REVERSE AUCTION BIDDING:

BIDDING STRATEGY PATTERN OF FIRST TIME BIDDERS

A Thesis

by

SHREYAS VINAYAK BEDEKAR

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

December 2010

Major Subject: Construction Management

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Bidding Strategy Pattern of First Time Bidders

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Approved by:

Co-Chairs of Committee, John Morgan Nichols
                        Boong Yeol Ryoo
Committee Members,   Ivan Damnjanovic
Head of Department,   Joseph P. Horlen

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ABSTRACT

Reverse Auction Bidding:

Bidding Strategy Pattern of First Time Bidders.

(December 2010)

Shreyas Vinayak Bedekar, B.E., Shivaji University, India

Co-Chairs of Advisory Committee: Dr. John Morgan Nichols
                                                    Dr. Boong Yeol Ryoo

The advancement of computer technology is playing an important role in almost all fields in the construction industry in the current era. It has become a tool for exchanging legal contract information, including bid data. In the traditional closed bidding system, the bidders were unaware of their competitors' bid quotes and had no opportunity available to make a counter an offer to the bid at a different level. However, in reverse auction bidding (RAB), contractors can track their competitors' bids and take the given opportunity to re-bid the projects at lower rates. Unlike traditional auctions, where buyers raise their purchasing prices to outbid competitors, reverse auctions permit buyers to purchase goods and services from suppliers who are encouraged to sell them at the lowest price. The benefit of the reverse auction bidding is either that the vendors are able to re-bid, or lower their bid multiple times. This is an example of transparent economic information.

Van Vleet initiated the ongoing Reverse Auction Bidding study at Texas A&M University. Van Vleet had created a Microsoft Access database system and ASP web based user interface for RAB study. The methodology developed by van Vleet is still being used today, and this study has been extended into analyzing different personality types and the impact on the bidding system. In the previous studies conducted by different researchers in TAMU, the performance of participants in the RAB process along with their behavior are being observed with respect to their personality. Personality of each player is tested using the Keirsey Temperament Sorter (KTS) test. The previous study states that there appears to be a strong correlation between personality type and game performance. The first case study conducted by van Vleet involved five participants who had no prior experience in Reverse Auction Bidding. The number of participants has varied from three to ten participants.

This research has been conducted on graduate students of the Construction Science Department of TAMU who have no prior experience in RAB. In continuation with the previous studies held in TAMU, the results show that there is an observable pattern in the bidding strategy of first time bidders while taking part in Reverse Auction Bidding.

ACKNOWLEDGEMENTS

NOMENCLATURE

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

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INTRODUCTION

BACKGROUND

With the global presence of computers and the nearly universal reach of the Internet, there is widespread use of online auctioning for the sale of goods. Therefore, it should be a surprise to no one that owners would think of a way to use them to get lower prices for purchase of goods and services. The concept is to describe what someone wants to buy and then let providers compete with one another to lower their prices until a pre-set time or other cut-off, and it is called electronic reverse auction bidding (ERAB).

In 2004 Van Vleet found that some construction firms were claiming they were finding it difficult to compete and remain profitable in the current economic market. He also observed that those firms had a high failure and lower rates of returns. Van Vleet then researched a new system of bidding called reverse auction bidding (RAB). Reverse auction bidding has created a great deal of dispute tied with the added issues of rising costs, increasing competition, high failure rates and marginal rates of return. However, comprehensive research at Texas A&M University has provided some evidence that RAB can offer a reasonable return to shareholders and banks of the contractors, even though with the strain of the bidding system perhaps interfering with the development of the contractor to owner relationship (van Vleet 2004).

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

Some researchers propose that RAB reduces contractor profit which in turn may compromise quality of the job and safety on the sites. Angelo (2002), Gregory (2006); and Panchal (2007) identified three different classifications of bidders as:

- Economic winner – One who generates the highest average job price

- Economic loser – One who generates the lowest average job price

- Average bidder – Bidder with average returns

Sushil (2009) proposed that an owner's representative's interference in bidding can affect the result of reverse auction bidding and his research demonstrated this phenomenal. Chouhan (2009) categorized the personalities of the bidder using Keirsey Temperament Sorter (KTS) and postulated the following classification as:

- Economically effective bidder

- Economically ineffective bidder

- Members generating average distribution returns

Guhya (2010) extended the above study and defined series of games within RAB. Machado (2009) proposed that Number of bidder's participating in Reverse Auction Bidding is directly proportional to psychological effect on bidder's personality and Aggressive bidder is more successful in Reverse Auction Bidding than Average bidder. Saigaonkar (2010) and Gupta (2010) showed that out of the four primary personalities according to the KTS, the Guardians have a better performance than the other three personality types in a controlled game.

PROBLEM STATEMENT

This research study is carried out to evaluate the bidding strategy and the observable typical pattern for the first time bidders of reverse auction bidding. The research will use game theory to analyze bidder's behavior changes in changing situations and personality testing to determine if there is a relationship between first time bidding and generated patterns.

RESEARCH PROBLEM

Is there an observational pattern of the bidding strategy of the first time bidders using   reverse auction bidding?

SUB PROBLEM

Is there any correlation between first time bidding and the profits patterns of the bidding, irrespective of the personality of the bidder in a Reverse Auction Bidding model?

LIMITATIONS

The scope of research study will be limited to following factors:

- The study is limited to construction management graduate students from the Department of Construction Science, Texas A&M University

- This study was performed in a controlled setting, limiting the variables that exist in the market place, as well as the risk related to the daily transaction of business. The controlled setting was necessary in order to establish clear lines for evaluating participant behavior patterns.

- This study will not address any misprint errors, omissions and miscalculations that are caused due to participant's online bidding process.

- The bidder's background e.g. their origin, past will not be taken into account in details.

SIGNIFICANCE

Although Reverse Auction Bidding has been proved to be very useful in procuring goods and services, there are some controversial arguments that it has created serious impact on owner-bidder relationship. This study aims to analyze first time bidder's behavior and strategy to gain strategic position over other bidders. This study will also try to analyze the profit patterns of the first time bidders.

LITERATURE REVIEW

INTRODUCTION

The research is divided into four detailed aspects namely definitions of the game, the reverse auction bidding process, the personality testing and the analysis of the game.

DEFINITIONS

A comprehensive set of definitions was provided by Guhya (2010) that are relevant to the reverse auction bidding system applied at Texas A&M University System. These definitions taken verbatim are as follows:

- *Reverse Auction Bidding:* 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 bidders with the lowest bids win (van Vleet 2004).

- *Game Theory:* A formal analysis of conflict and cooperation among intelligent and rational decision makers (van Vleet 2004).

- *Collusion:* A secret agreement between two or more parties for a fraudulent, illegal, or deceitful purpose (van Vleet 2004).

- *Bidders Personality:* "The dictionary defines personality in several ways. One definition emphasizes the public, social stimulus, or behavioral characteristics of a person that are visible to other people and make an impression on them. Another definition stresses a person's private, central, inner core. Included within this private core are the motives,

attitudes, interests, believes, fantasies, cognitive styles and other mental processes of an individual. Some definitions of personality emphasize its "person" quality, personal existence, or identity features. Other meanings of personality are associated with specific disciplines or professions" (Panchal 2007).

- *Responsive Bidder:* A bidder whose bid satisfies all the terms and conditions of bidding, delivery requirements, detailed specifications is called responsive bidder.

- *Aggressive Bidder:* Aggressive bidders are the bidders who attain highest overall returns in the entire bidding process (Chouhan 2009).

- *Average Bidder:* Average bidders are bidders who attain average distribution of returns in the entire bidding process (Chouhan 2009).

- *Success Rate:* It is a ratio of number of bids won by a bidder to total number of bids made by that particular bidder.

