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Efficiency of Public Procurement Function in Morocco

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ABSTRACT

Public procurement, involving the public sector's purchase of goods, services, or works from the private sector, accounts for 13-20% of global GDP (The World Bank, 2020). In Morocco, this sector represents 17% of GDP (The World Bank, 2014) and is a crucial source of business for SMEs, which make up 95% of all businesses (Augier, Castel & El Malki, 2019). The efficiency of public procurement is a central issue in research due to its strategic, economic, and managerial impact (Kakwezi & Nyeko, 2019). While past research often focused on practical assessments (Flynn & Davis, 2014) and overlooked the market structure (KLEMPERER, 1999), based on a renewal of the game auction model for first price sealed bid auctions, along with both a qualitative and quantitative empirical research, this paper examines Moroccan public procurement efficiency from a market-based, game auction model perspective. It demonstrates that Morocco's predominant open tender procedure exhibits patterns of an efficient game auction model with a Bayesian Nash equilibrium expression, suggesting opportunities for maintaining and improving the open tender mechanism itself and the surrounding procurement mechanisms.

INTRODUCTION

Public procurement, defined as the process by which the public sector procures goods, services, or works from the private sector, accounts for 13% to 20% of global GDP and represents a substantial expenditure of nearly 9.5 trillion US dollars (The World Bank, 2020). The efficiency of public procurement has long been a critical issue and continues to be a primary focus of discussion among both practitioners and academics due to its strategic, economic, and managerial implications, particularly in developing countries (Kakwezi & Nyeko, 2019). Despite its market-based nature and its role as a significant source of business for private companies, especially small and medium enterprises, research in this area has predominantly used various empirical methods (Flynn & Davis, 2014), with less emphasis on the market dimensions of this crucial function. This study, therefore, places greater emphasis on the market aspects of public procurement by examining the efficiency of Morocco's public procurement system from a market perspective, specifically through a game auction model. This paper posits that the open tender procedure, the primary method for awarding procurement contracts in Morocco, which represents 17% of its GDP (The World Bank, 2014), operates within a game auction framework that achieves an equilibrium that could potentially enhance the efficiency of procurement mechanisms. To validate this hypothesis, the research employed a combination of game theory and empirical analysis. The methodologies include both quantitative and qualitative data collection and analysis covering the entirety of the subject population. This research is organized as follows: Section 2 underscores the significance of public procurement

both in Morocco and globally, Section 3 outlines the research questions, hypotheses, and methodologies, Section 4 provides the theoretical framework that underpins the discussion, Section 5 presents the research findings along with ensuing discussions, and Section 6 concludes with insights drawn from the study.

Context and Importance of Public Procurement Function

Public procurement represents 13% to 20% of global GDP, equating to nearly 9.5 trillion US dollars in annual expenditures (The World Bank, 2020). This sector's growth is propelled by its increasing economic importance in developed economies, often accounting for a substantial portion of their GDP.

For instance, in the European Union (EU), government procurement reached nearly EUR 2 trillion, or 13.4% of EU GDP in 2016 (Dimitrova, 2018). Additionally, public procurement spending in EU countries varies from 10% to 30% of GDP, with many utilizing it to foster innovation, technology, and economic growth (Lember, Kattel & Kalvet, 2014).

In Morocco, significant reforms to public procurement were implemented starting January 1, 2014.

A comprehensive regulatory framework now outlines the primary principles and procedures, particularly the open tender process, used by all public entities including central and decentralized government bodies, state-owned enterprises, and local government units. The e-procurement platform enhances these processes by providing extensive online services for bidders and buyers (Lipson *et al.*, 2014).

According to the World Bank, Morocco's public

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procurement constitutes 17% of its GDP, totaling nearly 187 billion dirhams annually (World Bank, 2014). This sector is vital for a broad range of businesses, particularly small and medium enterprises (SMEs) in construction, public works, and engineering, which derive over 75% of their annual revenue from public contracts (Esec, 2012). Given that SMEs account for 95% of all businesses, contributing 40% to GDP and 46% to national employment, this sector is critical to Morocco's economy (Augier, Castel & El Malki, 2019).

The current public procurement regulations (decree issued on March 20, 2013) specify various contract awarding methods, with the open tender procedure being the most frequently used. This system underscores the critical role and widespread usage of public procurement in fostering Morocco's economic development. The graph below shows clearly this important fact.

Additionally, data gathered from the Moroccan public procurement portal reveals that within the open

procedures outlined in the Moroccan public procurement regulations, the lowest bid rule pre-dominates in contract awards. This rule is exclusively applied to contracts for works, goods, and services, apart from those involving studies and architectural services.

Also, in the total lowest bid rule share, the major part is attributable to the open tender procedure as shown by the following graph.

