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Analysis of price and entry barriers to bespoke-purpose application markets through static Bayesian game

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A B S T R A C T

We model the interplay entry barriers are structural variables that play an important role in explaining market power and unconventional profit. The causes and sources of entry barriers may be technical, legal issues or conditions of the market. In this research, the cause of entry barrier in the market of bespoke-purpose applications is assumed to be lack of differentiation in production. This entry barrier is structural and supply-side where entrance is blocked in a range of prices. In this article, the price of corresponding application and maximum entry forestalling price to the market was calculated through static Bayesian game and assuming lack of knowledge of computer companies about future demand. The results indicate that in case of software demand in more than one stage, maximum entry barrier price and consequently the height (intensity) of entry barrier increase with respect to an increase in the number of stages. In this case, the buyer will suffer from extra costs compared to purchase at once, and the increase in the number of these steps leads to a rise in the imposed costs.

1. Introduction

In recent years, significant advances and achievements have been obtained in various sciences, one of the most important of which has been in computer science. This is important in that currently, the achievement of most researchers in the world in various fields depends on the computational capability of computers. Almost in all various fields, computations, simulation, experiment etc. are performed by processors and calculators. This technology has widely spread among people and been incorporated in all aspects of life Overall, it could be said that computers have dominated the world of 21st century. The main components of a computer are hardware and software. Hardware refers to a set of physical components constituting a computer and software is a set of computer programs, trends and documentations carrying out various tasks on a computer. Software could be classified under various aspects, and the computer science experts have presented different classifications of this technological phenomenon. In one classification, software is divided into two general categories: system software and application software (multiwingspan.co.uk). System software is a set of programs written to service other programs and depends heavily on the physical structure of computer hardware. Operating system and drivers are system software. The application software is an independent program satisfying a certain trade need. The applications in this area process technical and trade data in a way to facilitate the trade operation or managerial- technical decision making (Pressman, 2010). Application software itself is classified into three categories of general-purpose application, special-purpose application and bespoke (or custom)-purpose application. General-purpose applications are written and compiled for various purposes and legal and natural objectives such as word processor. Special-purpose applications are those written for a special objective such as stock control software. Bespoke (or custom)-purpose applications are those written for special costumers and users such as telecommunication financial master plan software (multiwingspan.co.uk). In this study, bespoke applications are explored.

The type of activity and administrative, producing and financial processes of any company is different from those of others. In so far as the special-purpose application software packs are designed for a special process or a special industry, they cannot cover all demands of companies. On the other hand, the business type of a company might be so complicated and special that there would be no appropriate software in the market to meet that special need or it might be the case that companies request for designing special software for themselves for more convenience or security. Thus, another kind of software is needed that is called bespoke- purpose software. These software are mostly more expensive in that despite two previously mentioned applications, the designing costs are not divided between a wide number of buyers. Generally, the advantages of bespoke-purpose software include complete match of that software with the demands and requests of the company, the capability of modifying and adding facilities, and future demands, and the main deficiencies of these software are high cost, long production duration, and impossibility of resale.

One of the unique features of this kind of software is that if a computer company compiles bespoke-purpose software for an applicant and the applicant request for more capabilities and facilities, the computer company benefits from the advantage of early entrance to the market since any other computer company is required to design the software (initial designed software with more demanded capabilities and facilities) to be able to enter the market. From software designing experts' perspective, the reason is that despite the source of software, rereading and comprehending the programming of designed software in the first stage is usually more difficult that rewriting the program.

The companies requesting bespoke- purpose software could purchase them in different ways such as tender and abandonment of formalities (without holding tender) from computer companies. In case there are various companies capable of designing software and if the requesting company does not stipulate special conditions, the assumption of holding auction seems reasonable. For different reasons such as failure in planning, misappropriate need assessment or advancement in technology, software requesting company might decide not to propose all its demands in auction phase; instead, he might be inclined to mention his demands and needs in two phases or more. In this condition, the software designing company could prevent entry of other company or companies to related software market in the first stage (holding auction) through his pricing.

1. Utilizing static Bayesian game, the present study seeks to pursue the following objectives:
2. The comparison of expenses of related software in different demand states by the requesting company (demand in one stage, in two stages and in general, in n stages).

In order to fulfill the research objectives, the following sections have been considered in this paper. The second section deals with literature review; in the third section, the research methodology (static Bayesian game) has been presented. The modeling has been done in the fourth section and finally in the fifth section, the results and recommendations have been presented.

2. Review of the related literature

In the literature of economy, it is repeatedly tried to determine the market performance through its structure. There are many available documents and studies that support and promote the opposite opinion. However, some believes that market components mutually influence each other. Different approaches have created different schools, the most important of which is "Structure- Conduct- Performance" and Chicago schools. The proponents of "Structure- Conduct- Performance" (S-C-P) school believe that market structure is the essential component in any market and the conduct and performance of enterprises and the market performance are influenced by the variables of market structure. Opposite to S-C-P is Chicago school where the authors consider the causality direction from performance to structure and believe that the government's interference to change the market performance is a useless act. There are other theories in addition to the mentioned ones that rather than being independent and different, pursue and reinforce either of the above schools. One of these theories is theory of contestability markets of Baumol. He believes that the identity of any market depends on its entry conditions.

The entry barrier is among the structural variables that theoretically, plays effective role in establishing market power and achieving unconventional benefit. Entry barriers in its economic meaning refer to the fact that a new enterprise is inevitable to incur some costs to enter to an industry which the old ones are exempted from. Thus, in fact the entry barriers refer to the advantages of old enterprises over the new coming enterprises (Khodadad Kashi, 2012). It is expected that reduction of entry barriers to market has significant role in making competitive environment in the market since the entry barriers are considered as the most important resource of creating exclusive power for the present enterprises in industry. Thus, the enterprises try to increase these barriers with the aim of expanding their market power (Sadraei Javaheri, 2011).

