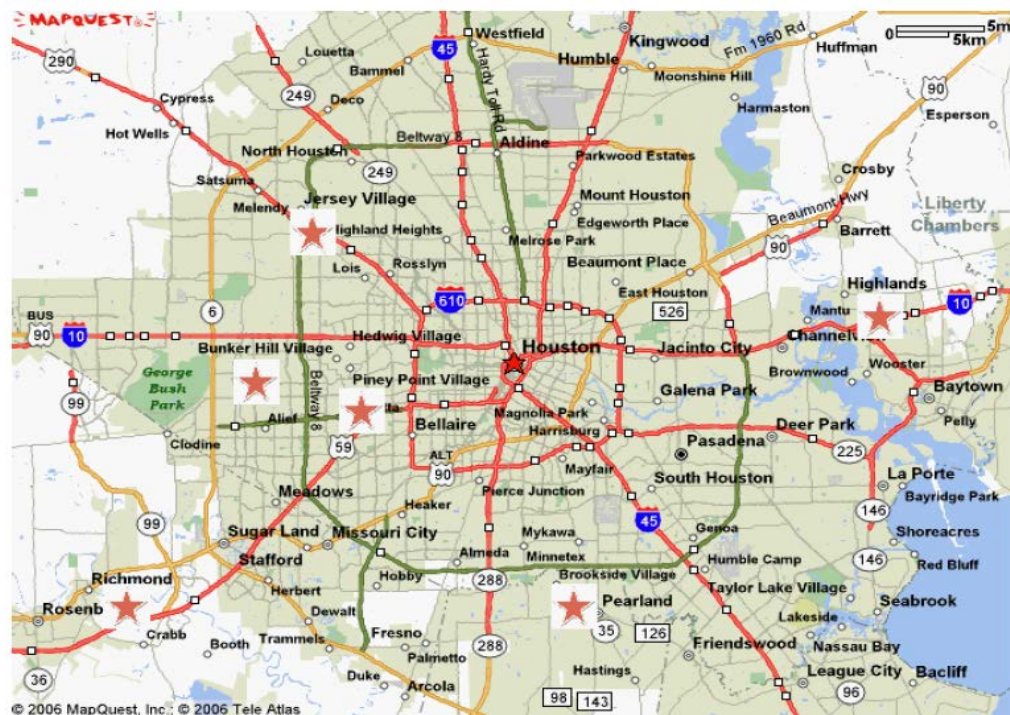


Figure 4. Construction Site Locations in Houston after MapQuest (2006) and (Guhya, 2010)

Table 5 shows the distance from each site to the main contractor's office in Sugarland.

Table 5

Site Location Details

Site #	Location of Development	Distance from Sugarland (miles)
1	Brookside Village	28.8
2	Piney Point Village	14.9
3	Highlands	40.5
4	Jersey Village	28.8
5	Brunker Hill Village	16.9
6	Richmond	8.9

Since the work is repetitive, it is assumed the experience and qualifications are not the most important factors for this bidding process. The bidding price is what matters most.

Every Monday the owner will post the jobs and all the related information, including the location of the jobs, estimated cost of the jobs, etc., on the ASP based website (Kingsley-Hughes, Kingsley-Hughes, & Read, 2004) for that week, and then all the bidders log on to the web site and starting bidding for the jobs. The web site was first created by W. Kim (2004) for van Vleet, including a major upgrade to SQL Server by Wellington (2006). All current research uses the SQL Server system.

Figure 5 shows the login screen for the game. Figure 6 shows a sample data collection screen for one of the bidders. From the figure, it clearly shows that the process is in the week 159 with five completed jobs, zero jobs in process and zero bids ongoing now. If the bidding process is ongoing, then every week when the bidder gets some jobs, it will be shown in the Jobs in Progress Screen. If the bidding is not over, and at that time, the bidder provides the lowest price for some job, then it will be shown in My Active Jobs Screen. Besides, all the information about those completed jobs (the location, the bid amount, the job start date, etc.) is posted here.

Reverse Auction Bidding Game

Login to the Game

Now: Day 1107 (Monday), Week: 159

11:07^{PM}
49

Time Details

Current Start Date: Thursday, April 05, 2012

Notice

This site is designed to undertake research into Game Theory for Reverse Auction Bidding.

Principal Investigator is John Nichols, (jm-nichols@tamu.edu),
Associate Professor in the Department of Construction Science

Login

User Name:

Password:

Department of Construction Science

Technical Problems, then please send email to [Web Admin](#).

Texas A&M University - [Software Version: February 28, 2012]

Institutional Review Board matters about the research, mail to [IRB](#).

This game is best played on the OPERA Web Browser.)

Figure 5. Reverse Auction Bidding Login Screen

Now: Day 1107 (Monday), Week: 159

My Active Bids

JOB#	LOCATION	CURRENT PRICE	CURRENT BIDDER	TIME REMAINING	MY LOWEST BID AMOUNT	OUTBID
------	----------	---------------	----------------	----------------	----------------------	--------

There are no my active bids !!!

My Jobs in Progress

JOB#	LOCATION	Bid Amount	Job Start Date	Delays	Construction days	Cost to Date
------	----------	------------	----------------	--------	-------------------	--------------

There is no work in progress !!!

My Completed jobs

Job#	Site	Bid Date	Bid Amount	Cost	Profit	Start day	End day	Rainy days	Profit Rate
2802	Brunker Hill	Day 1	\$ 13999	\$ 13213	\$ 786	Day 2	Day 6	Day 0	5.61%
2812	Brookside	Day 15	\$ 44742	\$ 14914	\$ 29828	Day 16	Day 20	Day 0	66.67%
2824	Piney Point	Day 22	\$ 38000	\$ 12835	\$ 25165	Day 23	Day 33	Day 6	66.22%
2827	Brookside	Day 22	\$ 35000	\$ 14914	\$ 20086	Day 23	Day 28	Day 1	57.39%
2834	Jersey Village	Day 29	\$ 44175	\$ 14725	\$ 29450	Day 30	Day 35	Day 1	66.67%

My summary

- Current Spare Capacity For Additional Work : 3 [Your total capacity : 3 (Initial capacity : 3, Added capacity by bank guarantee : 0)
- Current Financial Condition : \$ 114701 (No money paid to initiate work, No money paid in middle of job)
 [= Capital money [\$40000] + Profits from completed jobs - Costs of current jobs in progress - Bank Guarantee Fee(\$500/loan)]
 Current My Total Bank Guarantee Fee : \$ 0

Figure 6. Reverse Auction Bidding - Sample Data Screen

Table 6 shows the construction costs for each site. The aim is to make the bidding system as realistic as possible.

Table 6

Location of the Construction Sites in Houston

Site #	Location of Development	Distance from Sugarland (miles)	Travel Cost (\$)	Delivery Cost (\$)	Total Cost (\$)
Site 1	Brookside Village	42	858	624	1482
Site 2	Piney Point Village	24	495	360	855
Site 3	Highlands	70	1452	1056	2508
Site 4	Jersey Village	40	825	600	1425
Site 5	Bunker Hill Village	27	561	408	969
Site 6	Richmond	14	297	216	513

Specific Assumptions

The assumptions are:

1. The total duration of the game will be a maximum of nine consecutive weeks;
2. All bidders initially have an equal dollar amount of \$40,000 available in their bank accounts;
3. The original cost for every job is estimated to be \$10,000 excluding the travel costs and the delivery costs. The values of these costs are posted along the job site address;
4. The duration for completing each job is assumed to be five days, excluding the rain delay;
5. The work week is assumed to be five days long i.e. from Monday to Friday;
6. Initially, every bidder will only be allowed to work on three jobs in a week;
7. If a bidder decides to undertake more than three jobs in a week, then the bidder will have to take a loan from the bank. The additional charge for each loan is \$500 and this will be automatically charged irrespective of the fact that they have won the bid or not;
8. Since the base cost for all jobs is \$10,000, and the default duration is five days, the cost accumulated is \$2000 per day for all jobs. The travel expenses and the delivery charges would also be summed up on a daily basis accordingly depending upon the location;
9. The location of the owner is assumed to be located in Sugar Land, Texas and thus the additional expenses for travel and delivery are assumed on the basis of the proximity

of the job site from this place. The offices of the subcontractors are also assumed to be in Sugar Land, Texas;

10. The minimum acceptable return on investment derived from long term construction industry standards is 10%. However, this would not be tested during the game and the players would be cautioned of this condition;
11. Payment for work is scheduled to be delivered at the completion of 5th construction day;
12. The primary objective of all the bidders is to maximize their profits while maintaining bank assurance and satisfactory liquidity.

Rain Delay

For any construction site, rain is a problem for the development of an efficient process. In this research, the rain delay is also considered as a part of the bidding process. In van Vleet's research, the rain possibility was assumed to be 30% per day, in line with average rain days for Houston (van Vleet, 2004). All the data was obtained from the National Oceanic and Atmospheric Administration (NOAA) web page for the study to provide a random array of rain days for the game as shown in Figure 7.

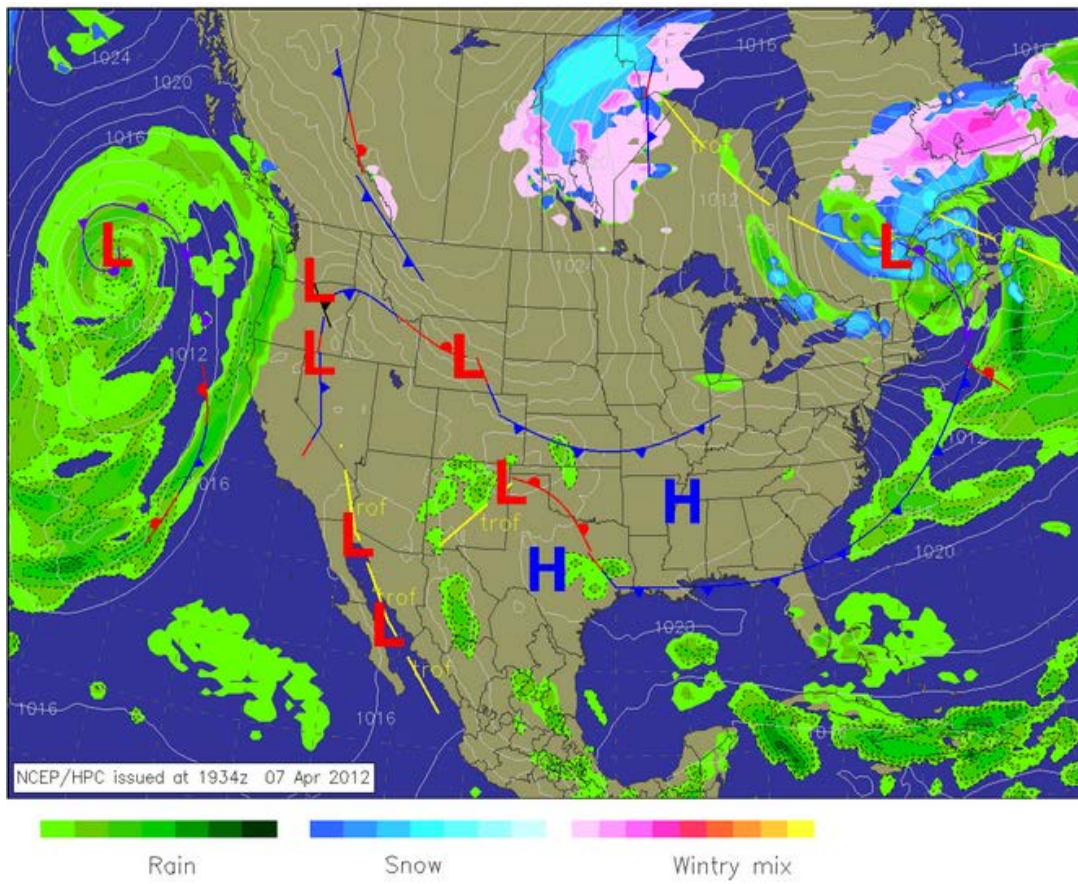


Figure 7. Sample Weather Map for Houston, after NOAA (2012)

Table 7 shows a sample of the rain delay table.

Table 7

Rain Delays for Week One

Day	Site					
	One	Two	Three	Four	Five	Six
Monday	1	0	0	0	1	0
Tuesday	0	1	1	0	0	0
Wednesday	0	0	0	0	0	0
Thursday	0	0	1	0	0	1
Friday	1	0	0	0	1	1
Saturday	0	0	0	0	0	0

As it is shown in the figure, there are two numbers – 1 and 0 here. Wherever there is a number 1, it means a rain delay, while number 0 is the opposite. The rain delays are a big influence on the work efficiency. Any delays may result in the work capacity for each participant during the rest the construction work, which may change the final completion date.

In this Reverse Auction Bidding process, the price needs to go lower each time. On the ASP based website only a lower than the current price bid will be accepted. If the bidder enters an inappropriate price, a notice will be shown on the screen to warn the bidder about the price submitted.

CHAPTER III

METHODOLOGY

Introduction

The game setup was described in the Literature Review. This methodology describes the three multiplayer games used in this research project. The methodology has the following sections:

1. Game Setup unique to this research;
2. Data Collection.

Game Setup

This study used three separate games to replicate the work by Gregory (2006) with Game 1 having three bidders, Game 2 having four bidders and Game 3 having ten bidders.

Each game followed this procedure:

1. Each test was conducted at a specified place and a specific time;
2. Before each test, all the participants will sit together and first finish the KTS personality test;
3. Then a short and brief introduction about the rules and the regulations will be given to the participants;
4. Each participant was given a unique logon username and password, and then they will start their own bidding process;

5. Communication and any kind of discussion was forbidden during the testing time to make sure each individual would use their own strategy to bid the projects.

Data Collection

The section on data collection is common to all TAMU Reverse Auction Bidding Studies and the key elements are kindly taken from the paper by (Plumber, 2010). The key elements are presented below.

Every participant of the RAB game was assigned a unique username and password to access the RAB website. The usernames assume random company names samples of which are as follows:

- i. Driver Co.
- ii. Pliers Co.
- iii. Concrete Co.
- iv. Hammer Co.

All the needed information related to bid process such as the cost of the job, all current bids, and the bidder's company name were made available to the bidders once they logged into the website using their unique usernames. The purpose is to present the needed bid information and thus improve the bidder's ability to respond in real time.

After logging on to the server the participants were directed to the All Current Bids Screen as shown in Figure 8. The All Current Bids screen shows all the information about the jobs such as the estimated cost, travel cost, delivery cost,

approximate profit and profit percentage. It also contained the My Bids column, in this column the bidder can insert their bid amount and click on **Submit** button to place each bid. Only one bid can be placed at a time.

Once a bid is placed all information was available to all the bidders. Each bidding session went on for 15 minutes and a different number of bidding sessions took place with a five minute break between each session in each game. As for all games, bidders were unable to place bids before the commencement of the bidding and after the end of the sessions.

As mentioned in the literature review, each bidder was constrained to bid on only three jobs within a given week without penalty. To bid on more than three jobs each participant had the cost option of taking a loan from the bank, for which a fee of \$500 was deducted from the bidder's available bank balance. The All Current Bids Screen, as shown in Figure 8. Figure 9 shows the form provided upon taking out a bank loan.

Now: Day 64 (Monday), Week: 10

06:11:38 PM

Notices

All Current Bids											
JOB#	LOCATION	TRAVEL COST	DELIVERY COST	ESTIMATED COST	CURRENT PRICE	Ept. Profit	Ept. Profit%	BIDDER	Bid Date	MY PRICE	SUBMIT
1683	Highlands	\$ 1452	\$ 1056	\$ 18316	\$ 45700	\$ 27384	59.92%	Driver Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1684	Richmond	\$ 297	\$ 216	\$ 11701	\$ 40952	\$ 29251	71.43%	Concrete Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1685	Highlands	\$ 1452	\$ 1056	\$ 18316	\$ 64105	\$ 45789	71.43%	Concrete Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1686	Brookside	\$ 858	\$ 624	\$ 14914	\$ 52190	\$ 37276	71.42%	Driver Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1687	Brunker Hill	\$ 561	\$ 408	\$ 13213	\$ 46240	\$ 33027	71.43%	Driver Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1688	Brunker Hill	\$ 561	\$ 408	\$ 13213	\$ 46240	\$ 33027	71.43%	Driver Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1689	Piney Point	\$ 495	\$ 360	\$ 12835	\$ 44900	\$ 32065	71.41%	Driver Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1690	Piney Point	\$ 495	\$ 360	\$ 12835	\$ 44922	\$ 32087	71.43%	Pliers Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>
1691	Highlands	\$ 1452	\$ 1056	\$ 18316	\$ 64106	\$ 45790	71.43%	Pliers Co.	Day 57	<input type="text"/>	<input type="button" value="SUBMIT"/>

Figure 8. All Current Bids Screen

Notice

- ◆ Click the job number or current price of active bids to check the bid history of each jobs.
- ◆ Remember your initial job capacity is only 3. You cannot bid anymore if your capacity is over, without taking out a loan at \$500 per site per contract.
- ◆ Refresh your browser or click [\[ALL CURRENT BIDS\]](#) button frequently during the bid time to check updated current bid prices.
- ◆ * "Ept." means "Expected".
- ◆ Bids start on the 10, 30 and 50 minute times for **2106 jobs**. Bidding Time is 15 minutes.
- ◆ You have a clock, but remember your clock may be different to the server clock and you need to allow for this fact.
- ◆ The tab [\[MY BIDS INFO\]](#) can take 1:30 minutes to refresh. Be warned.

**Currently your capacity is full including current winning bids and jobs in progress.
You cannot bid at this time.**

If you ask for a Bank Guarantee, you can increase your capacity. Bank Guarantee fee is \$500 per guarantee. Do you want?

Figure 9. Bank Guarantee Form

In the RAB game the bidder is only allowed to bid lower than an already placed bid, as it is a reverse auction and one has to follow the rules. If the bidder bids an amount higher than the current bid the following notification, Figure 10, will be shown to the bidder who can then respond to the rule infraction.

Notice

- ◆ Click the job number or current price of active bids to check the bid history of each jobs.
- ◆ Remember your initial job capacity is only 3. You cannot bid anymore if your capacity is over, without taking out a loan at \$500 per site per contract.
- ◆ Refresh your browser or click [\[ALL CURRENT BIDS\]](#) button frequently during the bid time to check updated current bid prices.
- ◆ * "Ept." means "Expected".
- ◆ Bids start on the 10, 30 and 50 minute times for **2106 jobs**. Bidding Time is 15 minutes.
- ◆ You have a clock, but remember your clock may be different to the server clock and you need to allow for this fact.
- ◆ The tab [\[MY BIDS INFO\]](#) can take 1:30 minutes to refresh. Be warned.

Your bid amount is higher than current lowest bid amount!!

Don't forget this is a reverse auction !!!!

Check the current bid amount and try again!!!

Figure 10. Higher than Acceptable Bid Screen

Now: Day 21533 (Monday), Week: 3077

My Active Bids

JOB#	LOCATION	CURRENT PRICE	CURRENT BIDDER	TIME REMAINING	MY LOWEST BID AMOUNT	OUTBID
------	----------	---------------	----------------	----------------	----------------------	--------

There are no my active bids !!!

My Jobs in Progress

JOB#	LOCATION	Bid Amount	Job Start Date	Delays	Construction days	Cost to Date
------	----------	------------	----------------	--------	-------------------	--------------

There is no work in progress !!!

My Completed jobs

Job#	Site	Bid Date	Bid Amount	Cost	Profit	Start day	End day	Rainy days	Profit Rate
2802	Brunker Hill	Day 1	\$ 13999	\$ 13213	\$ 786	Day 2	Day 6	Day 0	5.61%
2812	Brookside	Day 15	\$ 44742	\$ 14914	\$ 29828	Day 16	Day 20	Day 0	66.67%
2824	Piney Point	Day 22	\$ 38000	\$ 12835	\$ 25165	Day 23	Day 33	Day 6	66.22%
2827	Brookside	Day 22	\$ 35000	\$ 14914	\$ 20086	Day 23	Day 28	Day 1	57.39%
2834	Jersey Village	Day 29	\$ 44175	\$ 14725	\$ 29450	Day 30	Day 35	Day 1	66.67%

My summary

- Current Spare Capacity For Additional Work : 3 [Your total capacity : 3 (Initial capacity : 3, Added capacity by bank guarantee : 0)
- Current Financial Condition : \$ 114701 (No money paid to initiate work, No money paid in middle of job)
 [= Capital money [\$400000] + Profits from completed jobs - Costs of current jobs in progress - Bank Guarantee Fee(\$500/loan)]
 Current My Total Bank Guarantee Fee : \$ 0

Figure 11. Jobs in Progress Screen

After the end of each fifteen minute bid session the task would be automatically awarded to the lowest bidder for each job. To see information regarding, what jobs have been won by a bidder, each bidder can go to the My Jobs in Progress Screen which provides the relevant information about the jobs won, refer to Figure 11.

Figure 11 provides relevant financial information so that the bidder has a better idea about how many jobs can be bid on in the following week and how much money the bidder would have to borrow from the bank in order to bid on future jobs his information can be seen under the sub heading of My Summary and it shows the following relevant information:

- i. Current calculated cash assets;
- ii. Capacity for additional works including jobs with bank guarantees;
- iii. Cumulative loan charges till date;
- iv. Current financial condition.

Current financial condition (van Vleet, 2004) displays information regarding the working capital to the participants. The initial capital of \$40,000 is allotted to each player at the beginning of the game and the bank guarantee is \$500 per loan. The formula used to calculate the working capital is:

$$\text{Current Financial Condition} = (\text{Capital} + \text{Profits}) - (\text{Costs of Current Jobs} + \text{Bank Costs})$$

Figure 12 shows the All Completed Jobs Screen which displays information regarding the completed jobs. The bidder can view the status of the jobs they have won, whether the jobs are completed or are still running due to rain delays so that they can determine strategy for further bidding.

Now: Day 71 (Monday), Week: 11

My Completed jobs									
Job#	Site	Bid Date	Bid Amount	Cost	Profit	Start day	End day	Rainy days	Profit Rate
1602	Piney Point	Day 8	\$ 13500	\$ 12835	\$ 665	Day 2	Day 7	Day 1	4.93%
1603	Richmond	Day 8	\$ 11850	\$ 11701	\$ 149	Day 2	Day 7	Day 1	1.26%
1604	Richmond	Day 8	\$ 13500	\$ 11701	\$ 1799	Day 2	Day 7	Day 1	13.33%
1605	Brookside	Day 8	\$ 13500	\$ 14914	\$ -1414	Day 2	Day 8	Day 2	-10.47%
1606	Piney Point	Day 8	\$ 16000	\$ 12835	\$ 3165	Day 2	Day 7	Day 1	19.78%
1607	Brunker Hill	Day 8	\$ 17455	\$ 13213	\$ 4242	Day 2	Day 6	Day 0	24.30%
1608	Brookside	Day 8	\$ 17855	\$ 14914	\$ 2941	Day 2	Day 8	Day 2	16.47%
1609	Brunker Hill	Day 8	\$ 15000	\$ 13213	\$ 1787	Day 2	Day 6	Day 0	11.91%
1610	Piney Point	Day 8	\$ 19000	\$ 12835	\$ 6165	Day 2	Day 7	Day 1	32.45%
1611	Richmond	Day 15	\$ 13500	\$ 11701	\$ 1799	Day 9	Day 15	Day 2	13.33%
1612	Piney Point	Day 15	\$ 14000	\$ 12835	\$ 1165	Day 9	Day 14	Day 1	8.32%
1613	Brookside	Day 15	\$ 17900	\$ 14914	\$ 2986	Day 9	Day 16	Day 3	16.68%
1614	Piney Point	Day 15	\$ 15000	\$ 12835	\$ 2165	Day 9	Day 14	Day 1	14.43%
1615	Richmond	Day 15	\$ 12500	\$ 11701	\$ 799	Day 9	Day 15	Day 2	6.39%
1616	Brookside	Day 15	\$ 17425	\$ 14914	\$ 2511	Day 9	Day 16	Day 3	14.41%
1617	Brunker Hill	Day 15	\$ 15000	\$ 13213	\$ 1787	Day 9	Day 16	Day 3	11.91%
1618	Highlands	Day 15	\$ 21000	\$ 18316	\$ 2684	Day 9	Day 15	Day 2	12.78%
1619	Jersey Village	Day 15	\$ 17000	\$ 14725	\$ 2275	Day 9	Day 14	Day 1	13.38%
1620	Highlands	Day 22	\$ 21400	\$ 18316	\$ 3084	Day 16	Day 21	Day 1	14.41%
1621	Jersey Village	Day 22	\$ 17600	\$ 14725	\$ 2875	Day 16	Day 22	Day 2	16.34%

Figure 12. All Completed Jobs Screen

CHAPTER IV

RESULTS

Introduction

The results of this research are provided in three stages.