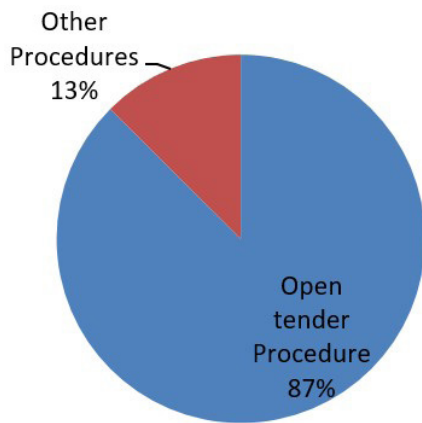


Figure 1: Share of open tender procedure in the total number of public procurement contracts awarded in Morocco between October 2016 and April 2022

Source: Moroccan procurement portal database

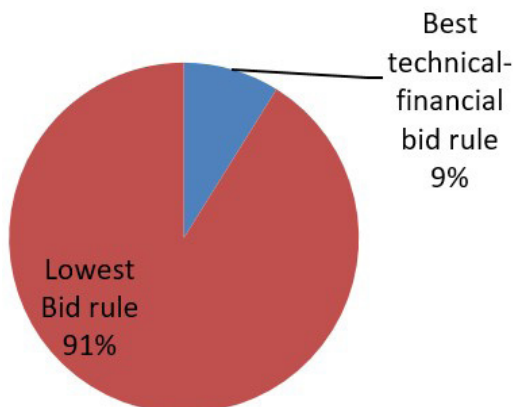


Figure 2: Lowest bid rule and best technical-financial bid rule shares in open procedures between October 2016 and April 2022

Source: Moroccan procurement portal database

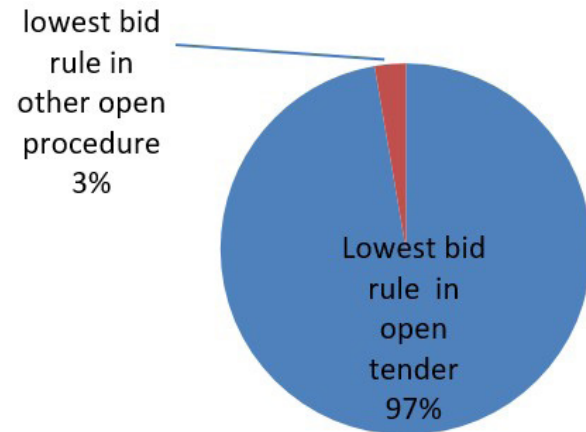


Figure 3: Lowest bid rule in open tender procedure and in other open procedures shares between October 2016 and April 2022

Source: Moroccan procurement portal database

The graph indicates that the open tender procedure, governed by the lowest bid rule, is the primary method for awarding public procurement contracts in Morocco. Consequently, the public procurement function is predominantly facilitated through this open tender procedure, serving as the principal channel for businesses to secure public procurement contracts.

METHODOLOGY

Given the prevailing patterns within the Moroccan public procurement function as previously outlined, this study aims to address the primary question: How does the public procurement market mechanism impact the efficiency of the public procurement function in Morocco? In this study, "efficiency" refers to both the successful completion of the tender process and the significant cost savings achieved through it.

To thoroughly explore this main question, several subsidiary questions arise:

- What is the predominant market mechanism in the Moroccan public procurement system?
- What type of market characterizes the Moroccan public procurement mechanism?
- What efficiency metrics are demonstrated by the public procurement market mechanism?
- How can other related procurement mechanisms be adapted to align with the efficiency metrics of the public procurement market mechanism?

To address these inquiries, the following hypotheses have been established as the foundation of this research:

H1: The primary market mechanism for public procurement in Morocco is the open tender procedure.

H2: The public procurement market mechanism operates as a game model for a first-price sealed bid auction.

H3: The Moroccan procurement mechanism, as a game auction model, exhibits an efficient Nash equilibrium.

H4: Key associated mechanisms can be restructured to conform to the efficiency standards of Morocco's procurement market mechanism.

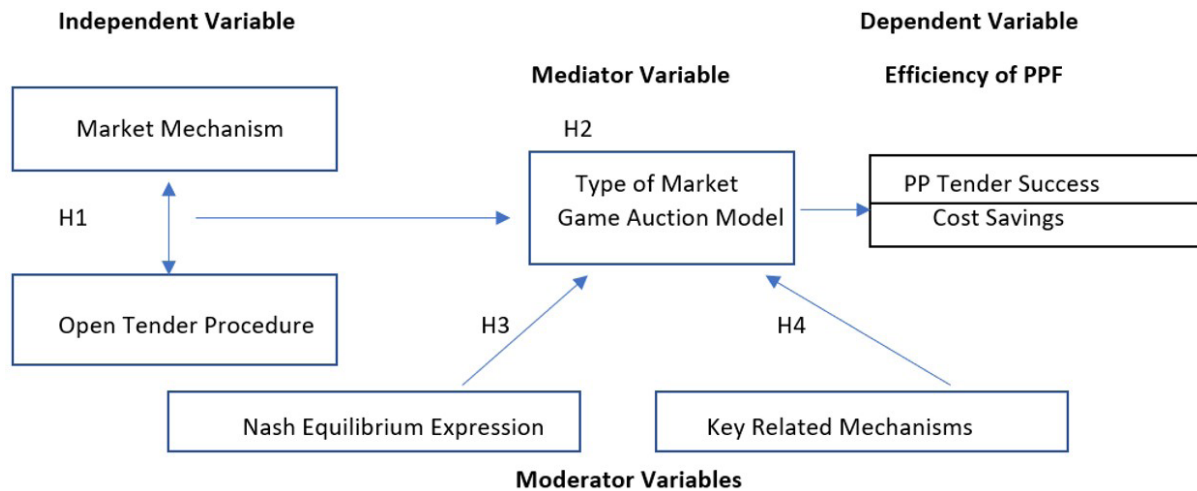


Figure 4: Conceptual Framework

The hypotheses outlined were examined through the following methodological stages:

