Behavioral Modeling of Last-minute e-Auctions in the Tourism Industry

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Abstract
Today's continuously changing environment forces companies to seek for new innovative products and processes in order to gain competitive advantages and thus sustainability. Information and Communication Technology (ICT) may aid companies to move towards that direction by providing them those tools that are necessary to apply to their systems efficient, productive and competitive improvements. Using the benefits of internet, companies have implemented e-Business models; especially for airline industry web provides a low cost distribution channel that multiplies the choices for both buyers and sellers, while at the same time it decreases transaction and operating costs. Furthermore, wireless and mobile networks have extended electronic commerce to a new application and research area, composing a lot of opportunities for m-commerce. Applications of m-commerce like LBS technologies have arisen giving substantial benefits to companies. For instance, the advantage of location sensitivity in auctions over mobile devices, (that is to say m-auctions) allows for better filtering of choices according to the current location and expressed interests of the concerned. This work proposes a model to plot bidding behavior in m-auctions so that it may be applied on the tourism market and especially on the area of airline industry. More specifically, it deals with the problem at hand by using quadratic equations to fit curves between knot points that have been collected from numerous auctions; the subject is of interest as it has been noticed that behavioral patterns exist in auctions of sibling items.

Keywords: ICT, m-commerce, LBS technologies, auctions, tourism, bounded rationality

Introduction

The sector of tourism services constitutes a promising field for the development of marketplaces based on the application of Information and Communications Technology (ICT) and mobile communication technologies. Particularly for business involving a high degree of mobility like airlines that have a long history in technological innovation, the effectiveness of the marketplace augments when supporting on-the-move participants for location-aware services subject to participants' actual (or projected) location, using technologies like Location-Based Services (LBS), (Emiris and Marentakis, 2010). LBS refers to services that utilize the ability of location-awareness in order to simplify user interactions on the purpose that they adopt the specific context.

When it comes to services with non-standard subjective value, the process of pricing and allotting tourism services may be efficiently yet effectively supported in an auction-based marketplace, for all participants involved. The use of auctions in the tourism services sector permits near-optimal allocation of the excess capacity while improving efficiency and price visibility, (Emiris and Marentakis, 2010). The two main categories of auctions according to the necessity for the physical presence of the involved members (seller, bidders and auctioneer) in the location that auction is hosted are: physical auctions and non-physical auctions. The latter include electronic auctions (e-auctions) and mobile auctions (m-auctions), with respect to platform that they take place.

M-auctions, among others, are applications of mobile commerce; the latter is defined as the exchange of buying and selling commodities, services, or information on the Internet and may be performed at any time and from anywhere by using mobile computing technology (e.g. mobile inventory tracking, dispatching, LBS and m-auctions) through the use of mobile devices, (Hu et al., 2005). Therefore, mobile devices can be very effective means of accessing on-line tourism auctions; they provide the additional advantage of location sensitivity that could be used over better filtering of choices in accordance with the tourist's current location and expressed interests, (Tsamakos et al., 2002).

Auctions, as a format of trade-off take into account different personal criteria of each party involved, that are not only never revealed to each other but also may be subject to bounded rationality, (Emiris and Marentakis, 2010). When referring to bounded rationality it is implied that humans are sabotaged from their intentions to act to the stimuli of their environment as the classic expected utility model would command due to inherent limitations of their cognitive and emotional structure.

Hence, in order to investigate the behavioral aspects of bidders in electronic auctions, a research has taken place; the subject is that behavioral patterns exist in auctions of sibling items. This research approaches the problem at hand using quadratic equations to fit curves between knot points that have been collected from numerous auctions. The aim of the study was to explore whether behavior can be modelled and whether the polynomial approach is adequate in order to capture the bounded rationality aspects of bidding behavior.

The rest of the work is organised as follows. Section 2 reports the applications of ICTs in the tourist industry. Section 3 makes a briefly report the bounded rationality elements that can occur in electronic auction market. Section 4 presents a dynamic model that aims to investigate the behavioral aspects of bidders in non-physical auctions that concern for sibling items. Finally section 5 presents the conclusions and highlights future research directions.

