REVERSE AUCTION BIDDING: AN ANALYSIS OF CASE STUDY FOR BID TIMING

A Thesis

by

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ABSTRACT

Reverse Auction Bidding is utilized by a significant number of enterprises for supply of materials and in part construction. This thesis investigates aspects of the Reverse Auction system using the web site developed by others to continue the work on understanding aspects of the impact of human personality types on the bidding results for a standard game.

A game theory was developed for the Reverse Auction Bidding framework used at TAMU to study the results of the bids collected in a standard game. This theory postulated two sub-games exist inside the main Reverse Auction Bidding game. The main sub-game is between the buyer and the set of bidders. The second sub-game is between the bidders.

The theory exists that the buyer seeks minimal costs, which must be acknowledged as prima facie correct for this study. Extent studies at TAMU have indicated that the costs distribution is non-Gaussian, indicating that the buyer's objective is not achieved for all bidders. The second sub-game is between the bidders, they utilize the non-Gaussian component of the profit distribution to amplify individual returns. Bidders have been proposed into three types, and the personality has been shown to have some impact on the participant's economic efficiency.

The bid timing data from previous studies shows that the bid arrival times follows a Poisson process. This study aims to confirm the previous investigation that the bid

timing data from the Reverse Auction Bidding case studies at TAMU fits the non-homogeneous Poisson process model.

The study involves a game scenario consisting of six construction sites for which the participants were asked to bid on the construction of house slabs. This is a simple and repeatable construction to minimize the problems of bidding. The study also involved determining the personality type of the participants. The game lasts for eight rounds.

The individuals were selected from the Construction Management Graduate program with varied experience. The hypothesis is a non-homogeneous Poisson process (NHPP) models the arrival time data for bidding from a number of new TAMU case studies within acceptable statistical limits. The hypothesis is neither proven nor disproven; the results from this study are moot to a large extent, except when included in the overall study of all of the games.

DEDICATION

In memory of my grandfather, Surendra Kumar.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Nichols, and my committee members, Edelmiro Escamilla and John A. Walewski for their helpful guidance and patient support throughout the course of this research.

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NOMENCLATURE

The following is a list of terms associated with the reverse auction bidding game. These terms were defined by the previous RAB researchers at TAMU:

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:	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 (Little, Fowler, Coulson, Onions, & Friedrichsen, 1973) 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: 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 υ player where the υ player has an objective of minimizing

the average bid for the game. The υ player sees the average price for purchases and a distribution of prices.

Economic Loser: An individual who generated the lowest average returns. Panchal (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 υ player where the υ player has an objective of minimizing the average bid for the game.

Efficiency: The ratio 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.

Reverse Auction Bidding: 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 (Chaudary, 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 (Chaudary, 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.

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CHAPTER I

INTRODUCTION

Objectives

The objectives of this study are:

- to confirm the previous investigation that the bid timing data from the Reverse Auction Bidding case studies at TAMU fits the non-homogeneous Poisson process model;
- determine the parameters for the model using a suitable goodness of fit test;
- Use the new set of case studies completed since the first work by Yuan in 2013 to confirm the findings.

Background

Reverse Auction Bidding is a process in which a buyer of goods and services continues to solicit bids from sellers until the buyer is satisfied it has received an acceptably low price. As used in construction, the process usually entails using a dedicated Internet web site. At a scheduled time, the bidding for a project opens and all interested bidders submit their prices to the web site. The host web site then posts the prices on the site for all bidders to observe. The bidders' identities usually remain anonymous. Bidders are then given a certain period in which to offer any lower price that they may choose to submit. Thus, the auction proceeds as the "reverse" of a typical

bids are received after a certain period following the receipt and posting of the last bid, the auction is closed. Award is then made to the lowest bidder (Shankar, 2005).

The non-homogeneous Poisson process (NHPP) model provides a model used in the study of eBay bid arrival timing data (Shmueli, Russo, & Jank, 2004). Yuan (2013) showed that a NHPP model fitted the RAB data. This research will confirm the finding by using a number of recent case studies not available to Yuan.

Hypothesis

The hypothesis is a non-homogeneous Poisson process (NHPP) models the arrival time data for bidding from a number of new TAMU case studies within acceptable statistical limits.

Significance

Among all characteristics of online Reverse Auction Bidding (RAB), bid arrivals is a crucial one for analyzing bidding dynamics, bidders' performance in order to reveal bidding strategies hiding behind those datasets. With this NHPP model, some special phenomena like "early bidding" and "bid sniping" can be examined in future studies.

Limitations

The limitations for the study are:

- The participants of this study are selected from students in the Department of Construction Science for the additional case study completed for this work
- The participants will be randomly selected and none of them has any experience on RAB before

- The types of personality won't be controlled, although the personality type will be studied as part of the research as this is of ongoing interest to others
- All games will be limited to four players as is normal in this RAB study
- 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

CHAPTER II

LITERATURE REVIEW

The range of this literature review lists the prior work completed at TAMU in the period 2004 to 2013 (Chaudary, 2009; Gregory, 2006; Guhya, 2010; Gujarathi, 2008; Gupta, 2010; Machado, 2009; Panchal, 2007; Piper, 2013; Plumber, 2010; Saigaonkar, 2010; Shankar, 2005; van Vleet, 2004; Zhou, 2012, Yuan 2013).

The Reverse Auction Bidding system, is considered by some to be a new variant for the older Dutch auction (van Vleet, 2004). RAB has become a widely used tool in the construction industry. The general opinion about these electronic reverse auctions bidding systems is that it reduces the cost and the cycle time for the purchasers for goods and services. For example, GE, one of the largest electronic companies in the world, has stated that it reduced procurement costs due to this method (Presutti Jr, 2003). This is of course not yet proven.

Like all new bidding systems, myths have arisen about the practice. Schoenherr and Mabert's (2007) graph enumerates some of the myths about reverse auction as shown in Figure 1.

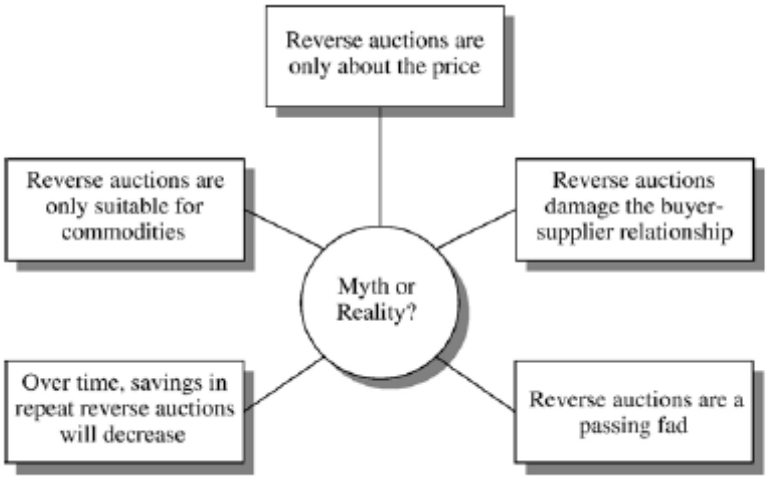


Figure 1: Common myths associated with online reverse auctions (Schoenherr & Mabret, 2007)

Taking the myths for left to right, it works for more than commodities, savings must decrease, price is the controlling factor, but the lowest price expected by the purchaser is not achieved, refer to the work by Guhya on this point(Guhya)

Plusgrade is a software solution company who currently serves 13 airlines globally with software's where there is a direct application of reverse auction bidding. These airlines using this technique allow economy class passengers after booking their ticket to bid for Business and First class tickets; the seat is allotted to the customer who most satisfies the criteria set by the Airline Company. The point is to maximize the return and allow the market to dictate prices, which is always more economically efficient than presetting a price (Hartford, 2005).

Other Auction Types

This section presents a summary of other auction types and issues associated with the system including:

- Traditional Types of Auctions
    - English Auctions
    - Dutch Auctions
    - Sealed First Price Auctions
    - Vickrey Auction
    - Other Types of Auctions
    - Reverse Auction Bidding
- Reverse Auction Bidding in Construction Industry
    - Posited Savings for RAB
    - Procured Items
    - Legal Issues
    - Buyer to Seller Relationship
    - Reverse Auction Bidding Myths and Reality
    - Influence of Personality Types to Reverse Auction Bidding Outcome
- Mathematical Theory of the Reverse Auction Bidding
- Bid Arrival Timing and Other Game Issues
- Summary

Traditional Types Of Auctions

An auction is an activity where one can procure goods and services through the use of a bidding mechanism. Traditional auctions are based on long-standing theoretical foundations and tested empirical work (Parente, 2008) . There are different kinds of traditional auctions and Klemperer (1999) classified four main types of auctions. These four auctions are English auctions, Dutch auctions, sealed first price auctions and the Vickrey auctions.

English Auctions

Also known as Forward auction or ascending auction, English Auction is the most commonly used form of auction. It is suitable for limited supplied goods or unique sold items (S.Wamuziri, 2009). In English auction, the offering procedure was begun with the most minimal satisfactory cost for vender, normally the store cost. Each one offer after that point must surpass this cost.

Thus, a vender could keep the thing from offering for short of what this store cost, where it has been set at the start of the bartering. Bidders then start offering over the things against one another by setting higher cost than the last offer. The sale ends when no more bidders are eager to offer a higher cost. Additionally, the thing offers at the most elevated offer. A dealer will hold the things, if the last offer cost does not surpass the opposite cost.

The notable characteristic of English auction is that each bidder knows the level of the current best bid during the whole auction process (McAfee & McMillan, 1987).

This type of auction is used to sell antiques or artworks. The point is to maximize returns by allowing the market to establish the price points (Hartford, 2005). As you would expect for these types of auctions for topline artwork the market has developed to a few centralized locations in England and New York.

Dutch Auctions

Dutch auction, also called multiple items auctions or open descending price auction (Krishna, 2009), is named for the Dutch tulip auctions. It is an opposite kind of closeout when contrasted with the English closeout. The merchant at first calls a high cost. Merchant will always bring down the cost through each one round of offer until a bidder is at last ready to acknowledge this cost. The Dutch closeout relates the value paid to the time of the bartering. Specifically, the more extended the closeout goes on, the bring down the cost.

In a Dutch auction, judicious bidders dependably have their own particular obviously satisfactory valuation of the thing available to be purchased. The closeout starts with a value, which is definitely over this valuation, while the bidder continues holding up. Once the progressively let deal value descends and achieves this sum, a purchaser may acknowledge this offer however get a zero benefit. Holding up more to offer a lower cost will expand the bidder's benefit. However, this behavior provides the economic risk that the bidder may end up losing the item to another bidder (S.Wamuziri, 2009).

So Dutch auctions drive bidders to contemplate their valuation of the thing before the sale and act unequivocally while offering. This type of auctions is often used for

perishable items (McAfee & McMillan, 1987) like flowers in the Netherland, fish in Israel, tobacco in Canada, and used furniture. These things are utilized by regional standards, as opposed to the art auctions, where the item may wind up at any area on the planet that a significant craft gatherer decides to live.

Sealed First Price Auctions

Sealed first price auction is a first price sealed bid auction (FPSB). Different from English auction, all bidders just simultaneously submit only one bid (Krishna, 2009). Like the English auction, the thing goes to the highest bidder. Frequently, a vender will pick the victor haphazardly from the individuals who name the same most astounding offer, if there is a tie. The fundamental rule of sealed first price auction is that all bidders could not know the bid information of other competitors before the end of the auction and also couldn't adjust their own bids according to other's bids (McAfee & McMillan, 1987). In sealed first price auction, the bidder gets three options. They are

- to bid his/her full valuation
- to bid a shaded value of the full valuation
- to bid considerably under the valuation(S.Wamuziri, 2009).

Option 3 may lead the bidder to losing the offer to their rivals, while option 1 could pick up the bidder no benefit if their offer was effective. Thus, balanced offering procedure for fixed first value closeout ought to be offering with a shaded estimation of the full valuation. With this approach, the bidder could make a benefit and win the offer in the meantime. The bidder picks up more benefit with higher shaded worth held. An excess of shaded quality may build the danger of losing the offer.

So, this kind of auction forces bidders to guess the valuation of others' and bid a little more than this amount (S. Wamuziri & Abu-Shaaban, 2005). This auction was used for construction procurement in UK. Construction there is often based on the work by the Quantity Surveyor who provides an estimate of the construction costs to the purchaser (RICS, 2000); this system has a number of economic advantages for the purchaser in having:

- a pre-bid estimate from an estimating expert
- a consistent set of quantity take offs guaranteed by an independent expert
- a standard for the quantity methods that is agreed across the industry
- a document that has been tested in the courts

Vickrey Auction

Fixed second value auction is like fixed first value auction, where all offer will be fixed and uncovered in the meantime. What makes them distinctive is that the winner of this sort of auction just needs to pay the second most highest value offer other than the most astounding one. It is likewise called Vickrey closeout to celebrate the economist who first set forward that this sort of activity as it pushes every bidders to offer their actual valuations (S. Wamuziri, 2009). By and large, the best procedure of fixed second value auction is to offer the genuine quality, which is indistinguishable to English closeout. However, they have different information transparency (S. Wamuziri, 2009), since sealed second price auction needs information transparency.

In addition, each bidder is in a passive condition. As a result, sealed second price auction is seldom used in practice. A sealed second price auction is a very good tool to

model bidder‘s behavior, since bidder needs to bid their true value. Vijay (Krishna, 2009) pointed out that sealed second price auction is in some ways similar to proxy bidding system, which is used by Internet auction site like eBay. In eBay, a bidder who bided the highest is awarded the bid by actually paying the current highest bid plus the current bidding increment (Krishna, 2009).