- *Bidding Aggression:* It is a ratio of total number of bids made by an individual bidder to total number of bids made by all the bidders in the reverse auction bidding pool.

- *Bidder:* An entity that submits bid. In this game, there are usually three to ten bidders.

GAME DEFINITIONS

The following list contains terms associated with the reverse auction bidding game. These terms were defined by Van Vleet (2004), Panchal (2007), Chaudhary (2009) and Guhya (2010). They are:

- λ player : This represents the bidder group, treated as a single entity for the purpose of game analysis.

- λ_i player : The ith bidder in the bidding group.

- υ 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 υ player, but the υ player created the system and so is responsible for the υ 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 υ 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 times τ that represents the work time in the game.

- B_j : i^{th} bid

- B_v : Accepted bid for each job.

- K : This variable is a fixed dollar sum, representing the υ player's base price, although in this game K is a vector of costs.

- Γ : This variable is a fixed dollar sum, representing the υ player's maximum incremental price above K

- Ξ : This variable is normally defined by the set of numbers $\{\Xi \mid 0 < \Xi \le 1\}$, 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_i 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.

PERSONALITY TYPE

Rogers (2010) originally suggested the use of the Keirsey Temperament Sorter Test to look at the difference in personality between a *Type ξ* and *Type ζ* types. It consists of 71 questions. The exact questions were listed in Appendix A.

DIFFERENT PERSONALITY TYPES

Table 1 below shows the Keirsey Temperament Sorter Test Summary.

Table 1 KTS Different Personality Types

	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 shows the individual components in the temperament scale. The issue is equal scores between groups being assigned to one category. The issue should be considered in future studies.

Table 2 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 *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 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 *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 possibilities

REVERSE AUCTION SYSTEM

Reverse Auction Bidding (RAB) is a process in which a buyer of goods and services continues to request bids from sellers until the buyer is satisfied they have received an acceptably low price although time does become a problem that ultimately limits the bidding process. In a conventional bidding method, general contractors submit their bids, or pre-selected general contractors plead for bids from subcontractors, and there is no opportunity for subsequent bidding after the specified time for bid opening.

In recent years, the Reverse Auction Bidding process has become a more accepted tool, which facilitates competitive and collaborative interactions among buyers and suppliers with online negotiations, even though with resistance in the construction field due to the perception of bid shopping.

Horlen et al., (2005) noted that reverse auction can harm owner-buyer long term relationship, collaboration, quality of product, reliability, service and product delivery. Further, involvement of third party and unknown bidders in competition will result in poor selection of bidders affecting long-term business relationships, standing, performance, and responsibility. This observation is not necessarily true for all relationships and requires further work to be proven at his stage, although Panchel (2007) briefly considered this issue in his research.

Jap (2007) provides quantitative evidence that suppliers tends to become suspicious about buyers strategy, which affects the owner – bidder relationship in reverse auction bidding. One can consider that the selection of a RAB system will not cultivate a positive relationship as the purchaser is making the strong statement that "Price is everything with all else equal" (Nichols, 2010). As stated by Nichols:

"In some settings this is acceptable, but the purchaser must expect the supplier to respond in kind". Van Vleet (2004) noted this behavior and it was termed as tacit collusions. Recent work suggests that it is part of a game strategy adopted by the suppliers in response to the purchaser's acquisition method. Nichols considers that it is normal economic behavior and reflects in part the lack of understanding of the

purchasers of the problems with RAB created by their adoption of this economic system. A simple way to look at it is "that a fool and his money are soon parted."

Jap (2007) reports that only 5% of the people they interviewed suggested that reverse auction process can improve relationships. Chouhan (2009) opined that this means that rest (95%) believe it is harmful, although the converse may simply be that the average supplier sees no change in the relationship as they continue to treat the client in a professional manner.

Engelbrecht – Wiggans (2007) argues that as there are repeated interactions between owner and bidders in the whole bidding process, bidder's behavior can be affected by issues external to auction like gaining a strategic position over other bidders and buyer for his own economic concerns. Jap conducted research on aggressiveness of bidder by considering various factors such as total number of bids a supplier make, the rate of making bids and degree of price concessions they offer. From this Jap concluded the following:

"Suppliers who are interested in making specific investment with buyer and also those who want to develop long term relationship with the buyer will submit few bids, bid at greater intervals and make less reduction in profit margin in the entire bidding process compared to rest of the suppliers". Guhya's (2010) work would not necessarily support this view, it is dependent on the Herfindahl Index of the bidding game and the personalities of the bidders.

Suppliers who frequently submitted bids and made heavy reductions in profit margin have lower propensity of relationship post-auction with the buyer, which suggest

that reverse auction is a "negative price haggling" process. Nichols suggests this may be personality driven by looking at the statistics of the lost money in the bidding process. Guhya was the first to determine the lost money.

From these observations, Jap concluded that, "Strategic bidding behavior of suppliers in which they appear to trade off potential economic and rational investments is long term exchange with short term pricing concessions".

There were several other key findings regarding reverse auctions in Jap's research as the number of bidders in the auction increases, suppliers lose interest in reverse auction bidding process and tend to bid less aggressively. The reasons for this are yet to be determined according to Jap. Although in any reasoned consideration of the cost of doing business this is to be expected. Some believe that bidders become skeptical about the presence of non-qualified bidders bidding in the reverse auction process or of faked bidding as studied by Panchal (2007).

There may be possibility that if number of suppliers is excessive within bidding process, bidders may lose interest, refuse to bid against non-responsible bidders and start looking for alternative buyers. Again this is normal economic behavior.

According to Staw (1976), "Bidding aggressiveness in response to total number of bids by others may represent a psychological escalation of commitment". Jap (2007) states that supplier's frequency of bidding decreases with increase in duration of event of reverse auction, which could affect overall price savings for the buyer. This is normal behavior observed in the current set of studies.

It has been postulated that emotions can affect a bidder's personality and response to the RAB game in a systematic way. Bosman and Riedl (2004) argue that bidders who are in negative emotional state of mind have a tendency to increase the number of made bids in bidding process. But, bidders with positive emotional state of mind remain unchanged in their bidding behavior. This statement suggests that negative emotions induce more competitive bidding, although this is far from proven.

Further Bosman and Riedl (2004) concluded that it is very necessary to understand bidder's behavior and his emotions need to be taken into consideration at the time of bidding. The available evidence suggests that people who feel good are inclined to take less risk than people who feel neutral, in particular when the stakes are high.

Bosman and Riedl (2004) noted that people with positive emotions retain their state of mind whereas people with negative emotions can affect risk behavior in different ways. Raghunathan and Pham (1999) suggested that anxious individuals opt for "low risk – low reward" option whereas sad individuals opt for "high risk – high reward" option. People in positive emotional states tend to make optimistic judgments and choices whereas people with negative emotional states tend to make pessimistic judgments and choices.

Chouhan (2009) postulated that there is a difference between aggressive and average bidders. Chaudhary (2009) suggests with good reason that this is due to personality types and factors.

ANALYSIS OF THE GAME

The standard methods were established by Guhya (2010) for an analysis of the Reverse Auction Bidding game.

The key factors are as follows:

- Rate of bidding in units of minutes

- Distribution of the bids during the game play

- Lost money

- Return

- Return against loan

- Personality

SUMMARY

It is a common held belief that reverse auction bidding drive down the cost of the project which in turns saves large amount of money for the owner. Horlen and others (2005) point out that there are lots of advantages to using reverse auction bidding to the owner, but along with all of these advantages there are lots of barriers. Reverse auction can and will harm the owner's long-term relationship with the contractor. It also may create some problem with quality of product, reliability, service, and product delivery. With the involvement of a third party and many unknown bidders in competition, it might result in a poor selection of bidders which will affect long term business relationships, reputation, performance and accountability (Horlen & others 2005, Machado 2009, Van Vleet, 2004, Jabs, 2007). This study will conclude some of these points.