Applications of ICTs in Tourism Industry

Tourism sector constitutes a promising field for implementing ICT-based marketplaces, like non-physical auctions. The latter may deal effectively with the intrinsic fluctuations in demand of the tourist product due to its special features. These are denominated by Tsamakos et al. (2002) as follows: 1) the tourist product holds properties that can be accounted only after its consumption, 2) it may considered to behave as a holarchy since it is consistent with various elementary yet independent products, 3) it is an experienced good being subject to different valuations on behalf of users, 4) it is perishable in a sense that its consumption is time- and space-critical as well as it cannot be stored in any way, since it is a service.

Auctions may be useful in equipoising demand with supply even when either facing a low season or allocating scarce resources. Also, small suppliers through auctions have the ability to encounter straightforwardly their competitors by dynamic pricing. Therefore, due to the fact that auctions in tourism industry, in general, are of the use to absorb divergences in demand, it is of great interest to engage on-the-move participants via a mobile ICT-based interface; thus, m-auctions have arisen, combing all assets of non-physical auctions and delivering tourism industry in the new era.

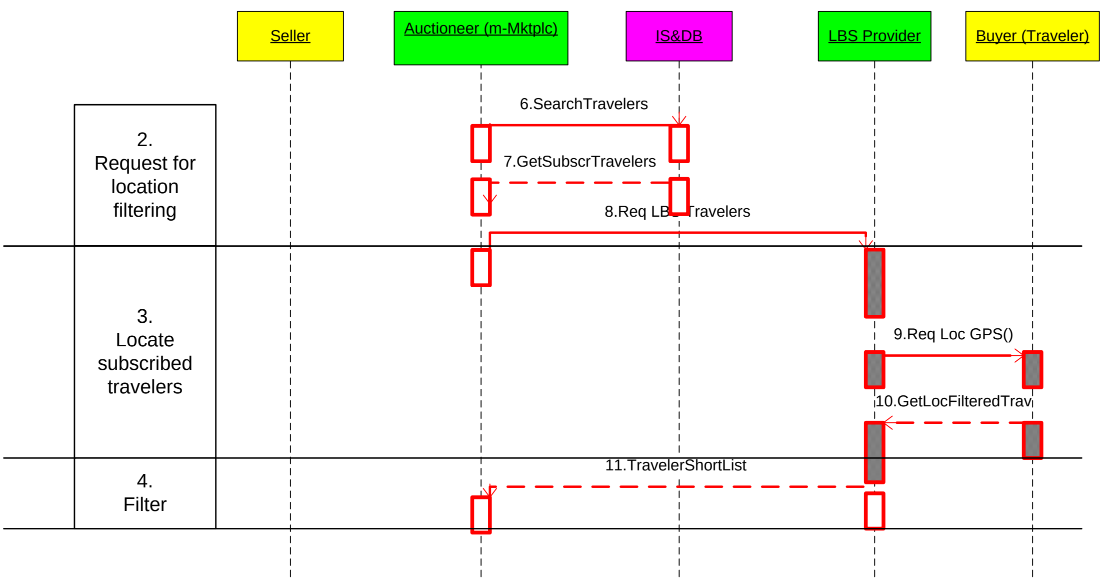
Information Communication Technology (ICT) has deeply affected the way business is performed and organizations compete each other. ICT supports all business functions and operations and provides the tools to search for meaningful and profitable niche market segments, to identify value added components for the product and to promote differentiated products through specialized media to particular market segments. Cost effectiveness and flexibility are also critical assets contributed by ICT, because of their assistance in cost reductions and efficiency maximization, (McIvor et al., 2003; Buhalis, 2004).

When it comes to travel industry, the influence of ICT is pervasive, as information is critical for both daily operations and strategic management, as well. The Internet, in particular, allows for the demonstration of their competitive advantages in a mass scale as well as for the direct communication with their prospective customers. For instance, complex and flexible bundles of tourism offerings can be configured; also personalization marketing to customers may be enabled via knowledge management tools, (Werthner and Klein, 1999). Furthermore, ICT may support the strategic management by empowering long-term decision making and by providing a platform for collaboration and transactions between partners; yet, reinforcement may be achieved in internal processes and partner coordination, (Buhalis, 2004). Generally speaking, in the freight transportation domain, Location-Based

Services (LBS) add value to commercial transactions whenever the distance between supplier and buyer becomes a prerequisite for the service. An LBS can be described as an application that is dependent on a certain location that is offered either upon user request or through an automatic triggering function, (D'Roza and Bilchev 2003; Ibach et al. 2005; Emiris and Marentakis, 2012).