1. Personality testing.
2. RAB Game Results Sections.
3. Analysis.

Personality Testing

Background

Previous studies had used personality type as a selection criteria, (Plumber, 2010), but this study did not control for personality. The personality results are given for the three games.

Game 1 Three Player

Table 8 provides the personality types of the bidders in the three player game. Previous research findings suggest that the guardians will have the best economic performance in this game. Participant Three had the best economic returns for the game, which was not expected from previous research. No work has yet differentiated the ξ

player, defined as the best player including personality traits, although Petersen (2011) tried to look at this knotty problem. This is an area of future research.

Table 8

Personality of the Participants in the Three Bidder Game

Participant Identifier	Personality Type
One	ESFJ: Guardians Conservator Provider
Two	ESFJ: Guardians Conservator Provider
Three	ESFP: Artisans Entertainer Performer

Game 2 Four Player

Table 9 provides the personality types of the bidders in the four player game. Participant One had the best economic returns for the game, as was expected from previous research, this may provide further data to support the study by Petersen (2011)

Table 9

Personality of the Participants in the Four Bidder Game

Participant Identifier	Personality Type
One	ESTJ: Guardians Administrator Supervisor
Two	ISFJ: Guardians Conservator Protector
Three	ESFJ: Guardians Conservator Provider
Four	ESTJ: Guardians Administrator Supervisor

Game 3 Ten Player

Table 10 provides the personality types of the bidders in the ten player game. Participant One had the best economic returns for the game, as was expected from previous research.

Table 10

Personality of the Participants in the Ten Bidder Game

Participant Identifier	Personality Type
One	INTP: Rationalists Engineer Architect
Two	ESFP: Artisans Entertainer Performer
Three	ESFP: Artisans Entertainer Performer
Four	ESTJ: Guardians Administrator Supervisor
Five	INFP: Idealists Advocate Healer
Six	ESTP: Artisans Operator Promoter
Seven	ISTJ: Guardians Administrator Inspector
Eight	ESFJ: Guardians Conservator Provider
Nine	ISTJ: Guardians Administrator Inspector
Ten	ESTJ: Guardians Administrator Supervisor

Game Results

Introduction

This analysis of the results follows the traditional methods developed in prior studies. Chouhan (2009) showed that in the Reverse Auction Bidding usually the bid process can be divided into four periods – Learning, Discovering, Competitive and Profit Gain.

Game 1 Three Player Bid Process

Figure 13 shows the profit plotted against job number.

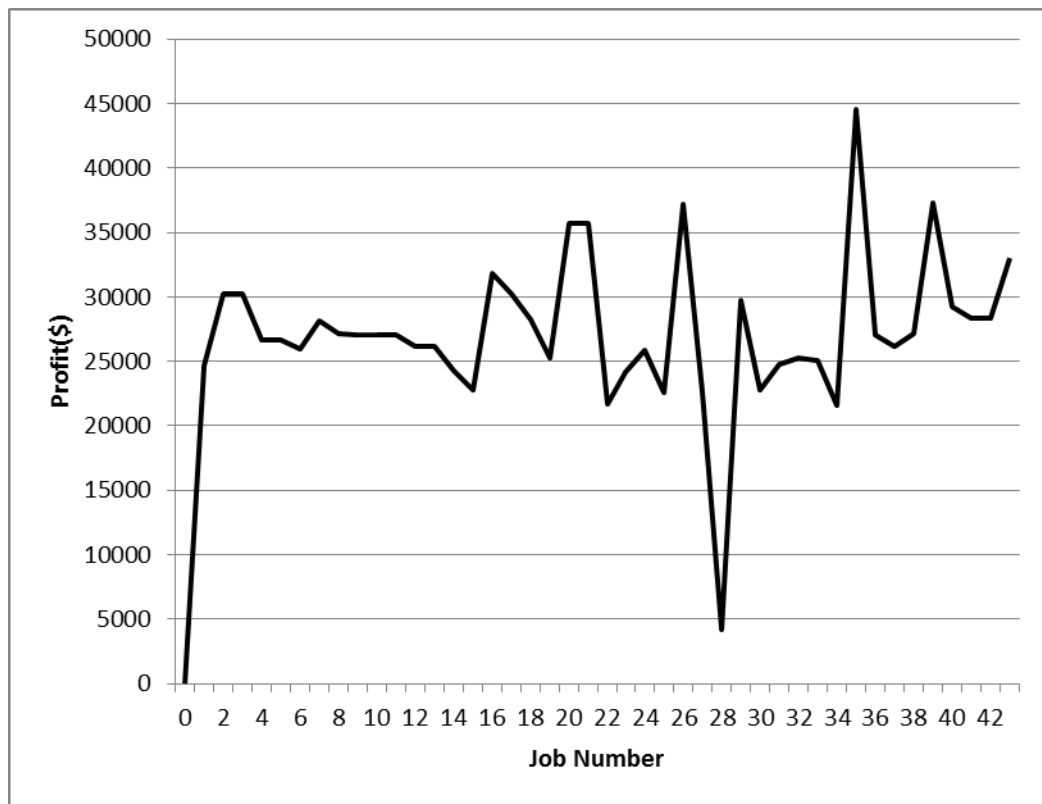


Figure 13. Profit to Different Jobs (3-bidders)

Table 11 shows the proposed trend periods to ascertain if Chouhan's theory applies at a three bidder game.

Table 11

Trend Period in Three Bidder Game

Description of the Trend Period	Job at Start of Period	Job at End of Period
Trend 1	1	21
Trend 2	22	26
Trend 3	27	43

Student's t Test analysis is typically used to determine if the trend period results are distinct (Miller & Freund, 1976). The results for the t Test are shown in Table 12.

Table 12

Student's t-Test Analysis of the Trend Periods (3-Bidders)

Period	1	2	3
1	-	0.58	0.51
2	-0.58	-	-0.18
3	-0.51	0.18	-

The results show that probably due to the tacit collusion in the three bidder game, there are no trends shown on the graph, as shown by the results of the t-Test. There are no perceived trends in this game. This finding can be cross checked against Gregory (2006) results when they are re-analyzed using more up to date theory.

In considering the Herfindahl Index for the first three player games, the Index for the 3-bidder game is 3333, which is larger than the nominal limit set by the Justice Department at 1800 (van Vleet, 2004). So it is considered to be a concentrated market. The increase in market concentration means a decrease in the efficiency and competitiveness and the increase of chances of the tacit collusion. This may also explains why there are no periods in the results.

Game 2 Four Player Bid Process

Figure 14 shows the profit against the jobs for the four bidder game.

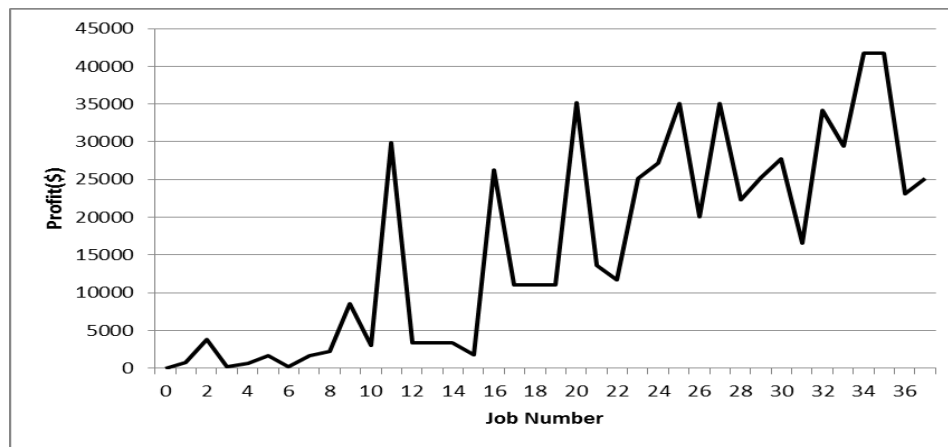


Figure 14. Profit to Different Jobs (4-bidders)

Table 13 shows the proposed trend periods to ascertain if Chouhan's theory applies at this four bidder game as it has at others, (Chouhan, 2009).

Table 13

Trend Period in Four Bidder Game

Description of the Trend Period	Job at Start of Period	Job at End of Period
Learning (1)	1	8
Discovering (2)	9	11
Competitive (3)	12	15
Profit Gain (4)	16	37

A Student's t Test analysis is typically used to determine if the trend period results are distinct. The results for the t Test are shown in Table 14.

Table 14

Student's t-Test Analysis of the Trend Periods (4-Bidders)

Period	1	2	3	4
1	-	-1.52	-2.69	-11.48
2	1.52	-	1.33	-1.40
3	-0.51	0.18	-	-10.80
4	11.48	1.40	10.80	-

From the 4-bidder game, it is statistically evident there are four trend periods. In the learning period, bidders tend to bid with low profits to get familiar with the game.

Then bidders try to increase the profit a little which is the discovering period. Being more familiar with the game, the competitive period came and resulted in the low profits again. But it is a short period, bidders figured out the strategy to this game, then the profit gain period started and most bidders began to gain profits. And the t-Test also shows the trend 1, 2 and 3 are quite competitive. In the 4-bidder game, the Herfindahl Index is 2500, which is still larger than 1800, so the tacit collusion may still exist, but it is much more competitive than the 3-bidder game.

Game 3 Ten Player Bid Process

Figure 15 shows the profit data for the ten bidder game.

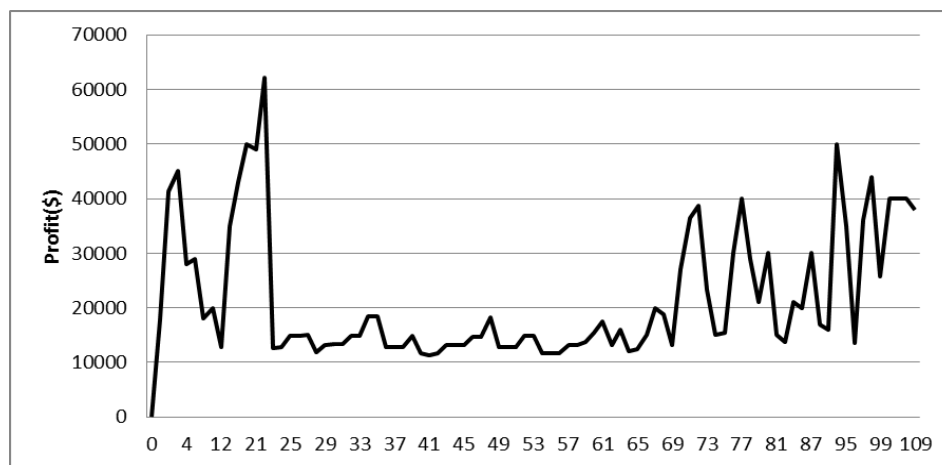


Figure 15. Profit to Different Jobs (10-bidders)

Table 15 shows the suggested trend periods for the ten player game.

Table 15

Trend Period in Ten Bidder Game

Description of the Trend Period	Job at Start of Period	Job at End of Period
Discovering (1)	1	22
Competitive (2)	23	69
Profit Gain (3)	70	109

Table 16 shows the ten bidder game's Student t Test results for the suggested game periods.

Table 16

Student's t-Test Analysis of the Trend Periods (10-Bidders)

Period	1	2	3
1	-	0.97	4.99
2	-0.97	-	7.26
3	-4.99	-7.26	-

The data in the graph shows that there are only three trends in the bidding process. The bidding process went directly into the discovering period. Besides, the competitive period is a little longer than the other two games. And the statistical analysis shows that

the competitive period is as competitive as the discovering period. The Herfindahl Index for the 10-bidder game is 1000, which means open competition. So it has the fiercest competition among all the three games.

Descriptive Statistics of The Bid Data

Game One Three Bidders

The comparison of the number of bids and the number of jobs per week for each test is shown in Table 17.

Table 17

No. of Jobs and Bids per Week (3-bidder)

Week	Jobs/Week	Bids/Week
1	7	16
2	7	11
3	8	10
4	5	17
5	6	11
6	4	11
7	6	6
Total	43	82

Game Two Four Bidders

The comparison of the number of bids and the number of jobs per week for each test is shown in Table 18.

Table 18

No. of Jobs and Bids per Week (4-bidder)

Week	Jobs/Week	Bids/Week
1	4	27
2	6	22
3	11	21
4	9	17
5	7	18
Total	37	105

Game Three Ten Bidders

The comparison of the number of bids and the number of jobs per week for each test is shown in Table 19.

Table 19

No. of Jobs and Bids per Week (10-bidder)

Week	Jobs/Week	Bids/Week
1	22	25
2	19	204
3	18	120
4	10	107
5	14	78
6	26	54
Total	109	588

Jobs Won By Bidders

Game One Three Bidder

In order to observe among different participants, Table 20 shows the number of bids and the number of jobs won by all the participants.

Table 20

Rank, No. of Bids and Jobs Won (3-bidder)

Rank	Participant	No. of Bids	Jobs Won
1	3	30	21
2	2	32	19
3	1	21	3

Game Two Four Bidder

Table 21 shows the number of bids and the number of jobs won by all the participants.

Table 21

Rank, No. of Bids and Jobs Won (4-bidder)

Rank	Participant	No. of Bids	Jobs Won
1	1	40	21
2	4	23	7
3	3	27	6
4	2	15	3

Game Three Ten Bidder

Table 22 shows the number of bids and the number of jobs won by participants.

Table 22

Rank, No. of Bids and Jobs Won (10-bidder)

Rank	Participant	No. of Bids	Jobs Won
1	1	65	16
2	7	15	8
3	9	108	9
4	4	58	11
5	3	57	15
6	8	74	4
7	6	70	4
8	2	72	4
9	10	22	7
10	5	47	10

Bank Loans

Introduction

The profits and the bank loan to each participant are shown in the tables below. In previous games, the bank loan rate has been a good indicator of performance.

Game One Three Bidder

Table 23 shows the data relevant to loans taken out by the bidders for this game.

Table 23

Rank, No. of Bids and Jobs Won (Three Bidder)

Rank	Participant	Bank Loan (\$)	Profit (\$)
1	3	5500	570583
2	2	8000	524440
3	1	4500	81258

Figure 16 shows the bank loan plotted against profit. Whilst the relationship is weaker than traditionally observed the results are consistent with previous findings.

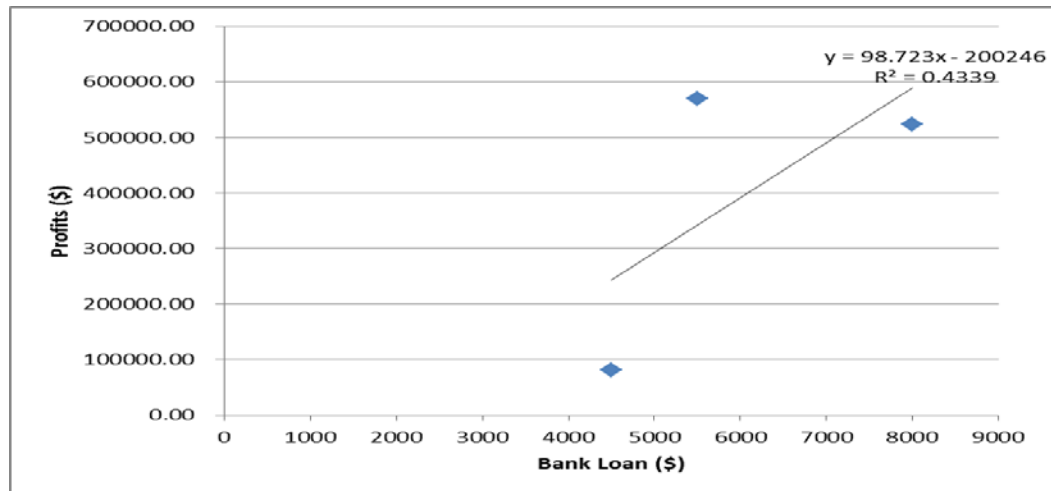


Figure 16. Relationship between Profits and Bank Loan (3-bidders)

Game Two Four Bidder

Table 24 shows the data relevant to loans taken out by the bidders for this game.

Table 24

Rank, No. of Bids and Jobs Won (Four Bidder)

Rank	Participant	Bank Loan (\$)	Profit (\$)
1	1	10500	265120
2	4	2500	137797
3	3	2000	129650
4	2	0	79598

Figure 17 shows the bank loan plotted against profit. The relationship shows the traditional strength.

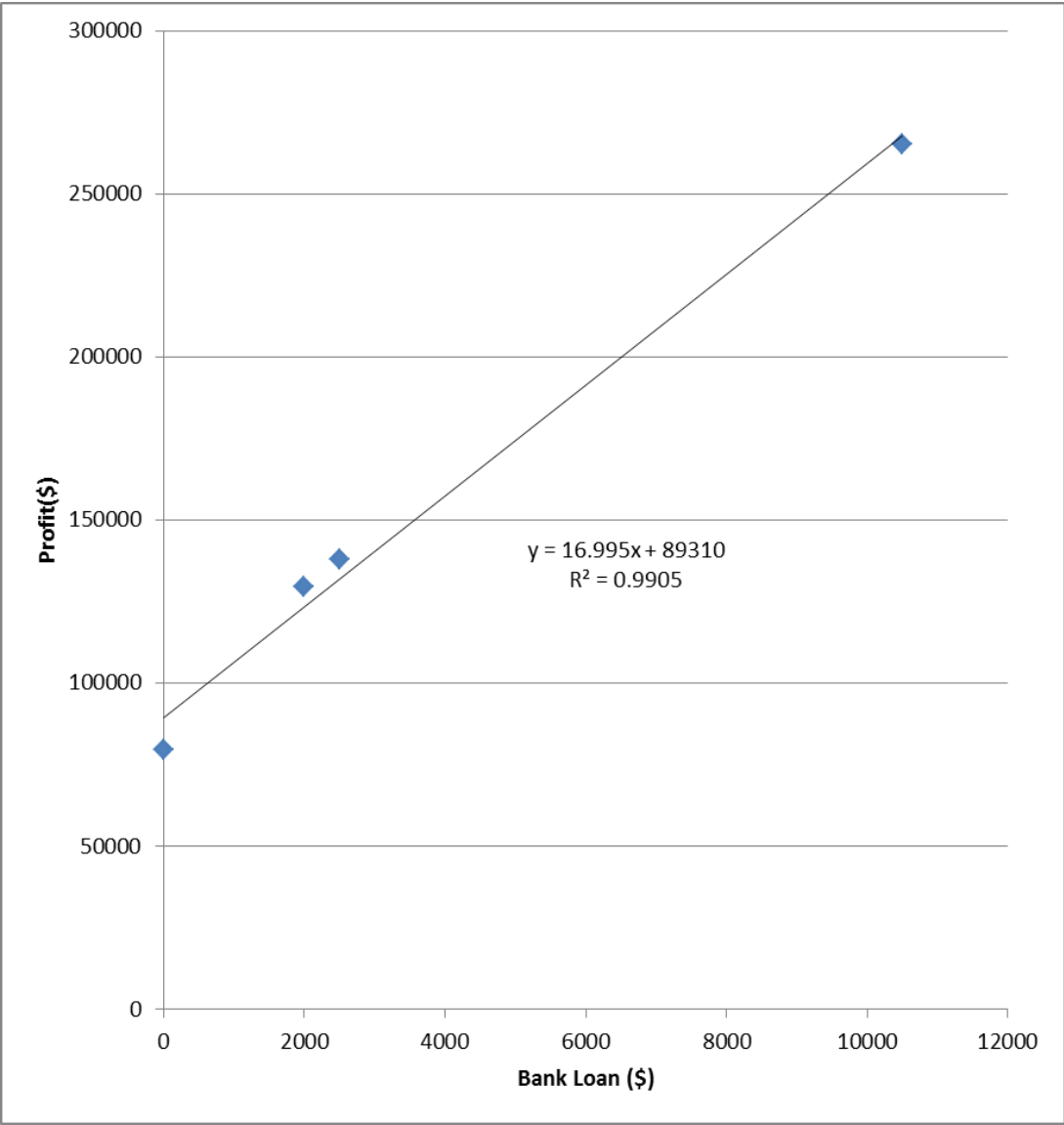


Figure 17. Relationship between Profits and Bank Loan (4-bidders)

Game Three Ten Bidder

Table 25 shows the data relevant to loans taken out by the bidders for this game.

Table 25

Rank, No. of Bids and Jobs Won (Ten Bidder)

Rank	Participant	Bank Loan (\$)	Profit (\$)
1	1	11000	232555
2	7	1000	124380
3	9	8500	84863
4	4	7500	81723
5	3	11500	77404
6	8	3500	62272
7	6	500	15108
8	2	10000	3675
9	10	2000	809
10	5	16000	498

Figure 18 shows the bank loan relationship. Clearly the results point to the known relationship between bank loans and performance. The three poor performers are noted for future research.

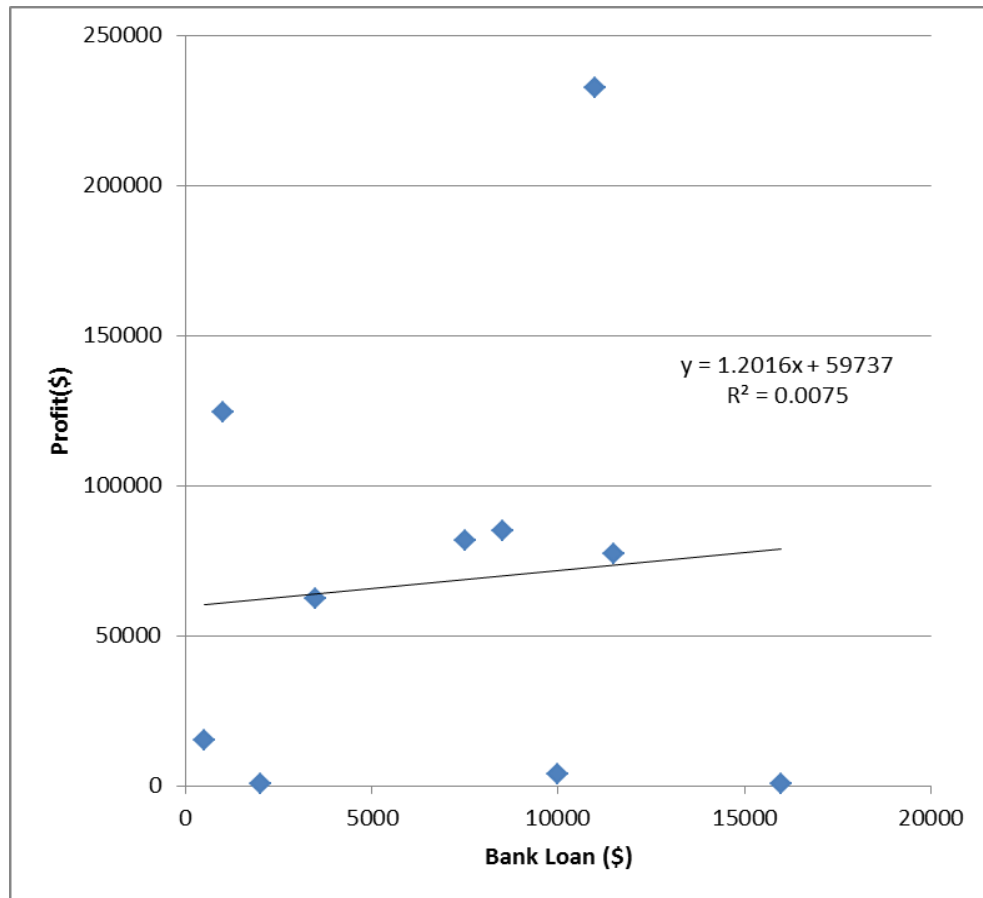


Figure 18. Relationship between Profits and Bank Loan (10-bidders)

Tables below show the bid efficiency for the three games. In the 3-bidder and the 4-bidder game, higher rank participants tend to have higher bid efficiency. But in the 10-bidder game, there is no relationship like this. So from the data it show in the Reverse Auction Bidding process, the bidders with higher bid efficiency can gain more profits among a small number of bidders, while the bid efficiency is not related to the profits in a large number of bidders.