Overall, the economists do not agree on the concept of entry barriers and its causes; thus, the existence of various definitions for entry barriers is due to disagreement of scientists on the causes and origin of the barriers (Khodadad Kashi, 2012). The causes and origin of entry barriers might be technical such as economies of scale or sunk costs; or legal such as being under the protection of patent or monopoly rights given by other enterprises or regulatory authorities; or they might result from market organization conditions such as distribution channels, marketing networks, good will and loyalty of consumers (Shy, 1995).

Table1

A brief review of main sub-criteria on creation of entry barriers in industry

Entry barrier	Explanation	Source
Price	In those industries were the enterprises intend to use the whole capacity of factor by reducing the cost, price war could be an important entry barrier	Needham(1976) and Smiley & Ravid(1983)
Sunk costs	Sunk costs are those costs that the enterprise could not cover them after entry to industry in case of leaving the industry and are sunk in short-term and mid-term even with stop of production. For example, sunk costs could be advertisement cost, permit cost or research and development cost; thus, it could be considered entry barrier	Baumol & Willig(1981)
Advertisement	Heavy advertisement by the enterprises in the market increases the entry costs for new enterprises	Brozen(1971), Comanor & Wilson(1967) and Demsetz, H(1982)
Absolute cost advantages	This advantage means lower mean production cost of enterprises in the industry compared to candidate enterprises for entry. Based on this, the absolute mean cost of enterprises in the industry is one of the entry barriers that is concluded from economics of scale and learning curve.	Bain, J. S(1956), Harrigan(1981), Porter(1980) and Henderson(1984)
Customer Switching Cost[1]	The customer switching costs is the switching of customer costs for purchase from new producer or supplier. The high level of these costs could be considered as entry barrier for potential enterprises.	Porter(1980)
Accessibility to distribution channels	First the enterprises that are candidate for entrance use the distribution strategies for limiting the accessibility of new enterprises to the distributers. Thus, this factor can be considered as the entry barrier.	Porter(1980)
Government's policies	The government confines the number of existing enterprises in a market with general policy makings, requiring permits and etc.	Beatty, Reim, & Schap(1985) and Porter(1980)
Monopoly of product or production method	Monopoly of product or production method is an endogenous entry barrier.	Harrigan(1981) and Shepherd(1997)
Research and development	This barrier has a short life and the enterprises could prevent the entrance of new enterprises with potential investment in R&D.	Harrigan(1981) and Schmalensee(1982)
Extra capacity	The extra capacity is the difference between real production of enterprise and maximum surplus capacity that could be used as the entry barrier at the entrance of new enterprises	Bain, J. S(1956), Harrigan(1981) and Kyle & Dixit(1985)
Technologic variations	Usually the production in industries of high technology is one of the main resources of cost advantages and could be considered as entry barrier	Arrow(1962) and Porter(1980)
Market concentration	Market concentration is one of the main entry barriers. In an industry with high concentration, the enterprises could influence the entry conditions by cooperation in price and value.	King, Arthur, & Thompson(1982)

1 .In terms of entry barrier, customer switching cost refers to the fact that the switching of supplier would be costly for customer, or, in other words, finding new supplier or seller would be costly for customer. Thus, the entry of new enterprise (or in fact new supplier) and selection of this new enterprise to be a new supplier would be costly for customer.

Trade mark	Trade mark includes information about products since a trade market could reduce unreliability, a more valid and known trade market could be considered as entry barrier for potential enterprises	Krouse(1984)
Capital needs	Demand for financial resources and high investment for entrance to industry is considered as entry barrier where in industries with high capital and asset, it is high.	Bain, J. S(1956), Eaton & Lipsey(1980) and Porter(1980)
Product difference	In markets where the products are not homogenous, the old enterprises benefits since they have previously attracted customers. If the customers remain faithful to the trade mark and products produced by old enterprises, product difference is considered entry barrier.	Bain, J. S(1956), Hofer & Schendel(1978), Bass, Cattin, & Wittink(1978) and Lipczynski, Wilson, & Goddard(2005)
Cost disadvantage ratio	This index that is defined as the ratio of per capital added value of worker in small enterprises who have created 50% of added value of industry to the per capita added value of worker in big enterprises who created 50% of added value of industry. This index evaluates the disadvantage of some enterprises to some other enterprises. The smaller is this ratio; it means that production in small scale is not economic.	Bain, J. S(1956), Harrigan(1981) and Kyle & Dixit(1985)
Investment risk	The need to investment of abundant financial resources and its associated risk could be considered as entry barrier.	Bain, J. S(1956), Harrigan(1981), Demsetz(1982) and Shaanan(1988)
The dominance of strategic resources	The exclusive access to strategic resource could create a cost advantage for enterprises and considered as entry barrier for potential enterprises.	Scherer(1970)

From Table 1, it could be seen that various factors lead to entry barrier. The cause of entry barrier in bespoke-purpose application software could be "Series Dependency of Production"[2], since the special and inherent difficulty in rereading and comprehending the programming of a designed software compared to its redesigning makes any software company think of full designing rather than completing the remaining part of software, part of which has been designed by another design company. This is called the feature of series dependency in production considered by the researchers of this paper.