METHODOLOGY

INTRODUCTION

The methodology of the research is divided into two distinctive sections namely the game setup and the data collection.

GAME SETUP

In this game, KTS is used to test the personalities of the bidders. Four players are invited to take part in the RAB game. The consent form will be signed by all the participants who are willing to participate in the RAB game. The bidders are encouraged to gain maximum profit out of each job. All bidders are provided with an initial amount of 40,000 USD. As we are assuming that this is a normal economic period, the RAB system Considers realistic scenarios and factors such as travel and delivery charges, rain delays, delays due to distant projects and other variables that affect the construction daily business. The bidders bid for 15 minutes.

A set of instructions and rules provided to the bidders (participants) in the game process during simulation. It includes the details related to the project, description, and variables that affect the project as well as its duration. The instructions set are as follows:

- *The total duration of the game will be a maximum of nine consecutive weeks.*

- *All bidders initially have an equal dollar amount of $40,000 available in their bank accounts.*

- *The base cost for each job has been estimated by a competent estimator as $10,000 (van Vleet, 2004). This cost does not include any applicable travel and delivery charges. The amount of these excluded costs will be posted on web site for each job along with some other relevant details such as job site address, access information and other details necessary to commence the job on time.*

- *The default duration to complete each job is five scenario days of construction time, excluding rain periods.*

- *Work week begins on Monday and ends on Saturday. The work week is six days long.*

- *All bidders are limited initially to work on only three jobs per week.*

- *If they desire to work on more than three jobs per week they then have to take a loan out to finance for each additional job. The additional borrowing charges are $500 that will be charged automatically every time they borrow a loan irrespective of whether they win a job or not.*

- *Since the base cost for all jobs is $10,000, and the default duration is five days, each bidder makes $2000 per day for all jobs. This construction cost will be accrued on daily basis. In addition, travel expenses and delivery charges are also accrued on a daily basis, as determined by the job site location costs built into the system.*

- *The main office of the owner is located in Sugar Land and the travel and delivery expenses will be determined on the basis of distance of job site*

from this location as all subcontractors have offices within a mile of the owner.

- *The minimum acceptable return on investment derived from long term construction industry standards is 10 percent. This is not checked during the game, but the players are warned of this requirement.*

- *Payment for work is scheduled to be delivered at the completion of the fifth construction day.*

- *They will have exactly 15 minutes to place bids.*

- *The main objective of all the bidders is to maximize their profits, whilst maintain bank confidence and acceptable liquidity.*

Table 3 below shows the location details of the different sites used in the RAB game.

Table 3 Site Location Details

Site #	Location of Development	Distance from Sugar Land (kilometers)
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

GAME PLAY

As the game had four players with a nominal capacity of three jobs per week, random dice rolls using two dice were used to determine the number of jobs that were available each week. The number of jobs per week had also been determined by using dice previously. However, bidders can increase the bid capacity and also can acquire an additional job above their financial capacity by utilizing the option of borrowing money taking a loan from the bank. This option was made available to each participant during actual bidding process. Once the bidders are at their full capacity, the program is set in such a way that it will ask the participant if they would like to increase their capacity.

DATA COLLECTION

In 2004 using Microsoft Access, van Vleet created a website using ASP programming connected to an access database. This ASP site was used to run the online simulation of the bidding game. This website allowed participants to submit their bid information, and the site would also collect the data for the analysis of the bidding behavior. Details of the ASP programming are given in the paper by Guhya (2010). Gregory encountered connection problems with the Microsoft Access database as ten bidders tried to get online at one time.

Wellington configured an alternative SQL Server 2005 database for the game site in 2006. Texas A&M University's College of Architecture computers were set as the server location created to host the reverse auction game where each participant enters the system and they assigned a login screen with username and password entry boxes for each individual participant.

Each participant was provided with a unique login name, being:

- Hammer Co.

- Driver Co.

- Pliers Co.

- Concrete Co.

Using a unique password, each participant controls their access to the site. These specific login name and password allowed each participant to enter the website and access the contract data. However, the limitation of the server is that it restricted participant's access to the information that was relevant only to their bidding.

In the design of the web page, allowances were made such that the bidding process minimized the irrelevant information given to the bidders. The significant information includes the job cost, current bids and the bidder's name. In addition, before bidding time commences or after bidding was closed, no bids could be placed. Bidding is set to occur for a 15 minute time span, and then the system was closed for 5 minutes. It is usually considered as a break time for the participants.

After starting a session, the participants were taken to the All Current Bids screen as shown in Fig. 1. This screen provides bid information including location of the site and related cost for each job. This was the identical information provided for all participants.

Figure 1. All Current Bids Screen from RAB Web Site (Guhya,2010)

As described earlier, participants were limited to bid on only three jobs per week. Upon accepting the bank guarantee, a fee of five hundred dollars was deducted from the bidders account located on the My Bids Info page. Fig. 2 shows the screen that offers the participant a chance to accept the bank cost.

Figure 2. Bank Guarantee Web Form (Guhya,2010)

There are some strict protocols established while designing the game to ensure that only a lower value is accepted during the bidding process. The screen is prompted as shown in Fig.3 to warn the bidders that they are not allowed to enter a higher bid amount than the current lowest bid amount.

Figure 3. Higher than Acceptable Bid Web Statement (Guhya, 2010)

My Jobs in Progress bar shows <u>My Bids Info</u> page as shown in Fig. 4.

Figure 4. My Bid Info Web Page (Guhya,2010)

As Saigaonkar (2010) noted 'My Bid Info Page' displays the bid and job information relevant to a particular bidder. Participants were able to have access to this page throughout this game process and they were encouraged to visit it frequently. This page contains job relevant information that helps the participant to ensure their job status. This page includes the following data:

- All active jobs that participant has won, under the category <u>My Jobs in Progress</u>

- Jobs that participant is bidding, under the category "<u>My Active Bids</u>. All information under this tab came directly from <u>All Current Bids</u> page, so this also provides the current status of the bidding game to show whether the participant had been outbid on a particular job.

- List of all successfully completed jobs, under the category <u>My Completed Jobs</u>.

This screen also shows the financial state of the participant, which helps the bidder in framing a future strategies such as how many jobs a bidder could bid for, and if the bidder is already lagging behind due to his uncompleted jobs, how much money a bidder would have to borrow from bank and other financial institutions to bid for a job in the following week. This financial information is provided under the category <u>My Summary</u>. The information is:

- Current calculated cash assets

- Capacity for additional works including jobs with bank guarantees

- Cumulative loan charges till date

Current financial condition provides the working capital information to the participants as shown on Fig. 5. It is calculated by deducting costs of current jobs and bank loans from the profits of completed jobs. The initial capitol is $40,000 and the bank guarantee is $500 per loan. The formula used is:

Current Financial Condition = (Capital + Profits) − (Costs of Current Jobs + Bank Costs)

Figure 5. All Completed Jobs Screen (Guhya,2010)

PERSONALITY TYPES

Each participant involved in the bidding was requested to take the Keirsey Temperament Sorter (KTS) Test. Guhya (2010) had developed the standard set of procedures to analyze the results. The information about personality type of a bidder involved in the game process was collected to compare the personality types against the returns each participant made in the game.

RESULTS

INTRODUCTION

The research is conducted in three phases, namely:

- Personality Testing

- Reverse Auction Bidding Game Play

- Analysis of the Results

PERSONALITY TESTING

The preliminary step of this research was personality testing. Four students from the graduate class in the Construction Science Department were randomly selected and tasked to take the Keirsey Temperament Personality Sorter Test. The precaution taken was none of the participant should have any prior experience of RAB. The bidders and their personality types are presented in Table 4.