Bid Efficiency

Table 26 , Table 27 and Table 28 show the bid efficiency of the players in each game. The results are consistent with previous findings

Table 26

3-bidder Bid Efficiency

Rank	Participant	No. of Bids	Jobs Won	Bid Efficiency (%)
1	3	30	21	70
2	2	32	19	59.38
3	1	21	3	14.29

Table 27

4-bidder Bid Efficiency

Rank	Participant	No. of Bids	Jobs Won	Bid Efficiency (%)
1	1	40	21	52.50
2	4	23	7	30.43
3	3	27	6	22.22
4	2	15	3	20.00

Table 28

10-bidder Bid Efficiency

Rank	Participant	No. of Bids	Jobs Won	Bid Efficiency (%)
1	1	65	16	24.62
2	7	15	8	53.33
3	9	108	9	8.33
4	4	58	11	18.97
5	3	57	15	26.32
6	8	74	4	5.41
7	6	70	4	5.71
8	2	72	4	5.56
9	10	22	7	31.82
10	5	47	10	21.28

Descriptive Statistics of The Won Job Data

Table 30 and Table 31 show another important aspect for the bidders – the profit efficiency. There is no big difference among the bidders in the 3-bidder game. In the 4-bidder game, the participants with highest profits tend to have lowest profit efficiency, which means they bid a lot of jobs with low profits. In the 10-bidder game, there is a trend that the bidders with the higher profits also have the higher profit efficiency, though bidder 6 is an exception. Bidder 6 bid all the four jobs with a very high profit, which brings the highest profit efficiency among all the bidders, and the personality type is “Promoter”.

Table 29

3-bidder Profit Efficiency

Rank	Participant	No. of Bids	Jobs Won	Profit Efficiency (\$)
1	3	30	21	27086.00
2	2	32	19	27602.11
3	1	21	3	27170.62

Table 30

4 -bidder Profit Efficiency

Rank	Participant	No. of Bids	Jobs Won	Profit Efficiency (\$)
1	1	40	21	12624.76
2	4	23	7	19685.29
3	3	27	6	21608.33
4	2	15	3	26532.67

Table 31

10-bidder Profit Efficiency

Rank	Participant	No. of Bids	Jobs Won	Profit Efficiency (\$)
1	1	65	16	14534.69
2	7	15	8	15547.50
3	9	108	9	9429.22
4	4	58	11	7429.36
5	3	57	15	5160.27
6	8	74	4	15568.00
7	6	70	4	3777.00
8	2	72	4	918.75
9	10	22	7	115.57
10	5	47	10	49.80

Figure 19, Figure 20 and Figure 21 shows the percentage of jobs won in descending rank order. The results are consistent with earlier findings on this area of the game.

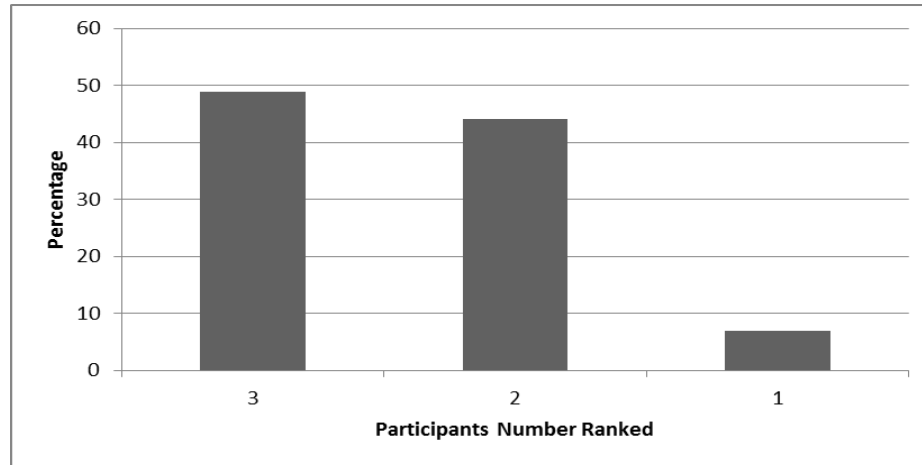


Figure 19. 3-bidder Participants Jobs Won Ranking

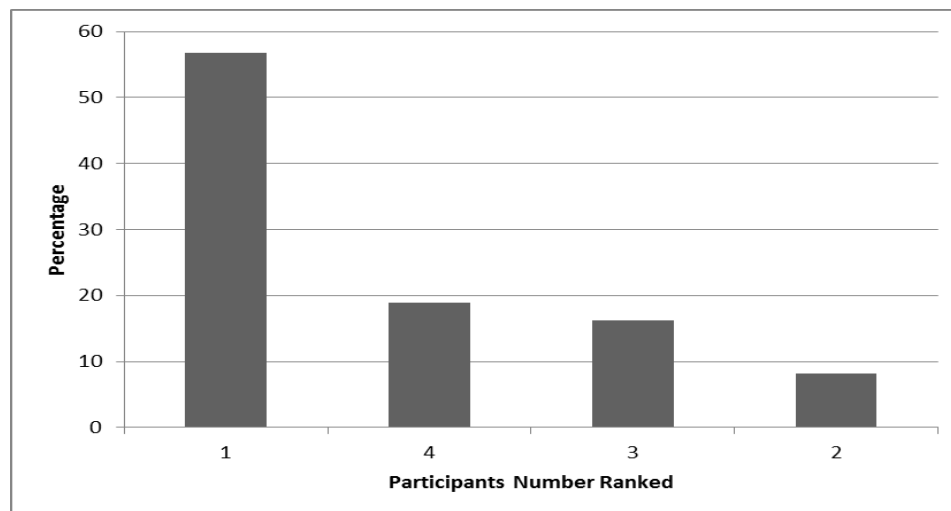


Figure 20. 4-bidder Participants Jobs Won Ranking

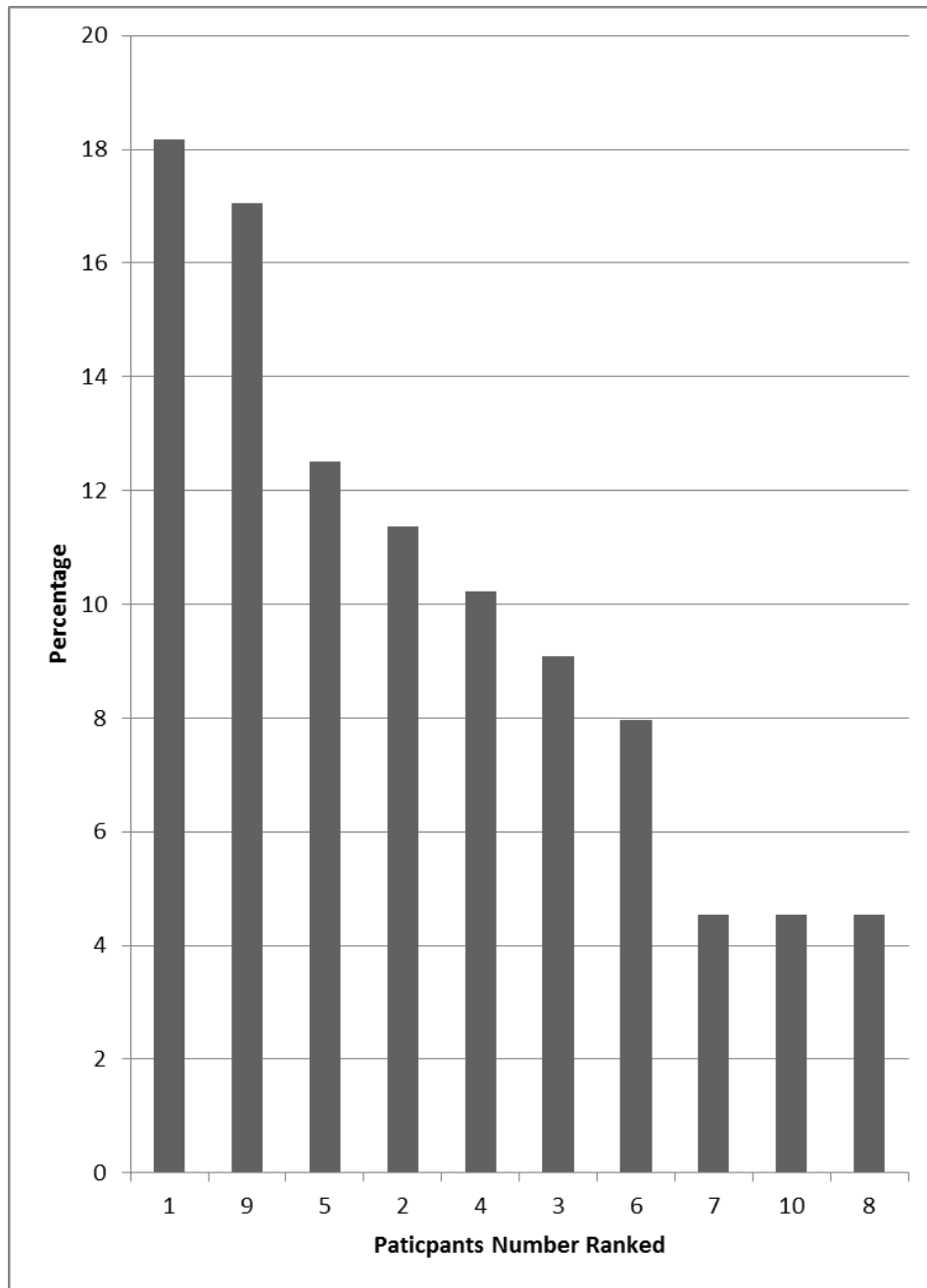


Figure 21. 10-bidder Participants Jobs Won Ranking

Figure 22 shows the first participants histogram of profits for the jobs won.

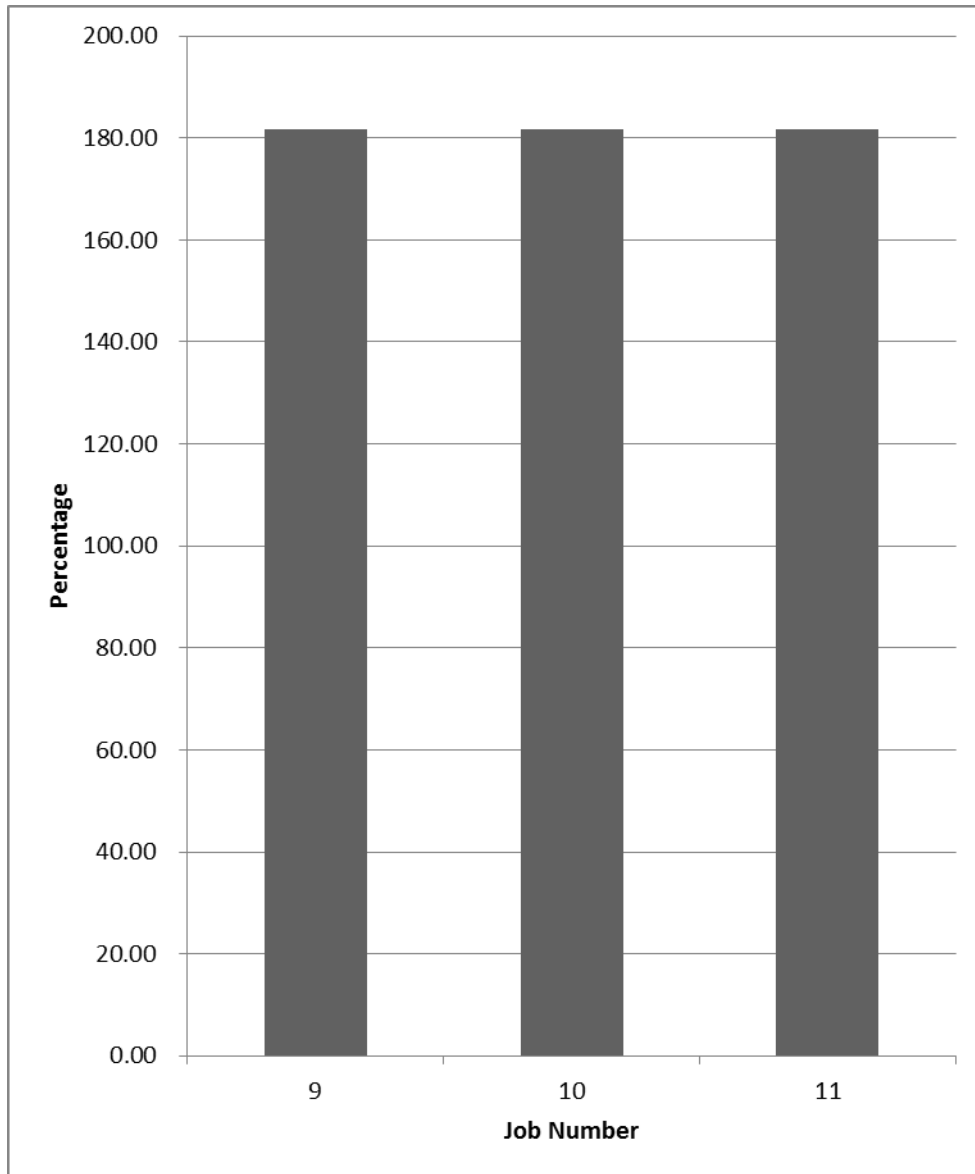


Figure 22. Participant One Histogram of Profit Percentage for Jobs (3-bidder)

Figure 23 and Figure 24 show the other two participants histogram of profits for the jobs won. The relative efficiency of these last two players is evident.

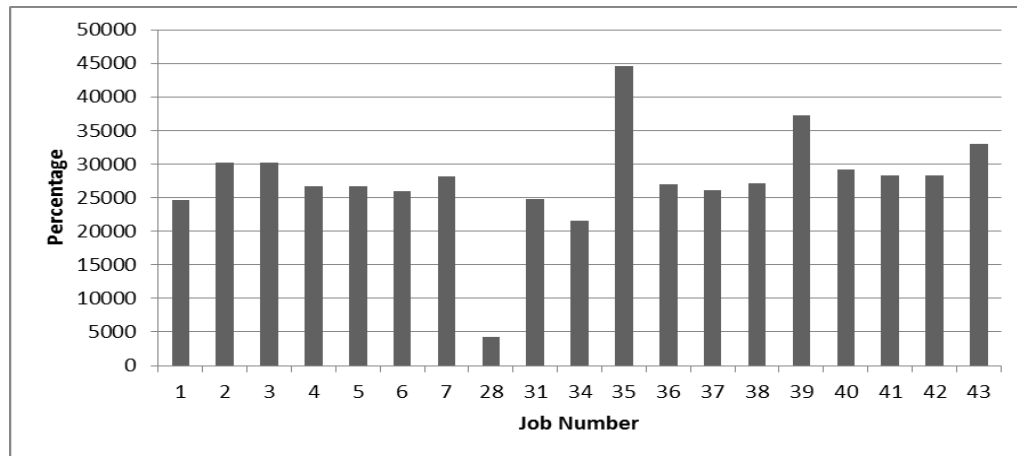


Figure 23. Participant Two Histogram of Profit Percentage for Jobs (3-bidder)

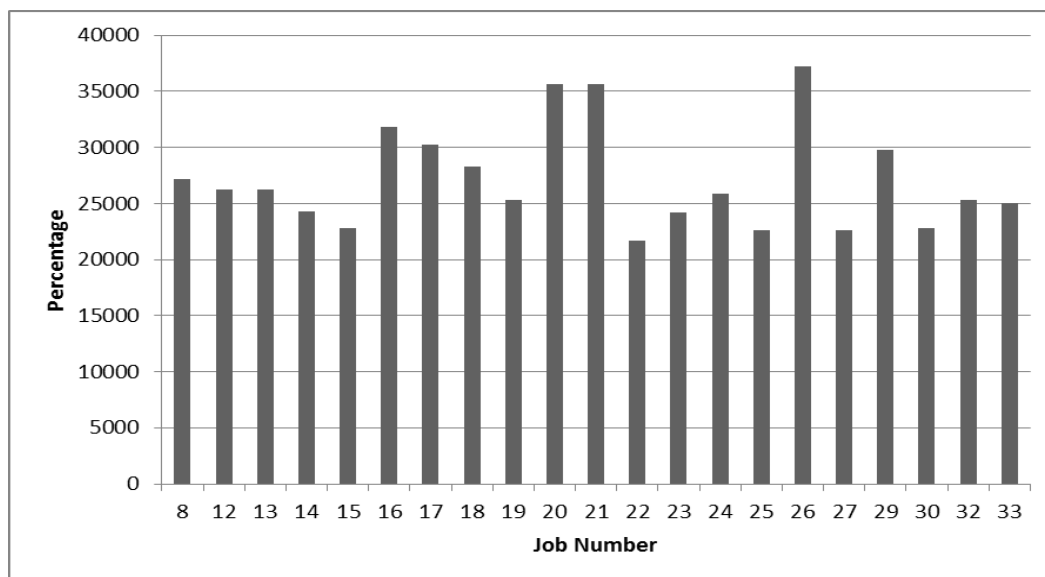


Figure 24. Participant Three Histogram of Profit Percentage for Jobs (3-bidder)

Figure 25 and Figure 26 show the first two participants profit percentage.

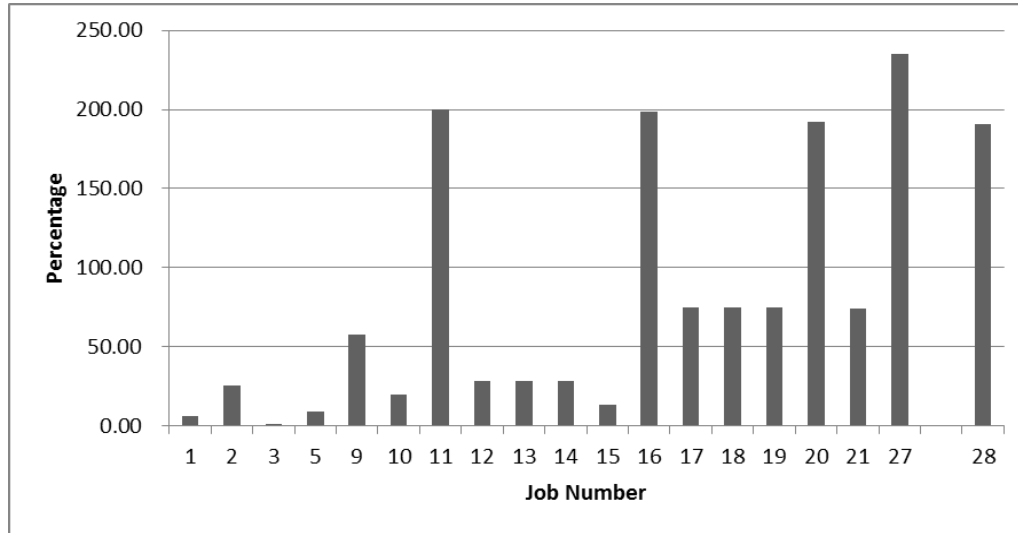


Figure 25. Participant One Histogram of Profit Percentage for Jobs (4-bidder)

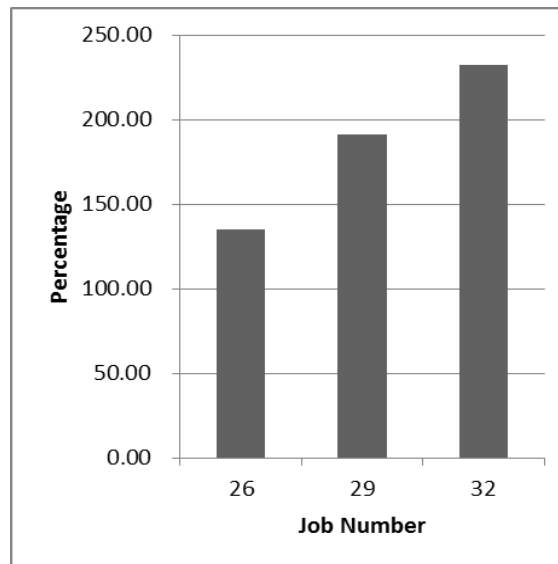


Figure 26. Participant Two Histogram of Profit Percentage for Jobs (4-bidder)

Figure 27 and Figure 28 show the next two.

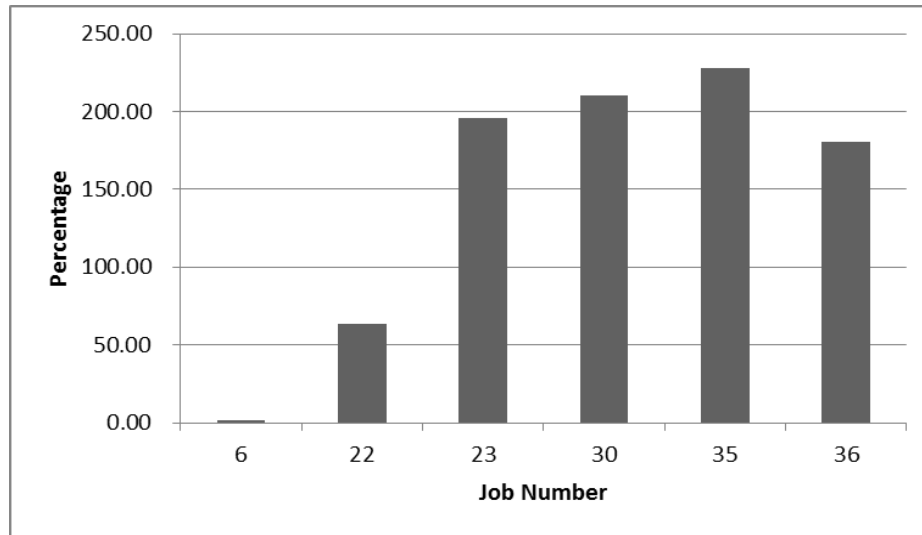


Figure 27. Participant Three Histogram of Profit Percentage for Jobs (4-bidder)

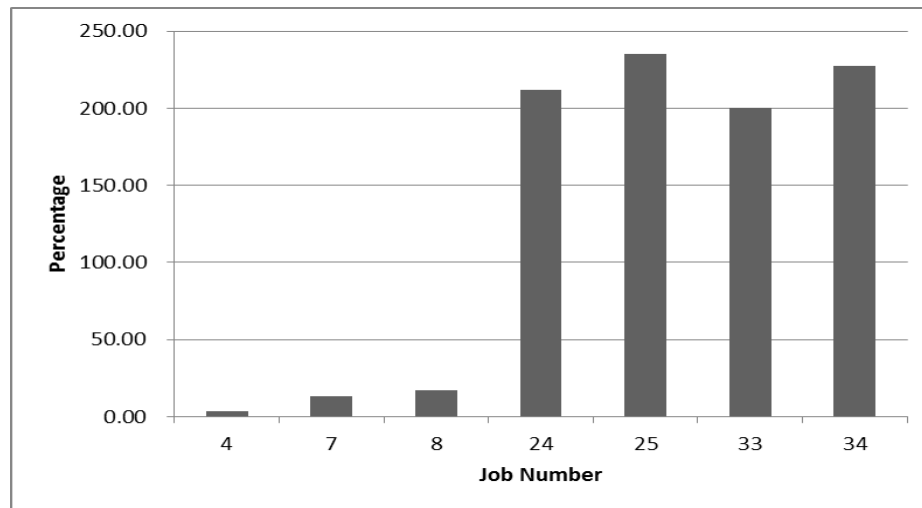


Figure 28. Participant Four Histogram of Profit Percentage for Jobs (4-bidder)

Figure 29 through to Figure 38 show the results for the ten bidder game.