It is possible to explain the factors causing entry barrier within different classifications. One of these classifications classifies the entry barriers into two categories of structural and strategic entry barriers. The structural entry barriers are related to main conditions of the industry including costs and production technology. In fact, these barriers do not result from the measures and actions of existing enterprises in industry; however, they are the inherent feature of industry. The strategic entry barriers are those created as a result of conscious measures of existing enterprises in the market in making the volunteer enterprises give up the entrance to market. In fact, the origin of strategic entry barriers is the measures and actions of existing enterprises on making market entry difficult. Based on this, the entry barrier in bespoke-purpose software is structural since the special feature of difficulty in rereading the designed software than its redesigning is the inherent feature of industry.

The other classification separates the entry barriers from supply side and those of demand side (Sadraei Javaheri, 2011). From this aspect, the entry barrier to bespoke-purpose applications is from supply side since the mentioned feature is associated with production.

The other classification of entry barriers could be blockaded entry, deterred entry, and accommodated entry. In blockaded entry, the entrance of new enterprise does not threat the active enterprise in the market; in fact, no enterprise recognizes the entrance to market as profiting even if the active enterprise produces the exclusive product. Deterred entry is taken to mean the strategic actions of active enterprises in industry at the time of confrontation with practical threat of entrance of enterprise or enterprises to their industries. The strategic actions mean those actions that the active enterprise sees as non-profiting to take in industry at the time of lack of any threat of entrance of other enterprises. In accommodated entry, the new enterprise enters the market based on which the active enterprise changes its conduct (Shy, 1995). Based on this, the entrance to bespoke-purpose application market is blocked in a range of prices[3].

As one of the leaders of industrial economy and the issue of entry barriers, Joe Bain (1956) explains that the terms and conditions of entrance to a market are determined in terms of the gap between price and minimum average costs in long-term. The bigger is this gap, the more entry barriers will exist and the slower and more difficult will be the free flow of resources' transfer between markets and various sections of economy and finally, the resource allocation will be inefficient. According to him, there is a price such as P_b below which the potential enterprises are not ready to enter to industry and in case of entrance, they will surely incur losses while the old enterprises profit. The reason for the loss of potential enterprises is the advantage of old enterprises over them. Thus, P_b is "maximum price of entry barrier" that the old enterprises could

2 . This term is proposed by the authors of this study.

3. In modeling section, more explanation will be provided.

establish based on which the new enterprises will not be ready to enter to the market. The cost advantage of old enterprises could be described based on cost structure and especially average cost. Based on this, it is possible to define the height of entry barrier (entry conditions) in terms of the difference between P_b and $MinLAC$ as:

$$HB = \frac{P_b - MinLAC}{MinLAC}$$

Where HB indicates the height of market entry barriers and terms, $MinLAC$ is mean cost of old enterprises and P_b is maximum entry forestalling price. However, P_b could be considered as minimum costs that make the potential enterprises ready to enter to the market (Khodadad Kashi, 2012)

Research methodology (Static Bayesian game)

Games are classified from various aspects including the number of players, the number of strategies, agreement or disagreement, complete and incomplete information etc. (Souri, 2012). One of these classifications is based on market being statistic or dynamic. Static game is the one where the actions of players are simultaneous. In dynamic game, the players' actions are consecutive, i.e. one player acts upon observation of the first player's action. The other classification of games is based on the players' information regarding the game conditions and status. If any player knows the number of players, their strategies and the rate of win or loss at the end of the game, it is called "complete information" game. However, in a game, it might happen that the players do not have complete knowledge of win and loss which is called, "incomplete information" game (Khodadad Kashi, 2012).

Based on this, static game could be classified into two categories: 1. Static game with complete information.

2. Static game with incomplete information (or static Bayesian games).

Thus, in static game with complete information, the players simultaneously select their action (strategy) and any player fully knows the players' gain in the game. In static game with incomplete information, the players simultaneously select their strategy and some of them do not know the gain of competitor/s for some or all combinations of strategies. In other words, some players have no information on the gains of their opponents. Even, it might happen that some players have private (personal) information in the game of which others are not aware. In such conditions, the players with lower information are obliged to consider the private information of competitors to form their expectations and select their own strategy. In so far as the selection of strategy is simultaneous for players, it is not possible to exchange data; thus, consideration of personal information of others will be based on speculation. The main assumption in these games is that while knowing the strategy suite of each other, players simultaneously select their own actions or strategies without knowing the competitor's selection. The other assumption is incomplete information, i.e. the gain of competitor from part or whole of his selectable strategies is not known for the intended player. Sometimes, this type is called asymmetric game or information (Abduli, 2012). In this study, static Bayesian games are used.

4. Game modeling

In order to develop the model, first the following definitions will be explained:

a. Tender: a competitive process to supply the intended quality (according to the bidding documents) where the commitments of the subject of transaction are transferred to the bidder proposing the lowest price.

b. Bid manager: the organization or entity holding the tender.

c. Bidder: the legal or natural person receiving the bid documents and participating in the bid (Zahedi, 2014).

Now, consider X company requiring bespoke-purpose software to perform its assignment and affairs. In order to supply the required items, X Company holds bid so that with the lowest possible price, it would be able to satisfy its needs. A and B computer companies have the required conditions to participate in this bid. They should send their sealed proposed price to the bid manager who declares the lower price as the winner of bid. The companies do not know the proposed price of each other but they know that the higher price will increase their profit while decreases their chance of winning since the competitor might propose lower price. In proposing the price, any company considers the probable behavior of his rival, i.e. his proposed price to increase his chance of winning with higher profit.

The assumptions of the model:

Some assumptions are to be considered to simplify modeling which are as follows:

✓ The entire demand of intended software is normalized to value 1; in other words, total demand is considered as equal to 1.

