DT
DECON

DOCUMENTO DE TRABAJO

Nº 530

EXPERIMENTS ON THE DIFFERENT NUMBERS OF BIDDERS IN SEQUENTIAL AUCTIONS

Hikmet Gunay y
Ricardo Huamán-Aguilar

Departamento
Académico de Economía

PUCP

DOCUMENTO DE TRABAJO N° 530

Experiments on the Different Numbers of Bidders in Sequential Auctions

Hikmet Gunay y Ricardo Huamán-Aguilar

Enero, 2024

Departamento Académico de Economía

DOCUMENTO DE TRABAJO 530
http://doi.org/10.18800/2079-8474.0530

Experiments on the Different Numbers of Bidders in Sequential Auctions
Documento de Trabajo 530

@ Hikmet Gunay y Ricardo Huamán-Aguilar (autores)

Editado:

Av. Universitaria 1801, Lima 32 – Perú.
Teléfono: (51-1) 626-2000 anexos 4950 - 4951
econo@pucp.edu.pe
http://departamento.pucp.edu.pe/economia/publicaciones/documentos-de-trabajo/

Encargado de la Serie: Gabriel Rodríguez
Departamento de Economía – Pontificia Universidad Católica del Perú
gabriel.rodriguez@pucp.edu.pe
Primera edición – Enero, 2024

ISSN 2079-8474 (En línea)

Experiments on the Different Numbers of Bidders in Sequential Auctions

HIKMET GUNAY
Department of Economics
University of Manitoba, Canada
Hikmet.Gunay@umanitoba.ca

RICARDO HUAMÁN-AGUILAR
Department of Economics
Pontificia Universidad Católica del Perú
rhuaman@pucp.edu.pe
https://orcid.org/0000-0002-6265-3934

This version: December 2023

ABSTRACT

In a second-price sequential auction with global and local bidders, we analyze the correct selling order of goods when the number of bidders in each leg of the auction is different with laboratory experiments. Theoretically, selling the good with a large number of bidders last should generate an (almost) efficient outcome but selling it first should result in an inefficient outcome with a positive probability. Our experimental results show that selling that good last generates a more efficient outcome than selling it first. Hence, the experimental results show that the selling order has to be taken into account while designing a sequential auction.

Keywords: experimental economics, lab experiments, sequential auctions, auction theory

Classification JEL: C90, C91, C92, D44

Diferente Número de Postores en una Subasta Secuencial: un Estudio Experimental

Hikmet Gunay
Department of Economics
University of Manitoba, Canada
Hikmet.Gunay@umanitoba.ca

Ricardo Huamán-Aguilar
Department of Economics
Pontificia Universidad Católica del Perú
rhuaman@pucp.edu.pe
https://orcid.org/0000-0002-6265-3934

Esta versión: Diciembre 2023

RESUMEN

Consideramos una subasta secuencial de segundo precio con postores globales y locales. Mediante experimentos de laboratorio analizamos el orden de venta correcto de dos bienes cuando el número de postores en cada etapa de la subasta secuencial es diferente. Teóricamente, vender el bien con un gran número de postores al final debería generar un resultado (casi) eficiente, pero venderlo primero debería resultar en un resultado ineficiente con una probabilidad positiva. Nuestros resultados experimentales muestran que vender ese bien al final genera un resultado más eficiente que venderlo primero. Por tanto, los resultados experimentales muestran que, al diseñar una subasta secuencial, es relevante tener en cuenta el orden de venta de los bienes.

Palabras Clave: economía experimental, experimentos de laboratorio, subastas secuenciales, teoría de subastas

Clasificación JEL: C90, C91, C92, D44

1 Introduction

Since some goods are sold repetitively, auctions in sequential nature have been used in the real-world a lot. Some examples include the Turkish 2000 cell-phone license auction ([GX07]) and some state highway procurement auctions ([Sil05]).

Theoretically, sequential auctions have been studied assuming that each leg of the sequential auction is identical or ex-ante identical (e.g. [KR96], [LPV12]). In such cases, the selling order of goods would not matter. However, if there is some heterogeneity in each leg of the auction, the selling order would affect the revenue and/or efficiency of the auction. In this paper, we study how the selling order of goods in a sequential auction affects the auction outcome by using experiments. Specifically, we test the theoretical predictions of [GM22], that uses different number of bidders in each leg of the auction.

In [GM22], it is shown that when global and local bidders are present and the good is synergistic, selling the good with a large number of bidders last would result in an efficient outcome. However, when such good is sold first, the outcome would be inefficient with a positive probability. As governments care about efficient outcomes ([McM94]), rather than maximizing the revenue, the results of the theoretical paper is policy relevant; however, it has not been tested with experiments.