Table 4 Player and Personality Type

Bidder Name	Assigned No.	KTS Result	Personality Type
Hammer	1	ISFP	Artisan-Composer
Driver	2	INFP	Idealist-Healer
Plier	3	ESTJ	Guardian-Supervisor
Concrete	4	ISFJ	Guardian-Protector

REVERSE AUCTION BIDDING GAME

The game was played on 21st Sep. 2010 at College of Architecture, TAMU. The game commenced at 4:00 PM and lasted for nine game sets of fifteen minutes duration each. Number of jobs available in each week is shown in Table 5.

Table 5 Number of Jobs per Week and Descriptive Statistics

Week	No. of jobs
1	6
2	13
3	3
4	5
5	9
6	7
7	11
8	4
9	11
Mean	7.67
Std. deviation	3.5
Total	69

Fig. 6 shows a histogram of the jobs per week.
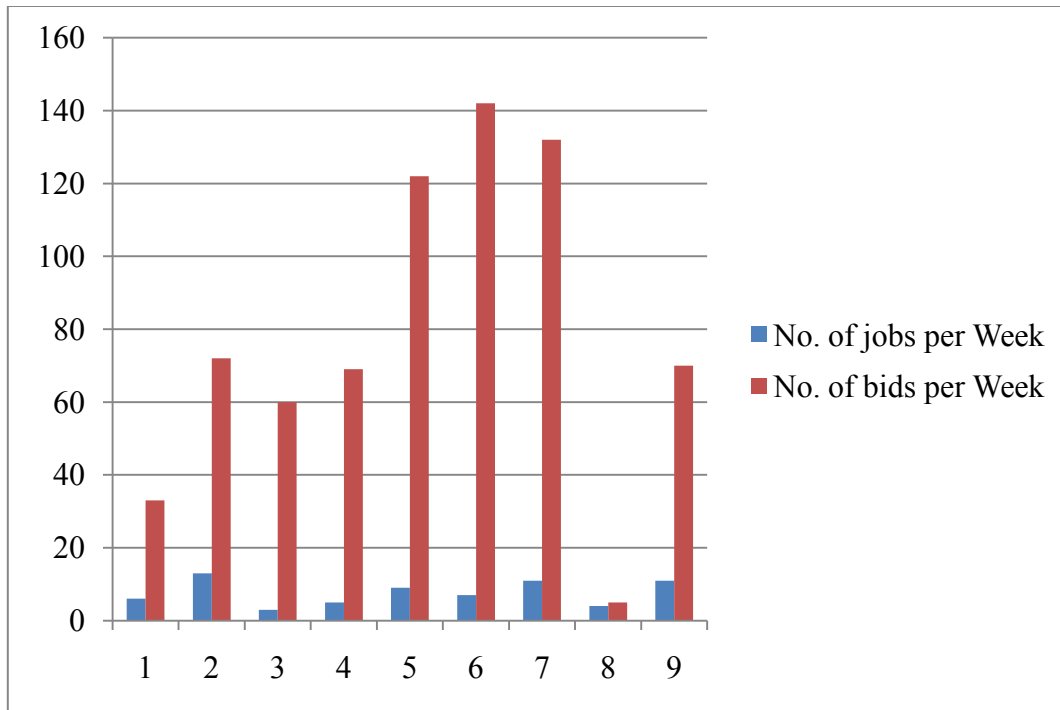
Figure 6. Histogram of Number of Jobs and Number of Bids per Week

ANALYSIS OF RESULTS

The analysis of results examines bid period results, profit data and differential bid data from the bidding process.

(Chouhan 2009) proposed that there are four trend periods which could be observed in a reverse auction bidding game. The trends were generally observed in the majority of the research studies conducted previously on Reverse Auction Bidding. The four trend periods are shown in Table 6.

Table 6 Trend Periods and Data as Postulated by Chouhan (2009)

Period Identifier	Description of the Trend Period
A	Learning
B	Discovering
C	Competitive
D	Profit Gain

The analysis of the bidding trend of the current participants was done by dividing the game into nine consecutive game sets. The profit gained by the winning bidder assists in identifying the trend. Table 7 provides the profit data and the winner in the first 15 minutes of the game play. It can be seen that profits range from $19 to $3086. This confirms that all the participants have not yet acquainted to the game play and are being competitive. The data showed that they also made some errors in bidding process. This tells us that it's their learning phase. The discovering trend of the participants is not observable in this study which is not a typical.

Table 7 First Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1645	37	$18,316.00	$34.00	1
1644	38	$11,701.00	$19.00	1
1643	39	$12,835.00	$65.00	2
1649	40	$12,835.00	$65.00	2
1648	41	$14,725.00	$1,675.00	2
1647	42	$14,914.00	$3,086.00	3
1646	43	$12,835.00	$165.00	4

Tables 8, 9, 10 show that during second, third and fourth period there was an observable discovering phase. The profit ranging from $0.50 to $2884 was observed. This shows that the participants were still discovering and exploring the game and highly competitive. It was also stated in the previous research that participants of the Guardian type personality are the most competent bidders and thus the competitive behavior of these participants can be seen in the respective tables (Gupta 2009).

Table 8 Second Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1613	7	$18,316.00	$1.00	4
1615	8	$18,316.00	$2,884.00	4
1616	9	$13,213.00	$2,786.00	4
1618	10	$12,835.00	$2,515.00	4
1619	11	$14,725.00	$1,275.00	4
1620	12	$13,213.00	$2,336.00	4
1621	13	$14,725.00	$25.00	4
1622	14	$18,316.00	$0.50	4
1625	15	$18,316.00	$33.00	4
1614	16	$11,701.00	$1,099.00	4
1617	17	$11,701.00	$749.00	4
1623	18	$11,701.00	$749.00	4
1624	19	$11,701.00	-$201.00	4

Table 9 Third Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1627	20	$18,316.00	$184.00	1
1626	21	$11,701.00	$1,099.00	2
1628	22	$12,835.00	$565.00	2

Table 10 Forth Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1630	23	$14,914.00	$1,086.00	1
1629	24	$18,316.00	$2,584.00	2
1631	25	$14,725.00	$2,275.00	2
1633	26	$18,316.00	$84.00	2
1632	27	$12,835.00	$2,165.00	3

Tables 11, 12, 13 show that during fifth, sixth and seventh period there was extremely high competition. Everybody tried to win the bid even though the profit margins were low. This is again atypical.

Table 11 Fifth Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1634	28	$14,725.00	$275.00	2
1635	29	$11,701.00	$199.00	2
1636	30	$13,213.00	$687.00	2
1638	31	$14,914.00	-$14.00	2
1641	32	$13,213.00	$1.00	4
1637	33	$12,835.00	$5.00	4
1639	34	$18,316.00	$2.00	4
1640	35	$18,316.00	$1.00	4
1642	36	$14,914.00	$1.00	4

Table 12 Sixth Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1645	37	$18,316.00	$34.00	1
1644	38	$11,701.00	$19.00	1
1643	39	$12,835.00	$65.00	2
1649	40	$12,835.00	$65.00	2
1648	41	$14,725.00	$1,675.00	2
1647	42	$14,914.00	$3,086.00	3
1646	43	$12,835.00	$165.00	4

Table 13 Seventh Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1659	44	$18,316.00	$133.00	1
1650	45	$12,835.00	-$1.00	2
1652	46	$12,835.00	$1,155.00	3
1651	47	$14,725.00	$14.00	4
1653	48	$13,213.00	-$3.00	4
1654	49	$14,914.00	$636.00	4
1655	50	$11,701.00	$1,148.00	4
1656	51	$11,701.00	$299.00	4
1657	52	$14,914.00	$86.00	4
1658	53	$11,701.00	-$502.00	4
1660	54	$14,914.00	$285.00	4

During eighth and ninth bid period we can observe the maximum profit gain range as shown in Tables 14, and 15. Even though there was one negative profit job in ninth period, rest all jobs have a higher profit which matches the Chouhan theory.