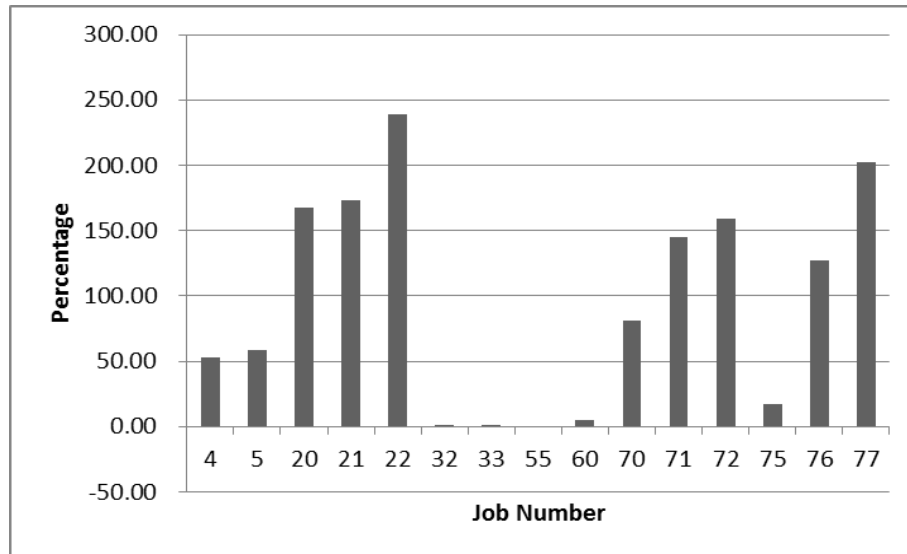


Figure 29. Participant One Histogram of Profit Percentage for Jobs (10-bidder)

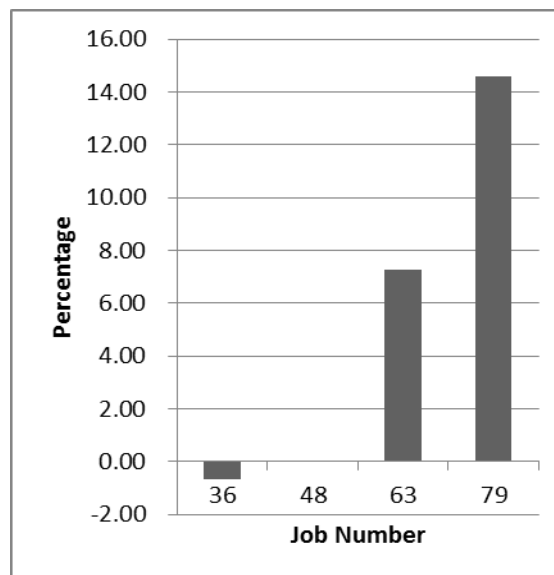


Figure 30. Participant Two Histogram of Profit Percentage for Jobs (10-bidder)

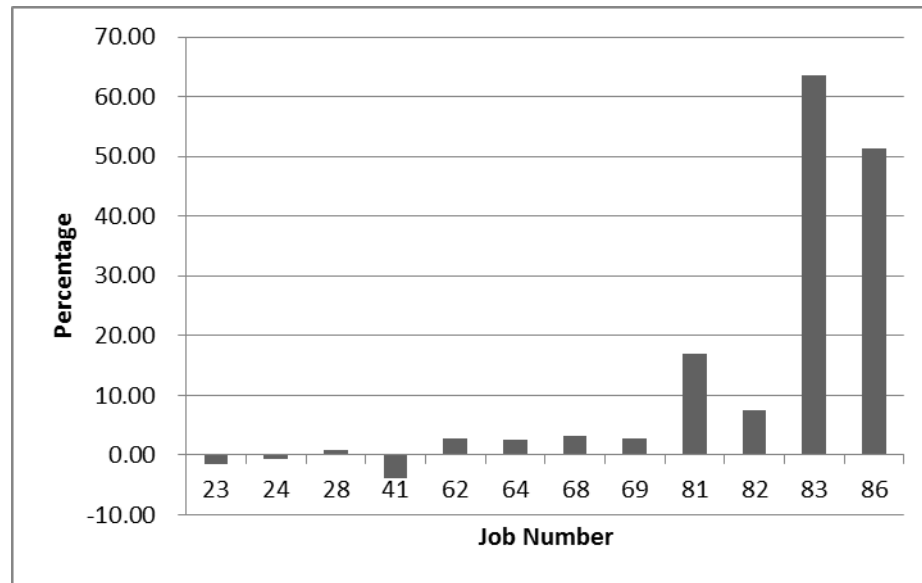


Figure 31. Participant Three Histogram of Profit Percentage for Jobs (10-bidder)

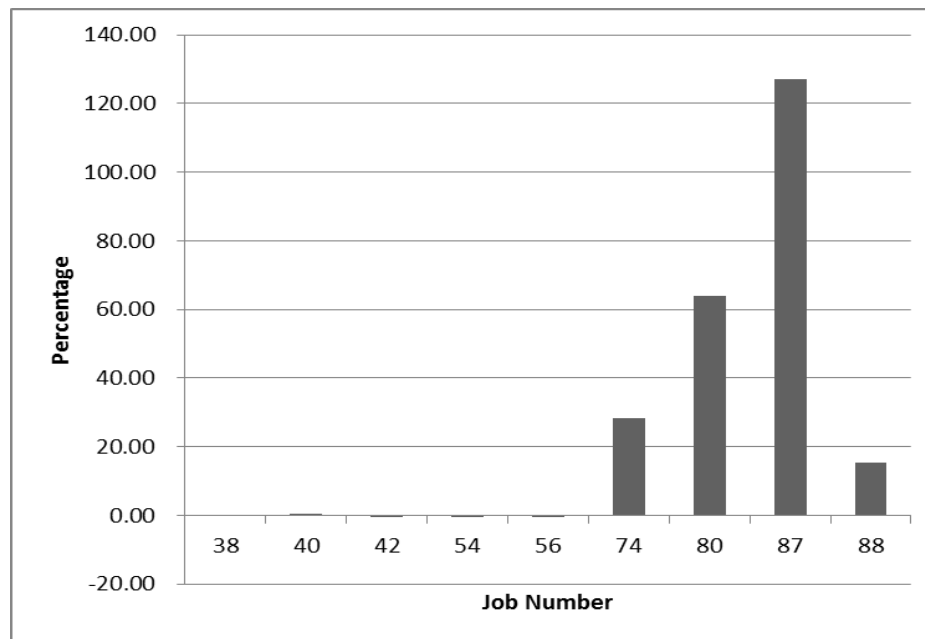


Figure 32. Participant Four Histogram of Profit Percentage for Jobs (10-bidder)

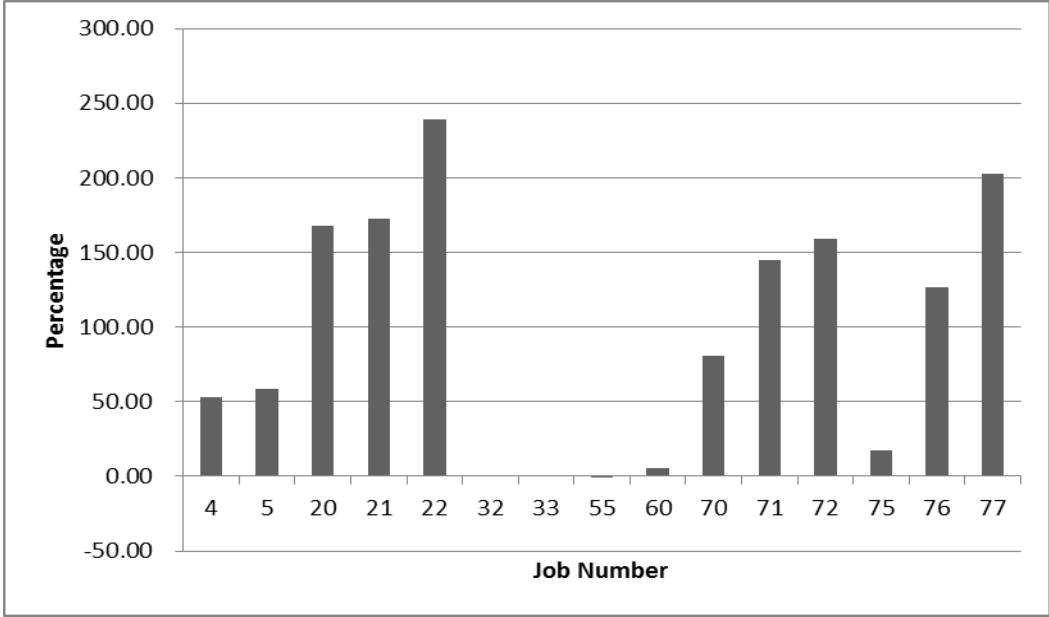


Figure 33. Participant Five Histogram of Profit Percentage for Jobs (10-bidder)

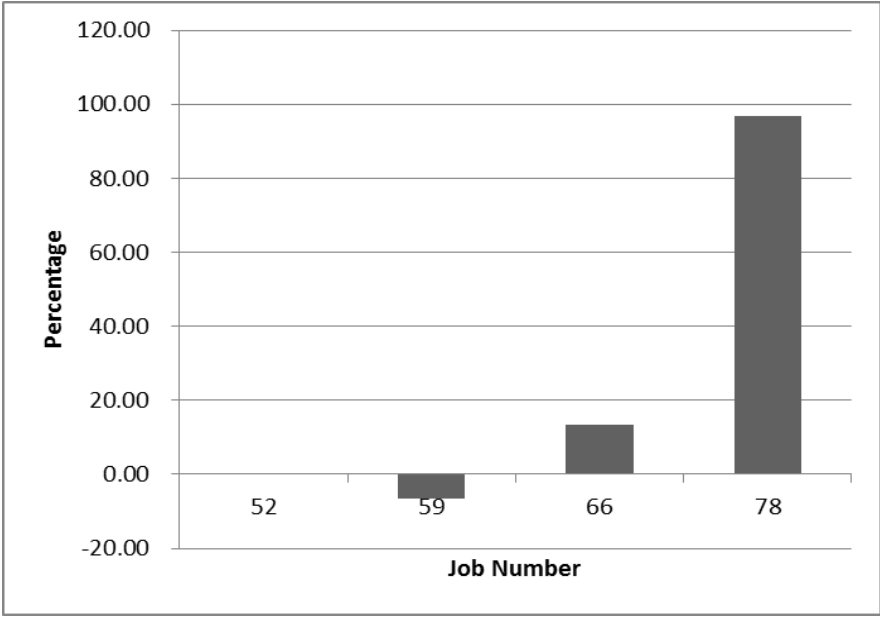


Figure 34. Participant Six Histogram of Profit Percentage for Jobs (10-bidder)

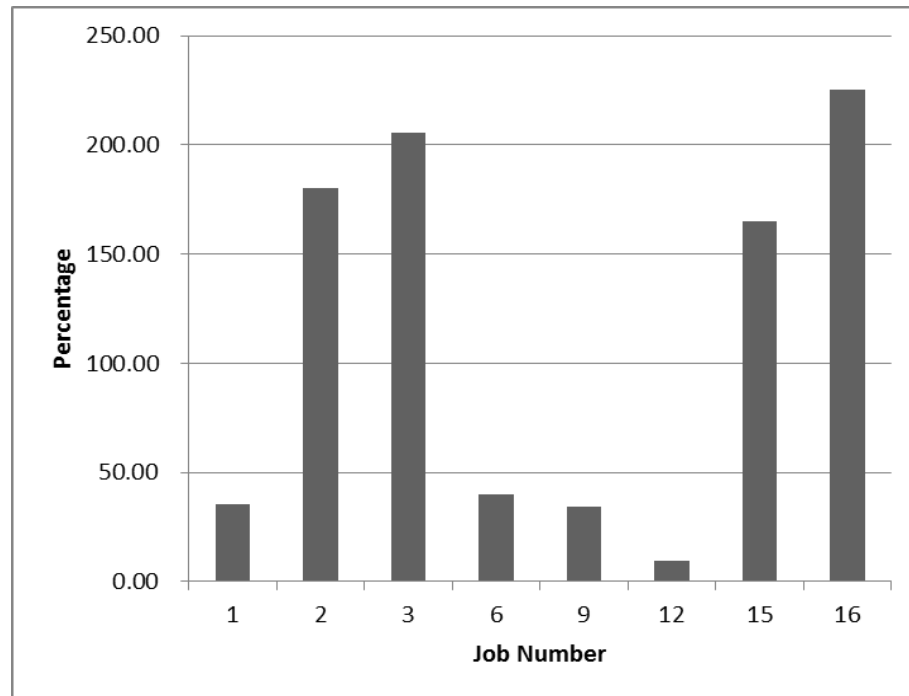


Figure 35. Participant Seven Histogram of Profit Percentage for Jobs (10-bidder)

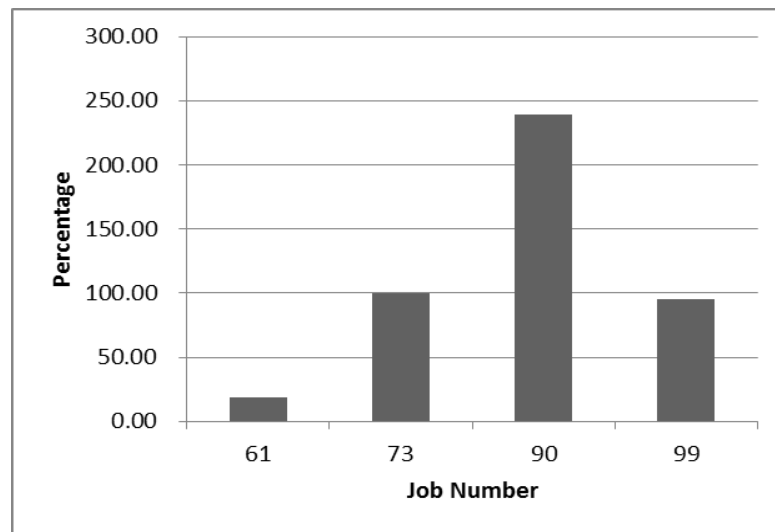


Figure 36. Participant Eight Histogram of Profit Percentage for Jobs (10-bidder)

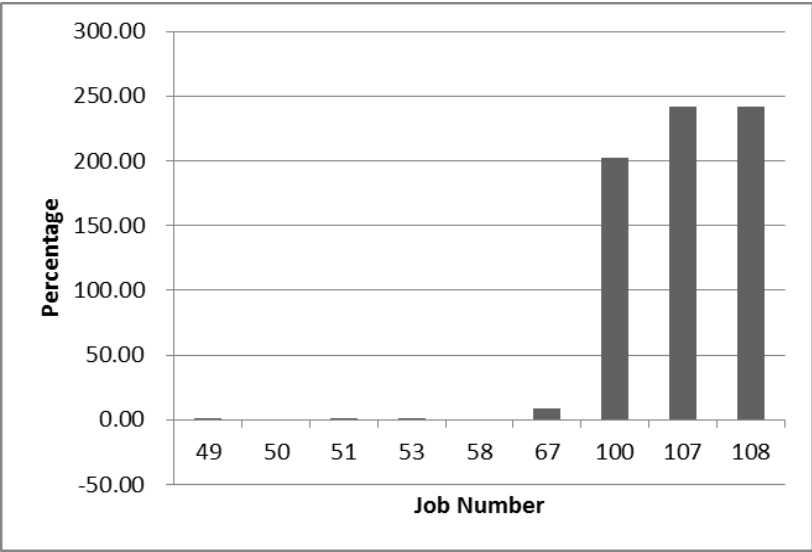


Figure 37. Participant Nine Histogram of Profit Percentage for Jobs (10-bidder)

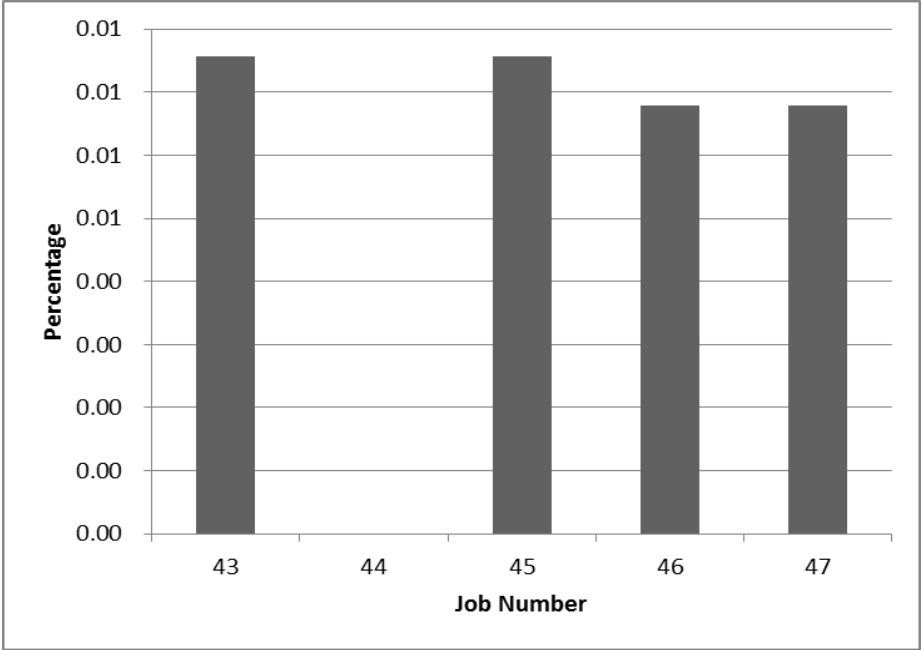


Figure 38. Participant Ten Histogram of Profit Percentage for Jobs (10-bidder)

The following Figure 39 to Figure 44 shows the bidding frequency of the best performer in each test and the bidding frequency of all the participants in each game.

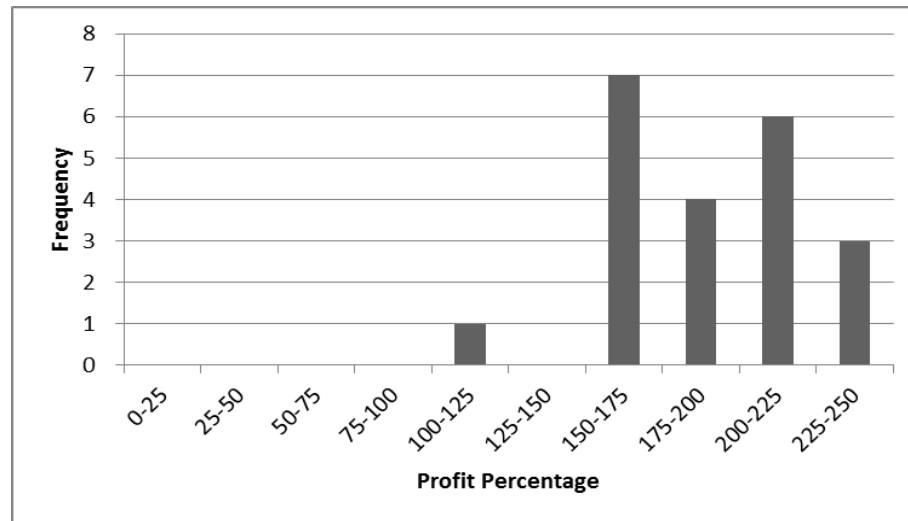


Figure 39. Histogram of Best Performer Profit Percentages (3-bidder)

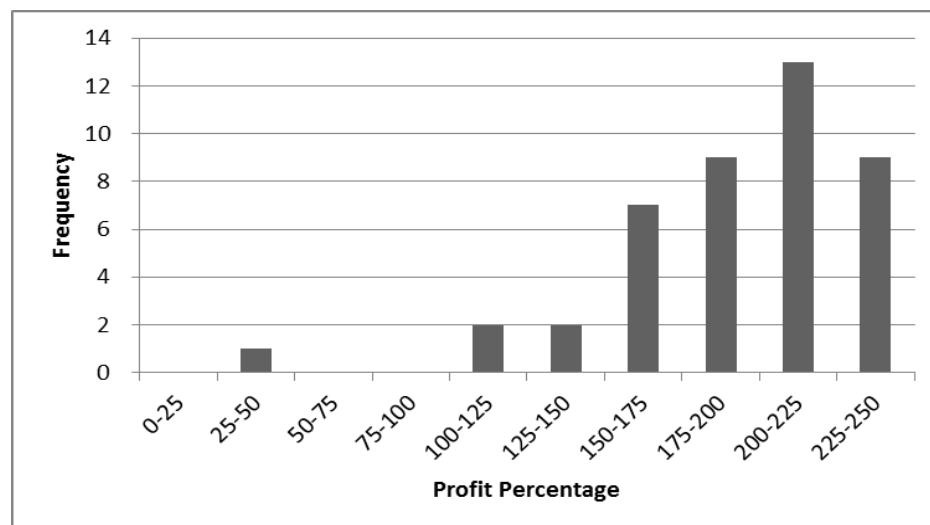


Figure 40. Histogram of All Participants Profit Percentages (3-bidder)

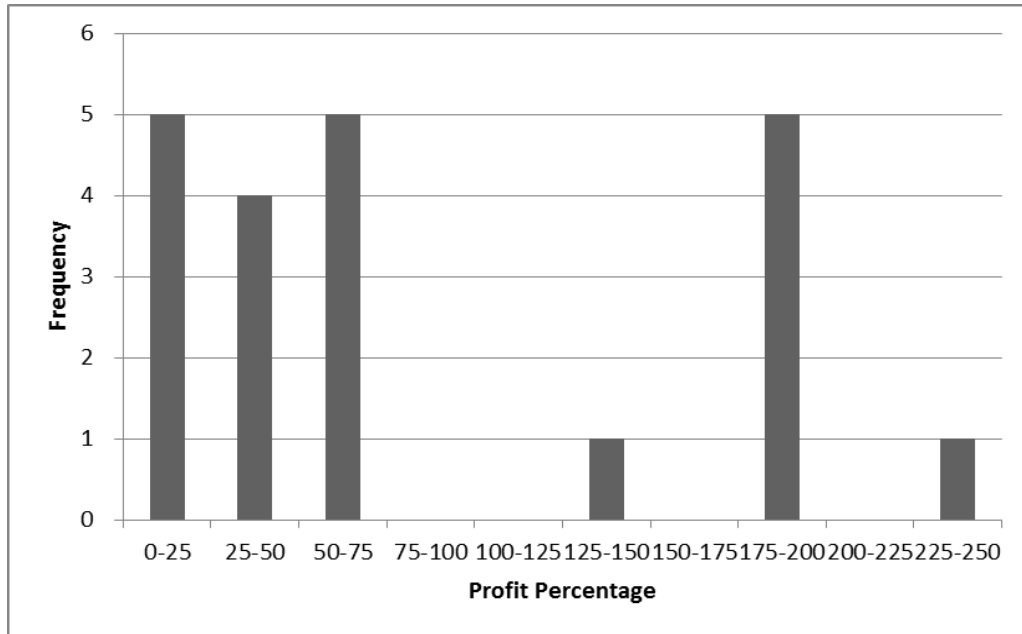


Figure 41. Histogram of Best Performer Profit Percentages (4-bidder)

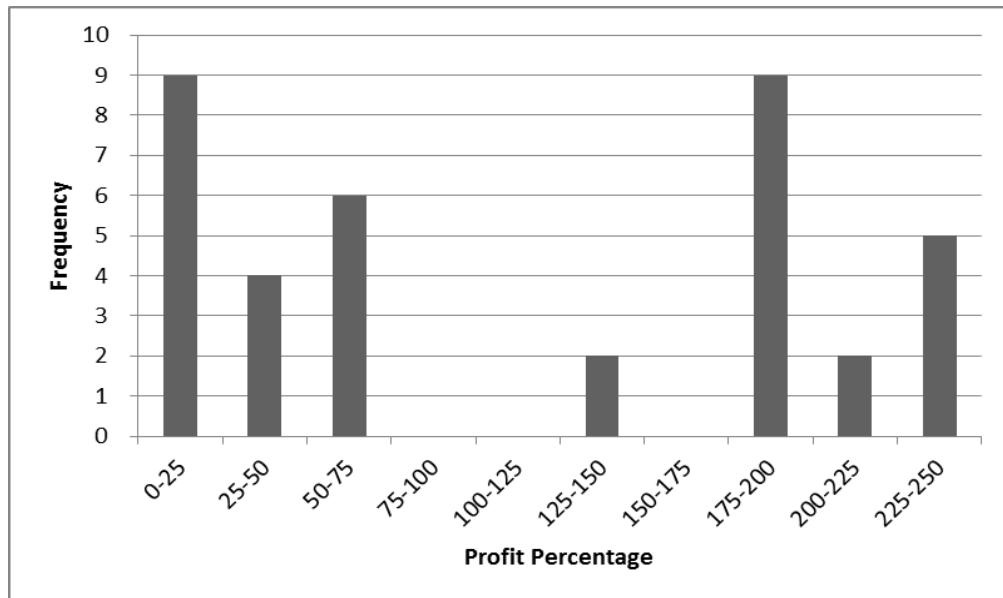


Figure 42. Histogram of All Participants Profit Percentages (4-bidder)

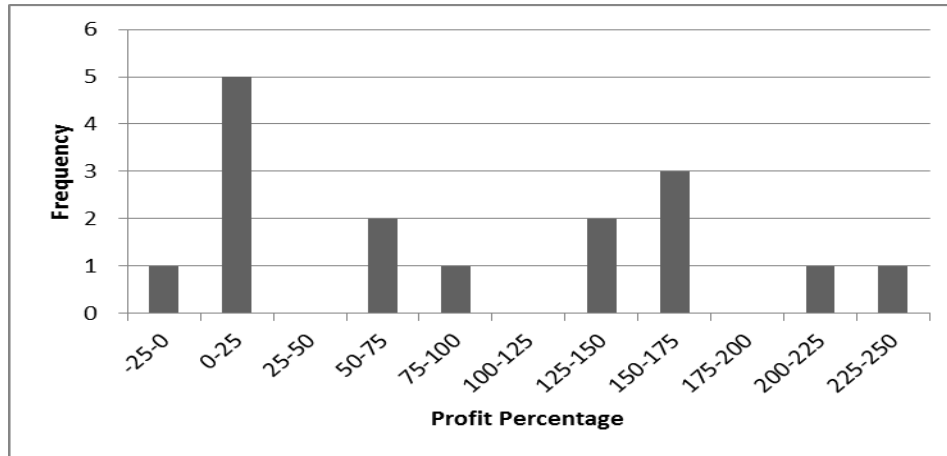


Figure 43. Histogram of Best Performer Profit Percentages (10-bidder)

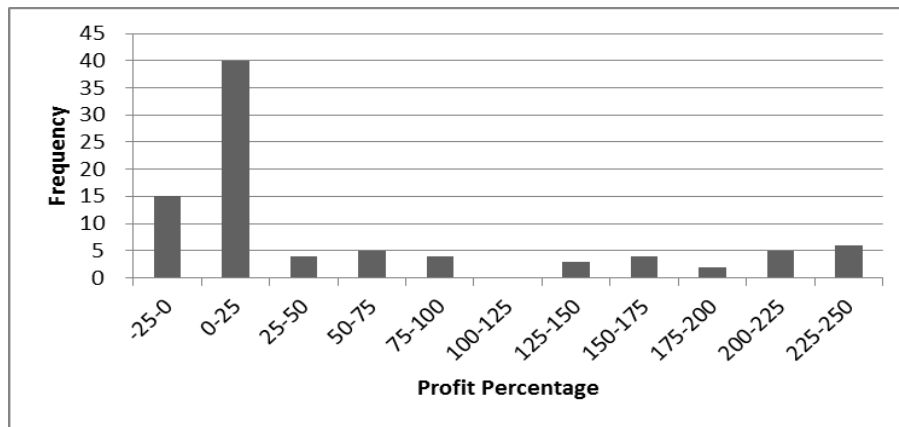


Figure 44. Histogram of All Participants Profit Percentages (10-bidder)

Bid Period Comparison

Table 32 through to Table 51 show the bidding pattern for each participant and all the participants in the three games.