In this paper, we test the aforementioned results with experiments as it will help policy makers to design the sequential auctions by using the correct selling order. Mainly, we test three hypothesis. The hypothesis are 1) having a large number of bidders in the last auction should provide an (almost) efficient outcome; 2) having a large number of bidders in the first auction, relative to the last auction, should end up with an inefficient outcome with a positive probability; 3) Selling the goods with fewer bidders first, and selling the good with more bidders second should be better at obtaining efficient outcomes. We find strong evidence supporting hypothesis 2 and 3. We also find that hypothesis 1 produces efficient outcome but with an estimate probability close to 70%. At a minimum, these results support that selling goods with more bidders in the second leg of a sequential auction is better at getting efficient outcomes. Hence, this is a policy relevant result.

We also test one question that the theoretical paper is silent about. That is, “is selling the good with fewer bidders first better at obtaining higher revenue?” We do not find a strong support for this question.

The novelty of our paper is that it is the first experimental paper showing that the correct selling order of goods in a sequential auction results in a (more) efficient outcome.

Therefore, our paper emphasizes that selling order in sequential auctions should get more attention from the literature when there are different types of heterogeneity in each leg of the sequential auctions.

As the setting where there are global and local bidders and the good is synergistic for the global bidder has practical applications, [CL12] tested first-price auctions with and without package bidding. They show that for high synergy levels, package bidding improves efficiency. [FB13] studies the FCC spectrum auctions in this setting for simultaneous ascending auctions. Selling order does not matter in package or simultaneous auctions unlike our paper so these papers do not test selling order.

[LPV12] study a setting with four bidders in each leg of a sequential auction. The goods are stochastically equivalent but the winner of the first leg enjoys a synergy in the second leg. They compare the first and second price auctions with experiments. As the objects are stochastically equivalent and bidders are ex-ante identical, they do not study the selling order unlike us, as it will not matter.

Our paper also falls into the experimental multi-good auction papers testing efficiency. [FLE15] study whether the resale of goods result in efficient outcomes in simultaneous second price auctions. They find an affirmative answer. Their paper focuses on simultaneous and Vickrey auctions unlike our paper. [PS19] study how the possibility of resale affects efficiency in uniform-price multi-good auctions. Since, resale is not permitted in some auctions, we do not study resale in this paper. We show that (more) efficiency can be achieved with the correct selling order in a sequential auction even without resale.

In the rest of the paper, we first explain the theoretical setting of the paper. Then, we explain all the efficient and inefficient outcome types in our auction setting. We discuss the hypothesis and experimental design after that. Finally, we present our results and conclude the paper.

2 Theoretical setting

The model is mainly based on [GM22] and the notation is almost the same. Consider a seller who has two goods, A and B, that has zero value to her. The seller uses a second-price sequential auction to sell both goods. There is one risk-neutral global bidder, G.[1] If she wins both goods, she enjoys a synergy of $\theta > 0$. Assuming the synergy level θ to be public or

[1] Assuming one global bidder is accepted in the literature since the strategies when there are multi global bidders cannot be defined analytically in the literature. See [MG17] for more on this.

private information has no effect on the results. There are also $N_i > 0$ risk neutral local bidders bidding for good $i = A, B$. $N_i + 1$ independent draws from the uniform distribution function F determines the private valuation, v_{ki}, for each bidder, $k = G, 1, 2.., N_i$, and good $i = A, B$.

We use symmetric subgame perfect Bayesian equilibrium in weakly undominated strategies.[2] The global bidder's second-auction equilibrium strategy will depend on the history of the game; that is, whether she won or lost the first leg. The global bidder bids v_{Gj} if lost good i in the first auction, and $v_{Gj} + \theta$ if won the first good, where $i, j = A, B$ and $i \neq j$. This is actually truthful bidding for the global bidder based on the history of the game. Local bidders also bid their valuations truthfully in both auctions as this is a second price auction.

By maximizing the expected payoff for the global bidder, we derive the global bidder's equilibrium strategy in the first auction for good i. But to calculate the expected payoff, we need the (expected) price the global bidder pays, if wins any of the goods. To calculate that price, let $p_i = max\{v_{ki}\}, k = 1, 2, \cdots, N_i$ denote the maximum valuation of local bidders for good $i = A, B$. This p_i is the price that the global bidder pays if he wins good i because the local bidders bid truthfully and this is a second-price auction. Since the valuations are not known, we need the distribution function for p_i to calculate the expected price that the global bidder will pay, which is $G_i(.) = [F(.)]^{N_i}$.

The following proposition gives the equilibrium bidding price b_{ij}, when good i is auctioned first and j second and it is taken from [GM22].