Other Types Of Auctions

Other than those four sorts of auction said above, there are still some different sorts, in the same way as Japanese auction, Take-it-or-leave-abandon it auction and Candle auction. In a Japanese auction, the value ascends through each one round of offer. Every bidder shows on the off chance that they are ready to stay at the current value level for each one round. When a bidder stops, the bidder won't reemerge the auction. In Take-it-or-abandon it auction, the vender proclaims the cost of each one task, and bidder can pick acknowledge ("take"), which heads the end of auction, or reject ("leave") the offer, after which dealer goes to the following. The clear advantage of this type of auction is that protect the private valuation information (S. Wamuziri, 2009). In Candle auction, the bid is awarded to the last bid price before a candle burns out (S. Wamuziri & Abu-Shaaban, 2005). This is similar to the RAB where a timer runs out.

Reverse Auction Bidding

Reverse Auction Bidding is a relatively new type of procurement method, where the roles of the bidder and seller are reversed. This has been studied for about 20 years. And is regarded as an internet-based system. This new type of auction was known as Business-to-Business (B2B) Reverse Auction in mid-1990'online (Schoenherr &

Mabert, 2007). The establishment of Web auctions as a tool to facilitate exchanges between buyers and suppliers is evolving as a new business prototype. It was after this experiment, a part of the Naval Supply Systems Command, in May 2000, tried Reverse Auction Bidding (Mabert & Skeels, 2002).

During the same time, many Fortune 1000 companies began tasting the benefits this new method of procurement (Emiliani & Stec, 2001). Web auctions of products like service or commodities are using sophisticated advertisement techniques to display the product being offered for sale. United Airline has started an online auction system for first class upgrade, this system has two similarities with Reverse Auction Bidding, the first one is that a group of bidders make offers for a special seat, the other one is the United Airline will select the best offer to maximize their returns, which is also the market driven for Reverse Auction Bidding. The overall expectation from this published research is that the overall average price for bids obtained using the Reverse Auction Bidding Process would be lower than a hard bid system.

This statement has not been shown to be correct at this time, nor is ever likely to be provable.

Reverse Auction Bidding in Construction Industry

In construction, the use of Reverse Auction Bidding is increasing. At a scheduled time, the owners open a bidding site with a "game" and bidders who are interested in the project submit their price to the web-based system. Then the web-based system posts the prices on the site for all bidders to compete. Contractors can lower the price to win the bid in a certain period of time. Compared to traditional sealed bidding, in which all bids

from other bidders are kept confidentially, Reverse auction bidding provide opportunities for subsequent bidding after prices are open (Shankar, 2005).

Some corporations use the Reverse Auction Bidding method to buy their construction materials. For instance, the Minnesota Department of Administration procure the construction products with the RAB method. In addition to the purchase of commodities, in a recent case, Pennsylvania's Department of General Services also use the RAB technique procure construction services.

Several private companies, such as Target have used Reverse Auction Bidding systems (Shankar, 2005; Yuan, 2013).

Posited Savings for RAB

One study indicated that a properly executed reverse auction has the potential to save an additional 8 percent to 20 percent cost for an organization below its current price (Guillemaud, Farris, & Hooper, 2002). The Minnesota Department of Administration benefited from the use of RAB, which enable the Minnesota Department of Administration drop the price of the aluminum it purchased from $1.555 per pound $1.029 in 45 minutes. The state achieved a saving of $150,000 for taxpayers about over the course of five years. As summarized by the state, "A reverse auction gets to the absolute lowest price a vendor will offer, as opposed to a bid price [under the traditional sealed bid approach] that might not be the bottom line price" (Shankar, 2005)

RAB has its own flaws or challenges to not only sellers but also buyers, everything has two sides. Strategic relationships and partnership between buyers and sellers might be impaired. "Because of excessively focusing on price, the online reverse

auction has caused a move away from the close partnerships that were once successfully working for both buyers and sellers. An empirical study concluded that high emphasis on two main benefits of reverse auctions, purchase price reduction and time savings (procurement process efficiency), negatively impact the buyer-seller cooperation and sellers' strategic relationships" (Pearcy & Larry, 2007). In order to win the bid, a seller has to lower its margin to a bare minimum. With such a low margin, there is no room for any adjusting and adapting to unforeseen situations. It can jeopardize long term buyer-supplier relationships; reduce the suppliers' trust and cooperation. Ultimately, it can even lead to the erosion of the supply base and result in less competition and higher prices.

Figure 2 clearly shows the problems with these claims. Results from earlier studies showed that the bidding set *L* has a distinct non-normal distribution when the data is normalized.

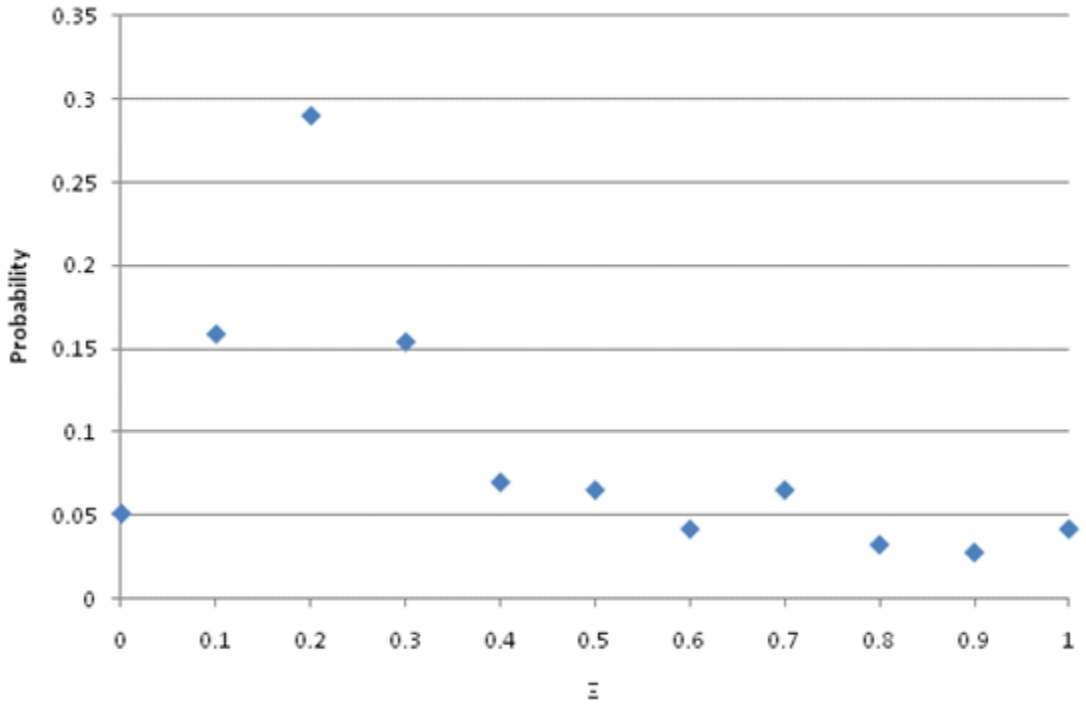


Figure 2: Normalized profit data for two earlier studies, after Saigaonkar (2010)

A good game strategy can provide some players with returns higher than the average. Anecdotal evidence on Reverse Auction bidding shows that this happens in real systems. In terms of game theory, an auction can be considered a game between players. One player, υ has a good for sale in a traditional auction and a good to purchase in a reverse auction.

The other player, λ is typically a group that is bidding to purchase the item in a traditional auction or sell the item in a reverse auction. The λ player derives from the concepts put forward by Church (1941). The λ player sees a different statistical distribution set for each player in the λ group, but the υ merely observes one statistical distribution set. These statistical distribution differences form the basic element to this

research work, as the point is to develop a machine bidder that outbids all human bidders, but is humanlike (Abelson, Sussman, & Sussman, 1987; Winston & Horn, 1989).

Procured Items

The discussion, which questioned the feasibility of Reverse Auction Bidding of all kinds of products, has never stopped. Some researchers (Mabert & Skeels, 2002) studied some cases and concluded that Reverse Auction Bidding could not be suitable for every purchasing contract. Products, like strategic items and direct inputs, are not that accessible to Reverse Auction Bidding due to their long-term contract requirement or oligopoly among sellers, (Schoenherr & Mabert, 2007). The suitable ones included complex and highly-engineered items (Wagner & Schwab, 2004) or standard projects. Jap (2002) put forward that the only suitable products should be commoditized products.

Schoenherr & Mabert (2007) explore this myths that Reverse Auction Bidding is commodities-products-only auction. They suggested having Reverse Auction Bidding for non-commodities products by refining the RFQ order, conducting market research and analysis, defining detailed and specific attributes of projects, and using specialized third-party consultant.

Legal Issues

As a new modern method of procurement, Reverse Auction Bidding attracted more and more attention from manufacturing and service sector business and government agencies. Its popularity also raised the concern of its legal and contractual issues. Research dealing with legal issue indicated that there was some unfair trade

practice (Engel & Emiliani, 2007) during Reverse Auction Bidding. The unfairness came from the unequal positions of buyer and sellers.

Sellers were facing sort of coercion in Reverse Auction Bidding. Horlen, Eldin, & Ajinkya (2005) analyzed the future legal challenges of Reverse Auction Bidding in terms of some legal grounds, like Federal Trade Commission, Anti-Dumping Act of 1916, Robinson-Patman Act, Clayton Antitrust Act and Business Method Patents.

Reverse auction was banned by the Federal Acquisition Regulation (48 CFR 245.610 and 48 CFR 15.610), because some flaws in legal performance (Merson, 2000), however, the prohibition was later removed. Though legal challenges existed in Reverse Auction Bidding awarded contract, Reverse Auction Bidding is still appealing to public buyer, like large international companies and government. The state of Texas, Pennsylvania, Kansas, New York State, Missouri, Minnesota, and Wisconsin (Horlen et al., 2005) had approved the legislation to allow Reverse Auction Bidding.

Economically the system is transparent and one could argue fair for all parties, provided that a coercive relationship does not exist or the game is not rigged, (Giampietro & Emiliani, 2007).

Buyer to Seller Relationship

Since price became the relatively decisive element in Reverse Auction Bidding process, the expected side effect is the negative impact Reverse Auction Bidding might bring to the buyer-supplier relationship. It is possible that buyer may omit the non-price elements like reputation, quality and previous partnership etc. This may result in deterioration of previous seller-buyer partnership. People question whether Reverse

Auction Bidding can be used in procurement, which requires long-term seller-buyer relationship. Reversed auction was recognized to bring new business to new sellers who could offer lower price, while making current seller annoyed at losing the hard-won long-term business (Emiliani & Stec, 2005). Due to its price oriented characteristic, Reverse Auction Bidding could lead to profit margin erosion (Emiliani & Stec, 2004) and coercion to sellers. In construction industry, seller-buyer partnership could be impaired when contractors, who won the contract with lowest price in Reverse Auction Bidding, would charge higher prices for change orders and extra work if client ordered, in order to keep their profit margin (S.Wamuziri, 2009).

While some researchers tried to refute by putting forward the idea that Reverse Auction Bidding could potentially benefit both sellers and buyers at the same time. Some researchers suggested that buyers, who need collaborative and long-term relationship sellers, can use Reverse Auction Bidding as a process improvement tools to check market price instead using it as a price weapon (Smart & Harrison, 2003). Also, the buyer-seller relationship can be kept fair to all by prequalifying bidders with non-price elements, detailing RFQ, providing education, training and assistance to bidders during Reverse Auction Bidding process (Schoenherr & Mabert, 2007).

An important economic observation is when all things are equal the prices should be the determining factor (Hartford, 2005) for projects funded by shared equity. Reinisch (2011) showed the problems with alternative bidding systems.

Reverse Auction Bidding Myths and Reality

Schoenherr and Mabert (2007) studied 30 case studies for companies that had participated in RAB systems, which enable them investigate the most common myths related with Reverse Auction Bidding. They discussed myths for Reverse Auction Bidding:

- Reverse Auctions are only about the price;
- Reverse Auctions are only suitable for commodities;
- Reverse Auctions damage the buyer-supplier relationship;
- Savings in Reverse Auctions will decrease;
- Reverse Auctions are passing fad.

Figure 1 shows the current myths about reverse auction in the industry. Schoenherr and Mabert (2007) studied the reality vesus the myths based on their study of 30 companies.

The findings are:

- While a lower price is one objective in reverse auctions, it is often not the most important one, and can be easily complemented with non-price attributes
- While commodities are usually easier candidates for reverse auctions, non-commodity items can also be put up for bid successfully
- While reverse auctions can hurt buyer–supplier relationships, there are many ways to prevent that from happening
- While first-time bidding events likely result in higher savings, continued cost advantages are possible

- While reverse auctions will not be used as much as in the past, they are here for the long-run.

Influence of Personality Types to Reverse Auction Bidding Outcome

Students from Texas A&M University have conducted studies on RAB for the last decade. The research was commenced by van Vleet (2004), the theoretical basis of the study is the simulated bidding process which reflected the project of supply of slabs in Houston. In the following year, Shankar (2005) tested the methods from van Vleet's study and showed that the results could be replicated. Rogers (2010) suggested that personality may have an impact on returns.

Further studies have been conducted by Machado (2009) and Saigaonkar (2010) at TAMU to analyze the bidders' personality impacts on the results. The work is based on the Keirsey Temperament Sorter test. Keirsey Temperament Sorter is a self-assessed personality questionnaire designed to help people better understand themselves and others. The test and scoring method are presented in Appendix A and B respectively.

The Keirsey Temperament Sorter test has seventy-one questions, and identifies sixteen types of personalities that fit into four groups SJ - The Guardians, SP - The Artisans, NT – The Rationales, and NF - The Idealists. The sorter matrix for this is shown in Table 1.

Table 1:

Keirsey Temperament Sorter Matrix

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

Table 2:

Summary of the Individual Components of the Different Personality Types

#	Name	Meaning
E	Extraversion	Feel motivated by interaction with people. Tend to enjoy a wide circle of acquaintances, and *gain* energy in social situations
N	Intuition	More abstract than concrete. Focus attention on the big picture rather than the details, and on future possibilities
F	Feeling	Value personal considerations above objective criteria. In 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 *expend* 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

This research has shown tentatively that the major personality type of Guardian always gives best performance in comparison to the other personality types. But in the recent study conducted by (Piper, 2013), three guardians are beaten by an idealist. This requires further studies and demonstrates the complexity of the personality problems. A significant amount of work has been completed on personality impact at TAMU, clearly personality is one factor that affects performance.