✓ The bid manager might bid for entire software or bid for part of it in the first stage and then request for the other parts in the next stages.

✓ Production cost for both bidders is the same and equals to C for complete designing of the mentioned software; thus, in case of designing part of software, its costs would be $\frac{C}{2}$ and in case of designing $\frac{1}{N}$ of it, the cost would be $\frac{C}{N}$. Moreover, the average and final costs will be equal.

✓ In case of multi-stage tender, the bidders are not aware of future demand.
✓ In case of multi-stage tender, the bidder who has not wined the bid will enter the market from second stage onward with higher prices than "entry barrier maximum price"[4].
✓ The bidders seek to maximize their reserve expected profit.

Introducing variables of the model

In this section, in order to facilitate perception of the model, the variables used in the model are introduced.
C: Total production cost
$\bar{r}, \underline{r}$: Respectively indicating minimum real output rate[5] and maximum real output rate of bespoke-purpose software industry in the range of [0, 1].
r^e: Expected output rate of bespoke-purpose application industry for bidders, shown as r_A^e and r_B^e for A and B bidders and in the range of [0, 1].
b_i: Proposed price of bidder *i* in single-stage game.
$b_{iq}, b_{i2}, b_{i3}, \dots, b_{in}$: Respectively indicate the proposed price of bidder *i* in stage 1, 2, 3…, n of a game of *N* stages.
For extraction of the model, three different states are considered. In the first state, the bid manager puts his total demand for bid in one stage. The second state is when the bid manager put part of his demand for bid in the first stage and the other part in another stage. However, for simplicity of extraction of the model, that state is considered where the bid manager put half of his request for bid in the first stage and the other half in the next stage. The third state is the extension of second state to *n* stages; i.e. the bid manager puts $\frac{1}{n}$ of his demand and in each $n-1$ next stages, $\frac{1}{n}$ of this demand.

4.1. Modeling of single-stage game

In this state, the bid manager puts his whole demand to bid in a single stage. Any bidder knows *i (i=A, B)* of expected output of his investment of software design, i.e. $r_i^e C$; however, he does not know the expected output of the competitor due to lack of information; thus, he obtains some estimations of the expected output of software designing with the probability of accuracy of each estimation. This probability shows his beliefs. In other words, according to the bidder, the expected output of the competitor of designing software is a random variable with continuous probability distribution that is the probability of his opinion and belief. Based on this, the bidder's probable estimations of the expected value of the competitor for designing software is in $[(1+\underline{r})C, (1+\bar{r})C]$ range and its probability distribution is $f(r_i^e)$.

In this bid, two bidders simultaneously send their proposed prices (b_i) to the bid manager. The reserve profit of A and B bidders after the closure of bid will be as follows:

$$\pi_A(b_A, b_B) = \begin{cases} b_A - (1+r_A^e)C & \text{if} \quad b_A < b_B \\ \frac{1}{2}(b_A - (1+r_A^e)C) & \text{if} \quad b_A = b_B \\ 0 & \text{if} \quad b_A > b_B \end{cases}$$

$$\pi_B(b_B, b_A) = \begin{cases} b_B - (1+r_B^e)C & \text{if} \quad b_B < b_A \\ \frac{1}{2}(b_B - (1+r_B^e)C) & \text{if} \quad b_B = b_A \\ 0 & \text{if} \quad b_B > b_A \end{cases}$$

This is a static Bayesian game with its strategic form as follows:

Players' set: $N = \{A, B\}$

Players' action set: $E_i = [0, +\infty) \qquad b_i \in E_i \qquad i \in N$

T_A is the set of bidder A states from bidder B point of view and T_B is the set of bidder B states from bidder A point of view:

$$T_A = [(1+\underline{r})C, (1+\bar{r})C], T_B = [(1+\underline{r})C, (1+\bar{r})C]$$

$f(r_A^e)$ is bidder B's belief in the expected bidder A's value and $f(r_B^e)$ is bidder A's belief in the expected bidder B's value in software design that is continuous probability distribution of probability density function:

$$f_A = f(r_A^e) \quad , \quad f_B = f(r_B^e)$$

In Bayesian Nash equilibrium, considering the proposed price of competitor, any bidder proposes a price that maximizes his expected outcome. The expected outcome or the outcome that the bidder expects to gain by proposing price b_i, equals to:

$$\begin{cases} \pi_A(b_A, b_B|r_A^e) = (b_A - (1+r_A^e)C)P(b_A < b_B(r_B^e)) \\ +\frac{1}{2}(b_A - (1+r_A^e)C)P(b_A = b_B(r_B^e)) + 0 * P(b_A > b_B(r_B^e)) \\ \pi_B(b_B, b_A|r_B^e) = (b_B - (1+r_A^e)C)P(b_B < b_A(r_A^e)) \\ +\frac{1}{2}(b_B - (1+r_A^e)C)P(b_B = b_A(r_A^e)) + 0 * P(b_B > b_A(r_A^e)) \end{cases}$$

Where, $P\left(b_i < b_j\left(r_j^e\right)\right)$ is the probability that bidder *i* wins.

Any bidder should propose a price that maximizes his expected outcome, i.e. Bayesian Nash equilibrium of the game is obtained from:

$$\max_{b_A \in E_A} \pi_A(b_A, b_B^*(r_B^e)|r_A^e) \qquad , \qquad \max_{b_B \in E_B} \pi_B(b_A^*(r_A^e), b_B|r_B^e)$$

4 . Due to software switching costs as well as training the new software to employers, it seems reasonable that the bid manager use the existing software in equal prices. It worth noting that in literature review, these costs were proposed as customer switching costs and as an entry barrier.
5 . Minimum output of bespoke-purpose software could be considered as equal to zero or equal to output rate without risk

Shown as $(b_A^*(r_A^e), b_B^*(r_B^e))$.