Table 32

Bids Made in 15-minute Time Intervals - Participant 1 (3-bidder)

Time (mins)	Bid Periods					
	17:50- 18:05	18:10- 18:25	18:30- 18:45	18:50- 19:05	19:10- 19:25	19:30- 19:45
1			2	1	3	2
2			1	2		1
3						
4		1				
5		1				
6	1					
7	1					
8	2					
9	1					
10					10	
11						
12						
13						
14						
15						

Table 33

Bids Made in 15-minute Time Intervals - Participant 2 (3-bidder)

Time (mins)	Bid Periods					
	17:50- 18:05	18:10- 18:25	18:30- 18:45	18:50- 19:05	19:10- 19:25	19:30- 19:45
1	1					2
2			3	3		1
3	2					
4		3				1
5					3	
6		1				
7	2					
8				3		
9						
10	2					
11						
12						
13						
14		1				
15						1

Table 34

Bids Made in 15-minute Time Intervals - Participant 3 (3-bidder)

Time (mins)	Bid Periods					
	17:50- 18:05	18:10- 18:25	18:30- 18:45	18:50- 19:05	19:10- 19:25	19:30- 19:45
1						1
2			1	2	1	
3				1		1
4		1				
5		2				
6						
7			2			
8	1	1				
9	2				1	
10	1					
11						
12						
13						
14						
15		1	1	5	1	1

Table 35

Bids Made in 15-minute Time Intervals – All Participants (3-bidder)

Time (mins)	Bid Periods					
	17:50- 18:05	18:10- 18:25	18:30- 18:45	18:50- 19:05	19:10- 19:25	19:30- 19:45
1	1		2	1	3	5
2	0		5	7	1	2
3	2			1	0	1
4	0	5		0	0	1
5	0	3		0	3	
6	1	1		0		
7	3		2	0		
8	3	1		3		
9	3			0	1	
10	3			0	2	
11	0			0	0	
12	0			0	0	
13	0			0		
14	0	1		0		
15	0	1	1	5	1	2

Table 36

Bids Made in 15-minute Time Intervals - Participant 1 (4-bidder)

Time (mins)	Bid Periods				
	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35	19:40- 19:55
1	1	1			
2	1	3		3	
3	1	2		3	
4		1	4		4
5					
6					
7	2		2		
8	1		2		
9					
10					
11					
12	3				
13					
14					
15	1	1	1	2	2

Table 37

Bids Made in 15-minute Time Intervals - Participant 2 (4-bidder)

Time (mins)	Bid Periods				
	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35	19:40- 19:55
1		1			
2	1				
3	1		2		1
4					
5	1				
6					
7					
8					
9				1	
10					
11					
12					
13					
14					
15	1	2		2	2

Table 38

Bids Made in 15-minute Time Intervals - Participant 3 (4-bidder)

Time (mins)	Bid Periods				
	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35	19:40- 19:55
1		2		1	
2			2	1	
3	2	1		1	2
4					
5	1				
6					
7					
8					
9		1			
10					
11					
12					
13					
14					
15	1	1	2	3	5

Table 39

Bids Made in 15-minute Time Intervals - Participant 4 (4-bidder)

Time (mins)	Bid Periods				
	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35	19:40- 19:55
1		1		3	2
2			3		
3	1				
4	1	1			
5	1				
6	1				
7					
8					
9	1				
10					
11					
12		2			
13					
14					
15	1	1	2		

Table 40

Bids Made in 15-minute Time Intervals – All Participants (4-bidder)

Time (mins)	Bid Periods				
	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35	19:40- 19:55
1	1	5	0	4	2
2	2	3	5	4	0
3	5	3	2	1	3
4	1	2	4	0	4
5	3	0	0	0	0
6	1	0	0	0	0
7	2	0	2	0	0
8	1	0	2	0	0
9	1	1	0	1	0
10	0	0	0	0	0
11	1	0	0	0	0
12	3	2	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	3	5	5	7	9

Table 41

Bids Made in 15-minute Time Intervals - Participant 1 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1						
2		1	1			
3		3	3			
4		2	2			
5		2	2	2		
6		3	1	1		
7		3	1	1		
8		3	2	1		
9		3	2			
10	1	2				
11	2	4				
12		2				
13		1				2
14		5			2	
15		4			1	

Table 42

Bids Made in 15-minute Time Intervals - Participant 2 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1		1		1		
2		1		1		
3		1	2	1		
4		3	2	1		
5		1	1	2		3
6		1	1	2		1
7		2	1	3		
8		1	2	1		
9	1		1	3		
10		2	2	1		
11				1		
12	1	1		3		
13				5	2	
14	1	1		1	1	
15	1	1		4	3	1

Table 43

Bids Made in 15-minute Time Intervals - Participant 3 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1						
2						
3		1				
4		1	1		2	
5			1			
6		1	2		1	
7			2	4		
8			2	1		
9						
10			1			
11		1				
12		1				1
13			2	2	2	2
14		5		1	2	4
15		5		1	3	5

Table 44

Bids Made in 15-minute Time Intervals - Participant 4 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1						
2		1				
3		1				
4		2				
5		1				
6		1		1		
7		1	1	1		
8			1	2		
9		1	1			
10		1	2			
11				2		
12			1	2	3	3
13		1		2	1	3
14		2	2	3	1	2
15		2	2	1	2	4

Table 45

Bids Made in 15-minute Time Intervals - Participant 5 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1			1			
2		3	6			
3		2	3			
4		1	1			
5						
6		2				
7		2				
8						
9		1				
10		2				
11		6				
12		5				
13		6				
14		4				
15		4				

Table 46

Bids Made in 15-minute Time Intervals - Participant 6 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1						1
2		2				
3		4	3		3	
4				2		1
5			2			
6			2	1	1	
7			1			
8		2	2	2		
9		1	3			
10		2	3			
11	1	1	1	1		
12	1	1				
13		2		1	1	
14	1	2	3	2	3	
15		2	2	3	3	

Table 47

Bids Made in 15-minute Time Intervals - Participant 7 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1		2				
2		1				
3					1	
4					1	
5						
6		1				
7		1				
8						
9				1		
10						
11						
12		1				
13	1		1			
14						
15			1	2	2	1

Table 48

Bids Made in 15-minute Time Intervals - Participant 8 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1			1			
2			2			
3		1	2			
4		2				
5		1				
6				2		
7				2	1	
8		3				
9		3				
10		2				1
11		1	2	2		1
12		3	1	3		1
13		3	2	2	3	
14	1	5	1	1	1	
15	2	6	2	4	2	2

Table 49

Bids Made in 15-minute Time Intervals - Participant 9 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1				1	1	
2				1	2	
3		3	3		2	
4				1		1
5		4	1			
6		1	3	2		
7		1	3	2		
8		1	3	2		
9	2	1	3			
10	1	1				
11	1	6				
12						
13	1	2			4	
14		4			6	4
15	1	2	5	5	10	6

Table 50

Bids Made in 15-minute Time Intervals - Participant 10 (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13					1	
14	2			2		1
15	3	2	3	1	3	3

Table 51

Bids Made in 15-minute Time Intervals – All Participants (10-bidder)

Time (mins)	Bid Periods					
	17:40- 17:55	18:00- 18:15	18:20- 18:35	18:40- 18:55	19:00- 19:15	19:20- 19:35
1	0	3	2	2	1	1
2	0	12	9	2	2	0
3	0	13	16	4	6	0
4	0	11	6	4	3	2
5	0	9	7	9	0	3
6	0	10	9	13	2	1
7	0	10	9	9	1	0
8	0	10	12	4	0	0
9	3	10	10	1	0	0
10	2	12	8	1	0	1
11	4	19	3	6	0	1
12	2	14	2	8	3	5
13	2	15	5	12	14	7
14	5	28	6	10	16	11
15	7	28	15	21	29	22

Figure 45 through to Figure 48 show the bidding data of the participant 1-3 individually and all participants together in the 3-bidder game. Participant 3 performed best in the game, and from the data it proves that the last minute bidding strategy is a way to success.

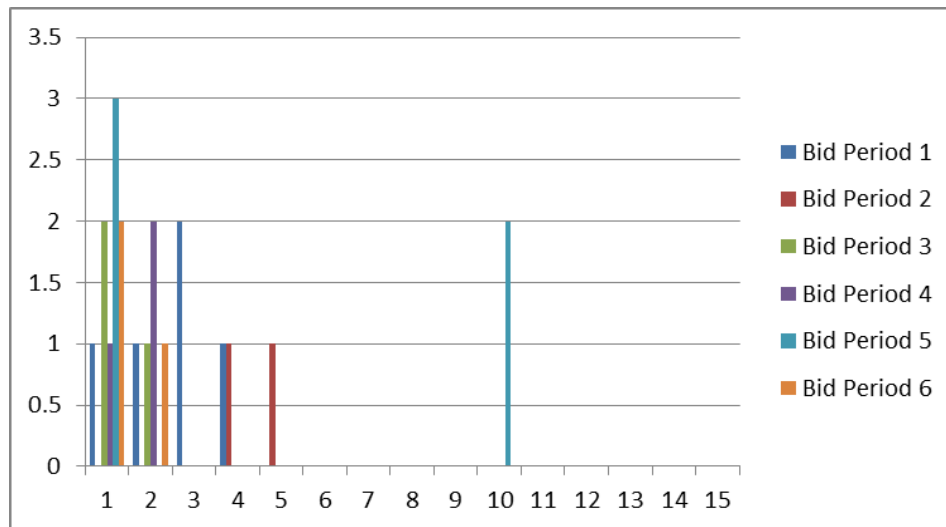


Figure 45. Participant 1: Bid Distribution per Minute (3-bidder)

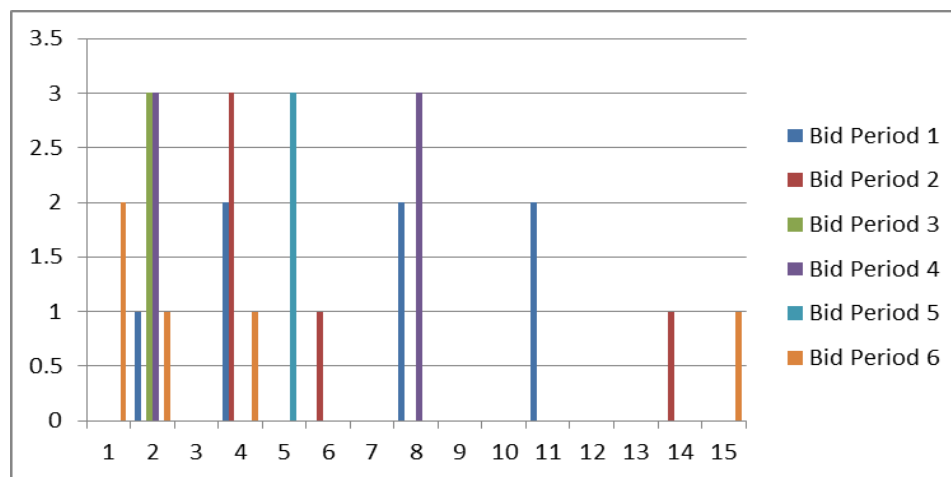


Figure 46. Participant 2: Bid Distribution per Minute (3-bidder)

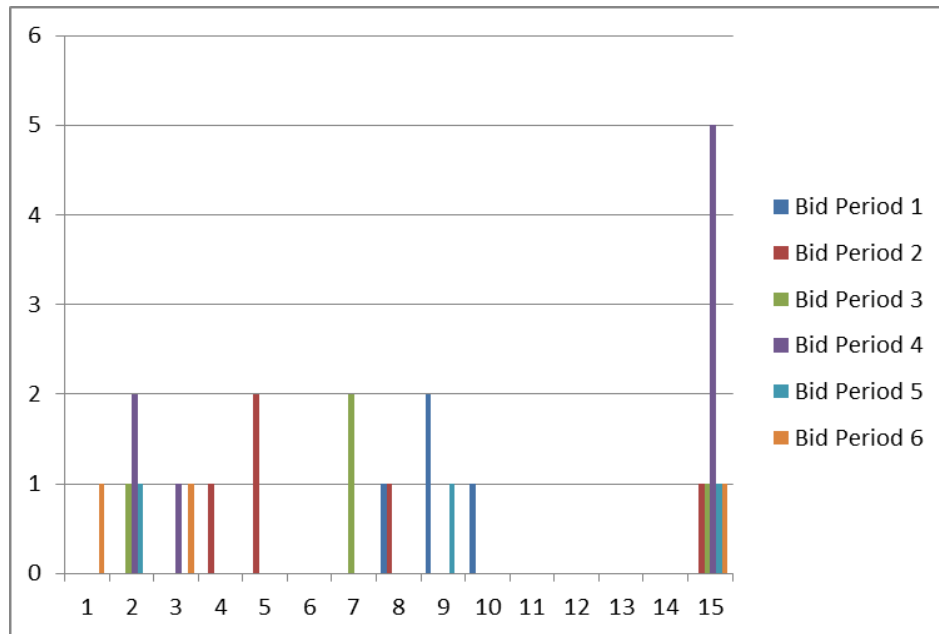


Figure 47. Participant 3: Bid Distribution per Minute (3-bidder)

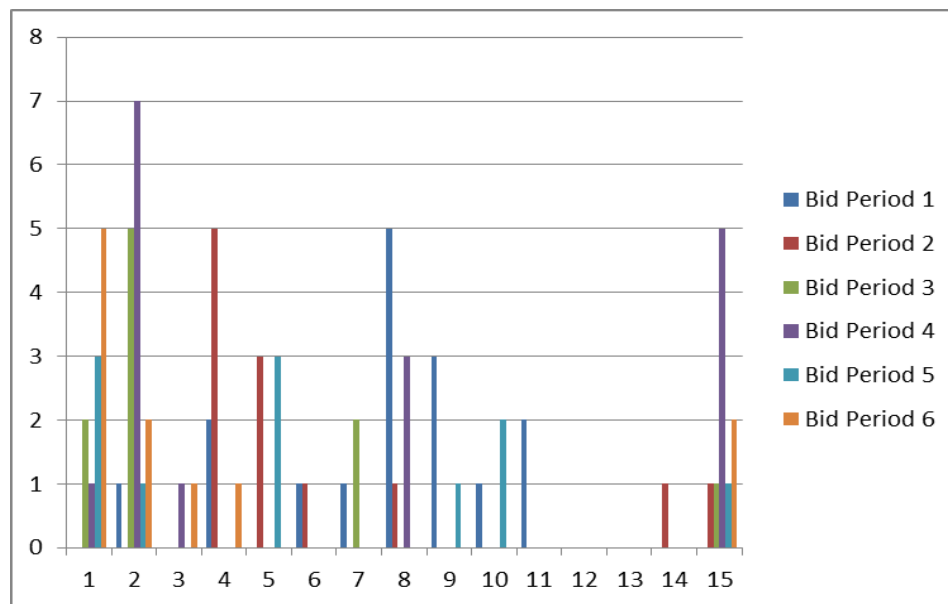


Figure 48. All Participants: Bid Distribution per Minute (3-bidder)

Figure 49 through Figure 53 shows the bidding data of the participant 1-4 individually and all participants together in the 4-bidder game. From the figure, all the participants use the last minute strategy. Participant 1 ranks first among all the bidders. And he bids the most jobs.

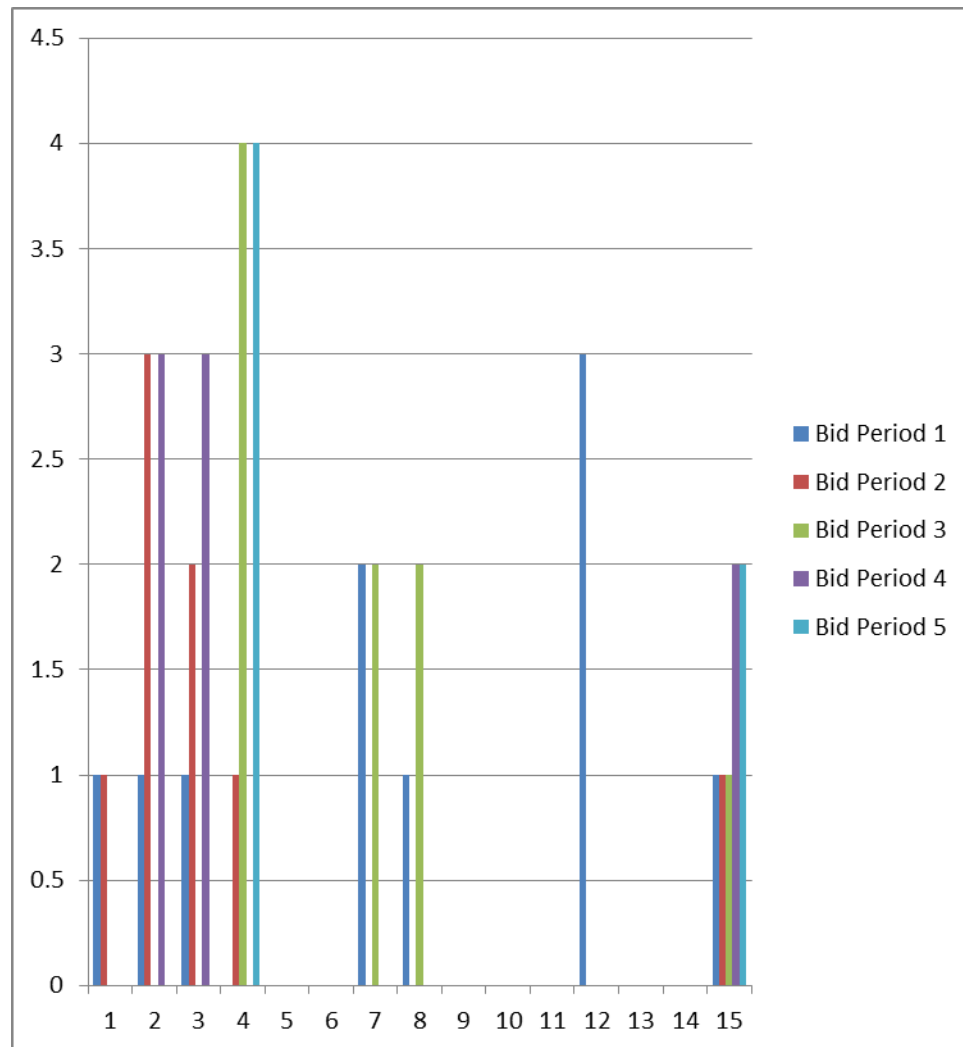


Figure 49. Participant 1: Bid Distribution per Minute (4-bidder)

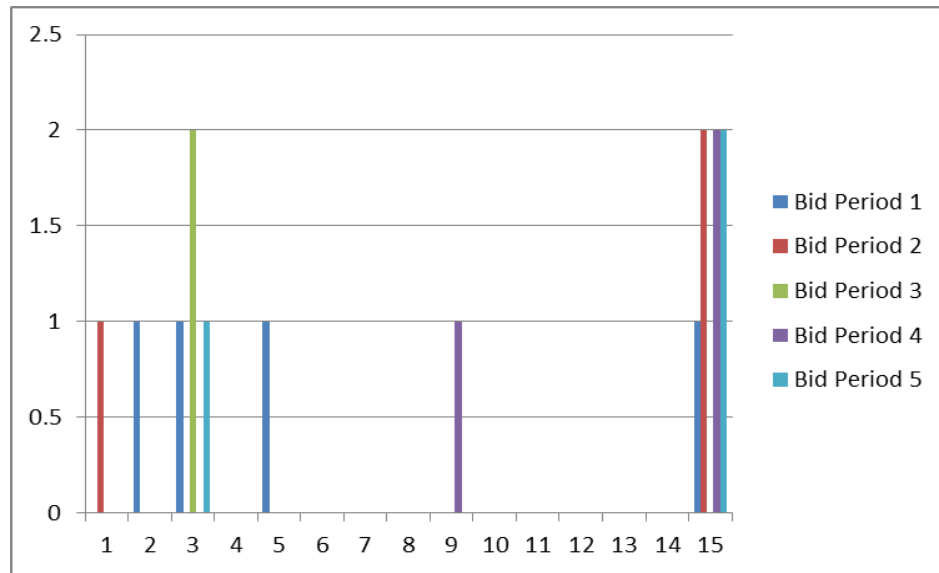


Figure 50. Participant 2: Bid Distribution per Minute (4-bidder)