Mathematical Theory of the Reverse Auction Bidding

The earliest research was interested in the ethical issues associated with Reverse Auction bidding systems. The main conclusion is that a purchaser is free to use a RAB system to purchase good, there are however several issues:

- If only a single bid is submitted it is not likely to be at the lowest cost
- Single bids occur frequently even in competitive games
- humans make mistakes and miss things

This mathematical theory has been used to review a number of case studies completed at TAMU, both with graduate students and now a set of four professional estimators (Piper, 2013). (Guhya, 2010) defined the bidders as Type ξ to represent a more economically effective bidder and as Type ζ to represent a less economically effective. Nichols (2010) defined Type ϕ Bidder as bidders who is within the middle of the range for complete the set L . Type ϕ have not yet been formally and statistically observed (Nichols, 2010).

(Guhya, 2010) also discussed the Mathematical Theory of the Reverse Auction Bidding. Consider a Reverse Auction Bidding game where the υ player is willing to accept bids of the type shown in equation (1):

$$\mathrm{B}_j = \mathrm{K} + \Xi_j \Gamma , \tag{1}$$

Γ Represents the upper limit the υ player is prepared to pay in the game above the nominal minimum bid amount K. A negative Ξ represents a loss on direct costs to the λ_i 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 Professor Feigenbaum (Guhya, 2010), who considered there had to be an upper limit everyone was prepared to pay for a service or good.

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

$$\mathrm{B}_v = \sum_{j=1}^{n} \mathrm{B}_j , \tag{2}$$

This total cost is based on the accepted lowest bid for each job, where a valid bid was submitted by the λ player. 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 results of this statistical analysis using equation (1) and (2).

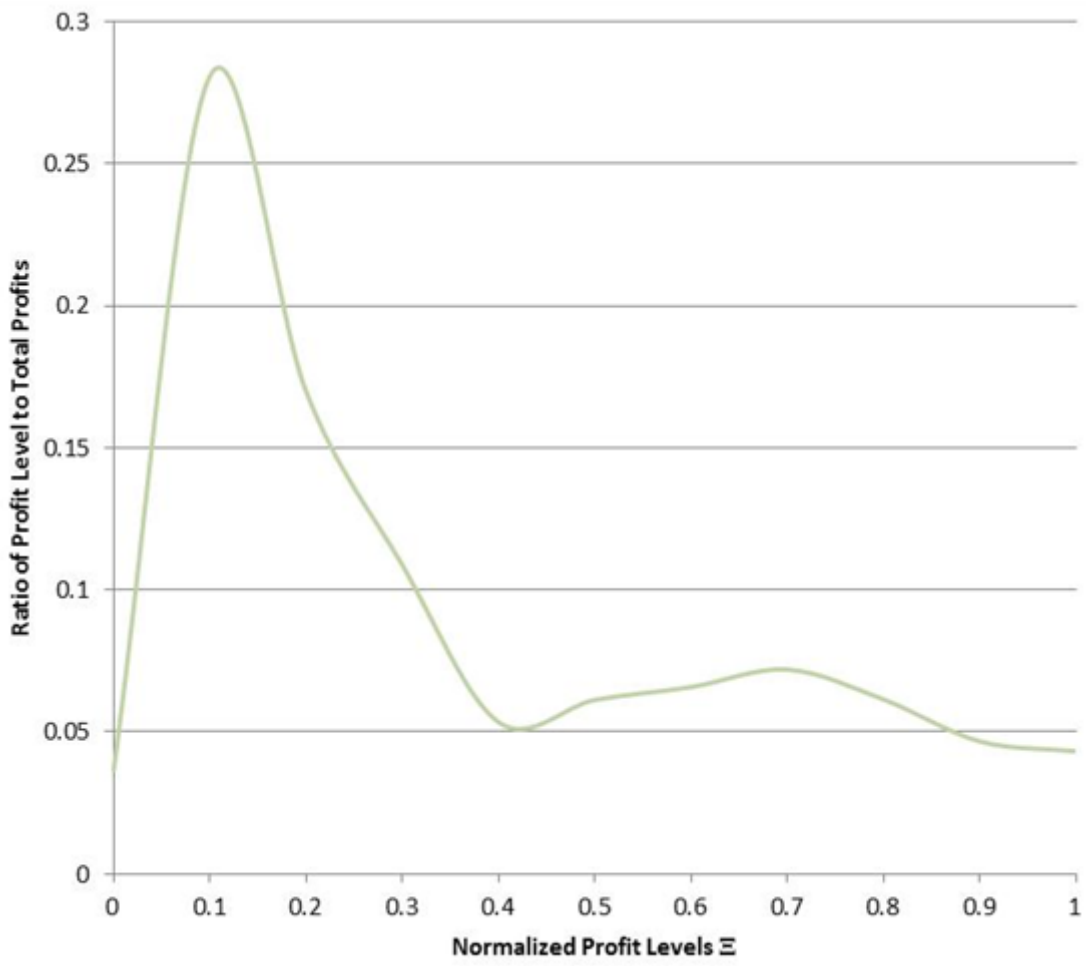


Figure 3: Normalized profit levels for the four player game

There are clearly two elements to the distribution, which has been consistent across game play from the earliest studies.

Current Analysis

The current stage in the analysis is to analyze the statistical properties of the profit drop on each bid, where the lost profit on a bid is defined as Δ_L^k . It is postulated that the

statistical analysis of the sets of lost profit, Δ_L^k , data will provide an indicator of the quality of the players. The data set of interest is shown in equation 3.

$$\mathrm{B}_j^i = B_{j-1}^i - \delta_j^i, \tag{3}$$

Bid Arrivals

A research group has studied the arrival time of eBay bidding (Shmueli, Russo, & Jank, 2007). They stated that the arrival time of eBay bidding will fit the BARISTA model. The BARISTA (Bid ARrivals In STAges) is a three-stage nonhomogeneous Poisson process. The first stage is "espresso stage" (short and intense), in which the biding start. The second stage is called macchiato stage" (stained), which is during the mid-auction period with increasing intensity. The third stage is last moment of bidding, called "ristretto stage" (extra intense). In this stage, there are extremely intensive activities. This study gives instructions about the best time to bid. A Poisson process is a special type of Markov process that happens in a fixed consecutive time period (Boxma & Yechiali, 2007). As a continuous-time process, it is a mathematical model of a completely random series of events (Cox & Lewis, 1966).

Yuan (2013) analyzed 6674 reverse auction bidding bid arrival times for nine previous TAMU reverse auction bidding case studies. Table 3 shows the individual Reverse Auction bidding games used by Yuan.

A Poisson process counts the numbers of occurring events along the timeline and the time of the occurred events in a certain time interval. According to its characteristics, it is also a type of point process of the real half line. Yuan as can be seen in Table 3 found that the results show that the Poisson process model for the arrival times fits the

non-homogeneous Poisson process (NHPP) model. The results from her study have the similar heterogeneity in RAB bidding dynamics to the situations of eBay online auction that were studied by others (Russo, Shyamalkumar, Shmueli, & Jank, 2004; Shmueli, Russo, & Jank, 2004; Shmueli et al., 2007).

Table 3:

Reverse Auction Games Studied by Yuan

Experiment Date	Researcher ID	No. of Contractors	No. of Section	No. of Projects	No. of Bids
5/4/2004	1	5	8	86	773
5/29/2006	2	4	25	118	192
6/4/2006	3	9	13	156	1077
11/5/2007	4	4	5	43	346
4/6/2010	5	5	8	54	804
4/3/2010	6	37	10	179	776
6/8/2010	7	4	10	97	865
6/10/2010	8	4	9	92	759
6/11/2010	9	4	9	91	1082
TOTAL	9	76	97	916	6674

Figure 4 shows a plot of the bid arrival times for the ninth case study, completed in November 2010. The data shows the bids pack into the higher end of the bidding time of 900 seconds, with most bids in the period 700 to 900 seconds.

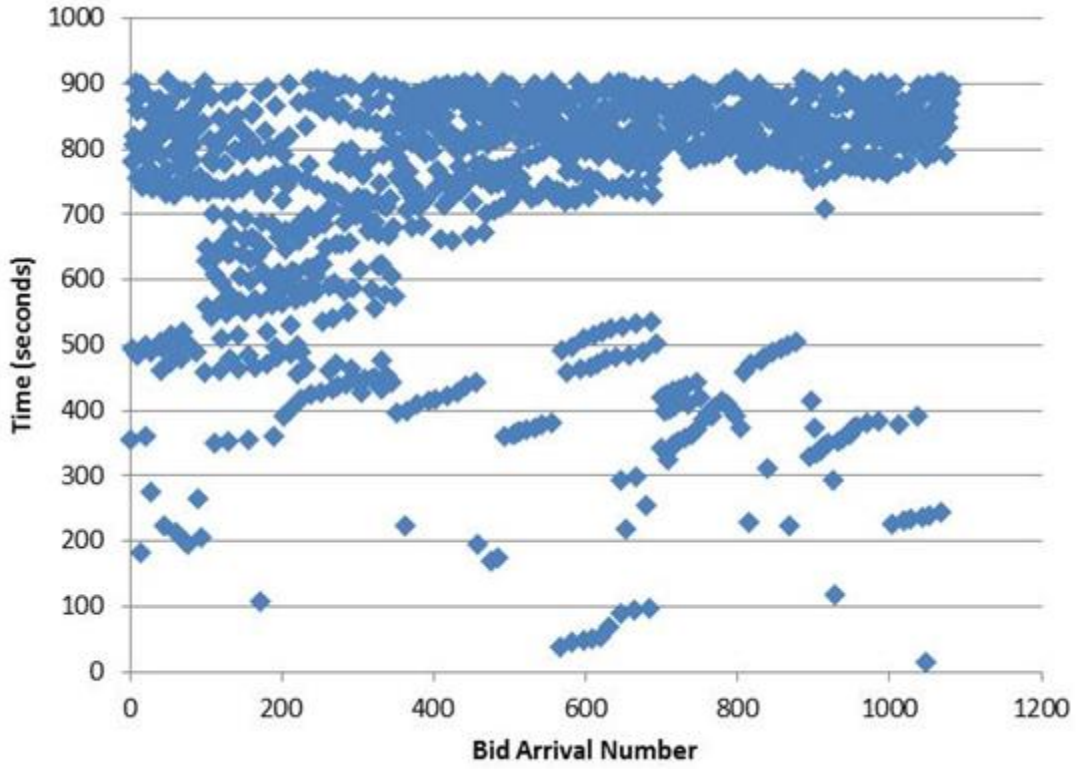


Figure 4: Bid arrival time data for case study nine

Yuan had divided the 900 seconds of game play into 180 intervals of five seconds each. She counted the arrival times for each 5 second interval for the complete data set. The results are plotted in Figure 5. The process has a theoretical upper limit of infinity, but one is constrained by the speed of human typing. Yuan in a simple study showed that a cutoff number of bids per second existed and determined this value. She showed that the upper limit of 140 matches the value reasonably.

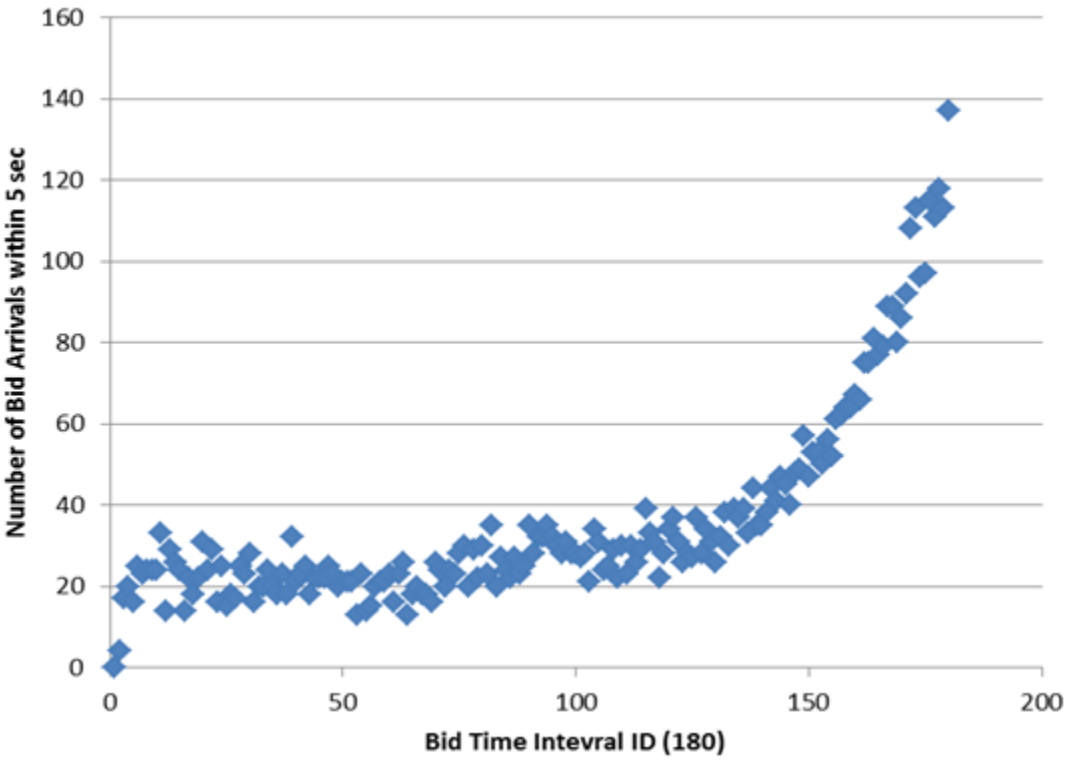


Figure 5: Bid arrivals for complete set

The author concluded from the analysis that reverse auction bidding bid arrival times follows a Poisson process, as for the eBay data (Shmueli et al., 2007).