Suppose the players' strategy is as follow:

$$\begin{cases} b_A(r_A^e) = a + k(1 + r_A^e)C \\ b_B(r_B^e) = a + k(1 + r_B^e)C \end{cases} \quad (1)$$

In this state, the strategy of bidders will be subjunctive and the obtained uniform and symmetric parameters and equilibrium will be symmetric, too.

The probability distribution r^e is considered uniform. In this case, the probability distribution r^e will be as follows:

$$f_i(r_i^e) = \begin{cases} 0 & \text{if} \quad r_i^e \leq \underline{r} \\ \dfrac{1}{(\bar{r} - \underline{r})} & \text{if} \quad \underline{r} < r_i^e < \bar{r} \\ 0 & \text{if} \quad r_i^e \geq \bar{r} \end{cases}$$

and its distribution function will be as follows:

$$P_i(r_j^e \leq r^e) = \int_{\underline{r}}^{r^e} f_i(t)\,dt = \begin{cases} 0 & \text{if} \quad r_i^e < \underline{r} \\ \dfrac{(r_i^e - \underline{r})}{(\bar{r} - \underline{r})} & \text{if} \quad \underline{r} \leq r_i^e \leq \bar{r} \\ 1 & \text{if} \quad r_i^e > \bar{r} \end{cases}$$

r_A^e And r_B^e have uniform distribution; thus, b_A and b_B that are respectively linear function of r_A^e and r_B^e will have uniform distribution. Thus, the lower limit b_i equals to $b_i(\underline{r}) = a + k(1 + \underline{r})C$ and upper limit b_i equals to$b_i(\bar{r}) = a + k(1 + \bar{r})C$. Thus, $b_i(r_i^e)$ will have uniform distribution in $b_i(r_i^e) \in [a + k(1 + \underline{r})C, a + k(1 + \bar{r})C]$.

Due to the symmetry of the game, the calculations will be performed for bidder A and then extended to bidder B. If bidder A proposes higher price than $a + k(1\bar{r})C$, he will not win and if proposes less price than $a + k(1 + \underline{r})C$ he will surely win since the competitor proposes in $[a + k(1 + \underline{r})C, a + k(1 + \bar{r})C]$ interval. If bidder A proposes in mentioned interval, his probability of wining will be as follows (the proof of the following equation is presented in appendix):

$$P_A(b_A \leq b_B(r^e)) = P_A(b_A \leq a + k(1 + r_B^e)C) = P_A\left(r_B^e \geq \frac{b_A - a}{kC} - 1\right)$$

$$= \begin{cases} 0 & \text{if} \quad b_A > a + k(1 + \bar{r})C \\ \dfrac{k\bar{r}C - b_A + a + kC}{k(\bar{r} - \underline{r})C} & \text{if} \quad a + k(1 + \underline{r})C \leq b_A \leq a + k(1 + \bar{r})C \\ 1 & \text{if} \quad b_A < a + k(1 + \underline{r})C \end{cases}$$

In continuous distributions, the probability of $b_A$being equal to certain value is zero, thus:

$$P_A(b_A = b_B(r^e)) = P_A(b_A = a + k(1 + r_B^e)C) = P_A\left(r_B^e = \frac{b_A - a}{kC} - 1\right) = 0$$

By replacing the answer of calculated probabilities in outcome function of bidder A, the following equation will be obtained:

$$\pi_A(b_A, b_B | r_A^e) = (b_A - (1 + r_A^e)C)P(b_A < b_B(r_B^e))$$
$$= \begin{cases} 0 & \text{if} \quad b_A > a + k(1 + \bar{r})C \\ \left(\dfrac{k\bar{r}C - b_A + a + kC}{k(\bar{r} - \underline{r})C}\right)(b_A - (1 + r_A^e)C) & \text{if} \quad a + k(1 + \underline{r})C \leq b_A \leq a + k(1 + \bar{r})C \\ (b_A - C) & \text{if} \quad b_A < a + k(1 + \underline{r})C \end{cases}$$

To get the optimum proposed price, the above equation will be differentiated in terms of $b_A$and put equal to zero; in this way, $b_A$will be obtained:

$$\frac{d\pi_A(b_A, b_B | r_A^e)}{db_A} = 0 \Rightarrow -\frac{(b_A - (1 + r_A^e)C)}{k(\bar{r} - \underline{r})C} + \left(\frac{k\bar{r}C - b_A + a + kC}{k(\bar{r} - \underline{r})C}\right)$$

$$= \frac{-b_A + C + r_A^e C + k\bar{r}C - b_A + a + kC}{k(\bar{r} - \underline{r})C} = \frac{-2b_A + a + r_A^e C + k\bar{r}C + (1 + k)C}{k(\bar{r} - \underline{r})C} = 0$$

$$\Rightarrow 2b_A = a + r_A^e C + k\bar{r}C + (1 + k)C \Rightarrow b_A = \frac{1}{2}a + \frac{1}{2}r_A^e C + \frac{1}{2}k\bar{r}C + \frac{1}{2}(1 + k)C \quad (2)$$

By comparison of obtained equation (1) and (2) it can be concluded that if $k = \frac{1}{2}$ and $a = \frac{1}{2}\bar{r}C + \frac{1}{2}C$, then, $b_i^*(r_i^e) = \frac{1}{2}\bar{r}C + C + \frac{1}{2}r_i^e C$ could be equilibrium. Concerning the symmetry, the above conclusion could be extended for the other bidder; this Bayesian Nash equilibrium will be:

$$\begin{cases} b_A^*(r_A^e) = \dfrac{1}{2}\bar{r}C + C + \dfrac{1}{2}r_A^e C \\ b_B^*(r_A^e) = \dfrac{1}{2}\bar{r}C + C + \dfrac{1}{2}r_B^e C \end{cases}$$

Thus, the proposed price of *i* bidder for complete designing of software will be equal to $b_i^*(r_i^e) = \frac{1}{2}\bar{r}C + C + \frac{1}{2}r_i^e C$.