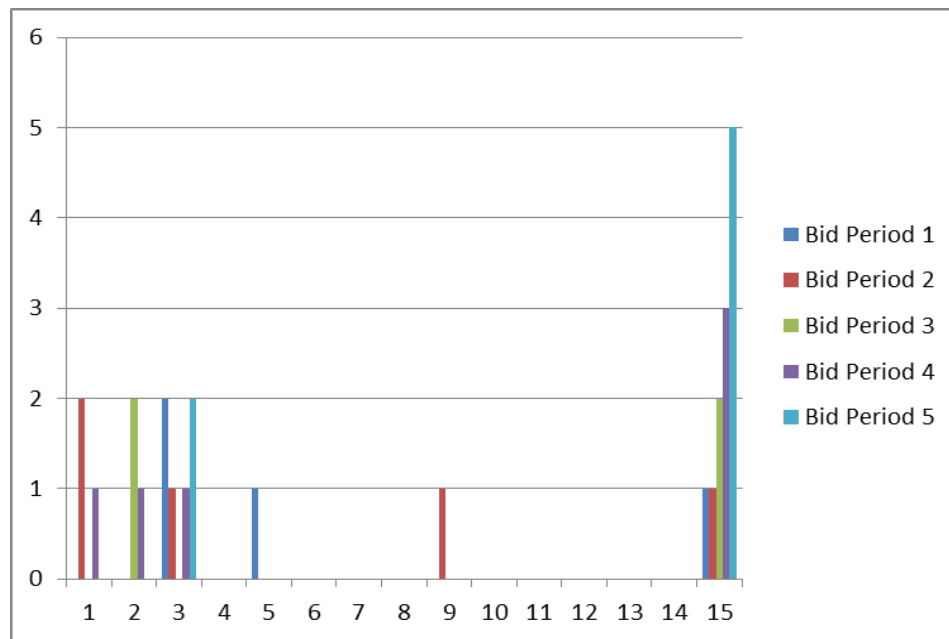


Figure 51. Participant 3: Bid Distribution per Minute (4-bidder)

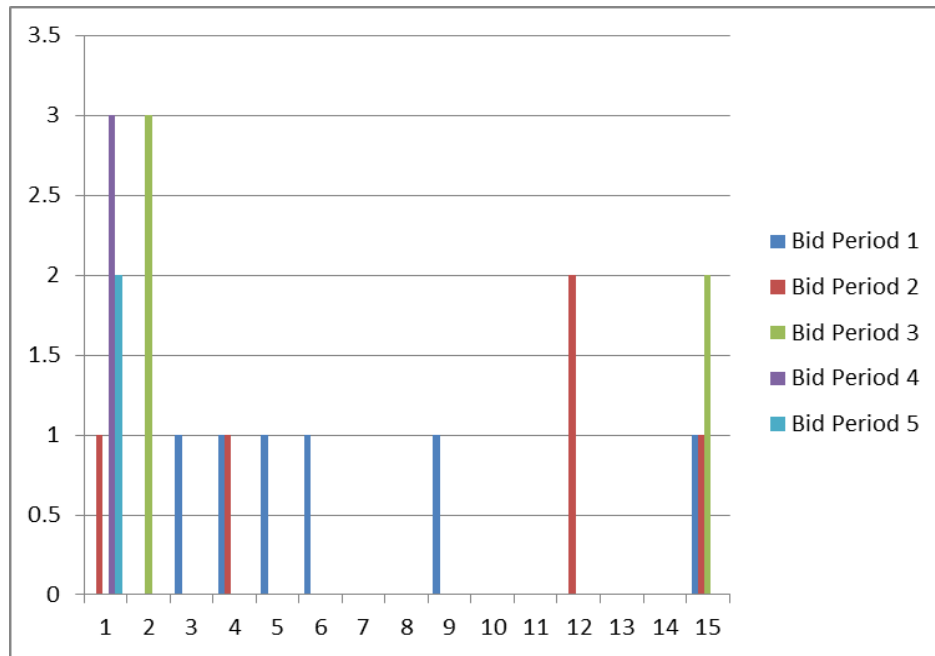


Figure 52. Participant 4: Bid Distribution per Minute (4-bidder)

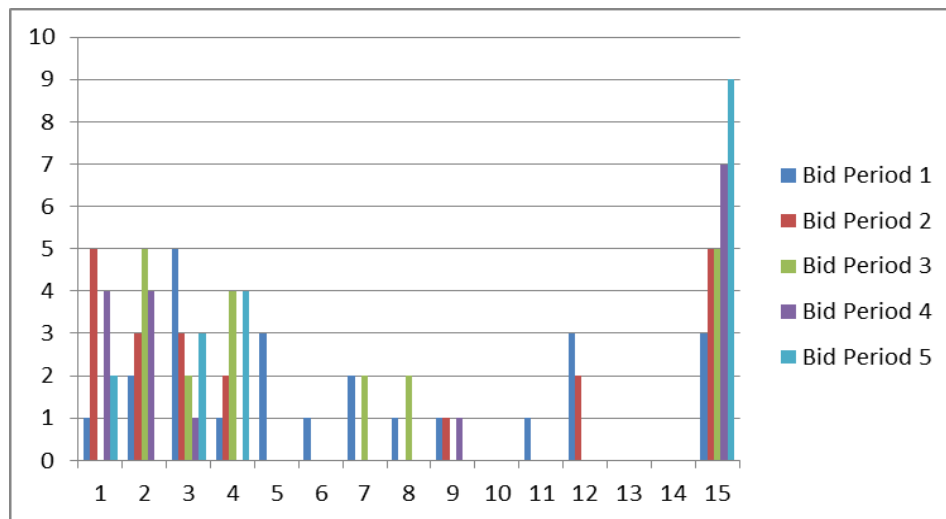


Figure 53. All Participants: Bid Distribution per Minute (4-bidder)

Figure 54- 65 shows the bidding data of the participant 1-10 individually and all participants together in the 10-bidder game. From the figure, most participants use the last minute strategy, except the best performer – participant 1.

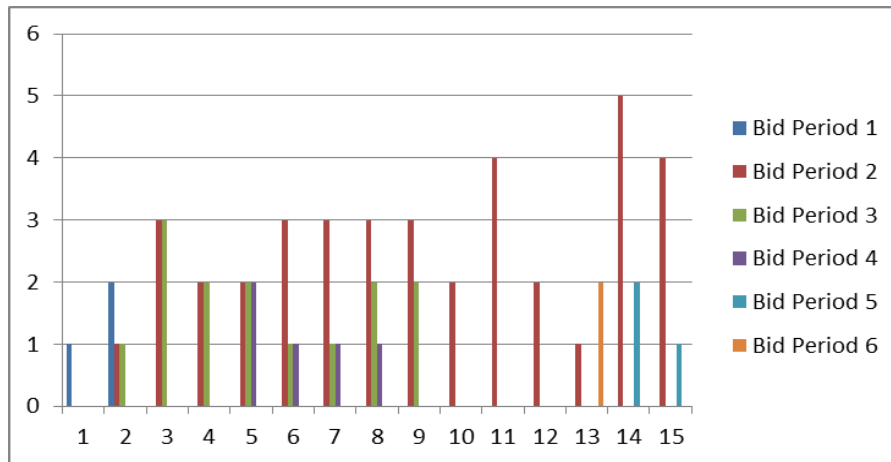


Figure 54. Participant 1: Bid Distribution per Minute (10-bidder)

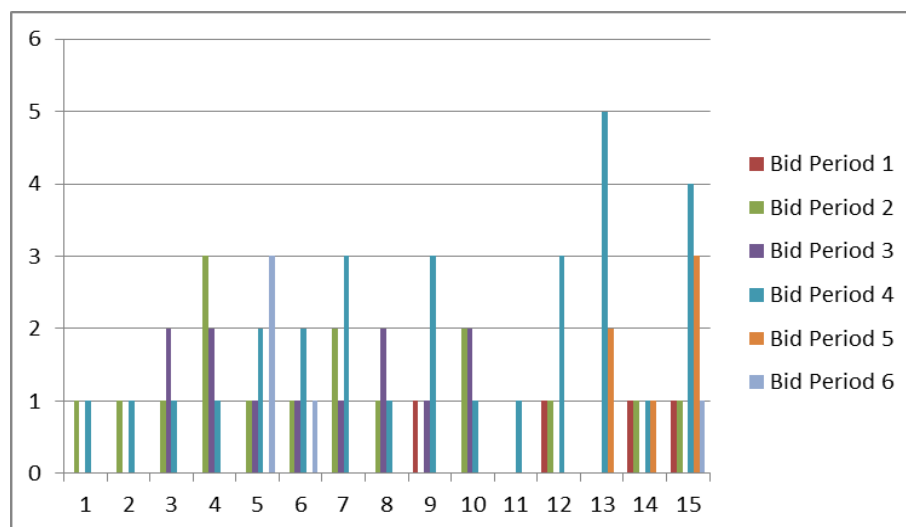


Figure 55. Participant 2: Bid Distribution per Minute (10-bidder)

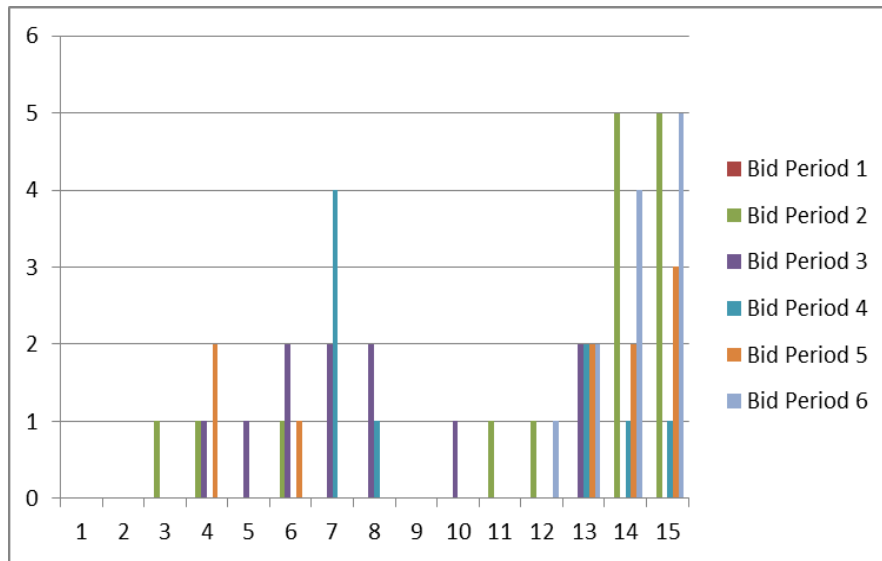


Figure 56. Participant 3: Bid Distribution per Minute (10-bidder)

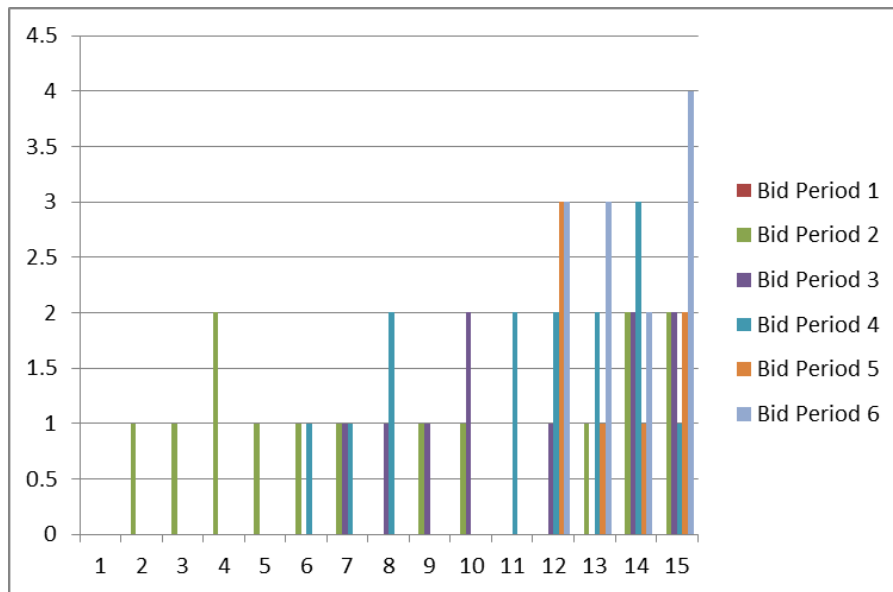


Figure 57. Participant 4: Bid Distribution per Minute (10-bidder)

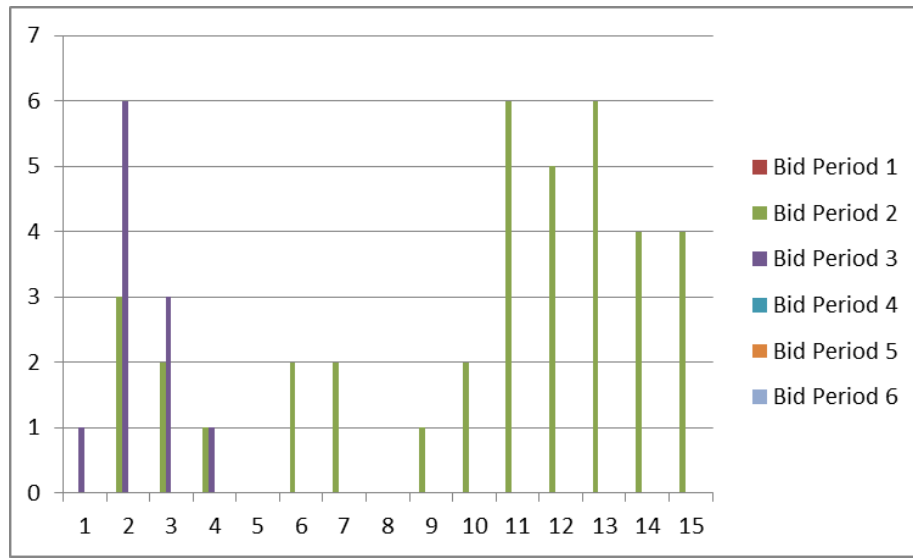


Figure 58. Participant 5: Bid Distribution per Minute (10-bidder)

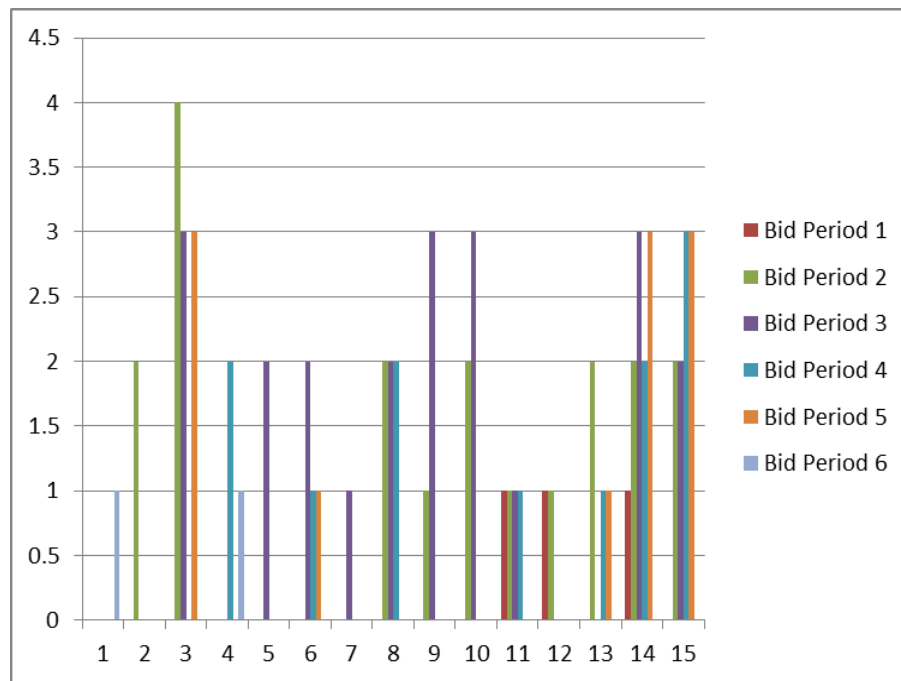


Figure 59. Participant 6: Bid Distribution per Minute (10-bidder)

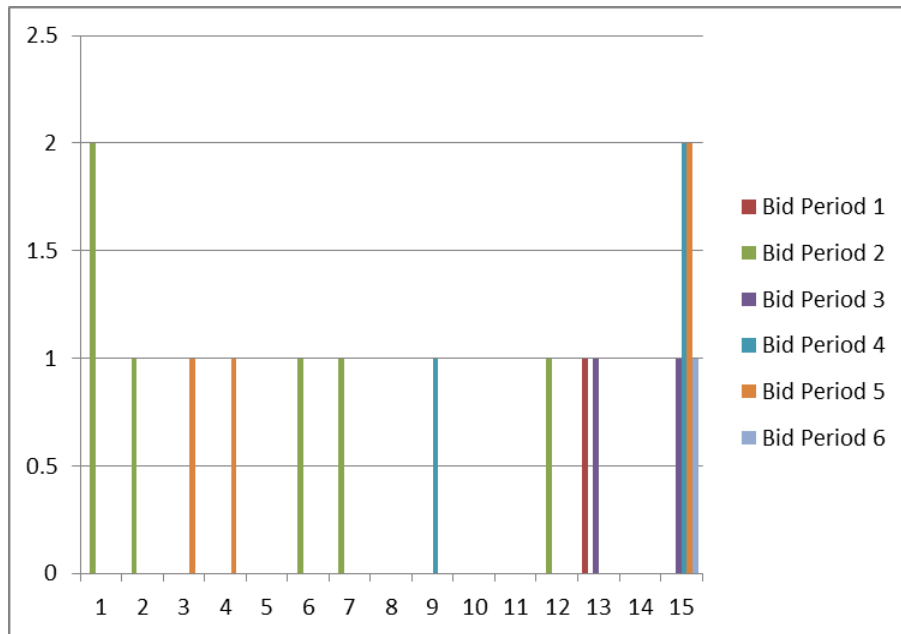


Figure 60. Participant 7: Bid Distribution per Minute (10-bidder)

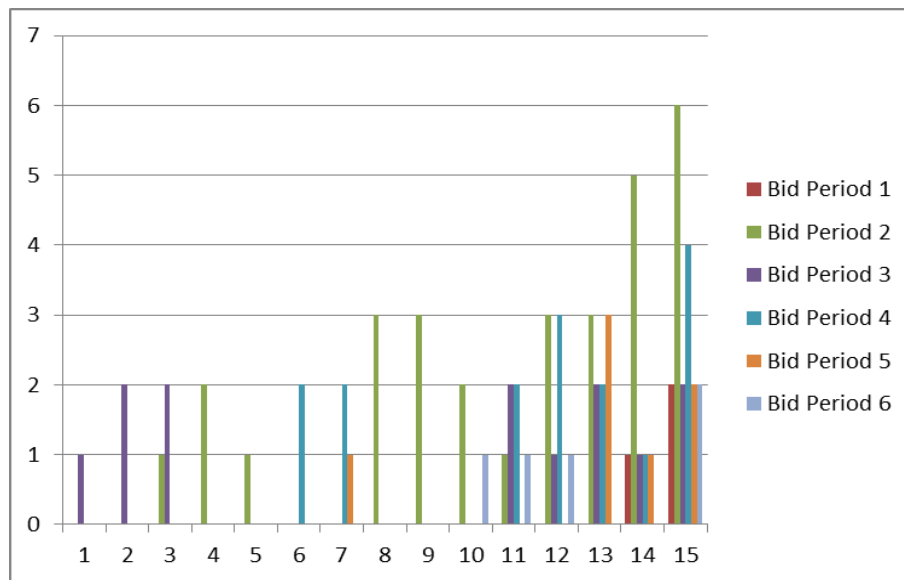


Figure 61. Participant 8: Bid Distribution per Minute (10-bidder)

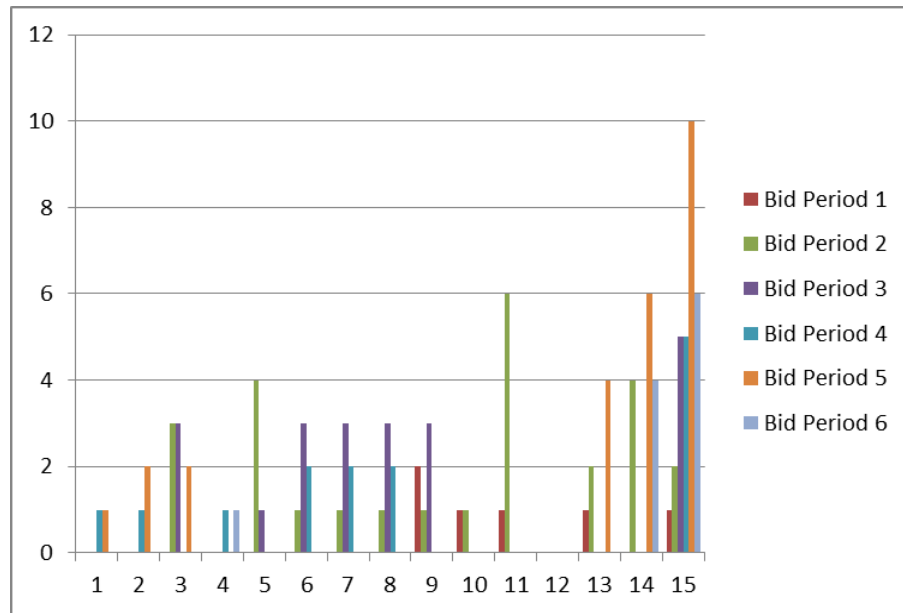


Figure 62. Participant 9: Bid Distribution per Minute (10-bidder)

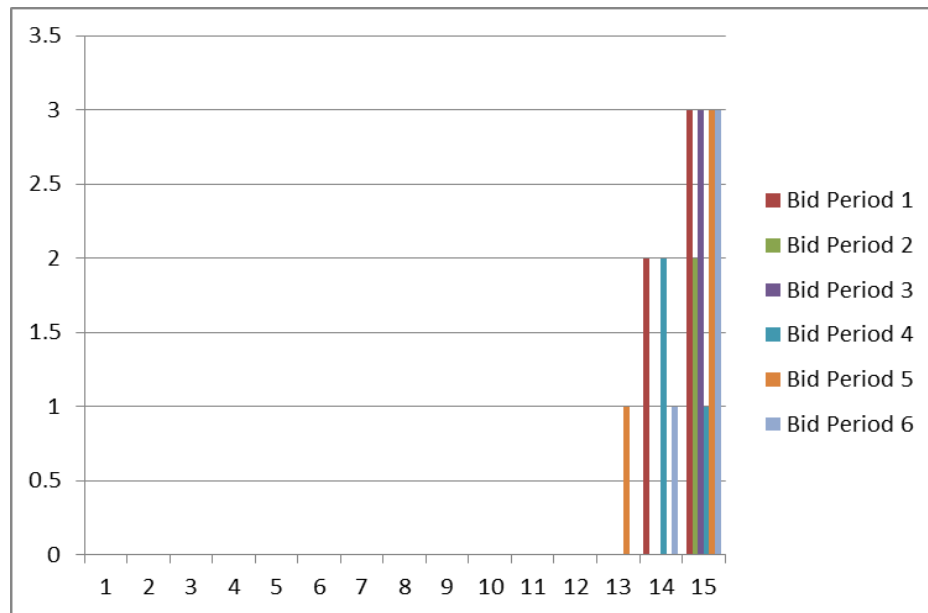


Figure 63. Participant 10: Bid Distribution per Minute (10-bidder)

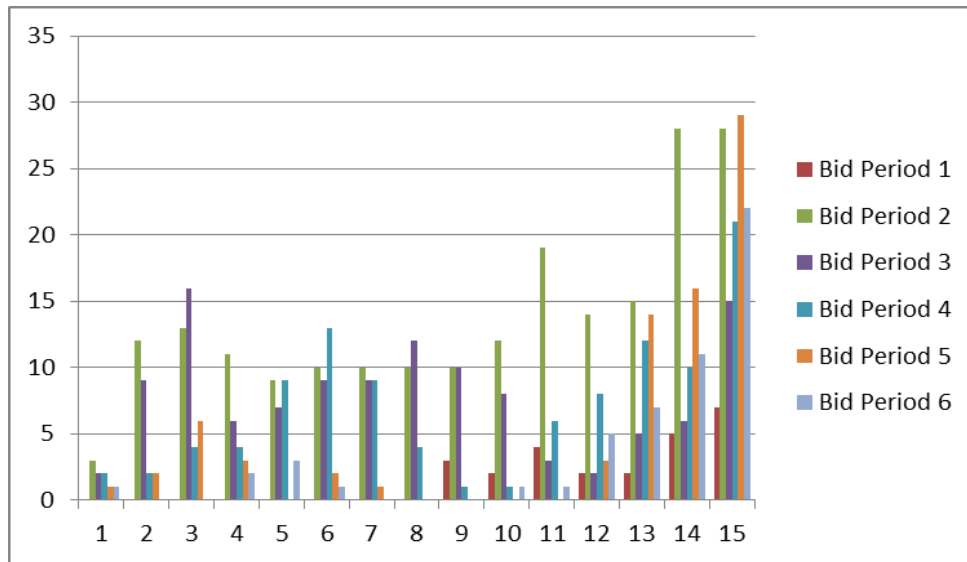


Figure 64. All Participants: Bid Distribution per Minute (10-bidder)

Tables 52 through 44 show the highest, lowest and average bids of each minute in all three games. Figure 66 – 68 shows the highest, lowest and average number of bids in each minute in a stock plot.