Table 14 Eighth Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1664	55	$11,701.00	$16,299.00	1
1661	56	$14,725.00	$5,275.00	2
1663	57	$13,213.00	$11,787.00	3
1662	58	$14,725.00	$5,274.00	4

Table 15 Ninth Bid Period

Job ID	Revised ID	Cost ($)	Profit ($)	Bidder ID
1665	59	$12,835.00	$2,164.00	4
1666	60	$18,316.00	$2,683.00	4
1668	61	$14,725.00	$2,175.00	4
1669	62	$14,725.00	$2,274.00	4
1670	63	$12,835.00	-$175.00	4
1671	64	$14,914.00	$2,536.00	4
1673	65	$13,213.00	$5,787.00	4
1674	66	$12,835.00	$1,155.00	4
1667	67	$11,701.00	$2,049.00	4
1672	68	$11,701.00	$2,299.00	4
1675	69	$11,701.00	$2,669.00	4

Table 16 compares the results of the bid periods using the statistical t-test analysis. This confirmed the bidding trends as postulated by Chouhan (2009). There was significant difference in bidding period one and two. Again during fourth and fifth, there was a very significant difference in bidding trend, which proved that the bidding trend shifted from discovering to competitive phase. The same difference was observed in seventh and eighth bidding period.

Table 16 Student's t-test Analysis

Bid Period	Compared to	t test value	Difference
1	2	3.37	Significant
2	3	0.69	Not Significant
3	4	1.58	Not Significant
4	5	4.31	Very Significant
5	6	1.67	Not Significant
6	7	1.27	Not Significant
7	8	6.11	Extremely Significant
8	9	4.37	Significant

Fig. 7 represents the nature of the bidding during the course of the game. Four different phases can be clearly marked and shown with the different colors as learning, discovering, competitive and profit gain. The boxplot shows the profit range of the participants. Fifth order polynomial trend line generated in the boxplot clearly identified

the four prominent trends of the bidding game. The trend is further increase by one interval to predict the future of the profit gain for all the participants. The R-square value of 0.808 shows a strong positive trend. Thus it can be said that during next rounds of the bidding game with the same players, maximum profit gain can be achieved.
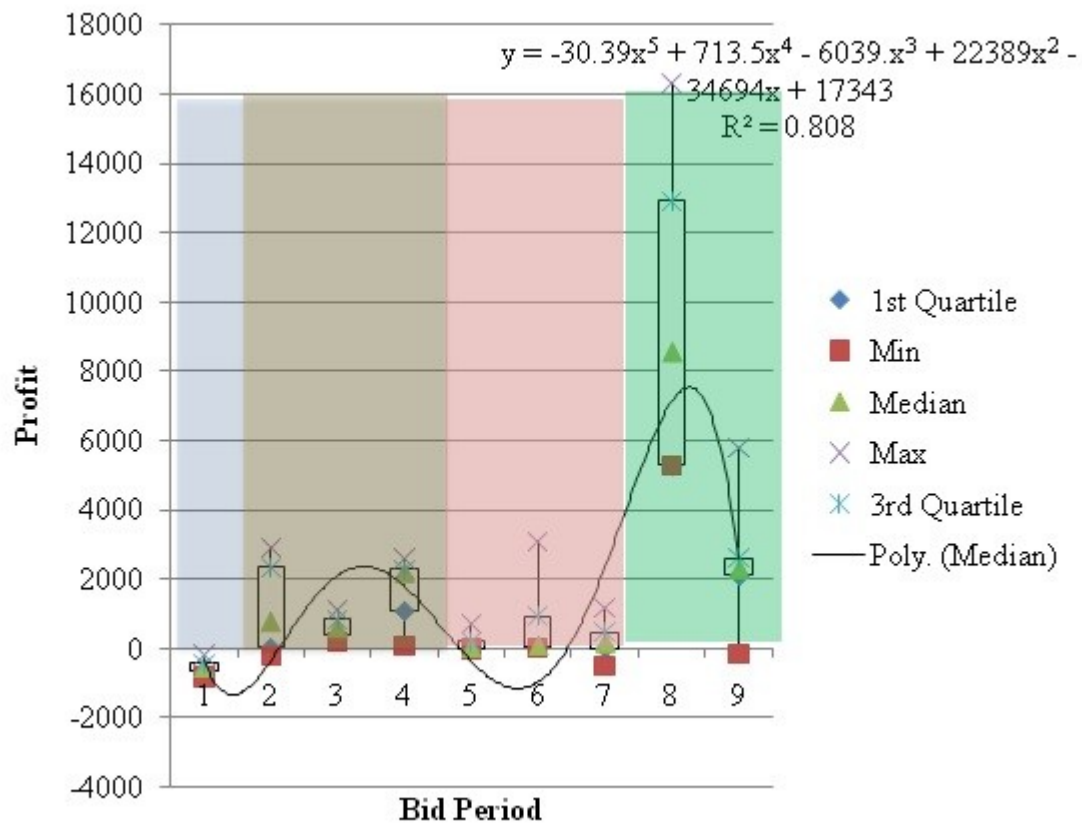
Figure 7. Boxplot for Profit

Fig. 8 represents a trend for the number of jobs against the number of bids. The trend clearly identified that a steady increase in the number of bids is seen with the increase in the number of jobs although the correlation is not so strong.
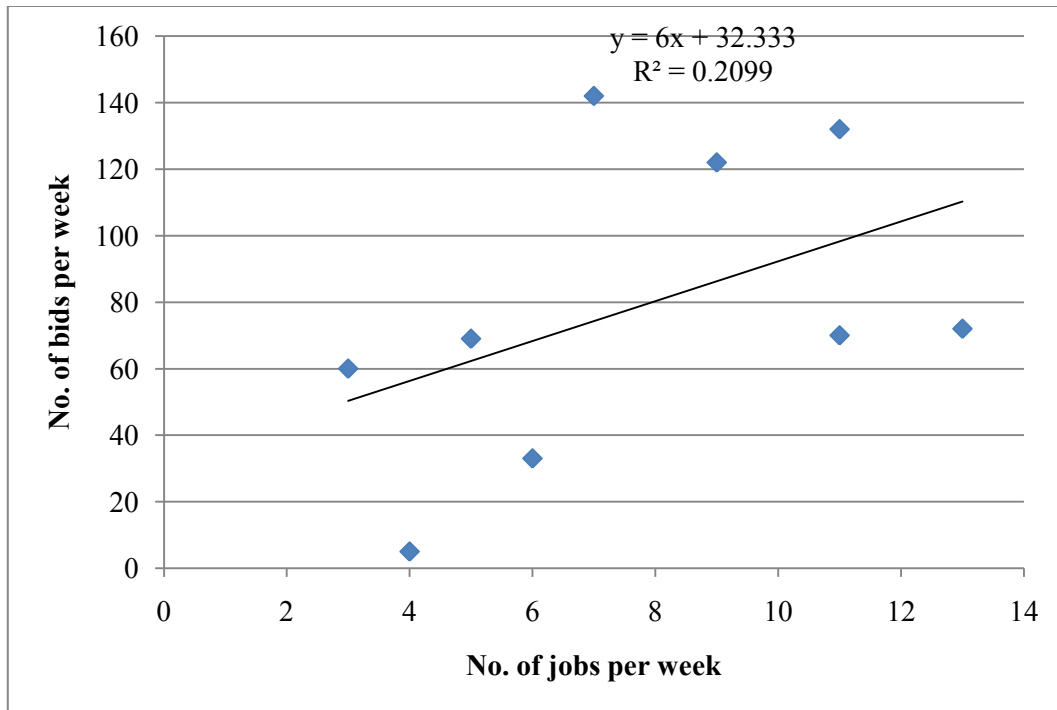
Figure 8. Number of Bids versus Number of Jobs

Table 17 and Fig. 9 show the number of bids in each minute of the bidding game play. A trend is observed. During first minute period the average bids were 4.44 and during last minute the average bids observed were 11.44. This is typical behavior.