One of the main issues over the last decade, relates to the issue of timing. The game is played on the internet, the clock time on the various devices may be different and most likely are, causing issues on determining "finish time" for each game. This is not a trivial issue, and one that should be of concern to all involved in such games.

Summary

As an innovative procurement method, the application of RAB is increasing and developed. This literature review introduces existing procumbent methods and their characteristics. Previous researched mainly studied on its external effects of RAB, such

as potential savings, the applicable industry, related legal issues and effects for the relation between buyers and seller. Further studied discussed the advantages of Reverse Auction Bidding, which mainly discusses the cost savings; while, the some researchers also imply that Reverse Auction Bidding has its flaws, such as impairing the long-term seller-buyer relationship.

The published article studying RAB dynamics (biding strategies and bidders' performance) is rare, while some researchers studied the eBay auction performance. Because the eBay online auction and the Reverse Auction Bidding have significant similarities in bidding process, this literature review referred some studies on eBay online auction. Russo (2010) has studied the arrival time of eBay bidding. She stated that the arrival time of eBay bidding will fit the BARISTA model. The BARISTA (Bid ARrivals In STAges) is a three-stage nonhomogeneous Poisson process. The first stage is "espresso stage" (short and intense), in which the biding start. The second stage is called macchiato stage" (stained), which is during the mid-auction period with increasing intensity. The third stage is last moment of bidding, called "ristretto stage" (extra intense). In this stage, there are extremely intensive activities. This study give instructions about the best time to bid. Yuan (2013) analyzed the bidding data of Reverse Auction Bidding from previous 9 experiments from TAMU, and the results have the similar heterogeneity in RAB bidding dynamics to the situations of eBay online auction that were studied by other Russo (2010). van Vleet (2004) started the ongoing study of Reverse Auction Bidding at Texas A&M University. This research continues today with twenty-four studies completed to date. The theoretical basis of the RAB study is the

simulated bidding process, using the supply of house slabs in Houston. The work is repetitive and simple, the participant is assumed to have a work capacity of three slabs per week, a rain element is introduced to provide a random element to the ability to complete work and the bank is willing to increase additional capacity for a fee, although for historical reasons the fee is termed a loan.

Not all of the studies are suitable for use in this study, because of constraints introduced by the research question of interest to a particular study, such as owner's interference. Nine studies had data suited to this study.

Studies have been conducted by Machado (2009), Guhya (2010) and Saigaonkar (2010) at TAMU to analyze the bidders' personality impacts on the RAB returns. The studies are based on the Keirsey Temperament Sorter test. There have been studies in the areas of game theory, tacit collusion among bidders, the significance of personality, the RAB game for the role variants of guardians in different types of industrial and some specific cases studies.

CHAPTER III

METHODOLOGY

The Reverse Auction Bidding System used for this research has developed through three stages as follows:

1. An Access database and ASP system was used for the earliest studies (Shankar, 2005; van Vleet, 2004)
2. Gregory (2006) found that with ten bidders attempting to access the system simultaneously that the Access database failed to allow access to all participants. Wellington developed a SQL Server based version of the ASP website.
3. Nichols in 2013 developed an ASP.NET MVC4 (Piper, 2013) front end for the SQl Server database. The purpose of this revision is to improve the time taken to analyse the data.

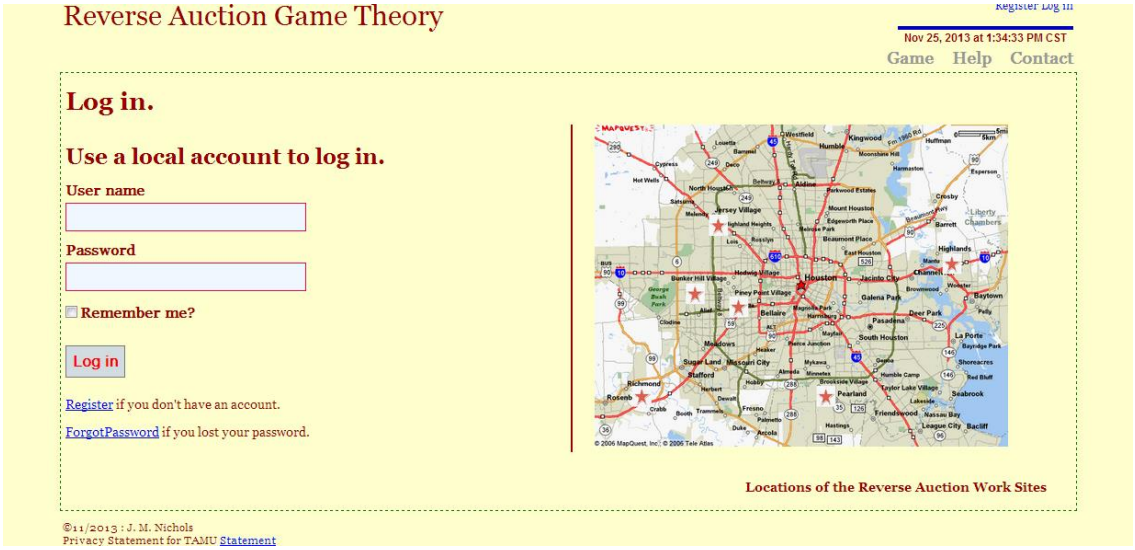


Figure 6: Reverse Auction Bidding Logon Screen

The game rules are:

1. Each game last twenty minutes
2. Each bidder has access to the site using a controlled login id and password, as shown in Figure 6.
3. Game play lasts for 15 minutes followed by five minutes of break
4. A set of dice are used to determine the number of games per week with the minimum equal to the number of dice and maximum three times the number of players
5. Each bidder has the capacity to bid on three jobs and is given a bank amount of $40000 at the start of the game.
6. Conditions are assumed to be economically stable
7. Price controls exist to stop low bids and extremely high bids, this is based on work by (Gujarathi, 2008; Panchal, 2007) on price ranges for staple goods.
8. The work is assumed to be house slabs for a homebuilder, which is repetitive work on six sites located around Houston as shown on Figure 7, the detailed locations are mentioned in Table 4.

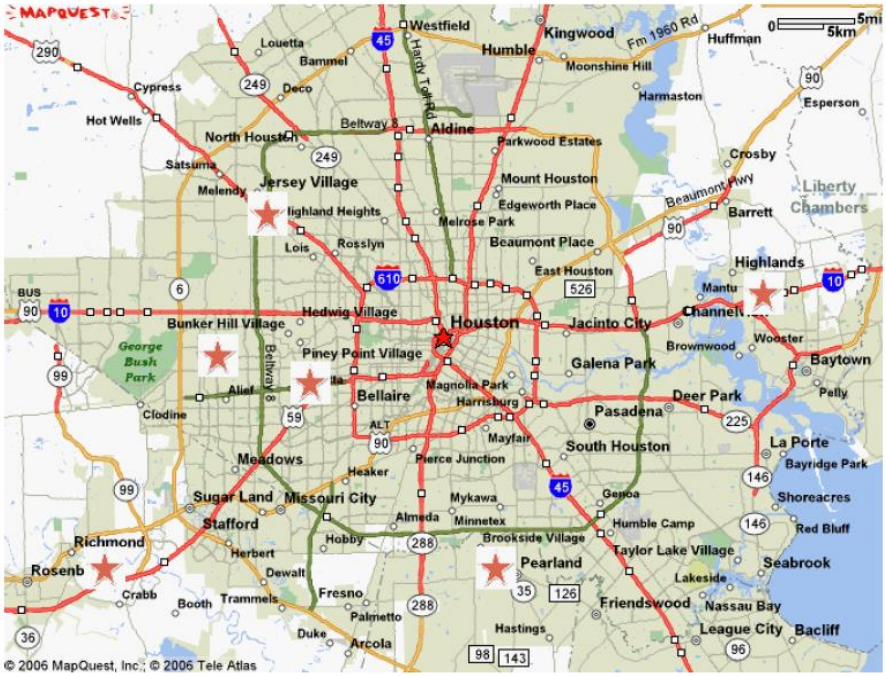
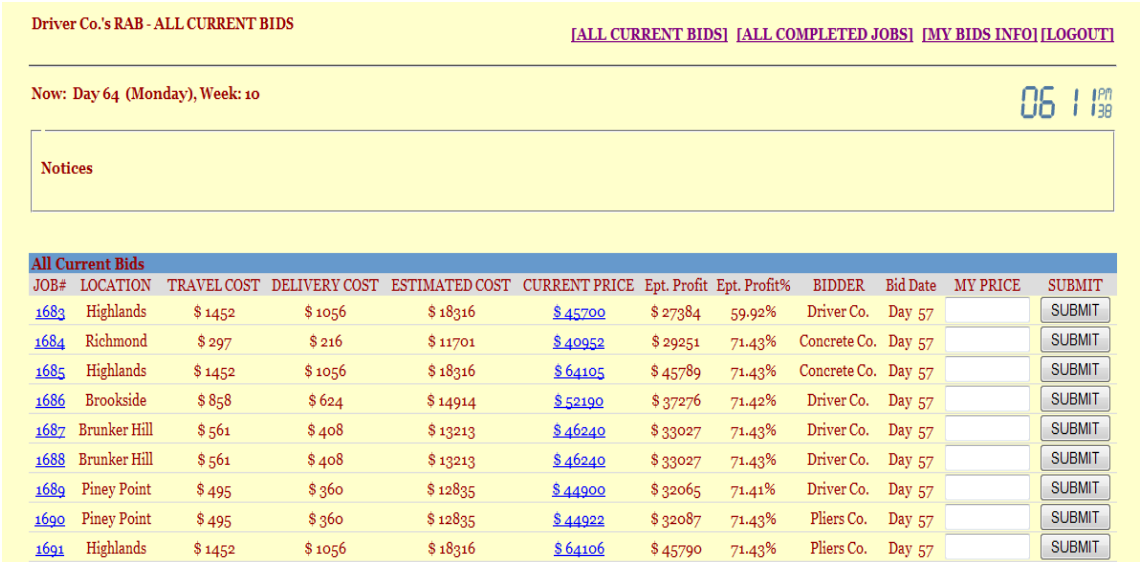


Figure 7: Construction Site in Houston (after MapQuest, 2006) (Guhya2010)

Table 4:

Location of the Construction Sites in Houston (Guhya, 2010)

Site #	*Location of Development*	*Distance from Sugarland (kilometres)*
1	Brookside Village	41.6
2	Piney Point Village	24
3	Highlands	70.4
4	Jersey Village	40
5	Bunker Hill Village	27.2
6	Richmond	14.4



Driver Co.'s RAB - ALL CURRENT BIDS

[ALL CURRENT BIDS] [ALL COMPLETED JOBS] [MY BIDS INFO] [LOGOUT]

Now: Day 64 (Monday), Week: 10

06 1 PM 38

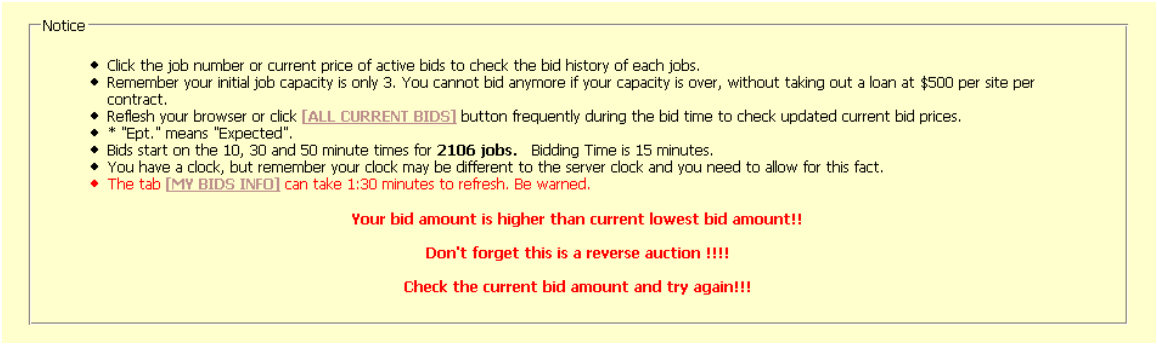
Notices

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		SUBMIT
1684	Richmond	$ 297	$ 216	$ 11701	$ 40952	$ 29251	71.43%	Concrete Co.	Day 57		SUBMIT
1685	Highlands	$ 1452	$ 1056	$ 18316	$ 64105	$ 45789	71.43%	Concrete Co.	Day 57		SUBMIT
1686	Brookside	$ 858	$ 624	$ 14914	$ 52190	$ 37276	71.42%	Driver Co.	Day 57		SUBMIT
1687	Brunker Hill	$ 561	$ 408	$ 13213	$ 46240	$ 33027	71.43%	Driver Co.	Day 57		SUBMIT
1688	Brunker Hill	$ 561	$ 408	$ 13213	$ 46240	$ 33027	71.43%	Driver Co.	Day 57		SUBMIT
1689	Piney Point	$ 495	$ 360	$ 12835	$ 44900	$ 32065	71.41%	Driver Co.	Day 57		SUBMIT
1690	Piney Point	$ 495	$ 360	$ 12835	$ 44922	$ 32087	71.43%	Pliers Co.	Day 57		SUBMIT
1691	Highlands	$ 1452	$ 1056	$ 18316	$ 64106	$ 45790	71.43%	Pliers Co.	Day 57		SUBMIT

Figure 8: All current bid screen from RAB website

In this game the bidder is only allowed to bid lower than a previous bid as it is a reverse auction. The following warning, will be shown on the screen if a bidder tries to bid a higher amount that the current bid. A sample of current bid screen is shown in Figure 8.



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.
- Reflesh 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.