4.2. Two-stage game modeling

In this state the bid manager puts part of his demand in the first stage of tendering, and the second part in another stage. However, as previously mentioned, for simplicity of model extraction, it is assumed that the bid manager requests for half of his demand of software in the first stage and the other half in the second stage. Based on this, the same as single-stage game, the bidder's possible estimations of the competitor's expected value for designing software will be in interval $\left[(1 + \underline{r})\frac{C}{2}, (1 + \bar{r})\frac{C}{2}\right]$ and its probability distribution is $f_i(r_i^e)$.

If in the first stage (call for biding) a bidder wins, he could demand for maximum entry forestalling price of lost bidder for designing the rest of intended software. For explained two-stage game, this price equals to software designing cost in the first and second stages plus the surplus of expected output of lost bidder which equals to:

$$b_{A2} = (1 + r_B^e)\frac{C}{2} + (1 + r_B^e)\frac{C}{2} = 2(1 + r_B^e)\frac{C}{2} = (1 + r_B^e)C$$

Since the proposed price for software design by the winner in the first stage is similar to single-stage game and thus half of it, the total price of two stages for winner equals to:

$$b_{g2} = b_{A1} + b_{A2} = \frac{1}{2}\left(\frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC\right) + (1 + r_B^e)C$$
$$= \frac{1}{4}\bar{r}C + \frac{1}{2}C + \frac{1}{4}r_A^eC + C + r_B^eC$$
$$= \frac{1}{4}\bar{r}C + \frac{3}{2}C + \frac{1}{4}r_A^eC + r_B^eC$$

This, the software price for the bid manager in two-stage game (b_{g2}) equals to sum of software price in the first and second stages, i.e. $b_{g2} = \frac{1}{4}\bar{r}C + \frac{3}{2}C + \frac{1}{4}r_A^eC + r_B^eC$. [6]

4.3. n-stage game modeling

This state is the extension of two-stage game where the bid manager puts $\frac{1}{n}$ of demand in the first stage of bid and the other $(1 - \frac{1}{n})$ in the next $n - 1$ stages. Based on this, the same as two-stage game, the possible estimations of expected value of the competitor for designing software by the bidder is in range $\left[(1 + \underline{r})\frac{C}{n}, (1 + \bar{r})\frac{C}{n}\right]$ and its probability of distribution is $f_i(r_i^e)$.

The same as two-stage game, if a bidder wins in the first stage of tender, at the second stage, he could demand for maximum entry forestalling price of lost bidder for designing the rest of the intended software. The price for various stages is presented in Table 2:

Table 2

The calculation of maximum entry forestalling price of lost bidder in stage 2 to n

$b_{A2} = (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} = 2(1 + r_B^e)\frac{C}{n}$
$b_{A3} = (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} = 3(1 + r_B^e)\frac{C}{n}$
$b_{A4} = (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} = 4(1 + r_B^e)\frac{C}{n}$
the same applies for n stages:
$b_{An} = (1 + r_B^e)\frac{C}{n} + (1 + r_B^e)\frac{C}{n} + \cdots + (1 + r_B^e)\frac{C}{n} = n(1 + r_B^e)\frac{C}{n}$

Source: Researchers' findings

In this case, total price of the last n -1 stage for winner bidder equals to:

$$b_{A2} + b_{A3} + b_{A4} + \cdots + b_{An}$$
$$= \left[2(1 + r_B^e)\frac{C}{n}\right] + \left[3(1 + r_B^e)\frac{C}{n}\right] + \cdots + \left[n(1 + r_B^e)\frac{C}{n}\right]$$
$$= \left[\frac{n(n+1)}{2} - 1\right](1 + r_B^e)\frac{C}{n}$$
$$= \left[\frac{(n+1)}{2} - \frac{1}{n}\right](1 + r_B^e)C$$
$$= \left[\frac{n^2 + n - 2}{2n}\right](1 + r_B^e)C$$

Thus, the total maximum entry forestalling price of lost winner in the last n-1 stage is obtained from $\left[\frac{n^2+n-2}{2n}\right](1 + r_B^e)C$.