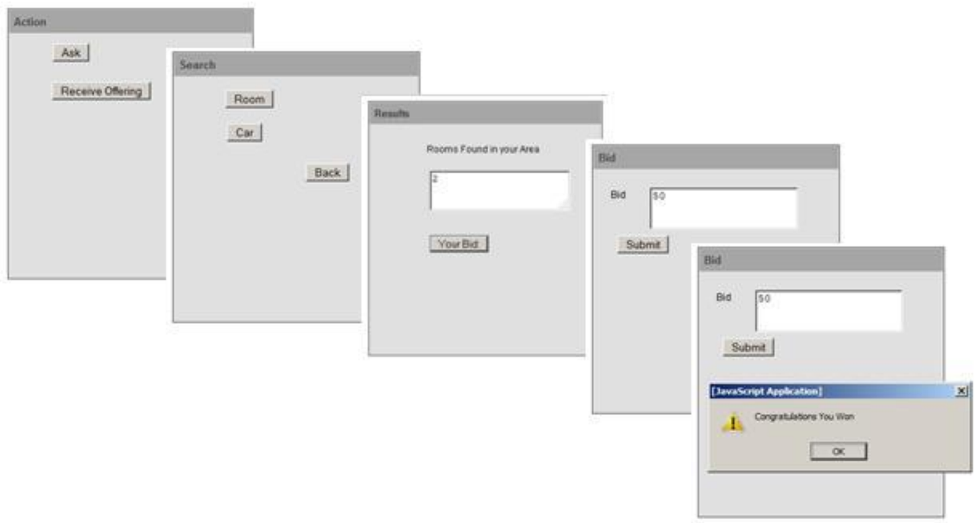
The combination of m-commerce with LBS enables the implementation of pricing tools which take into account carriers' current location to announce and execute geographically focused auctions over mobile networks (m-auctions), (Emiris and Marentakis, 2012). LBS may be used as a filter in order to narrow down the volume of the participants in the m-auction by using real-time geospatial location attributes of the auction participant and/or the auctioned service when the value of service is relevant to these spatial characteristics. From a systemic point of view, the implementation of this advanced marketplace engages four types of "physical" participants (service seller, auctioneer, travelers and LBS providers) and one "virtual" participant representing auctioneer's IT infrastructure. These entities are modeled as lifelines in the auction UML sequence diagram (Table 1). A typical architecture of a relevant LBS-based auction marketplace for tourism services and in particular the location-filtering process is presented in Table 2. Filtering is accomplished through a series of 3 discrete phases (stages 2-4): (a) auctioneer requests subscribed bidders' location from LBS provider, (b) LBS provider identifies subscribed bidders' location through their mobile devices (e.g. smartphones) and, (c) LBS provider filters subscribed bidders in accordance with the auctioneer's geographical area of interest and then, returns this shortlist to auctioneer who announce the mobile auction to the members contained within this list.

Table 1: LBS-supported filtering of potential bidders



Current software development technologies allow the rapid and costless development of working prototypes allowing not only their functional testing but also the evaluation of these innovative services. One indicative approach of a working instance has been developed by our research team for tourism services based on the systemic design described above and it is currently tested for mobile devices running on Android operational systems.

Table 2: Experimental *FairBid* application (bidding client)



An indicative sequence of bidder’s mobile Graphical User Interface (GUI) for the bidding stages is presented in Table 2. Notably, special attention has been given to tame limitations of mobile devices (e.g. screen size, data entry effort using small or virtual keyboards, etc.), by designing a simple GUI without frustrating and bandwidth-consuming whistles and bells which requires minimal data entry by user. The prototype, called “FairBid” serves as a platform supporting several LBS-based auctions beyond auctions for tourism services.

Bounded Rationality and e-Auctions

The nature of most electronic auction markets asserts that the bidders do not value the products according to Independent Private Values Model (IPVM) applications, which premise that each bidder has an exact valuation of the auctioned item, yet they are unaware of other participants' valuations but they know that all participants draw their valuations from a commonly known statistical distribution, based on the assumption that agents behave with a strictly rational way. However, bidders do not know their exact values or costs a priori, nor can make accurate predictions about others bidders’ behavior, thus Bounded Rationality (BR) issues can arise.