Table 17 High, Low and Average Bids in Each Minute

Minutes	High	Low	Average
1	12	0	4.44
2	12	0	4.33
3	12	0	4.00
4	6	0	2.00
5	6	0	3.00
6	13	0	2.22
7	6	0	2.89
8	9	0	3.67
9	19	0	7.22
10	17	0	7.22
11	14	0	4.56
12	16	0	5.11
13	19	0	6.67
14	24	0	9.56
15	30	0	11.44
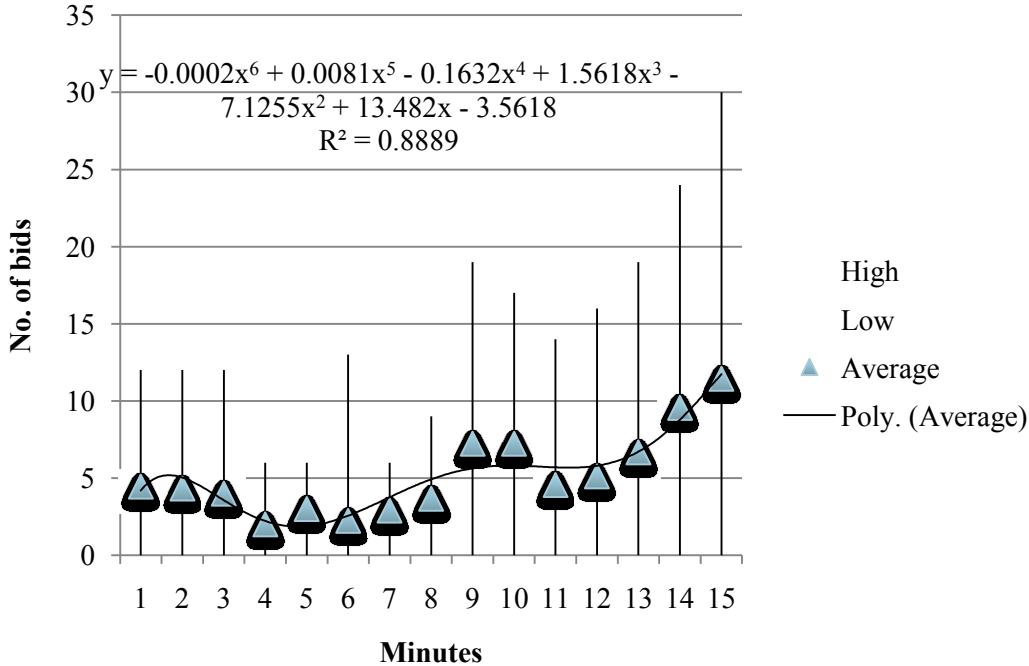
Figure 9. High, Low and Average Bid in Every Minute Boxplot

The trend line in Fig. 10 also shows an increase in the bidding. The R-square value of 0.862 confirmed this trend for the polynomial fit.
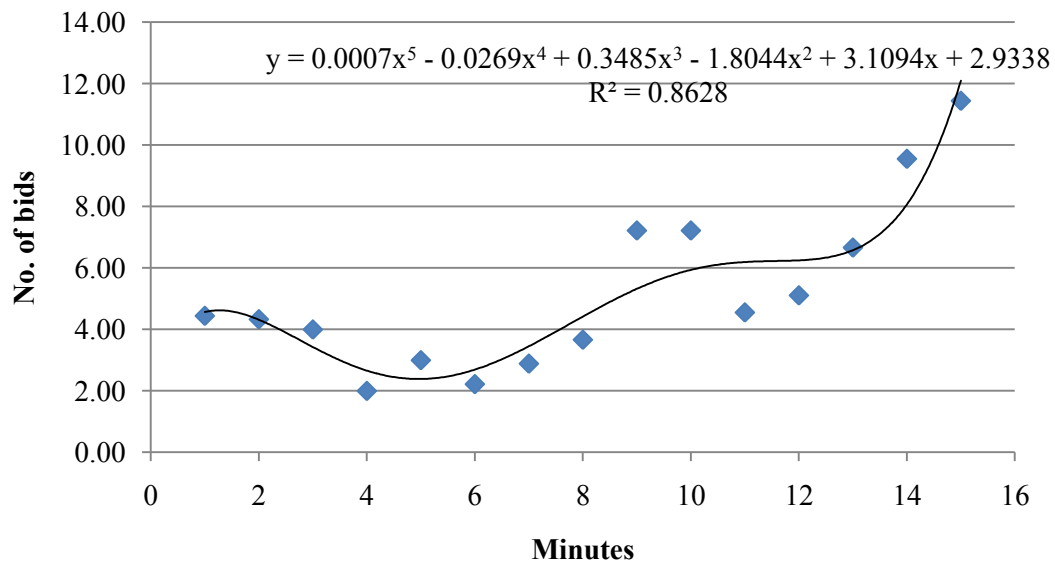
Figure 10. Trend of Average Bids per Minute

Table 18 summarizes the rank of the bidder along with number of jobs, number of bids and bid efficiency. First bidder has a highest bid efficiency (Saigaonkar 2010).This matches previous results.

Table 18 Bid Efficiency of Each Personality

Rank	Bidder	No. of Bids	No. of jobs	Bid Efficiency
1	4	113	45	40%
2	3	202	4	2%
3	1	174	6	3%
4	2	219	14	6%

Fig. 11 and Table 19 represent the rank of the bidder along with their loan amount and profit. It was clearly observed that rank one bidder took the minimum loan but gained maximum profit. This result is contradicting the previously stated results by Chouhan (2009), Peterson (2010), and Saigaonkar (2010) and requires further study.

Table 19 Bank Loan and Profit Data

Rank	Loan	Profit
1	500	44028.5
2	1000	18193
3	2000	17755
4	4000	14833
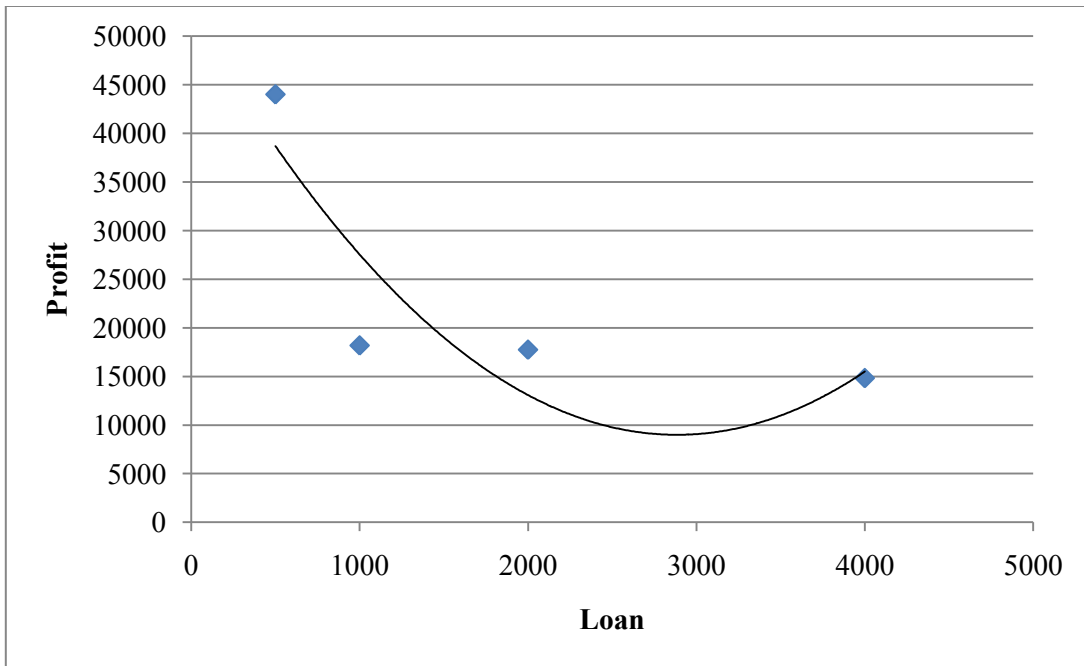
Figure 11. Bank Loan against Profit