Empirical Documentary Investigation for Hypothesis 1

To validate our first hypothesis, we utilized an empirical documentary investigation to gather and analyze qualitative data to identify the primary market mechanism within Morocco's public procurement function. We examined the patterns of various tendering procedures stipulated by Moroccan public procurement regulations—specifically, the open tender, negotiated, and concours procedures. These were evaluated against criteria derived from the widely recognized economic definitions of a market (Samuelson & Nordhaus, 2010), which include competition, information, price, and objects exchanged. Each procedure was scored based on its adherence to these criteria, with the highest-scoring procedure identified as most closely reflecting the market mechanism.

Hybrid Exploration for Hypothesis 2

Using a combination of auction and game theories relevant to public procurement (Klemperer, 1999) and the game auction model for first-price sealed bid auctions (Gibbons, 1992), we employed the Hybrid Exploration method (Thietart *et al.*, 2001) to assess our second hypothesis. This approach involved a qualitative examination of the key elements of the game auction model—competition (players and strategies), rules, and payoffs—both in theory and as implemented in the empirically identified market mechanism. Each element was scored for its intensity within the market mechanism of Morocco's public procurement.

Deductive Method for Hypothesis 3

To test the third hypothesis, we applied deductive reasoning using consistent and progressive mathematical steps and logic tailored to the previously identified market mechanism, as expected by the game auction model. The results from this deductive process were then compared with those of the theoretical model, and findings were analyzed, commented on, and interpreted in light of the efficiency issues raised in this research and within the conceptual framework established.

Empirical Documentary Investigation for Hypothesis 4

The final stage involved identifying and ranking the mechanisms related to the market mechanism of Morocco's public procurement in terms of their impact on its efficiency. This phase focused on mechanisms such as the ranking system used in contract awards, the design of the tendering process, and the role of cost estimation. Qualitative data on these mechanisms were collected and analyzed to determine the extent of their influence on the efficiency of the public procurement market mechanism in Morocco. The results provided a comprehensive view on how these mechanisms could be restructured to align with the efficiency criteria identified in the market mechanism.

Throughout the research, key theories were integrated into the theoretical framework, and a review of major empirical research on public procurement efficiency was compiled to support the empirical investigation approach.

Theoretical Background

Research in public procurement has long faced, and

continues to face, the challenge of developing a dedicated theoretical framework. This framework aims to enhance understanding and address both practical and theoretical issues within the field. Among these issues, the efficiency of public procurement stands out due to its strategic, economic, and managerial significance (Kakwezi & Nyeko, 2019). Research efforts in this area have produced a broad spectrum of theoretical approaches, drawing on diverse disciplines such as economics, mathematics, management, information technology, psychology, and more (Flynn & Davis, 2014). However, this article will focus on four key theoretical aspects: auction theory, game theory, efficient market theory, and mechanism design theory, which are vital to our current research topic.

Auction Theory

An auction is a sales environment where typically a single seller offers one or more items to multiple buyers, each valuing the items differently. Auctions serve various purposes, from setting prices in the privatization of public companies and the sale of mobile or radio spectrum, to maximizing revenue through treasury bills. They are commonly used for awarding government contracts and by companies for subcontracting work or purchasing services and materials (Klemperer, 1999). The literature identifies four primary auction formats: sealed bid first price auction, sealed bid second price auction, English auction, and Dutch auction (Milgrom & Weber, 1982).

a. In a first-price sealed-bid auction, bidders submit their bids in sealed envelopes to the auctioneer. The envelopes are opened, and the highest bidder wins, paying their bid amount. This auction type requires sophisticated game-theoretic analysis as bidders must consider not only their own valuation but also those of others and what they believe others value the item at (Avinash & Barry, 2008). In government procurement, however, an adjusted version of this format is often used where the auctioneer, representing the buyer, selects the seller offering the lowest bid.

b. In second-price sealed-bid auctions, or Vickrey auctions, bids are placed in sealed envelopes and handed to the auctioneer. The highest bidder wins but pays the second highest bid price. This mechanism ensures that the dominant strategy for all participants is to bid their true valuation. This format was first studied by William Vickrey.

c. In open ascending-bid auctions (English auctions), participants bid higher amounts progressively. The auction ends when no further higher bids are made, and the highest current bidder wins at their final bid amount.

d. In open descending-bid auctions (Dutch auctions), the auctioneer sets a high starting price, which is then lowered progressively until a bidder agrees to the current price and wins the auction (Menezes & Monteiro, 2005).