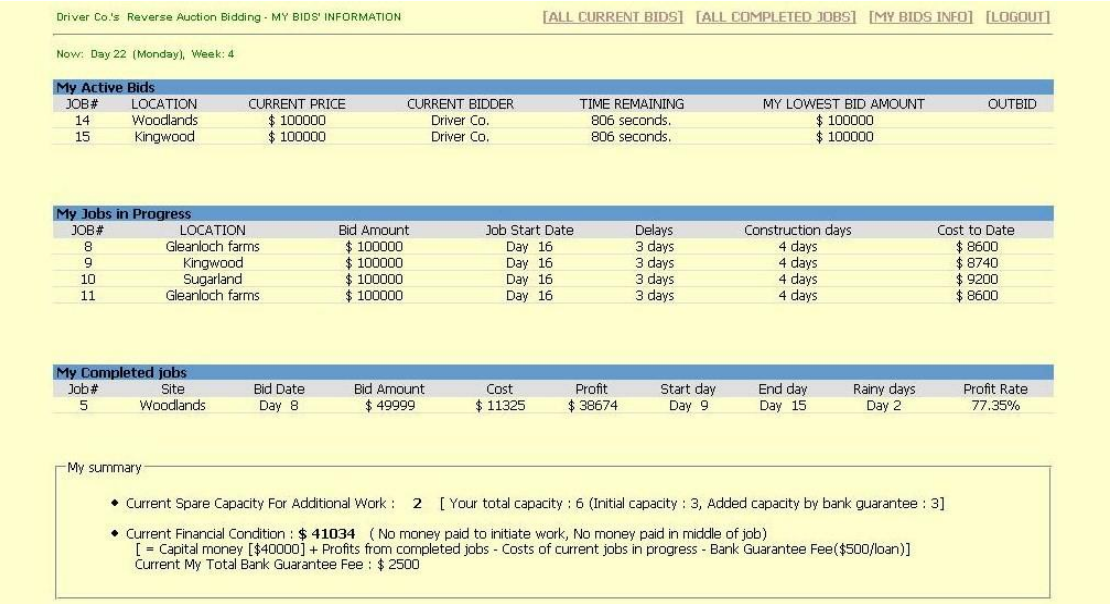
Your bid amount is higher than current lowest bid amount!!

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

Check the current bid amount and try again!!!

Figure 9: Higher than acceptable bid web statement

Figure 9 shows a warning that is seen when the bidder makes an invalid bid. Similar warning message is issued when the maximum number of bids by the bidder is reached as shown in Figure 11. Below in Figure 10 we can see a sample of the Bid Screen during the progress of the game.


Driver Co.'s Reverse Auction Bidding - MY BIDS' INFORMATION [ALL CURRENT BIDS] [ALL COMPLETED JOBS] [MY BIDS INFO] [LOGOUT]

Now: Day 22 (Monday), Week: 4

My Active Bids

JOB#	LOCATION	CURRENT PRICE	CURRENT BIDDER	TIME REMAINING	MY LOWEST BID AMOUNT	OUTBID
14	Woodlands	$ 100000	Driver Co.	806 seconds.	$ 100000	
15	Kingwood	$ 100000	Driver Co.	806 seconds.	$ 100000	

My Jobs in Progress

JOB#	LOCATION	Bid Amount	Job Start Date	Delays	Construction days	Cost to Date
8	Gleanloch farms	$ 100000	Day 16	3 days	4 days	$ 8600
9	Kingwood	$ 100000	Day 16	3 days	4 days	$ 8740
10	Sugarland	$ 100000	Day 16	3 days	4 days	$ 9200
11	Gleanloch farms	$ 100000	Day 16	3 days	4 days	$ 8600

My Completed jobs

Job#	Site	Bid Date	Bid Amount	Cost	Profit	Start day	End day	Rainy days	Profit Rate
5	Woodlands	Day 8	$ 49999	$ 11325	$ 38674	Day 9	Day 15	Day 2	77.35%

My summary

- Current Spare Capacity For Additional Work : 2 [Your total capacity : 6 (Initial capacity : 3, Added capacity by bank guarantee : 3]
- Current Financial Condition : **$ 41034** (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 : $ 2500

Figure 10: Summary of bids screen

Data Structure

There are twenty four research studies completed by previous master's students at TAMU. Eight high quality data sets were used for this analysis. Table 5 summarizes the detailed information about the data sets used in this analysis. Other sets were discarded because of issues including, ten players in the game and owner's interference in the play.

Table 5:

Study List

Study No	Student Name	Participants
1	Van Vleet	5
4	Gujarathi	4
9	Saigaonkar	4
11	Gupta	4
12	Patel	4
14	Plumber	4
15	Bedekar	4
16	Katakam	4

Table 5 shows a sample of the bid data taken from the first study.

The data is stored during the game in a SQL Server database. There are a total of six tables in the database. SQL-Table 1 holds the log data for the people logged onto the computer system. SQL-Table 2 holds the company names and login details. A company name is given to each player so that their confidentially is maintained during the game. SQL-Table 3 holds the job data, including start and end times. The numbers of jobs per week are determined using a set of die. SQL-Table 4 holds the bid data as shown below on Table 6 holds the weather delay data and SQL-Table 6 holds the summary of the

construction details. A number of integer flags are used to control data flow because a web site is essentially stateless (Paz, 2013).

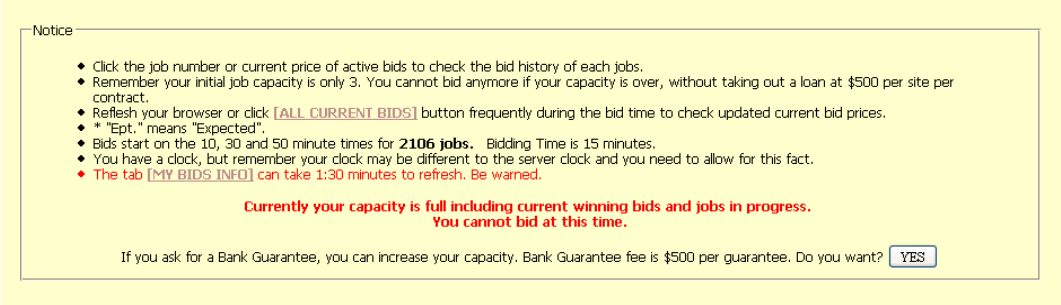


Figure 11: Bank guarantee web form

Table 6:

Bid Data – Sample after van Vleet (2004)

Bid ID	Job ID	Ctr ID	Bid Amount	Bid Date	Bid Time	Bid Status
1	1	9	$15,000.00	1	7:00:20 PM	0
2	1	8	$13,000.00	1	7:00:22 PM	0
3	3	9	$12,000.00	1	7:00:31 PM	0
4	2	8	$14,000.00	1	7:00:53 PM	0
5	1	4	$12,999.00	1	7:01:02 PM	0
6	4	4	$20,000.00	1	7:01:25 PM	0
7	12	6	$12,825.00	1	7:01:28 PM	0
8	2	7	$13,500.00	1	7:01:29 PM	0
9	5	9	$12,000.00	1	7:01:34 PM	0
10	4	7	$15,000.00	1	7:01:36 PM	0
11	1	8	$12,500.00	1	7:01:39 PM	0
12	4	7	$14,000.00	1	7:01:48 PM	0
13	7	8	$16,000.00	1	7:01:50 PM	0
14	2	7	$13,000.00	1	7:01:54 PM	0
15	11	4	$12,700.00	1	7:01:58 PM	0
16	13	6	$20,000.00	1	7:01:59 PM	0
17	6	8	$12,500.00	1	7:02:06 PM	0
18	4	4	$13,999.00	1	7:02:14 PM	0
19	1	4	$12,400.00	1	7:02:21 PM	0

The stored data is:

- Bid Id consecutive integer
- Job Id Job number applied to a particular site and day
- Ctr Id Bidder Identity number used for the program
- Bid Amount Offer
- Bid Date Each week is numbered, 1, 2, 3 etc…
- Bid Time Time that the bid is offered by the bidder
- Bid Status Reserved for program use

Table 7 shows a sample of the control data used for the game. The data is in four groups:

- Identity Number used to record all details in the SQL Server database as the key identity. Five is reserved for system use
- Name, Logon Name and Password. The logon name is usually a simple name such as shown here and does not link to the actual player
- Capacity current weekly capacity
- Loan amount and the amount taken in bank loans

It is suggested for future research purposes that the loan data include the timing of the loan data, so that the impact during particular rounds of the games can be studied effectively. The weekly capacity is recalculated at the end of each week to allow for rain and non-completion of some jobs and at the time of taking out a bank loan.

Table 7:

Reverse Auction Bidding Control Data

ID	Name	Username	Password	Capacity	Loan
1	Doc	Beith	Butcher	3	$0.00
2	Grumpy	Coll	WillGrimm	3	$0.00
3	Happy	Duir	HalfPint	3	$0.00
4	Sleepy	Gort	Napoleon	3	$4,000.00
5			Reserved for system use		
6	Bashful	Muir	Grub	3	$2,500.00
7	Sneezy	Nion	Chuck	3	$8,500.00
8	Dopey	Quert	Wolf	3	$2,000.00
9	Stealthy	Gus	Lenny	3	$11,000.00

Table 8 shows an example of the job and profit details. The data columns are:

- Control ID the contract number to identify each unique job
- ID player identity number, if 5 then not awarded
- Job ID the job identity number in the job list, some jobs may not be awarded
- Cost for the job including base, travel, delivery and site costs
- Profit for the job as a gross profit
- Delay number of days of delay in the job due to rain
- UC reserved for system use

- Begin Date are numbered 1, 2, 3, etc. so a week is seven days, commencing with Day 1 as a Monday, Sunday is observed as a day of rest as is common in the construction industry
- End Date at the end of the contract, if equation 4 is true then there has been no impact on the capacity due to rain

$$EndDate - BeginDate = 4 \quad (4)$$

Table 8:

Profit and Job Data

Control ID	ID	Job ID	Cost	Profit	Delay	UC	Begin Date	End Date
1	4	1	$10,350.00	$1,650.00	0	5	2	6
2	4	5	$10,350.00	$1,400.00	0	5	2	6
3	9	13	$10,000.00	$900.00	0	5	2	6
4	7	2	$10,450.00	$1,650.00	1	5	2	7
5	4	3	$10,450.00	$1,549.00	1	5	2	7
6	6	4	$10,450.00	$1,550.00	1	5	2	7
7	7	7	$10,700.00	$1,600.00	2	5	2	8

Petersen (2010) studied the performance of ξ bidders. The bid amounts for this game are shown on Figure 12.

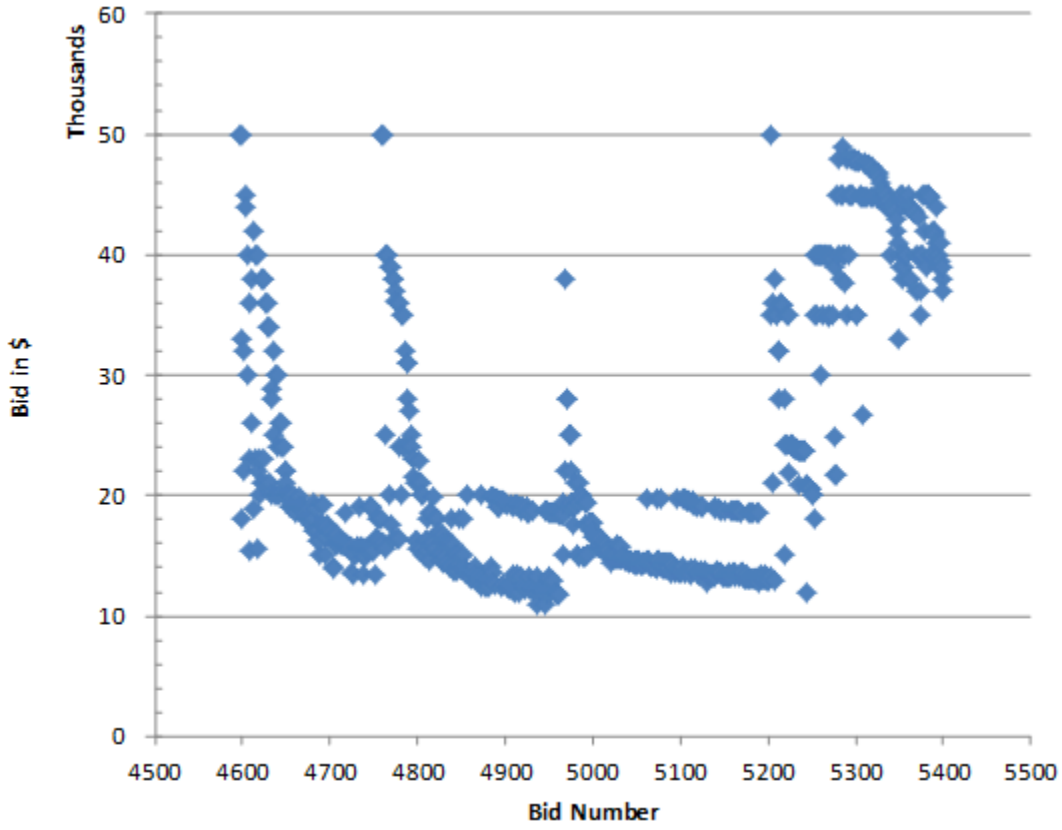


Figure 12: Bid distribution from RAB study ten after Petersen (2010)

Data Analysis

Guhya (2010) developed a number of the techniques used for the analysis of the Reverse Auction Bidding data, based on the work of the earlier researchers. The first stage in the data analysis is to sort the bid data for each different bidder. Figure 12 shows a sample of the bid data from RAB Study Number 10 (Petersen, 2010).

The data of interest is the bid reduction at each step of the play. This data can be collected from a sorted data set.