Fig. 12 and Table 20 compare this study and the behavior of participants to the previous studies conducted by Gupta (2010), Van Vleet (2004) and Saigaonkar (2010). The participants from these prior researcher's study were selected because they had no prior experience of bidding i.e. first time bidders. This is a key constraint to the current work. All the previous studies studied the behavior of four major personalities (Guardian, Rational, Artisan and Idealist), it is interesting to observe the pattern of four of the role variants of the previously winning personality.

The normalized profit is achieved by dividing all the profits in every job, by the maximum profit achieved. This procedure provides a maximum profit of one. The number of jobs being offered to participants was again observed to be different in previous studies (van Vleet, 2004; Saigaonkar, 2010; Gupta 2010), this is shown in Table 20. Thus these were again normalized using the same procedure. This procedure helps in making the comparison unbiased. It is clearly seen that the first time participants are more competitive driving the profits in the lower range (0 to 0.11). Again a high number of profits are observed in the range of 0.7 to 0.9. This indicates that during this phase the bidders have the strong understanding of the game thus gaining a high profit gain.
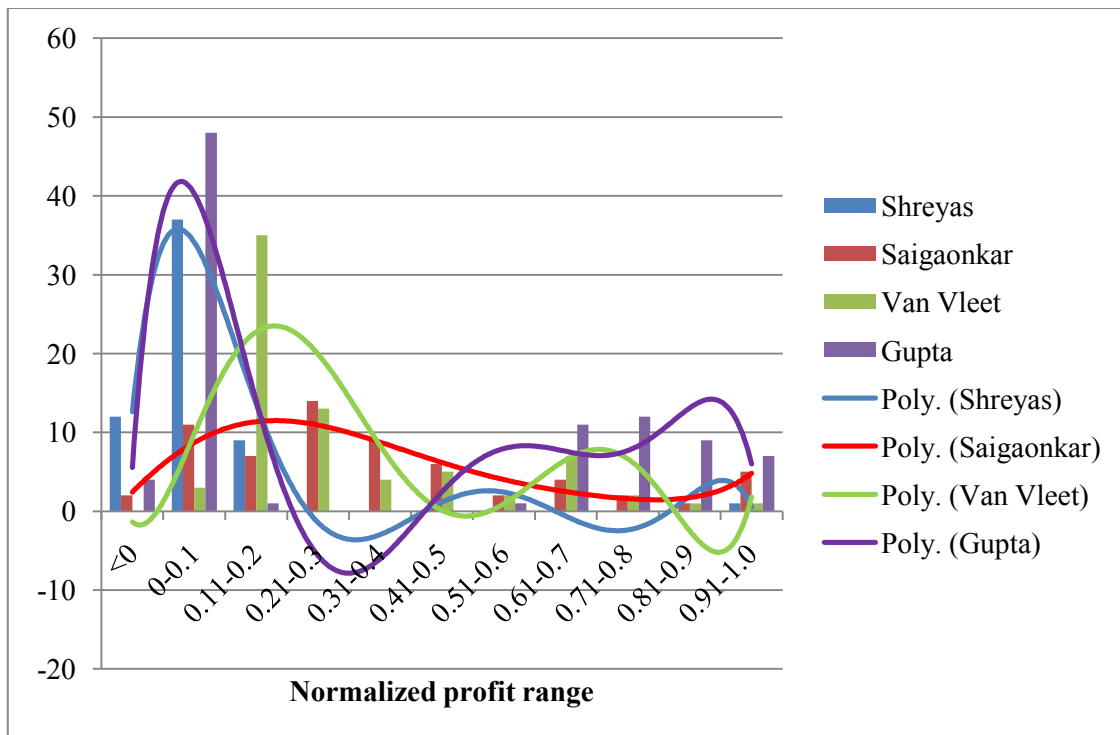
Figure 12. Number of Entries in the Each Normalized Profit Range

Table 20 shows the summation of total number of entries by Gupta (2010), Van Vleet (2004) and Saigaonkar (2010) and this research during each normalized profit period.

Table 20 Total Number of Entries in Normalized Profit Period

	Bedekar	Saigaonkar	Van Vleet	Gupta	Total
<0	12	2	0	4	18
0-0.1	37	11	3	48	99
0.11-0.2	9	7	35	1	52
0.21-0.3	0	14	13	0	27
0.31-0.4	0	9	4	0	13
0.41-0.5	0	6	5	0	11
0.51-0.6	0	2	2	1	5
0.61-0.7	0	4	7	11	22
0.71-0.8	0	2	2	12	16
0.81-0.9	0	1	1	9	11
0.91-1.0	1	5	1	7	14

Fig. 13 and Fig. 14 show the observable strategic pattern of the first time bidders in RAB. Fig. 13 shows the graph of total number of entries against the normalized profit range period and Fig. 14 shows the graph of cumulative total number of entries against the normalized profit range period.