Table 52

Highest, Lowest and Average Number of Bids in Each Minute (3-bidder)

Minutes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
High	5	7	1	5	5	1	2	5	3	2	2	0	0	1	5
Low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	2.5	3.5	0.5	2.5	2.5	0.5	1	2.5	1.5	1	1	0	0	0.5	2.5

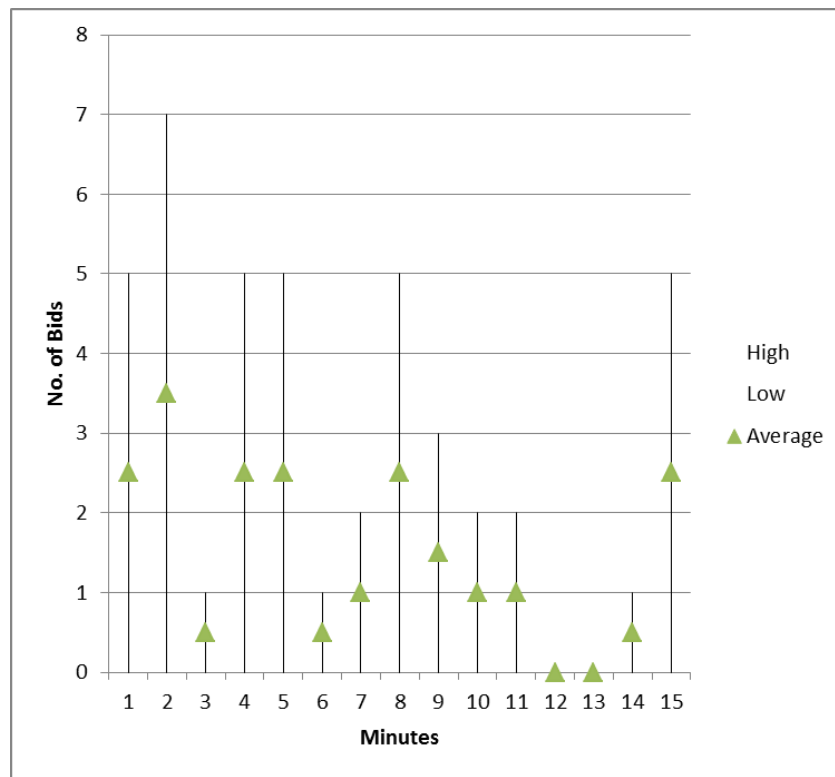


Figure 65. Highest, Lowest, and Average Number of Bids in Each Minute (3-bidder)

Table 53

Highest, Lowest and Average Number of Bids in Each Minute (4-bidder)

Minutes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
High	4	5	5	4	3	1	2	2	1	0	0	1	0	0	9
Low	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3
Average	2	2.5	3	2.5	1.5	0.5	1	1	0.5	0	0	0.5	0	0	6

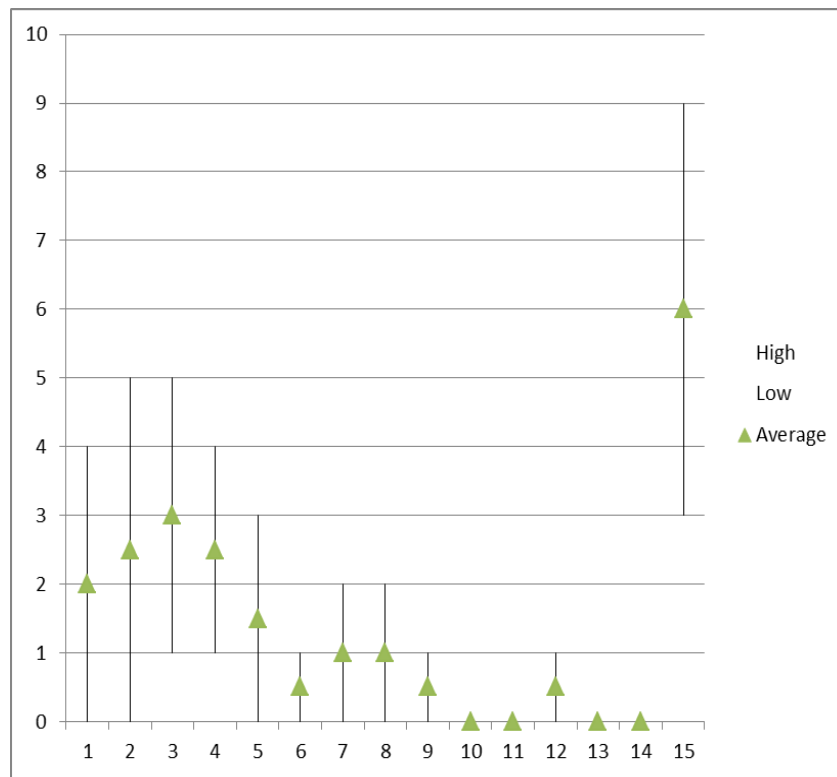


Figure 66. Highest, Lowest, and Average Number of Bids in Each Minute (4-bidder)

Table 54

Highest, Lowest and Average Number of Bids in Each Minute (10-bidder)

Min	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
High	3	12	16	11	9	13	10	12	10	12	19	14	15	28	29
Low	0	0	0	0	0	0	0	0	0	0	0	2	2	5	7
Average	1.5	6	8	5.5	4.5	6.5	5	6	5	6	9.5	8	8.5	16.5	18

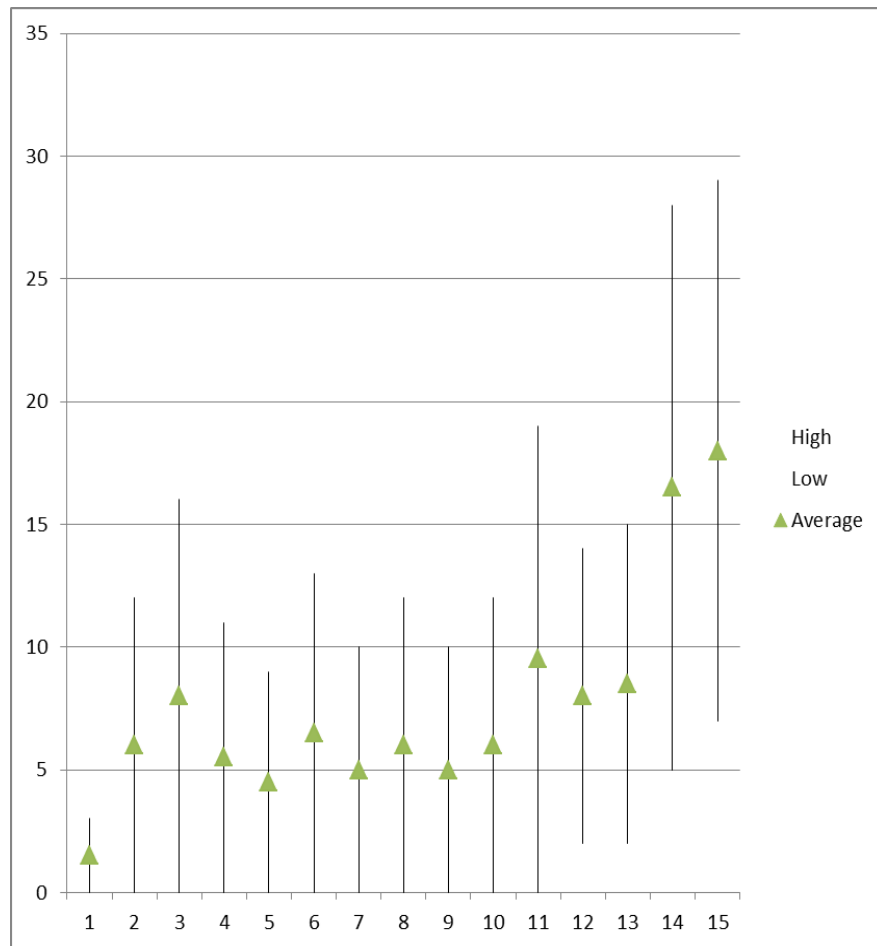


Figure 67. Highest, Lowest, and Average Number of Bids in Each Minute (10-bidder)

Figure 68 through to Figure 70 show the average bids per minute in the three games. Except for the 3-bidder game, the other two curves are pretty smooth. All the figures can be fitted by a sixth order polynomial. The regression co-efficient for the three sets of data is 0.57, 0.92 and 0.93, which means the fit is pretty good.

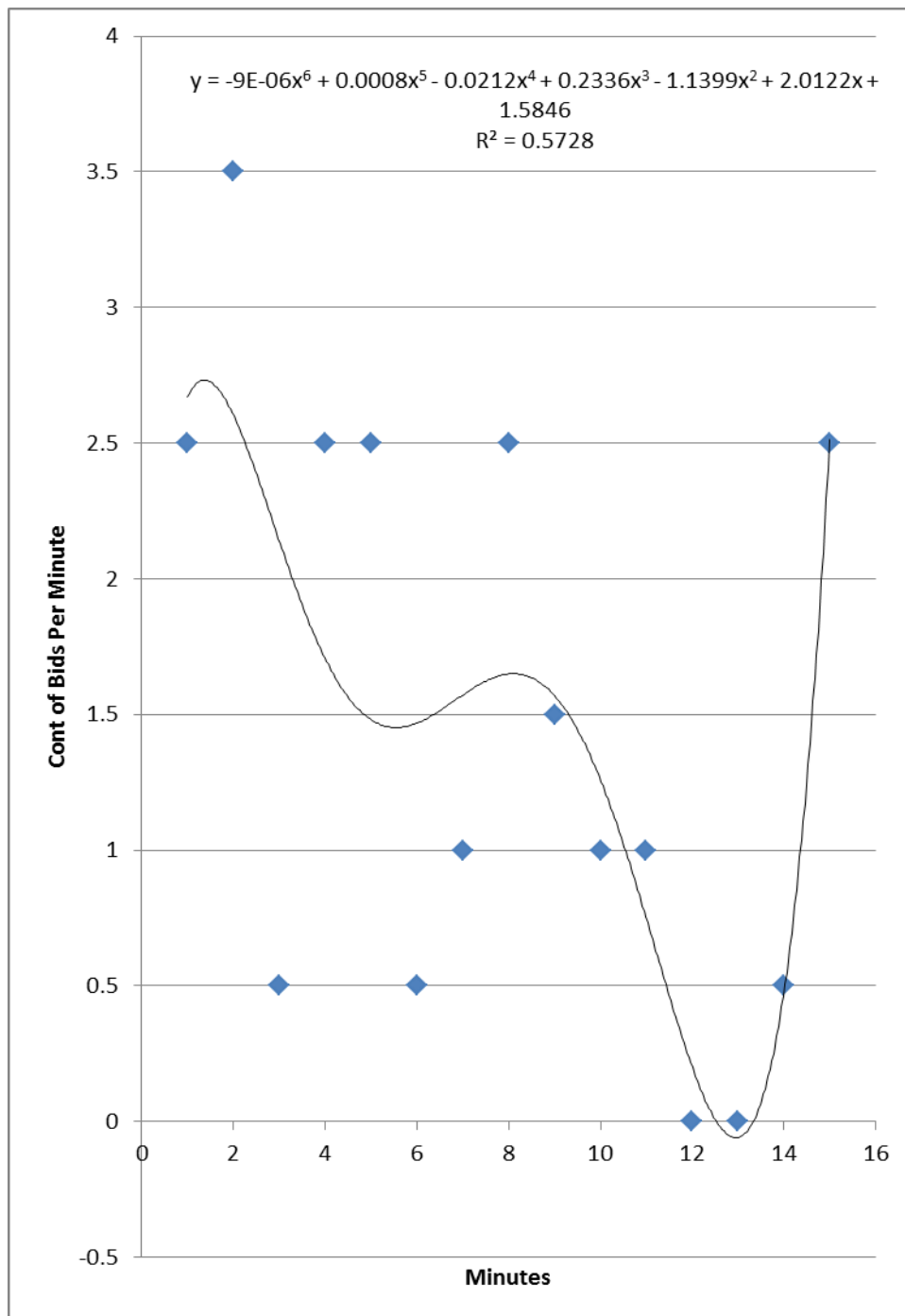


Figure 68. Histogram showing Average Bids per Minute (3-bidder)

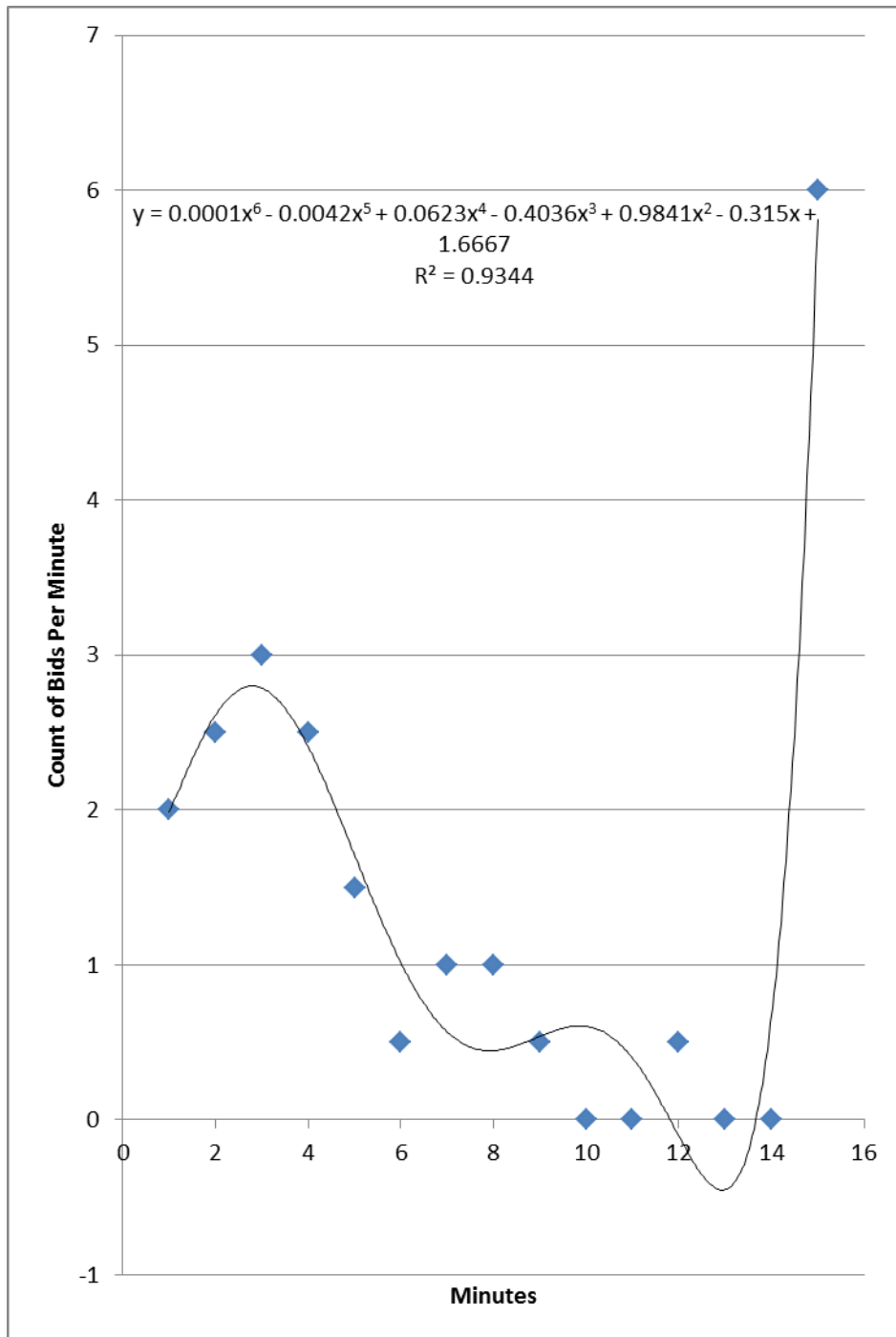


Figure 69. Histogram showing Average Bids per Minute (4-bidder)

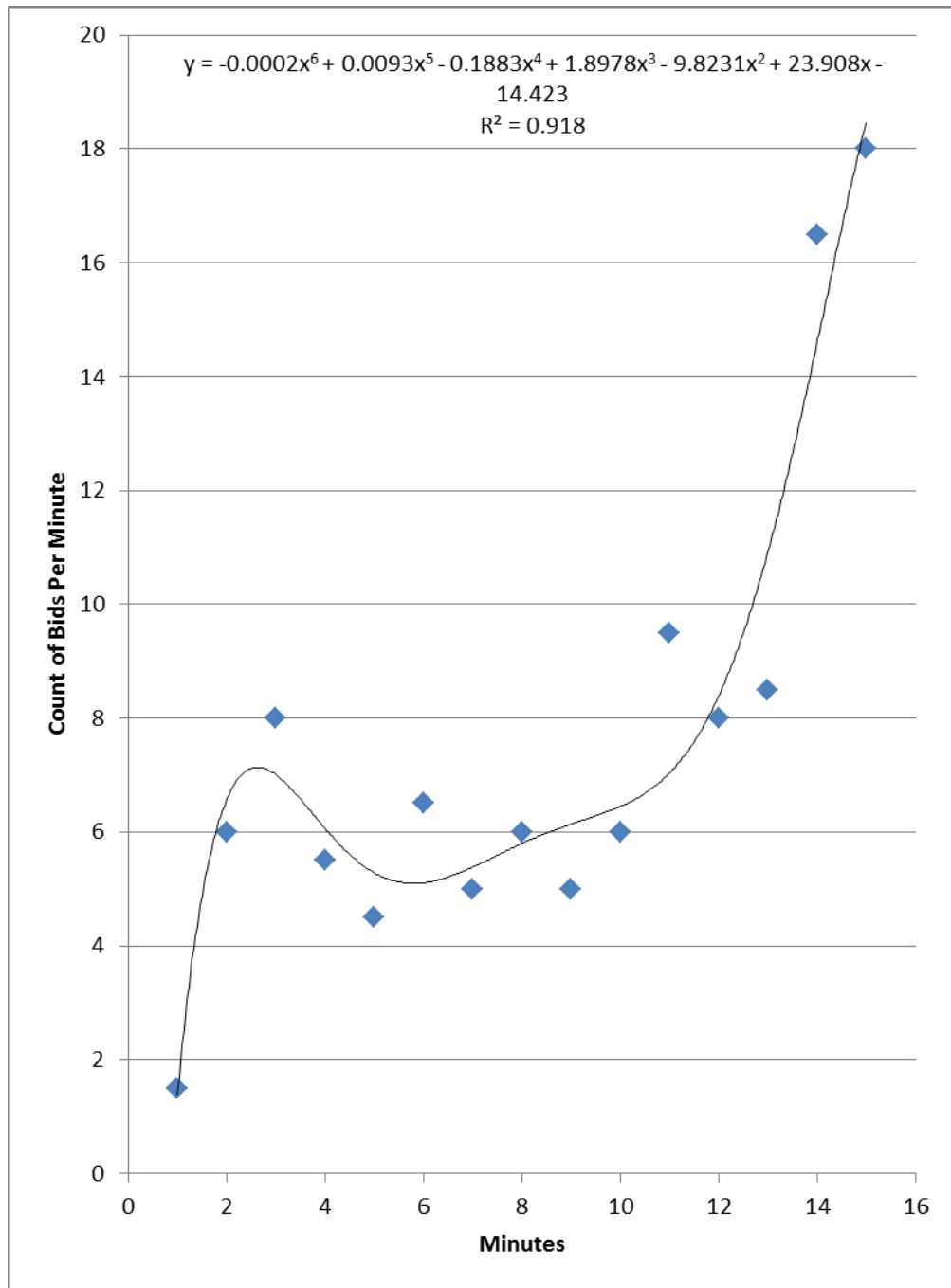


Figure 70. Histogram showing Average Bids per Minute (10-bidder)

Figures 71 – 74 shows the number of the bids submitted by the bidders to the jobs won by the bidders. The more bidders there are in the game, the weaker the relationship it seems to be.

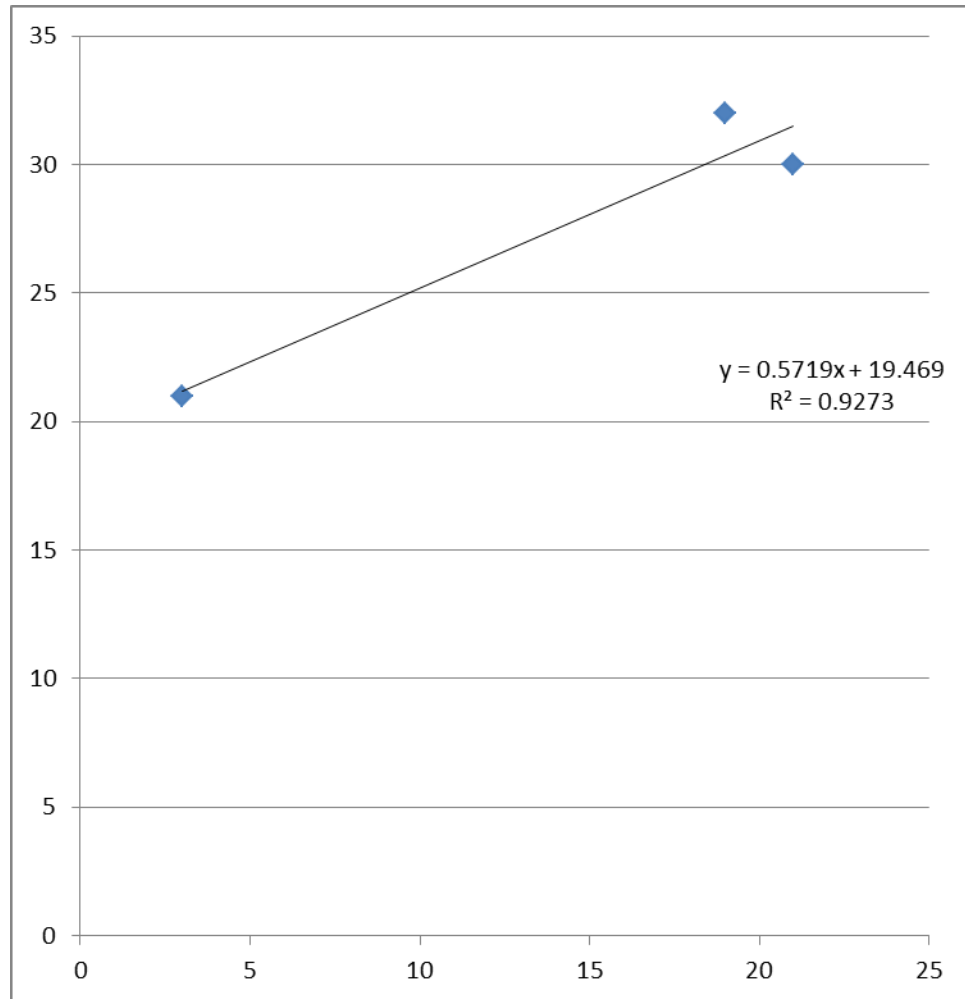


Figure 71. Histogram of Average Number of Bids to Jobs Won (3-bidder)