It is perceptible that there exist many parameters which can influence agents' behavior and therefore, the outcome of the auction result. The science occupied with the studying, recording and conduction of conclusions with respect to the elements affecting auctions is econometrics which however, so far, takes for granted that all participators act rationally. That is to say, auction agents are supposed to have a complete and clear picture of the auction parameters, thus they can be fully aware of their choice alternatives and they are able to make the appropriate analysis and calculations required to conclude to the respective optimal decision.

However, although auction agents are characterized by rationality, sometimes there is a mismatch between logically prospective and actual agents' behavior. Such mismatches between prospective rational and actual behavior concerning decision making are referred as Bounded Rationality.

When referring to bounded rationality it is implied that humans are sabotaged from their intentions to act to the stimuli of their environment as the classic expected utility model would command due to inherent limitations of their cognitive and emotional structure; however, this does not mean that people are irrational but despite being goal-oriented and adaptive, the limitations they are subject to, provoke a mismatch between the decision-making environment and the choices of the decision-maker. That is why, in recent years, a vigorous experimental movement in economics has emerged that involves a direct methodology; derive a result from theoretical economics, set up a laboratory situation that is analogous to the real-world economic situation, and compare the behavior of subjects to the predicted (Jones, 1998).

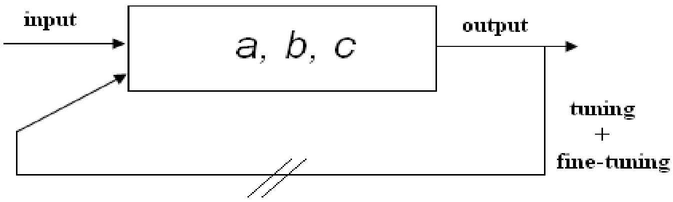
Presentation of the Model

This section presents a dynamic model that aims to investigate the behavioral aspects of bidders in non-physical auctions that concern for sibling items. It is noted that second order polynomial proves to depict rational bidding behavior since it expresses the augmenting tendency of price as bidders place their offers due to pursuing to acquire the item auctioned. By proceeding to the use of cubic polynomials (splines), bids expressed out of the expected rational behavior may be also captured; in statistics, to smooth a data set is to create an approximating function that attempts to capture important patterns in this data, while leaving out noise or other fine-scale structures/rapid phenomena. Curve fitting concentrates on achieving as close a match as possible between any two points that the order of equation involves; curve fitting implies that regression analysis is used, so that it may be attempted to explain how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed; the aim of smoothing is to give a general idea of relatively slow changes of value with little attention paid to the close matching of data values, while curve fitting concentrates on achieving as close a match as possible.

Since there were no auction data available about airline industry products, it was requisite that another product to be picked that provided real information, so that the mechanism proposed could be presented. Therefore, as a testbed, the electronic platform eBay is used, while as the category of auctioned items examined, without loss of generality, the family of antique maps and engravings has been selected. The reason why the sample studied concerned for this category of items lies in the fact that it constitutes a type involving as much collectability as perhaps perishability as features of a product. Such features are highly connected to relative evaluation therefore bounded rationality issues are more likely to be observed; also, by drawing attention of truly-interested-in-the-item bidders, aggressive behavior is likely to be observed, as well.

The research occupies with the training phase for the determination of the parameters *a, b and c* of the quadratic equation, so that the relations w.r.t. *c* would be determined with greater precision; ultimately, it is possible, by providing the system (Table 3) with various bids, to predict and forecast the price at which the item auctioned will be ultimately valued; to wit, in the following step – that of the application phase - the results extracted during training phase will be we employed in order to be able to, given only the starting bid and the time span of the auction, predict and forecast the behavior of the bidders for every item of that family.

Table 3: This approach circumvents the analytical econometric models that exhibit limited flexibility by neglecting the particular drivers of such models and focuses on the behavior of the bidders.



Hence, having set the target, that is, the type of items to be observed, the methodology followed during research, involved the *data mining* in a specified time interval (approximately 3 months), the *data filtering* so that the sample processed was cleared out, the *data analysis* using regression analysis with curve fitting and then the derivation of the results.