Game Theory

Game theory explores the dynamics where decision-makers interact strategically. Commonly understood as a framework for competitive scenarios where players abide by established rules, game theory's applications are diverse, ranging from firms vying for business to animals contesting prey, and notably, bidders in auctions (Osborne, 2000). The discipline evolved significantly with John Nash's development in the 1950s of the Nash equilibrium, a concept of strategic stability applicable to a broader array of games than those covered by earlier theories from the 1920s by von Neumann and Morgenstern. Nash demonstrated that every finite n-player, non-zero-sum, non-cooperative game possesses a Nash equilibrium in mixed strategies. By the 1970s, game theory had become a dominant force in microeconomics and extended its influence into various social and behavioral sciences (Osborne & Rubinstein, 1994).

A pivotal model in game theory is the auction theory model, which mathematically represents players, including buyers and sellers in an auction, each with a set of strategic actions and expected payoffs based on these strategies. Each player's bid function or reservation price translates their valuation (for buyers) or cost (for sellers) into a bid price, with the payoff for each being the expected utility from the chosen strategies. Game theory models for auctions and strategic bidding typically fall into one of three categories:

- The private values model, where each bidder believes the others receive a value from an independent random distribution.

- The common values model, where all participants estimate the item's value similarly but lack precise information.

- The affiliated values model, a broader category where a bidder's utility hinges on both their private signal and a shared unknown value. This model generally assumes symmetric bidders, meaning the value distribution each bidder draws from is uniform across all (Tong Isabelle & Quang, 2002).

William Vickrey first analyzed auctions through game theory, highlighting that in some auctions, bids are functions of bidders' values: $b(v)=b$. For auctions with each bidder's value drawn independently from a uniform distribution, Vickrey identified a unique Nash equilibrium bidding strategy, where:

$$b^*(v) = \frac{(n-1)}{n} \cdot v$$

with n representing the number of bidders and v their private value for the auctioned item (Vickrey, 1961). Later, in 1967, Harsanyi extended the concept to games with incomplete information, leading to the development of the Bayesian Nash equilibrium. This adjustment defines the optimal strategy considering the strategies of others in an environment of incomplete information about the players (Menezes & Monteiro, 2005).

Mechanism Design Theory

Mechanism design theory, a branch of economics and game theory, adopts an objectives-first approach to creating economic mechanisms or incentives in strategic settings with rational players. This approach, also known as reverse game theory, works by starting at the desired outcome and working backward. It has extensive applications across various fields such as economics, politics, market design, auction theory, social choice theory, and networked systems.

Mechanism design involves creating solutions for private-information games, characterized by two main features:

1. A “designer” intentionally constructs the game’s structure instead of inheriting an existing one.
2. The designer’s primary interest lies in the outcomes of the game.

Leonid Hurwicz explained that in mechanism design, the objective function is predetermined, making the mechanism itself the variable to solve for. This contrasts with traditional economic theory, which typically analyzes the efficacy of pre-existing mechanisms. The term “mechanism design” reflects its engineering roots, suggesting the design of systems or machines to meet specific functional standards. The concept traces back to debates in the 1930s about efficient resource allocation in socialist economies, encapsulating the principal-agent problem (Mookherj, 2008).

Mechanism design theory addresses challenges faced by a planner or principal in devising mechanisms that enable agents with varying productive capacities or consumption needs to interact, leading to desired resource allocation outcomes. Given that information about technological parameters, capacities, and preferences is often dispersed among agents and not fully accessible to the planner, the theory emphasizes the necessity of designing economic systems that facilitate effective communication and decision-making. These systems must also adapt to changing parameters and achieve outcomes that meet normative criteria like efficiency and equity (Mookherj, 2008).

Mechanism design has become a fundamental aspect of modern economics, influencing areas such as monopoly pricing, optimal tax theory, and public goods provision. Its most notable application has been in auction theory (Krishna & Perry, 1998). Originating from the socialist versus capitalist debates of the 1930s, mechanism design has enabled economists to abstractly consider all potential economic systems, analyzing and proposing alternatives within this framework.

The theory is bifurcated into designing optimal mechanisms, which aim to maximize seller revenue, and designing efficient mechanisms, which focus on social efficiency rather than revenue maximization (Vickrey 1961, Mirrlees 1971, Groves 1973). At its core, mechanism design is about resource allocation in environments where agents hold private information crucial for determining optimal outcomes. The challenge lies in extracting truthful information from agents who might benefit from

misrepresenting their data. This problem necessitates the creation of mechanisms that can still achieve optimal allocations even when agents act strategically, thus embodying the theory’s role in designing institutions or rules for interactions among strategic agents to realize desirable outcomes (Sen, 2007).

Empirical Research in Public Procurement

On both empirical and applied levels, extensive research has been conducted to explore various facets of the public procurement function. This research ranges from examining public procurement’s role as an innovation tool to its sustainability as a crucial economic and financial instrument. This particular study focuses on the efficiency of public procurement, drawing on significant applied and empirical research addressing this issue.