Thus, the total price of n stages will equal to:

$$b_{gn} = b_{A1} + b_{A2} + b_{A3} + \cdots + b_{An}$$
$$= \frac{1}{n}\left(\frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC\right) + \left[\frac{n^2 + n - 2}{2n}\right](1 + r_B^e)C$$
$$= \frac{1}{2n}\bar{r}C + \frac{1}{n}C + \frac{1}{2n}r_A^eC + \left[\frac{n^2 + n - 2}{2n}\right]C + \left[\frac{n^2 + n - 2}{2n}\right]r_B^eC$$
$$= \frac{1}{2n}\bar{r}C + \frac{1}{2n}r_A^eC + \left[\frac{1}{n} + \frac{n^2 + n - 2}{2n}\right]C + \left[\frac{n^2 + n - 2}{2n}\right]r_B^eC$$
$$= \frac{1}{2n}\bar{r}C + \frac{1}{2n}r_A^eC + \left[\frac{2 + n^2 + n - 2}{2n}\right] + \left[\frac{n^2 + n - 2}{2n}\right]r_B^eC$$
$$= \frac{1}{2n}\bar{r}C + \frac{1}{2n}r_A^eC + \left[\frac{n+1}{2}\right]C + \left[\frac{n^2 + n - 2}{2n}\right]r_B^eC$$
$$= \left[\left[\frac{r_A^e + \bar{r}}{2n}\right] + \left[\frac{n+1}{2}\right] + \left[\frac{n^2 + n - 2}{2n}\right]r_B^e\right]C$$

Thus, the price of software for bidder in n-stage game (b_{gn}) equals to total price of software in n stages, i.e. $b_{gn} = \left[\left[\frac{r_A^e+\bar{r}}{2n}\right] + \left[\frac{n+1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e\right]C$. In lower prices than b_{gn}, the entry to bespoke-purpose applications is blocked.

4.4. The calculation of height (intensity) of entry barrier

As mentioned in literature review, the entry barrier height is defined based on the difference between P_g and MinLAC as follows:

$$HB = \frac{P_g - MinLAC}{MinLAC}$$

In the above equation, HB indicates the height of entry barrier to market, MinLAC is minimum average price of old enterprises and P_g is maximum entry forestalling price. Based on the assumptions of the model, the production cost of two bidders is uniform and the same; thus, the average and final cost of production and minimum long term average cost will be equal. The calculation of height (intensity) of entry barrier is presented in Table 3.

Since the interest rates are in [0, 1], the fourth column of Table 3 indicates the fact that the increase in the number of the game stages ($n \geq 1$) leads to increase in the height of the entry barrier.

6 .It is noteworthy that the price of second stage is the maximum entry barrier price.

Table 3
The calculation of height (intensity) of entry barrier

Game	Price (P_g)	Minimum long term average price MinLAC	Height of entry barrier (HB)
Single-stage game	$\frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC$	C	7
Two-stage game	$\frac{1}{4}\bar{r}C + \frac{3}{2}C + \frac{1}{4}r_A^eC + r_B^eC$	C	$\frac{1}{4}\bar{r} + \frac{1}{2} + \frac{1}{4}r_A^e + r_B^e$
n-stage game	$\left[\frac{1}{2n}\bar{r} + \frac{1}{2n}r_A^e + \left[\frac{n+1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e\right]C$	C	$\frac{1}{2n}\bar{r} + \frac{1}{2n}r_A^e + \left[\frac{n-1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e$

Source: Findings of researchers

4.5. Price analysis of bespoke-purpose application in different states

4.5.1. The comparison of related software price in single-stage and two-stage game

The price of intended software in a single-stage and two-stage games is respectively $b_{g1} = \frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC$ and $b_{g2} = \frac{1}{4}\bar{r}C + \frac{3}{2}C + \frac{1}{4}r_A^eC + r_B^eC$. If the price difference of two-stage and single-stage games is shown by T_{2-1}, the following equation will be obtained:

$$T_{2-1} = b_{g2} - b_{g1} = b_{g2} = \frac{1}{4}\bar{r}C + \frac{3}{2}C + \frac{1}{4}r_A^eC + r_B^eC - \frac{1}{2}\bar{r}C - C - \frac{1}{2}r_A^eC$$

$$= -\frac{1}{4}\bar{r}C - \frac{1}{4}r_A^eC + \frac{1}{2}C + r_B^eC = \left[-\frac{1}{4}\bar{r} - \frac{1}{4}r_A^e + \frac{1}{2} + r_B^e\right]C$$

Since the interest rates are in [0, 1], the price difference of two-stage game and single-stage games is positive. Thus, the mentioned price difference indicates that if the bid manager demands for the bespoke-purpose application in two stages rather than in single stage, he will tolerate an extra cost of$\left[-\frac{1}{4}\bar{r} - \frac{1}{4}r_A^e + \frac{1}{2} + r_B^e\right]C$.

4.5.2. The price comparison in a single-stage and n-stage game

The price of the intended software in a single-stage and n-stage game has been estimated respectively as $b_{g1} = \frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC$ and $b_{gn} = \left[\frac{1}{2n}\bar{r} + \frac{1}{2n}r_A^e + \left[\frac{n+1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e\right]C$. If the price difference of a n-stage and single-stage games is shown by T_{n-1}, the following equation will be obtained:

$$T_{n-1} = b_{gn} - b_{g1} = \frac{1}{2n}\bar{r}C + \frac{1}{2n}r_A^eC + \left[\frac{n+1}{2}\right]C + \left[\frac{n^2+n-2}{2n}\right]r_B^eC - \left(\frac{1}{2}\bar{r}C + C + \frac{1}{2}r_A^eC\right)$$

$$= \frac{1}{2n}\bar{r}C - \frac{1}{2}\bar{r}C + \frac{1}{2n}r_A^eC - \frac{1}{2}r_A^eC + \left[\frac{n+1}{2} - 1\right]C + \left[\frac{n^2+n-2}{2n}\right]r_B^eC$$

$$= [\frac{1}{2}\left(\frac{1}{n} - 1\right)\bar{r} + \frac{1}{2}\left(\frac{1}{n} - 1\right)r_A^e + \left[\frac{n-1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e]C$$

As in the previous section, since the interest rate is in [0, 1], the price difference of n-stage and single-stage games is positive. Thus, if n- bid manager demands for the bespoke-purpose application in two stages rather than in single stage, he will tolerate an extra cost of$[\frac{1}{2}\left(\frac{1}{n} - 1\right)\bar{r} + \frac{1}{2}\left(\frac{1}{n} - 1\right)r_A^e + \left[\frac{n-1}{2}\right] + \left[\frac{n^2+n-2}{2n}\right]r_B^e]C$.