To wit, data mining included the recording of full bid history (date and time of bid, bid amount, bidder ID, starting price etc.) of the auction; data filtering entailed the conversion of bids into a treatable form so that bids would be represented as two-dimensional "points" (that is, *(y, t)* combinations, were *y* is the bid amount and *t* declares the respective time of bid) for every auction in order to determine the sample that would be processed; rules of exclusion of an auction from the sample suggest that i) auctions providing less than three points (a prerequisite number for curve fitting with 2nd order equations) after the clearing from "noise" (sudden high bids that blur the smooth monotonical augmentation of the auction) should be discarded and ii) lack of information provided as regards to the bidders, such as either private listing or no information over the winner. For uniformity reasons, these *(y,t)* combinations demand for the conversion of bids into a common currency as much as the conversion of time into a normalized form, of decimal type, so that $0<t<1$.

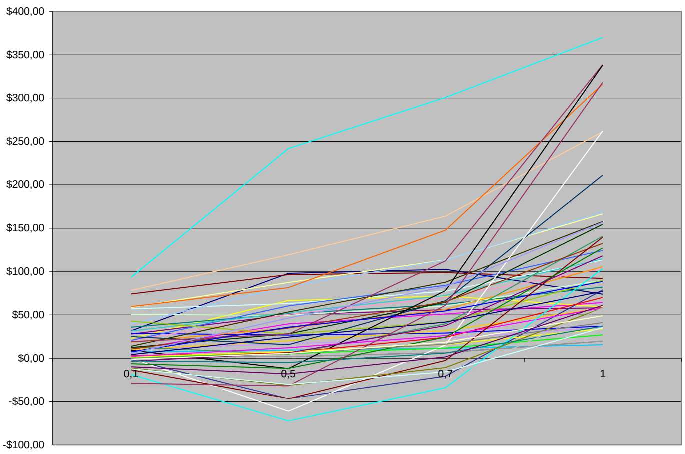
In *data analysis*, three from these points were selected so that regression analysis with curve fitting could occur. In order to construct the polynomial curve representing the bid expression, a quadratic function was used; then this fits in exactly three points: $[y^*] = a[t^{*2}] + b[t] + c$, where: $y^* = (y_1, y_2, y_3)$ and $t^* = (t_1, t_2, t_3)$. Then:

$$[y^*] = \begin{bmatrix} t_1^2 & t_1 & 1 \\ t_2^2 & t_2 & 1 \\ t_3^2 & t_3 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} \Leftrightarrow \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} t_1^2 & t_1 & 1 \\ t_2^2 & t_2 & 1 \\ t_3^2 & t_3 & 1 \end{bmatrix}^{-1} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$$

In order to retrieve the coefficients *a*, *b* and *c*, excel functions *MINVERSE ( )* and *MMULT ( )* as for matrices were used for each element of the set of auctions; to wit, having calculated t^{-1} = *MINVERSE (t)*, then matrix *Y* will be multiplied with matrix t^{-1} concluding in *(a, b, c) = MMULT* $(t^{-1}$*;Y)*; finally, the values for *a, b, c* were gathered in the respective aggregated matrix, w.r.t. the auction duration; in the end, it had to be investigated whether the results of the process were subject to any known statistical rules and whether there was any uniformity among these data; hence, a distribution of frequency was depicted. Thereupon, for each category per duration, the figures of the frequency distribution of the features -b/a, c/a and d/a were plotted, using the excel function *FREQUENCY ( )*.

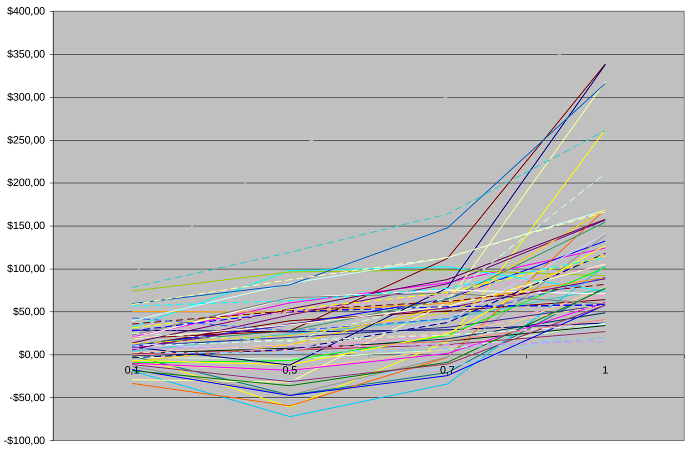
To this point, a few auctions noticed to provide negative or extremely positive values (since we deal with 2nd order equations) were filtered out. At first a restrained sample is processed w.r.t to the ratio of coefficients a/c presenting larger range; thereupon, the result over the interval *a/c = (-100, +100)* provides the results shown in the Table 4(a). Then, by moving to expand this interval in order to include all data, the outcome is depicted in Table 4(b).