It is very interesting to observe the competitive nature of the first time bidders in RAB. It is clearly observed in Fig. 14 that 50% of the total number of entries is located in the first 10% region of the normalized profit period.
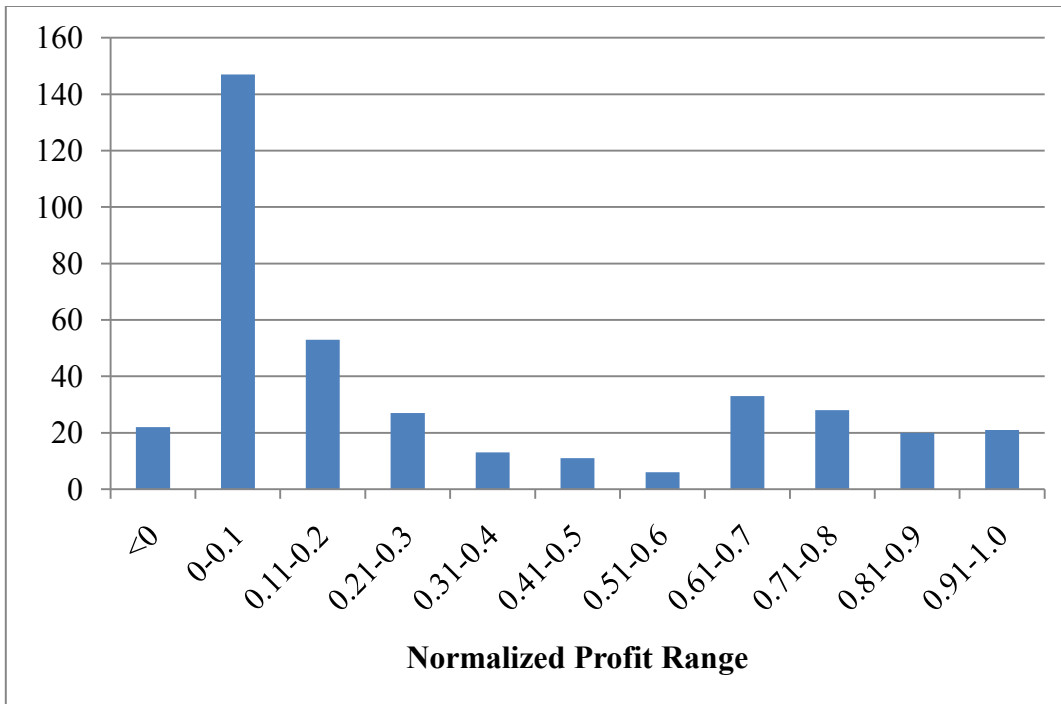
Figure 13. Number of Entries Versus Normalized Profit Range
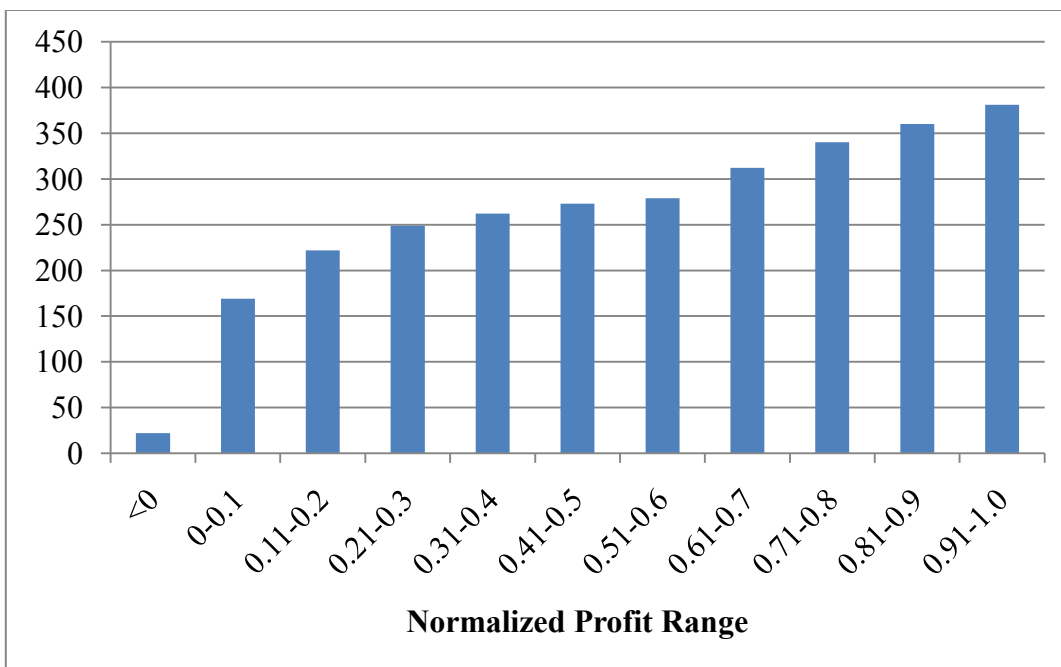
Figure 14. Number of Entries Versus Cumulative Normalized Profit Range

CONCLUSIONS

This study is a part of ongoing research on Reverse Auction Bidding at TAMU. To summarize, the game was conducted between four participants of the Construction Science Department who had no prior experience of RAB. Using KTS (Keirsey Temperament Sorter) test, the personality testing was completed for the bidders. The RAB game comprised 9 bidding periods, each 15 minutes long. The bidding data was analyzed so as to obtain different strategic patterns of the bidding. The studies which were carried out previously at TAMU analyzed different personalities, their competency levels and the effect of interference of owner's agent during bidding. Different personalities were tested in different competitive bidding scenario.

In this research, it is observed that the first time bidders have shown a significant pattern in their bidding strategy. The bidders were extremely competitive throughout the bidding, therefore the normalized profit level was very low. The profit gain phase started very late. During profit gain phase, bidders had enough understanding of RAB and nature of their competitors. The significant statistical pattern was found when the research results were compared with the previous first time bidding results. In this study, the bidder with the Guardian personality won majority of the jobs, hence confirmed the theory that the Guardians are the most proficient bidders. Four different phases of bidding namely learning, discovering, and competitive and profit gain were also observed during bidding process, but some were not strongly shown.

This research was under the final phase of the preliminary study of RAB in TAMU. It can be taken one step further by creating an algorithms and computerized programs which will be designed to recognize the bidding strategy of the most efficient bidders during RAB process. The study can also be taken to an extent that those algorithms and programs will outbid that efficient bidder.

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APPENDIX A

KEIRSEY TEMPERAMENT SORTER TEST

Test method

This test is taken from …………………………………………………

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 an 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

Scoring Method and Answer Sheet

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

	a	b		a	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		
50			51			52			53			54			55			56		
57			58			59			60			61			62			63		
64			65			66			67			68			69			70		

1   2 3   4 3   4 5   6 5   6 7   8 7

1

2
3

4
5

6
7
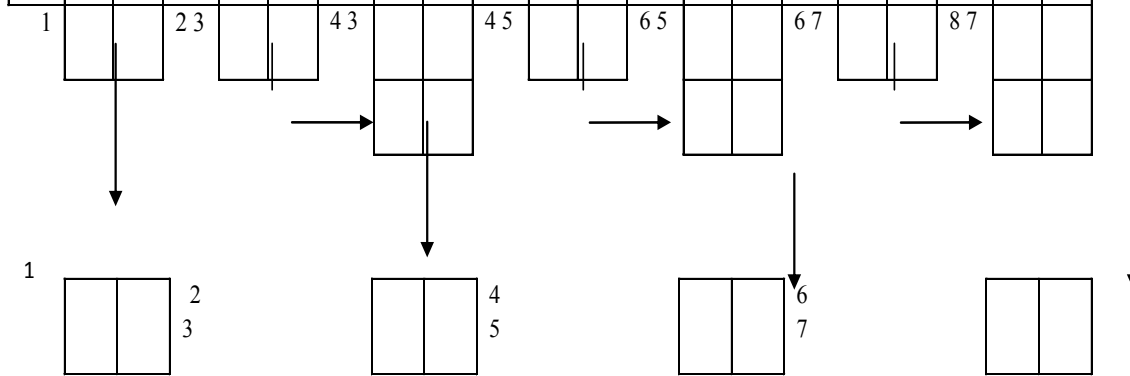
E   I   S   N   T   F   J   P

Directions for Scoring

These scoring directions are obtained from

- *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.*

- *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.*

- *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.*

APPENDIX B

IRB – APPROVAL FORM

TEXAS A&M UNIVERSITY
DIVISION OF RESEARCH AND GRADUATE STUDIES - OFFICE OF RESEARCH COMPLIANCE

1186 TAMU, General Services Complex   979.458.1467
College Station, TX 77843-1186   FAX 979.862.3176
750 Agronomy Road, #3500   http://researchcompliance.tamu.edu

Human Subjects Protection Program   Institutional Review Board

DATE: 15-Sep-2010

MEMORANDUM

TO: BEDEKAR, SHREYAS V
              77843-3578

FROM: Office of Research Compliance
              Institutional Review Board

SUBJECT: Initial Review

Protocol Number:	2010-0686
Title:	Studying Reverse Auction Bidding Game
Review Category:	Exempt from IRB Review

It has been determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

This determination was based on the following Code of Federal Regulations:
(http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

45 CFR 46.101(b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Provisions:

This electronic document provides notification of the review results by the Institutional Review Board.

VITA

Name:	Shreyas Vinayak Bedekar
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:	shreyasmani@gmail.com
Education:	B.E. (Civil Engineering), Walchand College of Engineering, Sangli, India, 2006
	M.S., Construction Management, Texas A&M University, College Station, Texas, 2010