Public procurement performance is a hotly debated topic globally, both politically and economically. In times of budgetary constraints, the substantial portion of public budgets allocated to procurement contracts makes the pursuit of ‘value for money’ highly pertinent. Government procurement of goods, services, and infrastructure plays a significant role in the economy not just due to its sheer volume, but because efficient and effective public spending can boost economic competitiveness, enhancing productivity and societal welfare (Rizzo, 2018).

Noteworthy studies include a 2019 empirical investigation by Matus Grega, Marta Orviska, Juraj Nemec, and Colin Lawson, which aimed to enhance understanding of the factors affecting public procurement efficiency in the Slovak Republic. This research also provided valuable insights for Slovak government officials on modifying public procurement regulations to improve efficiency (Grega *et al*, 2019). Key findings indicated that excessive bureaucracy and corruption increase procurement costs and can degrade the quality of services and goods provided. Moreover, a predominant reliance on the lowest-price selection mechanism, particularly for services and works, could adversely affect quality and reduce transparency in public procurement relationships. In 2011, Ercan Erdis’s study in Turkey concluded that revisions in procurement regulations significantly aided the timely and on-budget completion of government procurement contracts. The findings suggested that these observations could be applicable to similar economic and organizational contexts (Erdis, 2012).

Further, a 2014 case study by Boniface Ikumu Chimwani, Mike A. Iravo, and Ondabu Ibrahim Tirimba analyzed factors influencing procurement performance in Kenya’s public sector, particularly within the state law office. The study highlighted that motivation and qualifications of procurement personnel, along with effective records management systems, are vital for superior public procurement performance. Conversely, the lack of automated procurement systems negatively impacted performance (Ikumu, 2014).

In China, a 2019 study by Junqi Liu, Benshan Shi, Jinjie Xue, and Qi Wang examined the enhancement of green

public procurement performance among Chinese local governments. The study demonstrated that improving procurement officials' awareness and training on green procurement policies positively affects their performance practices (Liu *et al*, 2019).

A 2015 article by Stéphane Saussier and Jean Tirole discussed the significance of public procurement in France, where it is estimated to represent nearly 15% of the GDP. The authors argued that significant efficiency gains could be achieved through better management of the procurement process, including greater freedom for contracting authorities at selection and execution stages, within a framework of enhanced transparency and competition (Saussier & Tirole, 2015).

In 2021, Tarik El Haddadi, Taoufik Mourabit, and Anass El Haddadi explored the tender preparation phase of public procurement in Morocco from a sustainability perspective. Their study concluded that successful sustainable public procurement in Morocco requires not only increased awareness and involvement among public buyers but also stronger regulatory mechanisms (El Haddadi *et al*, 2021).

RESULTS AND DISCUSSIONS

1. The Moroccan public procurement regulation, established by the Decree on March 20th, 2013, and its supplementary regulations, delineates three principal tendering methods: open tender, negotiated procedure, and concours procedure.

Open Tender Procedure

This method mandates that public buyers publicly disclose all relevant information about procurement contracts up for tender for a minimum of 21 calendar days. Information dissemination is accomplished through tender calls published both in print media and on the official Moroccan public procurement website

(www.marchespublics.gov.ma). The primary aim of this widespread publication is to attract as much competition as possible. During this procedure, all potential bidders can freely submit their bids in sealed envelopes. However, only the price proposals of bidders who have passed a preliminary qualification phase are opened and evaluated at the final stage.

Negotiated Procedure

Unlike the open tender, this procedure involves limited dissemination of information, occurring directly between the public buyers and the selected bidders. There is no public announcement of the tender, and competition is restricted to those bidders whom the public buyers have directly contacted. Negotiations typically focus on two main aspects: the price and the timeline for contract execution.

Concours Procedure

This method is restricted to highly qualified bidders, where the procurement information is both disseminated and published. However, the contract award is not solely based on the bid amount but involves a combined assessment of technical and financial criteria, following a best-scoring process where the bidder with the highest overall score secures the contract.

For contracts involving the procurement of goods, execution of works, or provision of services (excluding studies), the contract is generally awarded to the prequalified bidder who submits the lowest bid, except in the concours procedure. In cases where the procurement involves studies, the contract is awarded based on the highest final score after a weighted evaluation of both technical and financial aspects.

Overall, each tendering procedure reflects distinct approaches to competition and bidder selection, shaping the dynamics and outcomes of public procurement in Morocco.

Table 1: Comparison of Moroccan procurement tendering procedures on market criteria basis

P. Procedures Market Criteria	Open Tender Procedure	Negotiation Procedure	Concours procedure
Competition	Full (5)	Absent (0)	Medium (3)
Information	Disseminated (5)	Non Disseminated (0)	Disseminated (5)
	Published (5)	Non Published (0)	Published (5)
Price	Entirely Defined in the Process (5)	Negotiated (0)	Partially defined in the process (3)
Objects covered	All (5)	All (5)	Partial (3)
Final Score	25	5	19

From the comparative analysis, the open tender procedure emerged as the top-performing method among the three evaluated procurement tendering procedures. This method scored the highest on the retained market criteria, with each criterion being rated on a scale from 0 to 5 based on its in-corporation by each procedure. In contrast, the negotiated procedure scored the lowest,

indicating that it aligns least with the common market mechanism criteria identified in this study. Thus, the initial hypothesis positing the open tender procedure as the primary mechanism reflecting common market criteria in Moroccan public procurement is validated.