Table 9:

Game 10 Bid Data Sample

Bid Number	Job Number	Participant	Bid Amount
4750	1368	4	15450
4741	1368	2	15550
4733	1368	4	15582
4730	1368	2	15600
4713	1368	4	15850
4710	1368	2	16000
4708	1368	4	16750
4707	1368	2	16800
4701	1368	4	16890
4700	1368	1	17000
4698	1368	4	17400
4696	1368	2	17500
4691	1368	4	17520
4675	1368	2	18000
4661	1368	4	18500
4653	1368	2	19000
4643	1368	6	19999
4619	1368	2	20000

The price reduction data is collected and then sorted into different bin range: between 1 and 10, between 10 and 100, between 100 and 1000, between 1000 and 10,000, and 10,000 above. Figure 13 shows the counts of the number of bid drops made by Participant 1 in RAB Research Number Four.

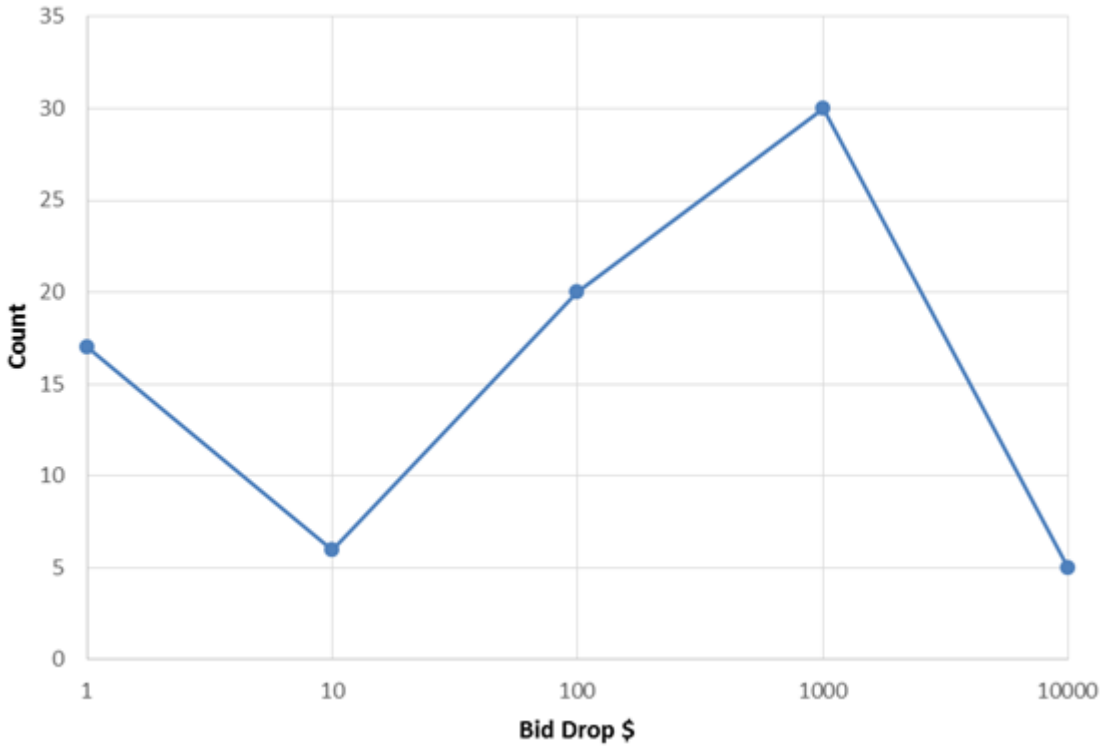


Figure 13: Frequency of different profit level

The figure shows that the bidder reduced the total bid group by $82,077. This represents a significant portion of the available profits.

CHAPTER IV

RESULTS

Introduction

This chapter provides a summary of the results for the analysis of the several games used for this study. These games are from the current study as well as comparisons from the previous studies.

Summary of the Study Data

This research is in continuation of the Research on Reverse Auction bidding games completed at Texas A&M University since 2004. Table 10 lists the studies used in this research work.

Table 10:

Study Results Summary

Study No	Participants	Number of Bids	Maximum Bid	Minimum Bid	Winning Bidder ID
1	5	698	$1,200,000	$2,000	9
4	4	347	$300,000	$133,335	3
9	4	903	$60,000	$12,898	12
11	4	865	$62,000	$11,700	2
12	4	759	$64,000	$12,499	1
14	4	1282	$60,416	$12,000	4
15	4	708	$35,000	$11,800	1
16	4	403	$64,000	$11,900	1

Table 10 shows the study number, relating to the order of the studies in the overall research work, the number of participants, the number of bids, the maximum bid and the minimum bid. Games are played by unique participants with construction knowledge, although a player was once used twice. Figure 14 shows a plot of the bid data for the original study by van Vleet (2004).

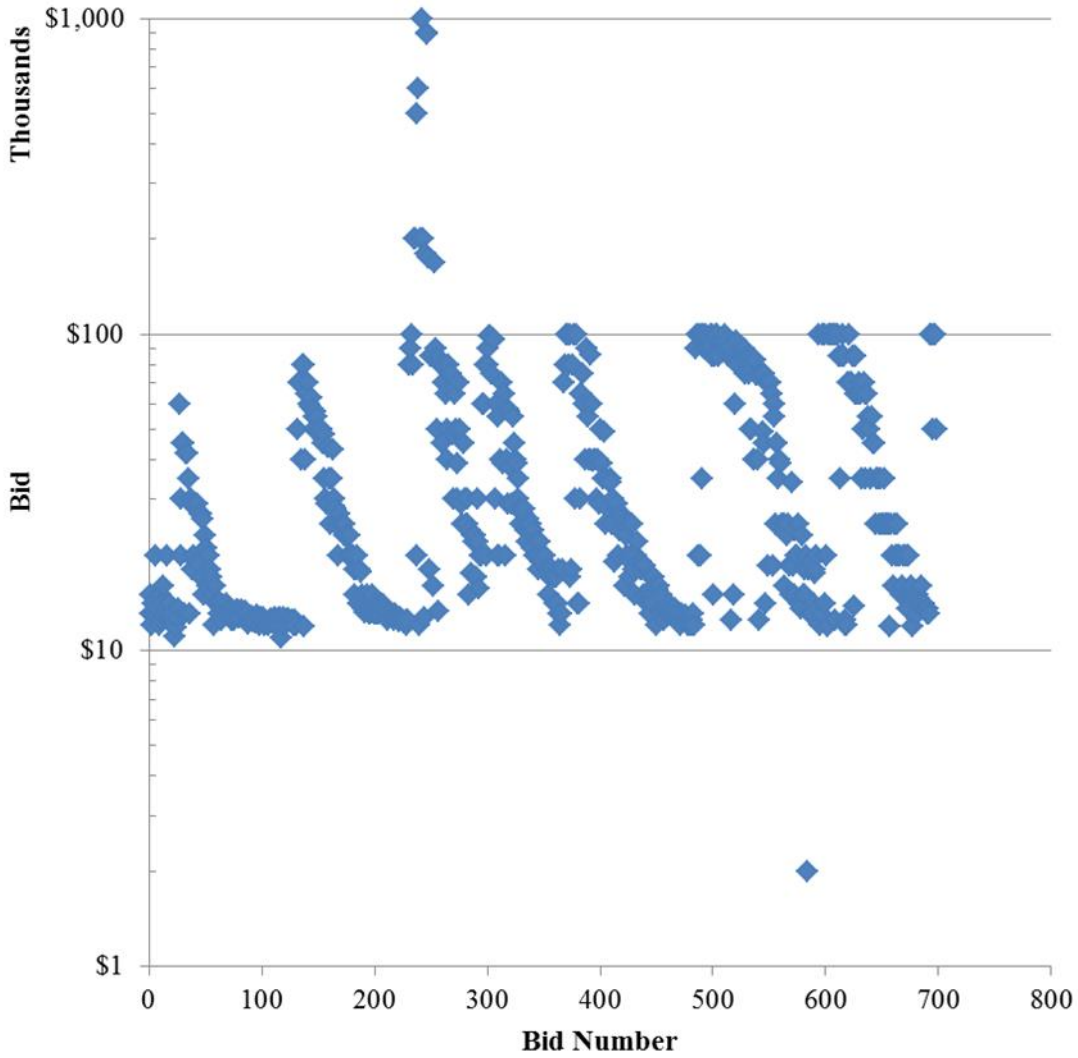


Figure 14: Study number 1-bid data

The other importance of the above Figure 10 is the variation in the maximums of the bid. The results pointed the need for conceptual development of the upper limit to the bid price. An upper bid limit was introduced by Gujarathi (2008) to provide an upper limit price point to match the real world limits, which is 3.5 times the base price and include the travelling and delivery costs. The costs for travel and delivery are updated and reflect cost conditions. This idea stems from the reasonable concept that the purchaser has the economic sense to understand values that are economically excessive (Hartford, 2005).

Figure 14 shows the early stage of low bids, which was studied and formalized by Chouhan (2009). The bid of $2000 at a time when the average bid is $20,000, is the type of error that will lead to a court case or a broken relationship as most small contractors cannot absorb such a loss, although it might be a problem of typing errors. This issue was fixed with the introduction of the check on low prices. There is also a bid limit of 0.9 times the base costs; this is in place to catch typing errors that would otherwise spoil the game data. Occasionally bid data includes losses instead of profits. Dharamshi (2014) Recently completed a three game study; the 24th study in this research set. The third game in Dharamshi's study shows atypical results including a number of losses and unusal profit levels. This game will be discarded for future analysis.

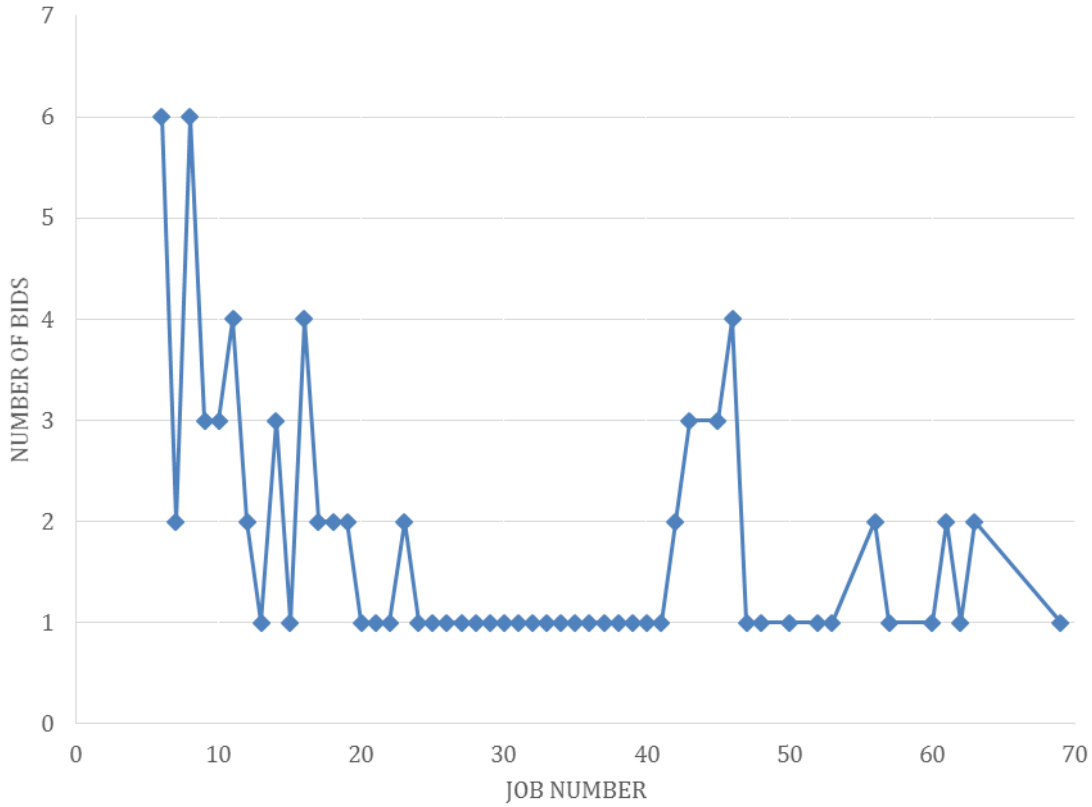


Figure 15: Number of bids per job

The key observations are the issue of flagging interest after job number 40, the high number of bids in the early game play, which leads to an erosion of profit, but it slows down and for the rest of the game the bids are lesser and profits are substantial. This observation on flagging interest has led to the standard eight round game, which based on an average of 7 to 8 jobs per game yields about 50 to 60 jobs in each game.

In studying the profits levels between games, the method developed by Guhya (2010) was to normalize the profit using equation (1). Guhya's method is applied to the profit on each job.