Table 4: Depiction of the modeled bidding behavior in the auction observed; (a) those belonging to the interval a/c = (-100, +100) and (b) the whole set of auctions.



(a)

a/c = (-100, +100)	a	B	c
Average	177,04	-81,96	22,34
Standard Deviation	240,28	203,04	22,78

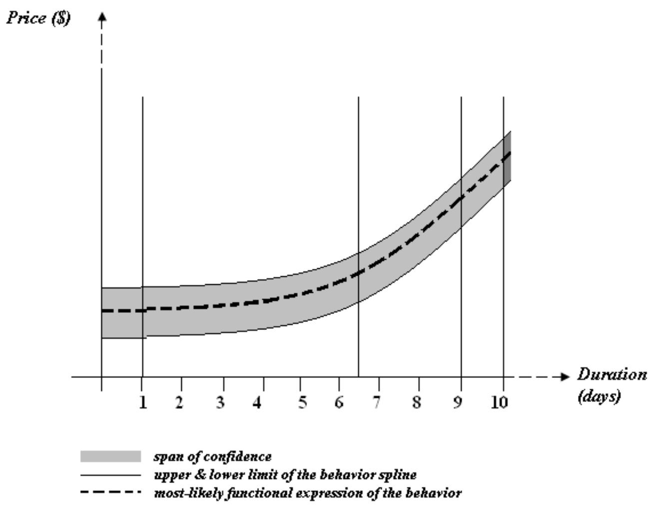


(b)

Total	a	b	c
Average	185,01	-88,44	20,20
Standard Deviation	238,00	201,55	22,47

What is observed is that as bids are expressed as the auction goes, the bidding behavior follows a certain route, regardless of the duration of the auction; this route is of type $y = at^2 + bt + c$; what may differ in each auction examined in terms of price evolution is the magnitude of this route. An area of behavior called "span of confidence" is consistent with all these different magnitudes of auctions concerning products of the same family. In this span of confidence the most-likely functional expression arises that reflects the most-expected-to-happen behavior. **Figure 5** in the following summarizes, qualitatively, the above mentioned for 2nd order equations that reflect the clear path of price.

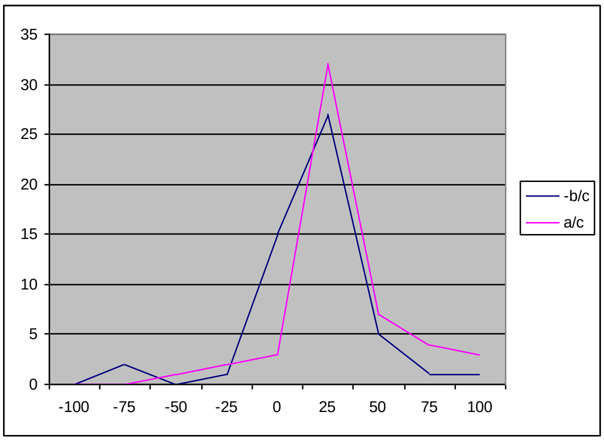
Table 5: Span of confidence arises from the different magnitudes of auctions concerning products that belong to the same family.



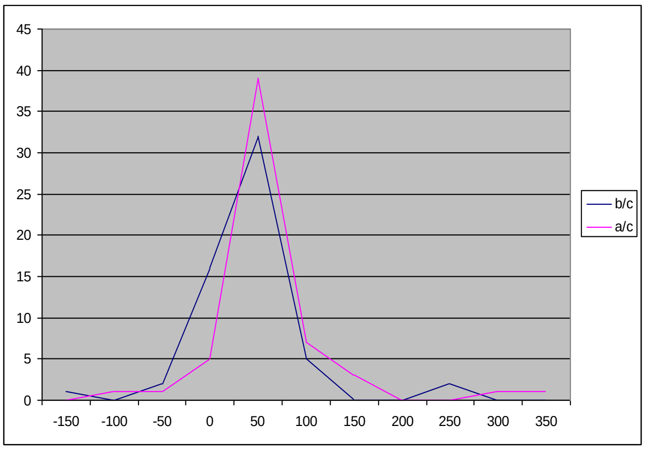
However, although the interval was expanded, *a, b* and *c* coefficients didn't change significantly, although the system has to be constantly updated in order to be fine-tuned. Also, both cases confirm that bid expression is lukewarm during the first phase of the auction and goes more and more aggressive as the auction reaches at its expiration date. "Last-minute" bidding presents a boost in price dynamics; that is, the speed at which price travels during the auction and the rate at which this speed changes (Jank and Shmueli, 2005).