2. Further detailing the auction theory within the context of Moroccan public procurement, the model described by

R. Gibbons for the first price sealed bid auction format is referenced. However, adjustments are necessary to align this model with specific elements of the Moroccan public procurement system, as outlined in Appendix 1. Key differences include:

Bidders and Buyers

In the Moroccan system, the bidders are consistently sellers, and the sole buyer is the public institution or unit.

Nature of Auctioned Object

Unlike typical auctions where single items are auctioned, the Moroccan system involves contracts that may encompass multiple items. However, each contract is designed to be sufficiently homogeneous, treating it as a single object for procurement purposes.

Awarding Criteria

For most procurements, excluding those related to studies, the Moroccan open tender procedure mandates that contracts be awarded to the prequalified bidder submitting the lowest bid at the final stage.

These unique aspects of the Moroccan public procurement system necessitate specific adaptations to the game auction model employed in this research. Notably, when considering only the final bidding stage among prequalified bidders, the open tender procedure mirrors the core dynamics of the first price sealed bid auction model. The subsequent table illustrates the alignment scores between the game auction model and the open tender procedure, showcasing their compatibility within the framework of Moroccan public procurement practices.

Table 2: Matching patterns between game auction Model and the open tender procedure

	Game Auction Model	Open Tender Procedure	Matching Score
FPSB Auction format	Yes	Yes	1
Competitive players	Yes	Yes	1
Rules	Yes	Yes	1
Payoffs	Yes	Yes	1

* FPSB: first price sealed bids

From the analysis presented in the table above, we can confidently conclude that the open tender procedure captures all the essential elements of a game auction model. Consequently, the second hypothesis, which posits that the Moroccan public procurement open tender procedure exhibits the same characteristics as the game auction model for first-price sealed bid auctions, is affirmed.

3. The open tender procedure within the Moroccan public procurement system functions as a game auction where bidders (players) compete to secure a contract (the object of the auction). This sets the stage for a non-cooperative game environment. In this context, players are equipped with private valuations (types) for the contract, employ various strategies (actions), and hold beliefs about the actions and potential outcomes of other players. Given this scenario of incomplete information—where players possess distinct types and submit their bids simultaneously in sealed envelopes—the open tender procedure must align with a Bayesian Nash equilibrium bidding strategy, as predicted by the game auction model (detailed in appendix 1). However, the development of this symmetric Bayesian Nash equilibrium bidding strategy within the framework of the Moroccan public procurement system’s open tender procedure must consider the following specifics:

- Each player’s value v is defined as the inverse of his expected total cost of fulfilling the terms of the procurement contract: $v = c^{(-1)}$. Players have higher values for the contracts they expect to fulfill with lower costs and vice versa.

- The bidding strategy of a bidder i , $b(v_i) = b$ is a strictly decreasing function: bidder i will always submit lower bids if his value for the contract is higher (his estimated total cost to fulfill the contract is lower).

- Finally, since the bidder with the lowest bid wins the contract, then his probability to win is defined as follows if this bidder is bidder i and there are n bidders competing in the auction:

$$Pr(w)_i = Pr(b(v_i) > b)^* \dots \dots \dots * Pr(b(v_{(i-1)}) > b)^* Pr(b(v_{(i+1)}) > b)^* \dots \dots \dots * Pr(b(v_n) > b)$$

The processing of the adjusted game auction model for the Moroccan procurement open tender procedure, as detailed in the appendix 1 below, produces the following outcome as the symmetric Bayesian Nash equilibrium bidding strategy:

$$b^*(c) = n / ((n-1)) * c$$

with $n \in \mathbb{N}$ and $n \geq 2, c \in \mathbb{R}^{(+)}$ and $c \geq 1$

The equilibrium strategy specified above presents exactly the reverse terms of the Bayesian Nash equilibrium strategy defined by GIBBONS for the game auction model associated with the first price sealed bid auction format, with b^* , being the equilibrium bidding function (strategy) (notice that $b^*(c) > c$), c the expected bidding cost, estimated by each bidder in the auction which is supposed to be superior or equal to the real cost of fulfilling the procurement contract, and n a natural integer representing the number of bidders bidding in the auction which must be 2 or more for the game to be properly processed. $(n / ((n-1)))$ tends to be closer to 1 as n increases, and its 2 when $n=2$. In open tender procedure game auction with decreasing competition (2

competitors), the best strategy is to submit higher bids which can reach the maximum of twice the expected cost for fulfilling the procurement contract.

$$b^*(c) = 2 \cdot c, \text{ if } n=2$$

Reversely, as competition increases, the best strategy is to submit bids very close to the expected cost for fulfilling the procurement contract.

let N be a natural number with $N \gg n$.

$$\text{we then have } \lim_{n \rightarrow N} b^*(c) = c$$

Bidders with higher expected costs tend to refrain from submitting bids, as their chances of winning the contract decrease with higher bids, especially under conditions of intense competition. Conversely, those with lower costs are more incentivized to submit bids, as their chances of winning improve with lower bids, regardless of the level of competition. Additionally, the strategy for any bidder in this context is perpetually caught between maximizing the probability of winning the contract and maximizing the potential payoff. Thus, bidders must carefully navigate this strategic trade-off between securing the contract and achieving the most favorable financial outcome.