4.6. Calculation of model with hypothetical data

Now consider software whose designing cost for bidder is 10,000,000,000 Rails, maximum output rate of the intended industry is 0.3 and the expected output of the winner bidder is 0.1 and the expected output of the lost bidder is 0.15. The price of intended software for bid manager for single stage to five-stage game has been calculated and presented in second column of Table 4. The price for bid manager is calculated and presented in columns three to six of the mentioned table for the states where the designing cost for bidder reaches 20 billion Rials, maximum output of the intended industry increases to 0.4, the expected output of the winner bidder to 0.14 and the expected output of the lost bidder to 0.2.

The second column of Table 4 shows that by increasing the number of the game stages, the software price significantly increases. For example, its price increases from twelve billion IRR in a single-stage game to sixty three billion and three hundred million IRR in the ten-stage game. The third column of the table indicates that the higher the designing cost of software is, the more its price increases by increase in the number of game stages. Increase in the expected output rate of the winner bidder and maximum output rate of the intended industry leads to increased price in tender and thus increased price of related software that is shown in columns four and five. The expected output rate of the lost bidder leads to increased price of the software in the next stages after tendering whose effect is presented in sixth column.

Now, the height of entry barrier is calculated in Table 5 with explained hypothetical data. In the

7 .Note that in single-stage game, there is no entry barrier since any company has yet produced related software.

following table, HB_i indicates the height of entry barrier in i^{th} stage of i-stage game.

The second column of Table 5 shows that the increase in the number of game stages leads to increase in the height of entry barrier such that the height of entry barrier increases from 0.75 in single-stage game to 5.33 in a ten-stage game. Column three indicates that the higher average long-term cost (which is fixed in this model and equals to average and final cost) of designing intended software leads to increasing the height of entry barrier with increase in the stages of the game. Columns four to six also show that the height of entry barrier of the intended software will increase with increase in the real output of the intended industry, expected output rate of winner and loser bidder.

Extra imposed cost to bid manager has been calculated with intended hypothetical data and the results have been presented in Table 6.

Table 4

The purchase price of software for bid manager with hypothetical data (in terms of billion IRR)

	$c = 1000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/15$	$c = 2000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /4, r_A^e = /1, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /14, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/2$
b_{g1}	1200	2400	1250	1220	1200
b_{g2}	1750	3500	1775	1760	1800
b_{g3}	2317	4633	2333	2333	2400
b_{g4}	2887	5775	2900	2892	3000
b_{g5}	3460	6920	3470	3464	3600
⋮	⋮	⋮	⋮	⋮	⋮
b_{g10}	6330	12660	6335	6332	6600

Source: Researchers' findings

Table 5

The calculation of height of entry barrier with hypothetical data

	$c = 1000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/15$	$c = 2000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /4, r_A^e = /1, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /14, \quad r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/2$
HB_2	0.75	0.75	0.775	0.76	0.8
HB_3	1.32	1.32	1.33	1.32	1.4
HB_4	1.89	1.89	1.9	1.89	2
HB_5	2.46	2.46	2.47	2.46	2.6
⋮	⋮	⋮	⋮	⋮	⋮
HB_{10}	5.33	5.33	5.34	5.332	5.6

Source: Researchers' findings

Table 6

The extra imposed cost to bid manager with hypothetical data (billion IRR)

	$c = 1000, \bar{r} = /3, r_A^e = /1, r_B^e = 0/15$	$c = 2000, \bar{r} = /3, r_A^e = /1, r_B^e = 0/15$	$c = 1000, \bar{r} = /4, r_A^e = /1, r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /14, r_B^e = 0/15$	$c = 1000, \bar{r} = /3, r_A^e = /1, \quad r_B^e = 0/2$
T_{2-1}	550	1100	525	540	600
T_{3-1}	1117	2234	1083	1103	1200
T_{4-1}	1687	3374	1650	1672	1800
T_{5-1}	2260	4520	2220	2244	2400
⋮	⋮	⋮	⋮	⋮	⋮
T_{10-1}	5130	10260	5085	5112	5400

Source: Researchers findings

The second column of Table 6 shows the extra cost exposed to bid manager due to increase in the number of software demand stages. The related cost considerably increases with increase in the number of the demand stages; for example, if the bid manager demands the software in two stages, he will incur extra cost of 5,500 billion IRR compared to single-stage state; while if he demands the same software in ten stages, he should incur extra cost of 51 billion and three hundred million Rials.

The third to sixth columns respectively indicate the increased extra imposed cost to bid manager due to the increase in the software design costs by bidder, increased maximum output rate of the intended industry and the expected output rate of the winner and loser bidders.

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5. Conclusion and recommendations

In modeling section, it was shown that in case of purchasing bespoke-purpose application in more than one stage, the maximum entry forestalling price and thus its height (intensity) would increase by increasing the number of stages of purchasing software. In this case, the buyer would incur extra cost compared to purchase in one stage and the more this number of stages increases, the imposed cost also increases. In this regard, the organizations, offices and companies requiring such software are recommended to fully examine their software demand and then propose their request and demand to reduce their expenses. Moreover, any time they realize their remaining demand, they should demand it at once in order to avoid any further increase in the software price.

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