In both cases shown in Table 4, the span of confidence is made obvious; of course, all negative values resulted for $t<0,5$ are neglected, as they don't have any physical meaning. In each one of the spans of confidence the most-likely functional expression has arisen reflecting the most-expected-to-happen behavior. Since *a, b* and *c* haven't change significantly herewith the expansion of the set of auctions examined, no significant divergences in prediction, during the application phase are expected to be observed, by using either the one or the other of the results. In the following, the ratio of coefficients -b/c and a/c were calculated in order to produce clusters of behavior. Therefore, the frequency distributions of both ratio of coefficients a/c and –b/c as much for the interval a/c = (-100, +100) as for the whole set of auctions examined were calculated; Table 6 presents their depictions.

Table 6: The frequency distributions of the ratios of coefficients a/c and -b/c as much for (a) the interval a/c= (-100, +100) as for (b) the whole set of auctions examined.



(a)



(b)

As it is shown in Table 6 (a) and (b) of frequency distribution as much as for the interval (-100, +100) as in the whole set of auctions examined, a/c and -b/c ratios follow a Gaussian distribution. That is, they may be divided in three categories/intervals/clusters: [-s, +s], [-2s+s)U(s+2s] and [-3s+2s)U(+3s-2s.

Conclusions and Future Research

E-commerce applications like non-physical auctions (e-auctions and m-auctions) may generate an infinite pool of choices which provoke the consumer to search globally in order to identify their set of preferences regarding the trade-offs between, to say, commodity price, consumer's convenience and uncertainty. According to what was mentioned to the previous sections, it can be observed that during the initial phase of the auction there is a smooth bidding display, while as it approaches to its end phase an upheaval bidding increase may be noticed.

This phenomenon may be occurred because during the auction bidder tries not to divert from his predefined strategy, by which he has specified his valuation for the product or service. A declination from their initial strategy may lead the rate of either product or service to higher levels on the contrary with bidder's initial valuation. That is, the sooner the bidder reveals their valuation, the more likely it becomes for another bidder to bid at a higher price and therefore, eventually the price would exceed the initial valuation, (especially when it concerns outcry auctions). This is seemingly a rational behavior, however, when it comes to many different stakeholders it becomes unlikely for the individual bidder to determine the intention of the others due to the lack of sufficient information; hence, the bidder can only intuitively predict the others' behavior and thus, draw their strategy. Consequently, although the initially strategy might seem rational, because of the uncertainty that either the lack of information for other bidders' strategy or excessive alternatives generate, it is likely for the initial strategy to be redefined with the incorporation of bounded rationality elements.

Due to the fact that our research has taken place under an electronic platform like eBay that does not provide any information over the bidders it is unlikely to unveil the individual bounded rationality elements that each one of the bidders take into account during the decision making process of whether and when to place a bid. Yet another important issue that prevents us from being able to extract the bounded rationality elements of the bidders is that in each one of the auctions belonging to the sample processed, engaged a different group of bidders and consequently, each one of the items auctioned was subject to a different bounded rationality mix.

Thereupon, in order to determine the bounded rationality elements in the tourism sector it is suggested that two new experiments should take place implementing the mechanism proposed above; the first one would be held on under a controlled environment where the group of bidders would be fixed and thus the experiment would subject to the same bounded rationality mix; then the bounded rationality elements would be revealed as also their weights would do. Afterwards, the second experiment would be held; this one would take place in the real world where the groups of bidders vary and by that the outcome of the first experiment would be compared and then fine-tuned so much qualitatively as quantitatively; by fine-tuning it is meant that declinations and tolerances of the weights would be determined; then by incorporating decision making tools the cause effects relationships between these elements would be defined, as well.

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