The formulation of the equilibrium bidding strategy supports the conclusion that the Moroccan public procurement open tender procedure is an effective game auction mechanism. It ensures the procurement contract is allocated to the bidder who values it most highly—the one with the lowest expected costs to fulfill its terms. This strategic formulation also provides terms that no rational bidder would be motivated to deviate from, regardless of the strategies adopted by others. As a result, we can infer from the analysis that the open tender procedure, as a game auction mechanism, positively impacts the efficiency of Morocco's public procurement system. It enables public buyers to achieve significant savings on estimated contract costs through the game auction awarding process, assuming there is adequate competition among bidders ($n \rightarrow N$).

Furthermore, as competition intensifies, public buyers consistently receive bids that are much closer to the actual cost of the contract. Increased competition, coupled with the ranking mechanism inherent in the open tender procedure, greatly enhances the likelihood of a successful contract award. With a large number of bidders in contention, the probability that the contract will be successfully awarded to a suitable bidder is significantly higher. Therefore, the third hypothesis, which proposes that an efficient Nash equilibrium bidding expression exists for the game auction model applied in the Moroccan public procurement open tender procedure, is validated.

4. The direct mechanisms associated with the open tender procedure in Morocco, serving as the market mechanism for public procurement, primarily include the ranking mechanism in the awarding process, the design of the tendering process, and the role of cost estimation. During the awarding process of an open tender procedure, all accepted bids are ranked from the lowest to the highest. The bidder with the lowest bid is then asked to

complete their bidding files with the required documents. Occasionally, the winning bidder fails to complete their files, prompting the public buyer to invite the bidder with the next lowest bid to complete theirs. This process may continue up to the highest bid, potentially increasing the contract cost for the public buyer and undermining the efficiency the open tender procedure is meant to ensure. This mechanism aims to guarantee the effectiveness of the tendering process by ensuring the contract is awarded to the winning bidder, thus avoiding the need to restart the process with additional costs. Additionally, the design of the open tender procedure involves prequalifying bidders before initiating the auction process. This approach may reduce overall efficiency as all bidders must submit prequalification files, yet only one bidder is awarded the contract, raising the cost of bid submission for the others. Furthermore, the cost estimation made by the public buyer, often based on inaccurate price information, can cause significant distortions in the auction completion, or make the tendering process unfeasible if the estimated costs are significantly misaligned with market prices. Bidders may choose not to submit bids at all if they believe they have no chance of winning the contract, negatively impacting the efficiency of the public procurement function by reducing or eliminating competition.

These mechanisms require redesign to better align with the game auction patterns of the open tender procedure. Although the ranking mechanism is useful for avoiding a restart of the tendering process, it should not compromise the efficiency of the procedure. One possible adjustment could be allowing the public buyer to accept higher-ranked bids provided the winning bidder agrees to fulfill the contract at the initially lowest defined bid instead of their own. Moreover, the open tender procedure could be redesigned to begin with the auction component—evaluating financial bids and selecting the winning bidder first, then inviting them to submit their qualifying files. This reverse process does not contravene the rules of the procedure or the ranking mechanism.

In cases where accurate cost information is lacking or misleading, and unless cost estimation is technically necessary for the procedure to be properly conducted, it is advisable for public buyers to abstain from including any cost estimations in the tendering process to maintain the integrity of the mechanism. However, when such an estimation is mandated by the procedure, for instance, to determine if bids are abnormally higher or lower than the estimated cost, it should be based on real, reliable, and up-to-date market data.

CONCLUSION

The public procurement market in Morocco is a significant source of business opportunities for local companies. It is primarily driven by an efficient game auction mechanism facilitated through the open tender procedure. This mechanism's efficiency is characterized by a Nash equilibrium bidding expression, which adapts to a range of equilibrium scenarios based on competition

intensity and bidders' cost evaluations. However, to maintain this market mechanism's efficiency, associated mechanisms need to be redesigned to align with the surrounding environment.

Despite the availability and diversity of data provided by the electronic Moroccan procurement database and its regulatory documentation, significant challenges were encountered in this research. These include a notable lack of closely related research papers within Moroccan literature, data fragmentation requiring additional time and effort to collect and process, and a shortage of time to conduct the empirical investigations necessary to support the findings of this study.