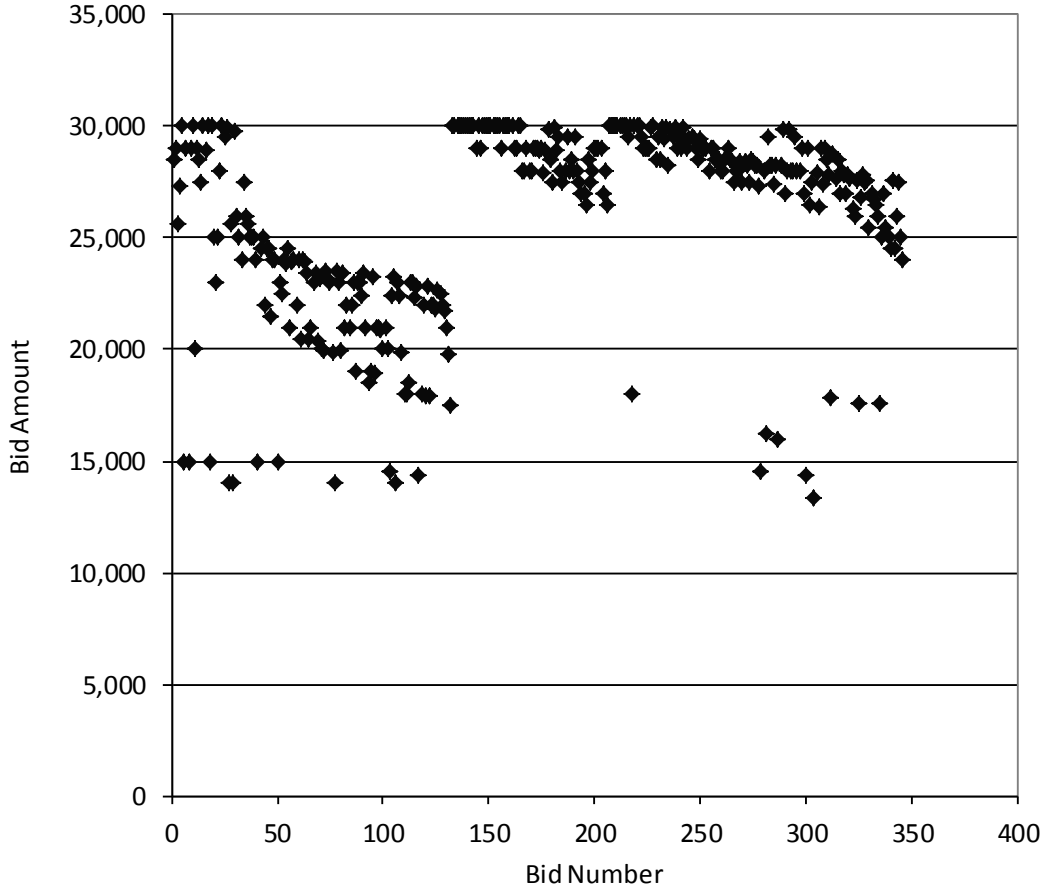


Figure 16: Previous RAB study – bid amounts

Figure 16 shows the bid amounts plotted against the bid numbers for RAB Study 4. Figure 17 shows the issue with the binning procedure, the maximum drop in price is 18,000, which does not fit into the 10,000 bin, but is included in the 100,000 bin.

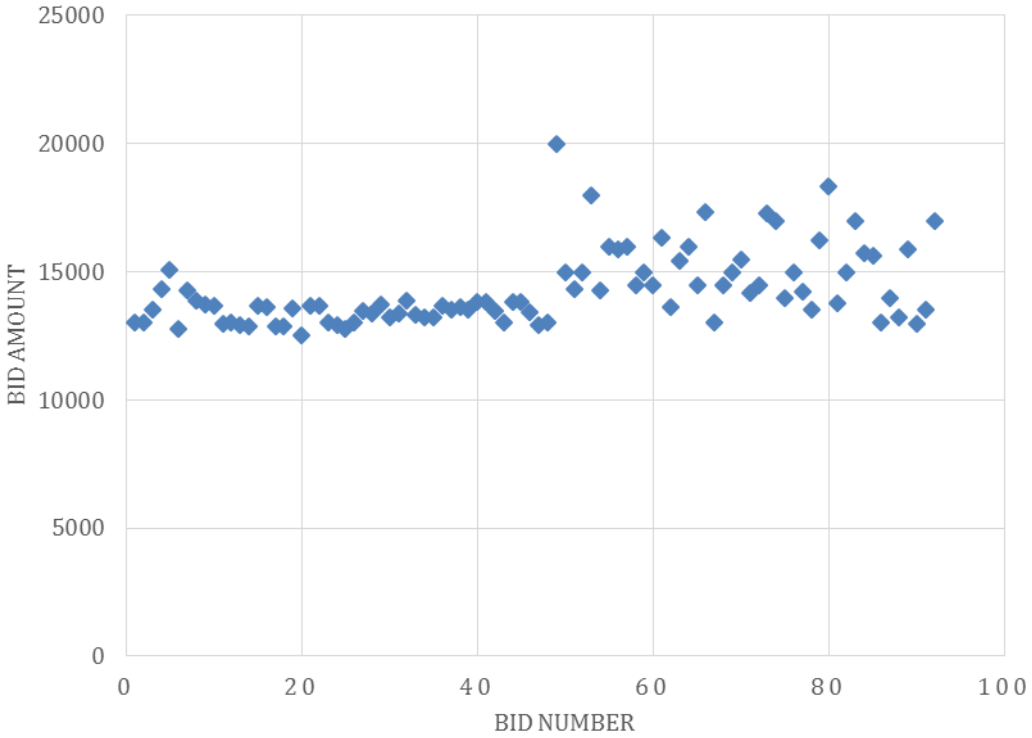


Figure 17: RAB study 25- bid amounts

Figure 18 shows the complete bid drop data plotted as a histogram for the set of studies used in this research.

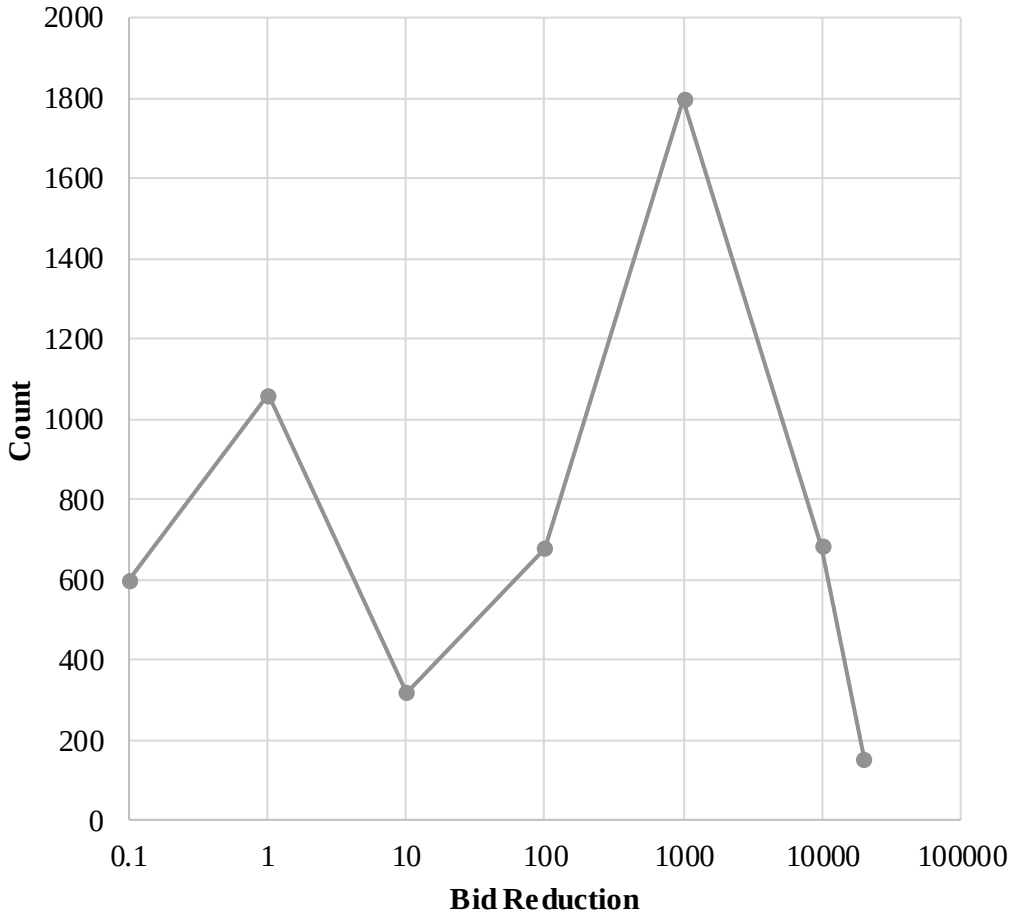


Figure 18: Study set: bid drop count

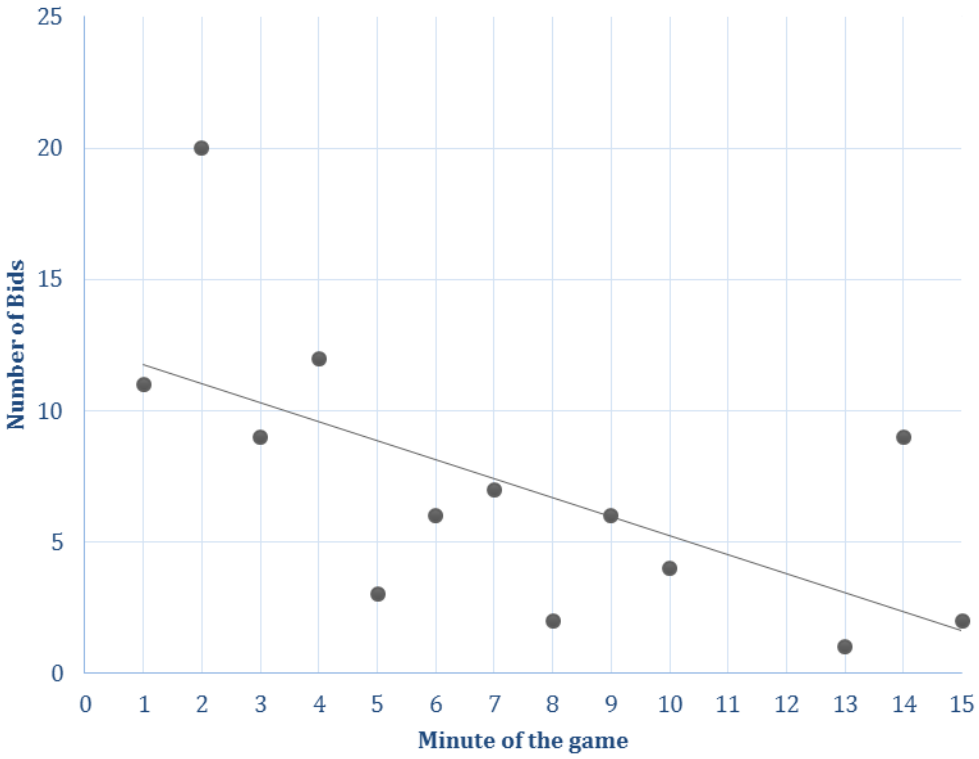


Figure 19: Bids per minute current study

The Figure 19 above shows that most of the bids by the players was done in initial phase of the game and the bidders were not too concerned towards the end. There seems to be only 2 bids in the entire game made in the last minute.

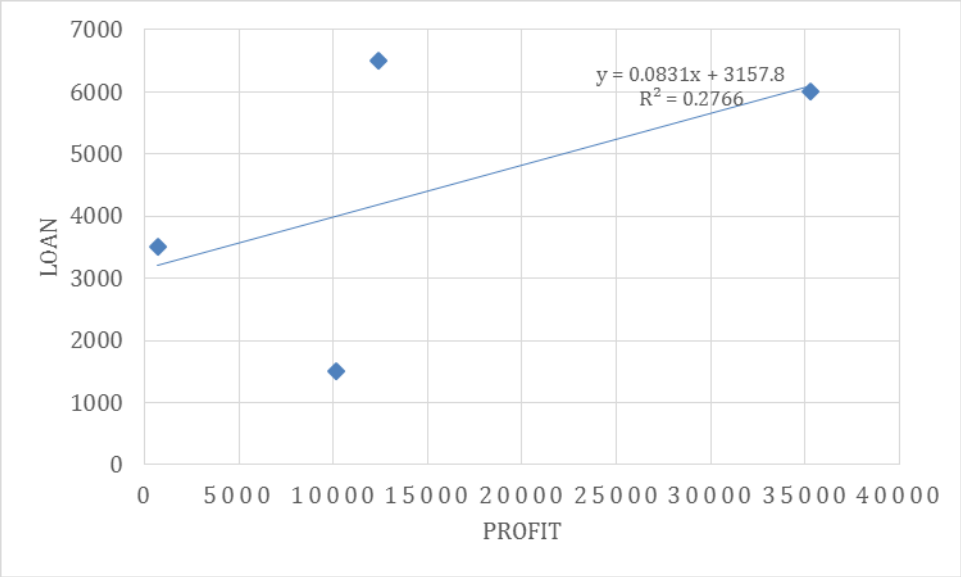


Figure 20: Profit and loan trends for current study

The Profit to Loan graph for this population is slightly different from the previous studies of RAB. There is also a case of higher loan and lower profit, but the general trend seems to remain that higher the loan amount better profits were made by the bidders.

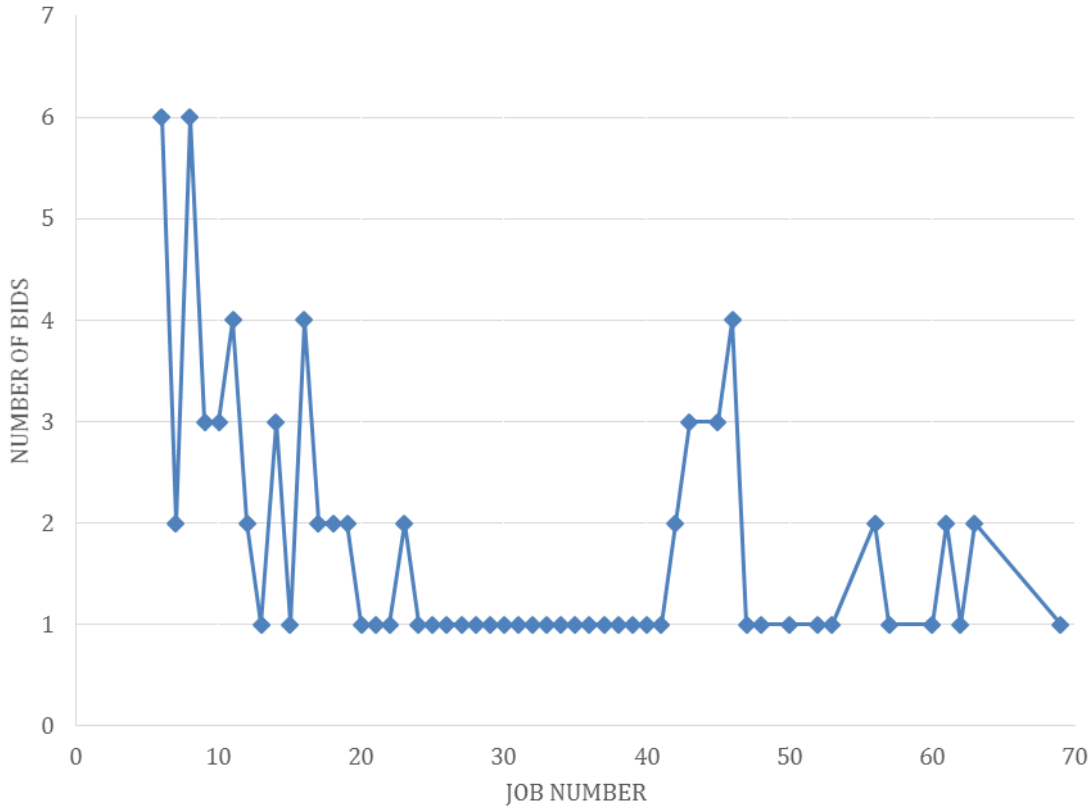


Figure 21: Bid Profits in each job.