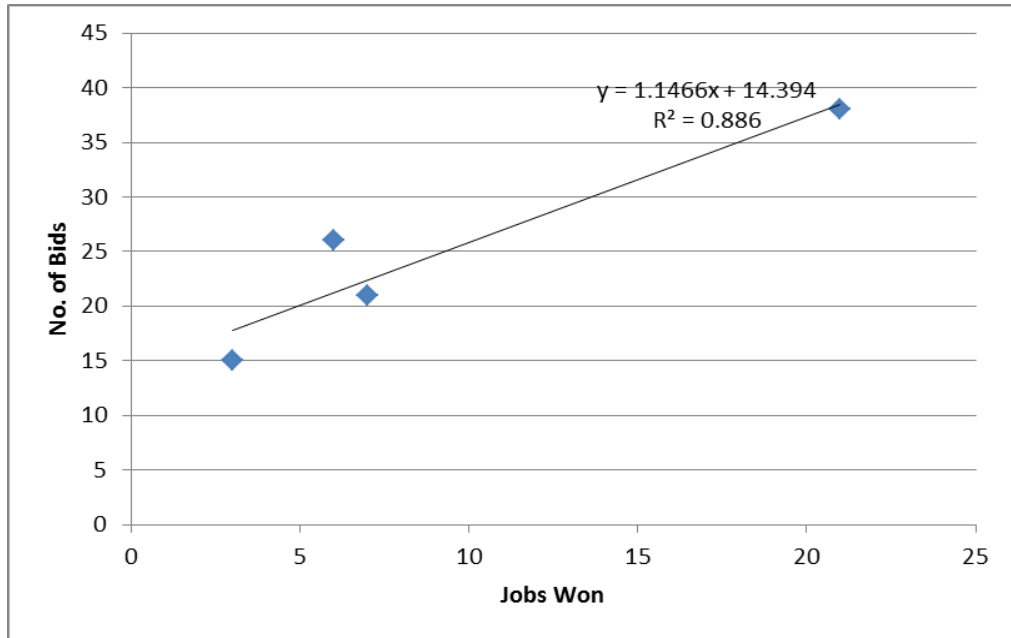


Figure 72. Histogram of Average Number of Bids to Jobs Won (4-bidder)

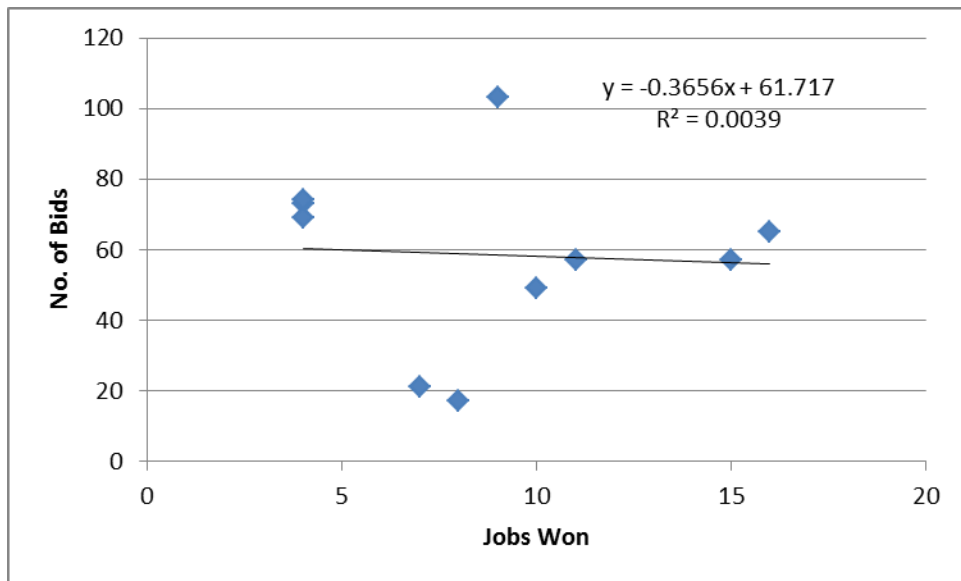


Figure 73. Histogram of Average Number of Bids to Jobs Won (10-bidder)

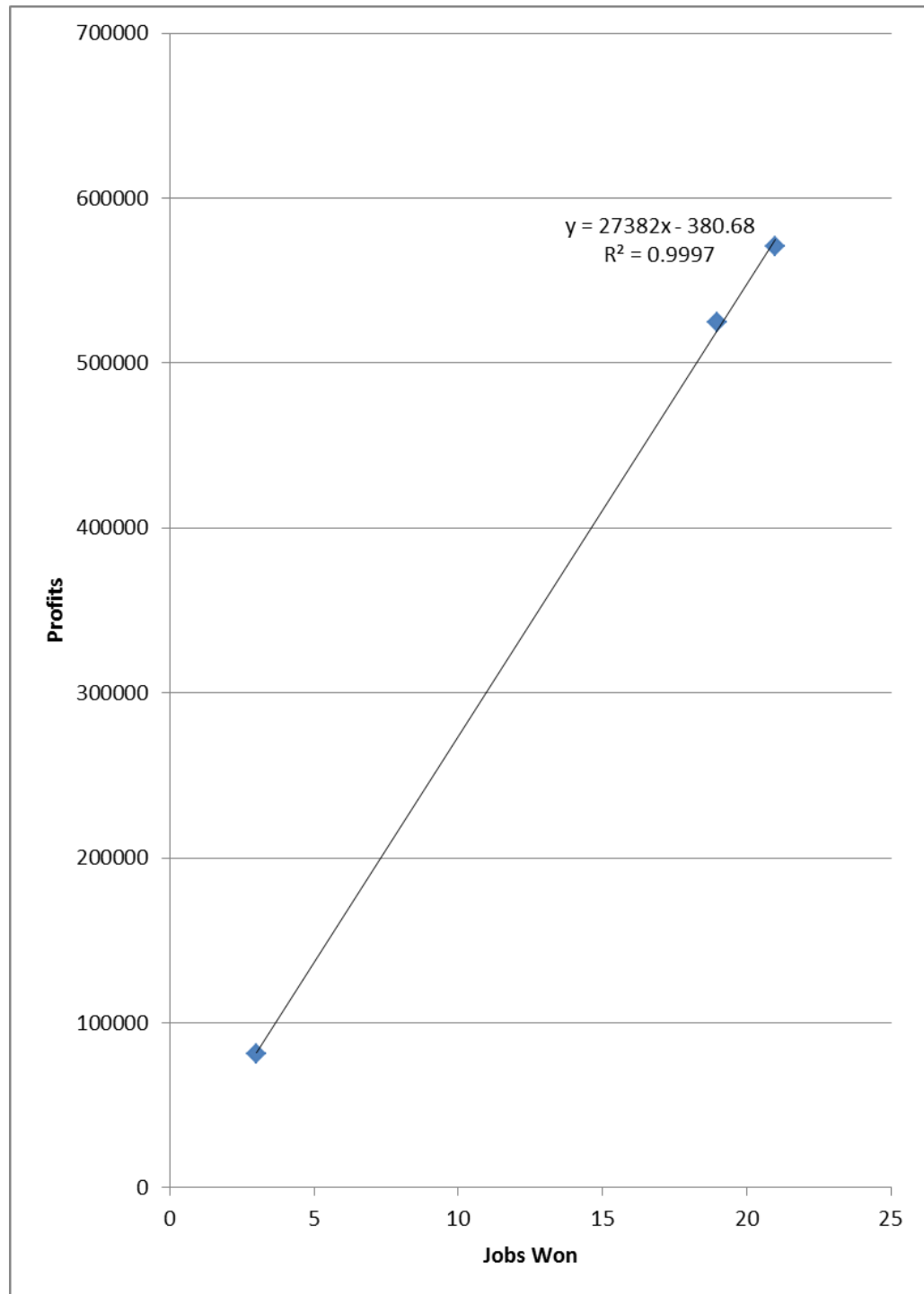


Figure 74. Histogram of Profits to Jobs Won (3-bidder)

Figures 75 and Figure 76 show profits gained by bidders to the jobs won by the bidders. The more bidders there are in the game, the weaker the relationship it seems to be.

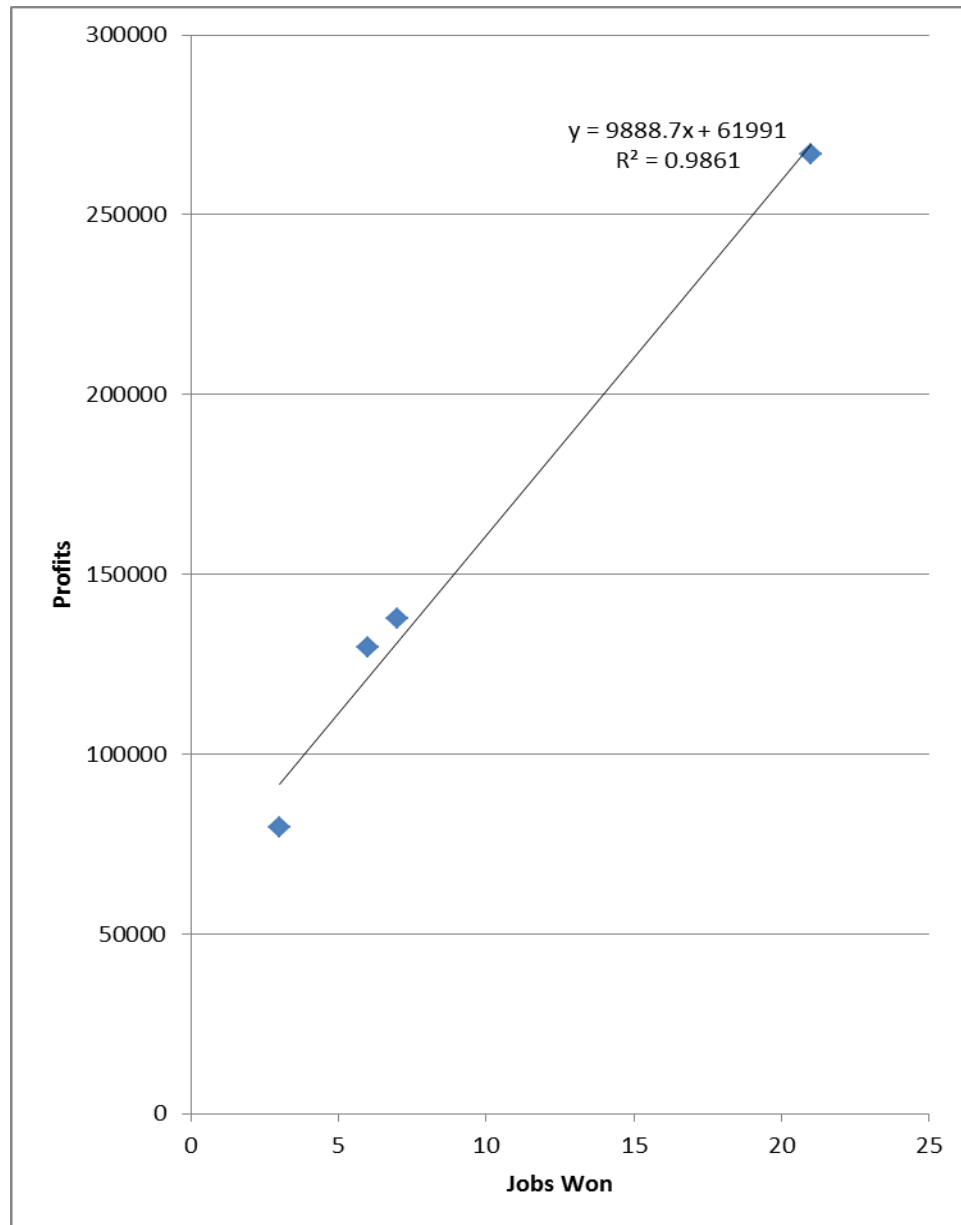


Figure 75. Histogram of Profits to Jobs Won (4-bidder)

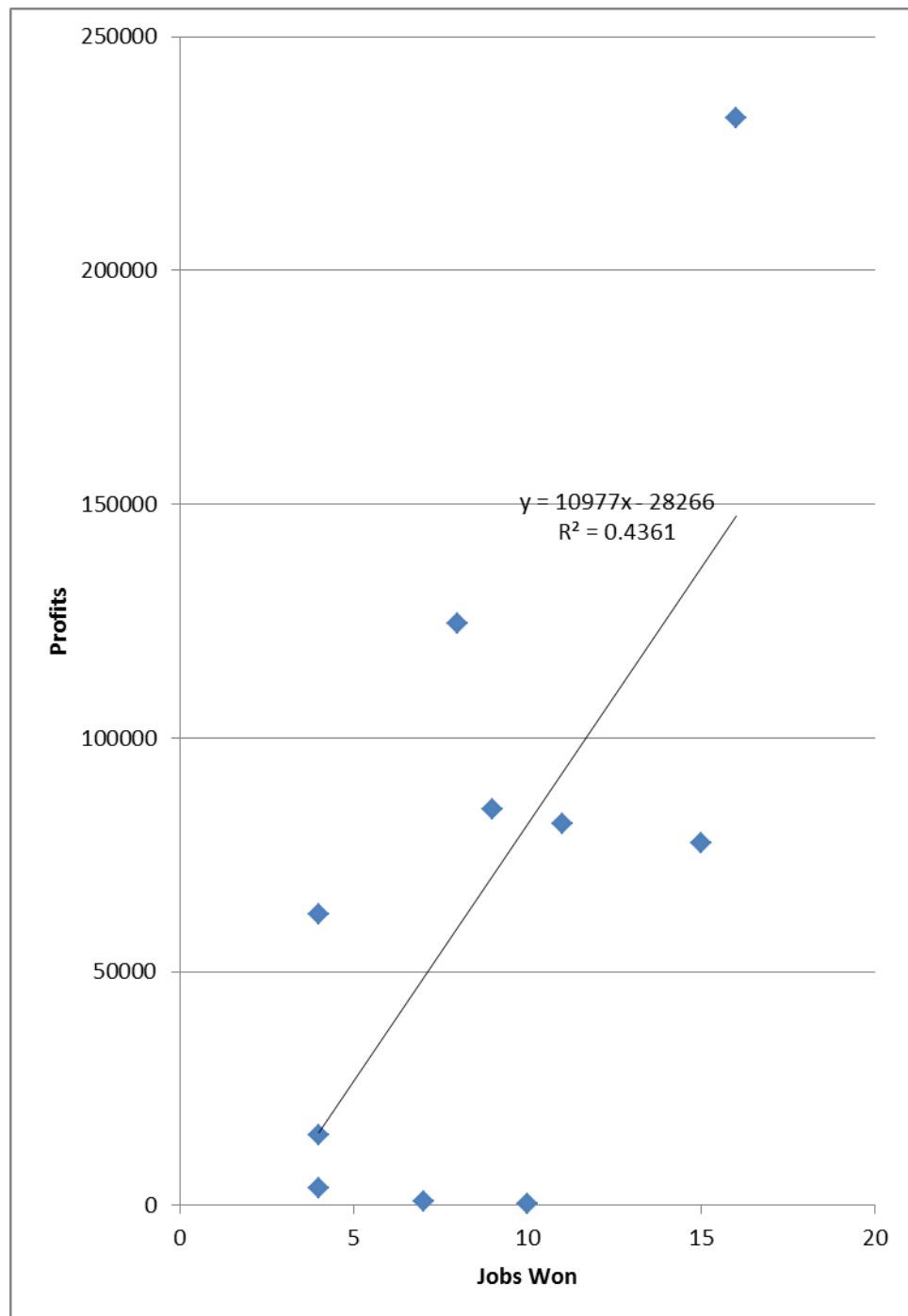


Figure 76. Histogram of Profits to Jobs Won (10-bidder)

CHAPTER V

CONCLUSIONS

Van Vleet first studied the Reverse Auction Bidding game at Texas A&M University in 2004. Previous research has shown an impact of the bidders' personality types with the profit returns. It has been shown that usually the Guardian performs better than the other types of bidders. The Guardian and other types are defined according to the categories from the Keirsey Temperament Sorter Test.

This current research, the sixteenth study in Reverse Auction Bidding at TAMU, was conducted to compare the difference in games played with different numbers of bidders, three four and ten participant games.

A theory of four trend periods was developed by Chouhan (2009), as usual the four bidder game fits into the four defined trends. The three bidder game showed the probable existence of tacit collusion, generated by the perfect economic knowledge given in the games. The first or learning period is missing in the ten bidder game, as this is only the second time a ten bidder game has been studied there is insufficient information to determine if this is usual or an aberration.

The 10-bidder game shows a long competitive period in the whole game which is good for the buyer to drive down the price. As the number of bidders increase, the competitiveness among the bidders increase which drives down the profits for each bidder. In this research, the best performer's personality for each game is different from the usual Guardian.

The best performer's personality for the three bidder game is Artisan; the best performer's personality for the four bidder game is Guardian, as expected; and the best performer's personality for the 10-bidder game is Rational, which requires further study. Even though the best performer's personality may not all be Guardian, the type Guardian still ranks generally higher than the other types of personality.

The results for the three games show that competition is important in the returns to the participants and the costs to the purchaser. The issue is however the likelihood that one will have ten participants in a real auction is considered low, the standard of four adopted for the long running study is considered more realistic.

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APPENDIX A

KIERSEY TEMPERAMENT SORTER TEST

For each question, decide on answer a or b and put a check mark in the proper column of the answer sheet. Scoring directions are provided. There is no right or wrong answers since about half the population agrees with whatever answer you choose.

1. When the phone rings do you
 - a. hurry to get to it first
 - b. hope someone will answer
2. Are you more
 - a. observant than introspective
 - b. introspective than observant
3. Is it worse to
 - a. have your head in the clouds
 - b. be in a rut
4. With people are you usually more
 - a. firm than gentle
 - b. gentle than firm
5. Are you more comfortable in making
 - a. critical judgments
 - b. value judgments
6. Is clutter in the workplace something you
 - a. take time to straighten up
 - b. tolerate pretty well
7. Is it your way to
 - a. make up your mind quickly

- b. pick and choose at some length
8. Waiting in line, do you often
 - a. chat with others
 - b. stick to business
 9. Are you more
 - a. sensible than ideational
 - b. ideational than sensible
 10. Are you more interested in
 - a. what is actual
 - b. what is possible
 11. In making up your mind are you more likely
 - a. to go by data
 - b. to go by desires
 12. In sizing up others do you tend to be
 - a. objective and impersonal
 - b. friendly and personal
 13. Do you prefer contracts to be
 - a. signed, sealed, and delivered
 - b. settled on a handshake
 14. Are you more satisfied having
 - a. a finished product
 - b. work in progress
 15. At a party, do you
 - a. interact with many, even strangers
 - b. interact with a few friends
 16. Do you tend to be more

- a. factual than speculative
 - b. speculative than factual
17. Do you like writers who
- a. say what they mean
 - b. use metaphors and symbolism
18. Which appeals to you more:
- a. consistency of thought
 - b. harmonious relationships
19. If you must disappoint someone are you
- a. usually frank and straightforward
 - b. warm and considerate
20. On the job do you want your activities
- a. scheduled
 - b. unscheduled
21. Do you more often prefer
- a. final, unalterable statements
 - b. tentative, preliminary statements
22. Does interacting with strangers
- a. energize you
 - b. tax your reserves
23. Facts
- a. speak for themselves
 - b. illustrate principles
24. Do you find visionaries and theorists
- a. somewhat annoying
 - b. rather fascinating

25. In a heated discussion, do you
 - a. stick to your guns
 - b. look for common ground
26. Is it better to be
 - a. Just
 - b. merciful
27. At work, is it more natural for you to
 - a. point out mistakes
 - b. try to please others
28. Are you more comfortable
 - a. after a decision
 - b. before a decision
29. Do you tend to
 - a. say right out what's on your mind
 - b. keep your ears open
30. Common sense is
 - a. usually reliable
 - b. frequently questionable
31. Children often do not
 - a. make themselves useful enough
 - b. exercise their fantasy enough
32. When in charge of others do you tend to be
 - a. firm and unbending
 - b. forgiving and lenient
33. Are you more often
 - a. a cool-headed person

- b. a warm-hearted person
34. Are you prone to
- a. nailing things down
 - b. exploring the possibilities
35. In most situations are you more
- a. deliberate than spontaneous
 - b. spontaneous than deliberate
36. Do you think of yourself as
- a. an outgoing person
 - b. a private person
37. Are you more frequently
- a. a practical sort of person
 - b. a fanciful sort of person
38. Do you speak more in
- a. particulars than generalities
 - b. generalities than particular
39. Which is more of a compliment:
- a. "There's a logical person"
 - b. "There's a sentimental person"
40. Which rules you more
- a. your thoughts
 - b. your feelings
41. When finishing a job, do you like to
- a. tie up all the loose ends
 - b. move on to something else
42. Do you prefer to work

- a. to deadlines
 - b. just whenever
43. Are you the kind of person who
- a. is rather talkative
 - b. doesn't miss much
44. Are you inclined to take what is said
- a. more literally
 - b. more figuratively
45. Do you more often see
- a. what's right in front of you
 - b. what can only be imagined
46. Is it worse to be
- a. softy
 - b. hard-nosed
47. In trying circumstances are you sometimes
- a. too unsympathetic
 - b. too sympathetic
48. Do you tend to choose
- a. rather carefully
 - b. somewhat impulsively
49. Are you inclined to be more
- a. hurried than leisurely
 - b. leisurely than hurried
50. At work do you tend to
- a. be sociable with your colleagues
 - b. keep more to yourself

51. Are you more likely to trust
 - a. your experiences
 - b. your conceptions
52. Are you more inclined to feel
 - a. down to earth
 - b. somewhat removed
53. Do you think of yourself as a
 - a. tough-minded person
 - b. tender-hearted person
54. Do you value in yourself more that you are
 - a. reasonable
 - b. devoted
55. Do you usually want things
 - a. settled and decided
 - b. just penciled in
56. Would you say you are more
 - a. serious and determined
 - b. easy going
57. Do you consider yourself
 - a. a good conversationalist
 - b. a good listener
58. Do you prize in yourself
 - a. a strong hold on reality
 - b. a vivid imagination
59. Are you drawn more to
 - a. fundamentals

- b. overtones
- 60. Which seems the greater fault
 - a. to be too compassionate
 - b. to be too dispassionate
- 61. Are you swayed more by
 - a. convincing evidence
 - b. a touching appeal
- 62. Do you feel better about
 - a. coming to closure
 - b. keeping your options open
- 63. Is it preferable mostly to
 - a. make sure things are arranged
 - b. just let things happen naturally
- 64. Are you inclined to be
 - a. easy to approach
 - b. somewhat reserved
- 65. In stories do you prefer
 - a. action and adventure
 - b. fantasy and heroism
- 66. Is it easier for you to
 - a. put others to good use
 - b. identify with others
- 67. Which do you wish more for yourself
 - a. strength of will
 - b. strength of emotion
- 68. Do you see yourself as basically

- a. thick-skinned
 - b. thin-skinned
69. Do you tend to notice
- a. disorderliness
 - b. opportunities for change
70. Are you more
- a. routinized than whimsical
 - b. whimsical than routinized

APPENDIX B

KIERSEY TEMPERAMENT SORTER SCORING

Test Sample Sheet

Enter a check for each answer in the column for a or b.

a		b		a		b		a		b		a		b		a		b		
1			2			3			4			5			6			7		
8			9			10			11			12			13			14		
15			16			17			18			19			20			21		
22			23			24			25			26			27			28		
29			30			31			32			33			34			35		
36			37			38			39			40			41			42		
43			44			45			46			47			48			49		
55			51			52			53			54			55			56		
57			58			59			60			61			62			63		
64			65			66			67			68			69			70		
1			23			43			45			65			67			87		

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1 2

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3 4

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5 6

T F

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7 8

J P

Directions For Scoring

1. **Add down** so that the total number of a answers is written in the box at the bottom of each column. Do the same for the b answers you have checked. Each of the 14 boxes should have a number in it.
2. **Transfer the number** in box #1 of the answer grid to box #1 below the answer grid. Do this for box # 2 as well. Note, however, that you have two numbers for boxes 3 through 8. Bring down the first number for each box beneath the second, as indicated by the arrows. Now add all the pairs of numbers and enter the total in the boxes below the answer grid, so each box has only one number.
3. **Now you have** four pairs of numbers. Circle the letter below the larger numbers of each pair. If the two numbers of any pair are equal, then circle neither, but put a large X below them and circle it.

VITA

Name: Xun Zhou

Address: 3137 TAMU, Langford Building A, Room 422, Department of
Construction Science, College of Architecture, Texas A & M
University, College Station, Texas 77843-3137

Email Address: allerzhou@gmail.com

Education: B.E. (Construction Management), Chongqing University, 2010
M.S., Construction Management, Texas A & M University,
College Station, Texas, 2012