While this work contributes to the literature on public procurement by offering a new market perspective on addressing relevant issues, it does not provide a comprehensive understanding of all aspects of this market perspective. Notably, many non-open procedures of public procurement in Morocco, which may represent a substantial market share, were not covered in this research. Despite its limitations, this paper can be seen as initial research aimed at exploring new perspectives to tackle the classic efficiency issues associated with public procurement, particularly considering the role of information dissemination mechanisms.

Appendix 1

Adjusted Game Auction model for the public procurement open tender procedure
The following adjusted game auction model is based on the game auction model for first price sealed bid auction developed by R. GIBBONS.

Assumptions

Procurement contract is homogeneous and is the object being auctioned,
Each bidder has a private value for the contract being auctioned which is inversely proportional to his estimated total cost of fulfilling the contract: $v = c^{(-1)}$ with $c \in \mathbb{R}^{(+)}$ and $c \geq 1$;
These values v_i are independent and uniformly distributed over $[0, 1]$.

Rules of the Game in the Auction

There are many sellers (bidders) and one buyer (auctioneer) in the auction.
Bidders simultaneously submit sealed bids b_1, \dots, b_n .
The lowest bid is the first price in this auction,
The bidder with the lowest bid wins the auction (the contract) and gets paid his bid after fluffing the contract.

Remarks

This game is a Bayesian game auction of incomplete information because bids are simultaneously submitted and bidders have private values that they don't share.
There is a bidding function of this game: $b(c) = b$. But, for simplicity and convenience of this model, we will

consider $v = c^{(-1)}$.

The payoff of any bidder (player) can be defined as $\pi(b|v) = \Pr(\text{win})(v-b)$

Problem set:

What is the Bayesian Nash equilibrium strategy $b^*(v) = b$ of this game auction?

Solution

If bidder b with a value v believes all other bidders use b^* , then this bidder must also use this same function $b^*(v)$ because it is this function that will maximize his expected payoff π .

So, we are Looking for a symmetric Bayesian Nash equilibrium bidding strategy.

b^* is a strictly decreasing function: bidder i will always bid less if his value for the contract is high (his estimated total cost for fulfilling the contract is low).

$b^*(0) = 0$ if the bidder's estimated cost of fulfilling the contract is too high $v=1/c$, then his value will be 0, so he will not submit a bid.

b^* is a strictly decreasing function, so b^* has a well-defined inverse strictly decreasing function $\varphi = b^{*(-1)}$ for all b, v : $\varphi(b) = v \leftrightarrow b^*(v) = b$.

What is the probability of bidder 1 to win the auction?
Recall that the bidder 1 wins the auction if he submits the lowest bid.

$$\Pr_1(\text{win}) = \varrho(b) = \Pr(b^*(v_2) > b) \dots, x$$

$$\Pr(b^*(v_n) > b).$$

$$\Pr_1(\text{win}) = \varrho(b) = \Pr(v_2 < \varphi(b)) \dots, x$$

$$x \Pr(v_n < \varphi(b))$$

As v is uniformly distributed on $[0,1]$, then:

$$\varrho(b) = [\varphi(b)]^{(n-1)}$$

$$\text{So } \pi(b|v) = [\varphi(b)]^{(n-1)} (v-b).$$

Looking for the Symmetric Bayesian Nash equilibrium strategy of this game auction requires that the expression $\pi(b|v)$ should be maximized. It is maximized when $b^*(v) = b$: when b equals what the Symmetric Bayesian Nash equilibrium will prescribe as the equilibrium symmetric bidding strategy.

$\varrho(b)(v-b)$ is maximized when the first order condition is satisfied: derivative must be zero.

$$\delta\pi/\delta b (b|v) = (n-1) [\varphi(b)]^{(n-2)} \delta\varphi/\delta b (v-b) - [\varphi(b)]^{(n-1)} = 0$$

, when $v = \varphi(b)$

$$\delta\pi/\delta b (b|v) = (n-1) [\varphi(b)]^{(n-2)} \delta\varphi/\delta b (\varphi(b)-b) - [\varphi(b)]^{(n-1)} = 0$$

$$\delta\pi/\delta b (b|v) = (n-1) \delta\varphi/\delta b (\varphi(b)-b) - \varphi(b) = 0$$

is a differential equation (*).

Check if φ is linear $\rightarrow \varphi(b) = \alpha b + \beta$ with $\alpha > 0$ and β could be any number.

Recall that $b^*(0) = 0 \leftrightarrow \varphi(0) = 0 \rightarrow \beta = 0$ which implies that $\varphi(b) = \alpha b$.

$$(n-1) \delta\varphi/\delta b (\varphi(b)-b) - \varphi(b) = 0 \rightarrow (n-1).\alpha(\alpha b - b) - \alpha b = 0.$$

So $\alpha = n/((n-1))$ solves the differential equation (*)

$$\varphi(b) = n/((n-1)).b \rightarrow b^*(v) = ((n-1))/n.v$$

Since $v = c^{(-1)}$, then $b^*(c) = n/((n-1)).c$

$$\text{And } \pi'(b^*|c) = \Pr(\text{win})(b^* - c) \leq 1/((n-1)) .c$$

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