The sample population used in this study follows similar trends to previous studies and shows that initially the bidders did try to win jobs by making lesser profits, later the bidders were careful and made significantly higher bids. Also since the number of bids for the jobs decreased over time it shows that the bidders agreed that making profit was important rather than winning jobs.

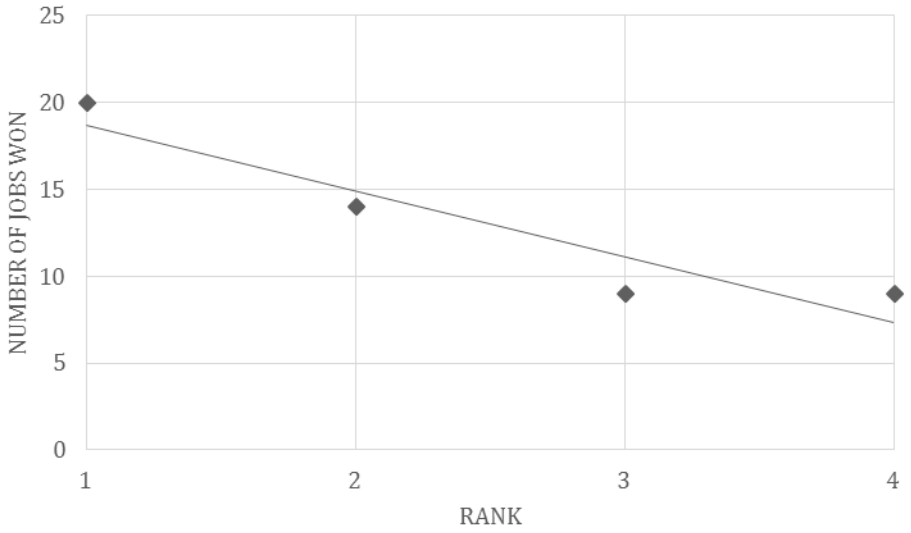


Figure 22: Rank according to number of jobs won.

An analysis of the rank order plotted against games per rank is shown in the Figure 23. The results shown above clearly show that profit being related to the number of jobs won in the games. This is a reasonable relationship and is thus of interest to the researchers. This area deserves further research.

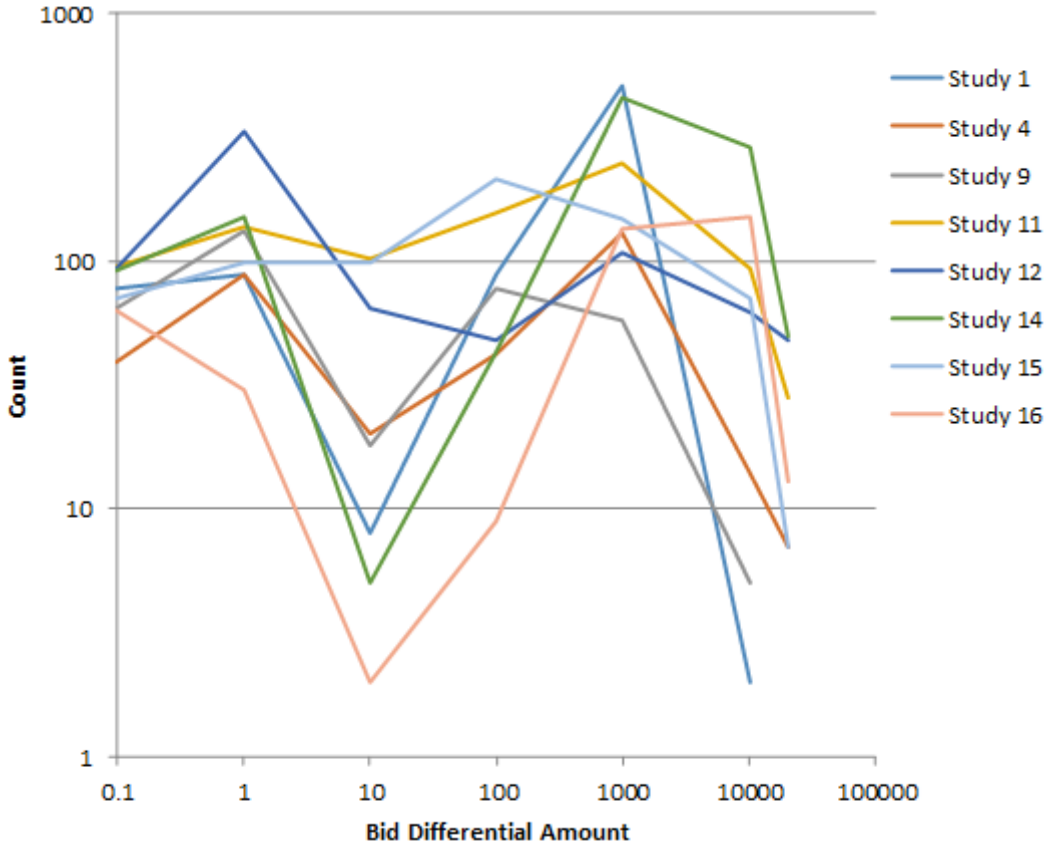


Figure 23: Bid differential data – all studies

Feigenbaum (2014) Opined that a procedure existed to beat the bidders who brought down by just a dollar. The technique was to make an offer that is fundamentally lower, indicating that the bidder is aggressive and the key bidder might look for benefits somewhere else. This example inquiry is a different study.

The hypothesis is a non-homogeneous Poisson process (NHPP) models the arrival time data for bidding from a number of new TAMU case studies within acceptable statistical limits.

A Poisson process is a special type of Markov process that happens in a fixed consecutive time period (Boxma & Yechiali, 2007). As a continuous-time process, it is a mathematical model of a completely random series of events (Cox & Lewis, 1966).

This study found that the results show that the Poisson process model for the arrival times doesn't fit the non-homogeneous Poisson process (NHPP) model. The results from this study doesn't have the similar heterogeneity in RAB bidding dynamics to the situations of eBay online auction that were studied by others (Yuan 2013; Russo, Shyamalkumar, Shmueli, & Jank, 2004; Shmueli, Russo, & Jank, 2004; Shmueli et al., 2007).

CHAPTER V

CONCLUSION

van Vleet started the study of Reverse Auction Bidding (RAB) game at Texas A&M University in 2004. This research work now extends to twenty four studies by Masters Students in the Department. This thesis investigates aspects of the Reverse Auction system using the web site developed by others to continue the work on understanding aspects of the impact of human personality types on the bidding results for a standard game.

Reverse Auction Bidding is utilized by a significant number of enterprises for supply of materials and in part construction. These companies are generally convinced that the Reverse Auction Bidding framework enhances the effectiveness of the offering bid, by reducing costs, and helps spare a considerable measure of expense throughout the development process and bid times. The assumption that one achieves savings in using this method is not proven.

A game theory was developed for the Reverse Auction Bidding framework used at TAMU to study the results of the bids collected in a standard game. This theory postulated two sub-games exist inside the main Reverse Auction Bidding game. The main sub-game is between the buyer and the set of bidders. The second sub-game is between the bidders. The theory exists that the buyer seeks minimal costs, which must be acknowledged as prima facie correct for this study. Extent studies at TAMU have indicated that the costs distribution is non-Gaussian, indicating that the buyer's objective

is not achieved for all bidders. The second sub-game is between the bidders, they utilize the non-Gaussian component of the profit distribution to amplify individual returns. Bidders have been proposed into three types, the first is a monetarily productive bidder, a financially wasteful bidder, and a mid-range bidder. Personality has been shown to have some impact on the determination of a participant's economic efficiency.

The bid timing data from previous studies shows that the bid arrival times follows a Poisson process. This study aims to confirm the previous investigation that the bid timing data from the Reverse Auction Bidding case studies at TAMU fits the non-homogeneous Poisson process model.

The study involves a game scenario consisting of six construction sites for which the participants were asked to bid on the construction of house slabs. This is a simple and repeatable construction to minimize the problems of bidding. The study also involved determining the personality type of the participants. The game lasts for eight rounds.

The individuals were selected from the Construction Management Graduate program with varied experience. The statistical results of the bidding data show patterns not similar to the previous studies. The hypothesis is a non-homogeneous Poisson process (NHPP) models the arrival time data for bidding from a number of new TAMU case studies within acceptable statistical limits. This result had been confirmed in a previous study looking at a large number of games. This set of players made limited bids, made a significant amount of bidding in the early minutes of the game and bid low relative to the game limits. These players performed in an interesting fashion, as they are

part of a Poissonian process, this type of anomalous play is rare, but it happens. It is rare in the Poissonian process, but given that about 40 games have now been played one of this form should not be unexpected. The game now forms part of the data set of all games. The personalities were all Guardians. All Guardian games have been shown to elicit poor performance for the entire group in two previous studies. In determining the recommendations for future studies, one is mindful of the need to understand the economically efficient bidders first and the economically inefficient bidders second. The interest is in why bidders win. Games of all Guardians are not further recommended. The hypothesis is neither proven nor disproven; the results from this study are moot to a large extent, except when included in the overall study of all of the games.

A further study is suggested to combine a bid arrivals study and profit strategy to look for the strategies for optimum price and most awards.

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APPENDIX A

THE KEIRSEY TEMPERAMENT SORTER

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.

KEIRSEY TEMPERAMENT TEST QUESTIONS : Keirsey, D. (1998)

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. 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

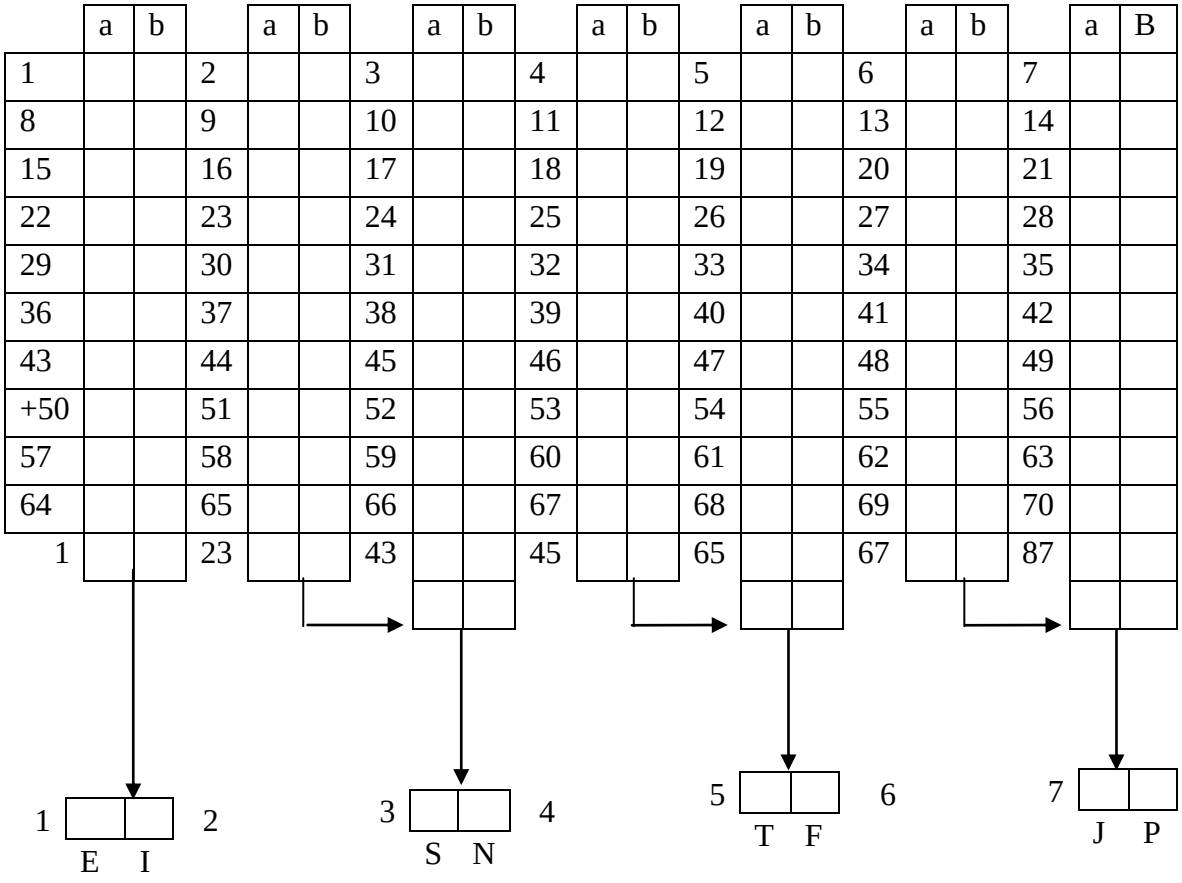
APPENDIX B

KEIRSEY TEMPERAMENT SORTER SCORING

Keirsey, D. (1998) Enter a check for each answer in the column for a or b.

Table 11:

KTS Scoring



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 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.