Proposition 1 *The global bidder's first-auction equilibrium bid, b_{ij}, for good i is*

$$a)\ \text{If } v_{Gj} + \theta < 1, \text{ then } \ b_{ij}(v_{Gi}, v_{Gj}, N_j) = v_{Gi} + \int_{v_{Gj}}^{v_{Gj}+\theta} G_j(p_j, N_j) dp_j$$

$$b)\ \text{If } v_{Gj} + \theta \geq 1, \text{ then } \ b_{ij}(v_{Gi}, v_{Gj}, N_j) = v_{Gi} + (v_{Gj} + \theta - 1) + \int_{v_{Gj}}^{1} G_j(p_j, N_j) dp_j$$

For the proof (for a general case of distributions rather than the uniform distribution only), see [GM22]. The global bidder's bid b_{ij} is the price where she is indifferent between losing and winning the first leg of the auction. We note that the number of bidders in the first auction, N_i does not affect the bidding price at all but only the number of local bidders

[2] In describing the model below, we closely follow [MG17].

in the second auction, N_j matters as this affects the probability of winning the second good and the synergy. This is explained in the first part of the corollary below taken from [GM22].

Corollary 2 *i) The number of local bidders in the first auction has no effect on the bidding price.*

ii) As the number of local bidders in the second auction approaches infinity, the global bidder's bid is

$b_{ij} \to v_{Gi}$, *if* $v_{Gj} + \theta < 1$.

$b_{ij} \to v_{Gi} + v_{Gj} + \theta - 1$, *if* $v_{Gj} + \theta > 1$.

As the number of local bidders in the second auction, N_j, gets arbitrarily large, $G_j = F[.]^{N_j}$ approaches to zero. Therefore, the integrals in proposition 1 approaches zero. The global bidder bids his valuation v_{Gi}, if $v_{Gj} + \theta < 1$, as he knows that he cannot win the second good given that the maximum of local bidders valuation approaches to 1. If $v_{Gj} + \theta > 1$, the global bidder knows that she will win the second good for sure if she wins the first one. She again bids truthfully in this case.

The corollary implies that the selling order of goods in a sequential auction has implications for efficiency. As the number of bidders in the second auction gets arbitrarily large, the outcome is always efficient, as all bidders bid truthfully. But this is not the case if the number of bidders in the first auction gets arbitrarily large. We summarize the results in the following proposition taken from [GM22].

Proposition 3 *i) Assume that* $0 < \theta < 2$. *As the number of local bidders in the first auction approaches infinity, the outcome of the sequential auction might be inefficient with a positive probability.*

ii) As the number of local bidders in the second auction approaches infinity, the outcome of the sequential auction is efficient.

The inefficiencies occur even if there are infinitely many bidders in the first auction. For example, the global bidder might still win the first auction by bidding over 1 (but pay a price of 1 as there are infinitely many local bidders). However, if the global bidder loses the second auction (as it will not bid over 1 when the synergy and her valuation for the second good is not too high), there will an ex-post loss. We prove that such inefficient outcomes occur with a positive probability. There are other types of inefficiencies which we will discuss in the next section. The proof is in [GM22].

3 Efficient Outcome

An efficient auction outcome occurs when the bidders who value the goods **most** receive those goods at the end of the auction. For example, consider the table below that shows valuations for each bidder. Global bidder values good A at 0.6 and good B at 0.3. However, if wins both goods, he enjoys a synergy level of $\theta = 0.35$, which makes his total valuation for both goods as 0.6+0.3+0.35. In other words, goods are complementary for the global bidder. This is documented empirically in many auctions ([FB13]; [Sil05]). But if the global bidder wins only one good, then he cannot get this synergy level but instead just the stand-alone valuations, which are 0.6 for good A and 0.3 for good B.

	Stand-Alone Valuation for A	Stand-alone Valuation for B	Synergy = θ
Global Bidder	0.6	0.3	0.35
Local Bidder A	0.7	0	0
Local Bidder B	0	0.6	0

The local bidders should win both goods for the efficient outcome as local bidders value goods more than the global bidder in this example as:[3]

$$0.7 + 0.6 > 0.6 + 0.3 + 0.35$$

However, if the global bidder bids 0.8 in the A auction (as it always bids over its stand-valuation of 0.6 in the first auction -as shown by proposition 1 in the model), it wins A by paying 0.7 as local bidder A bids his valuation of 0.7 truthfully and that this is a second-price auction. Then the global bidder bids $0.3 + 0.35 = 0.65$ for good B (as it bids his stand-alone valuation for B plus the synergy level when it wins the first auction as discussed in the model part). But local bidder B bids its valuation truthfully, which is 0.6 in this example. Hence, the global bidder also wins B and pays 0.6, the second highest bid. However, the global bidders ends up in a loss despite winning both goods and getting the synergy level:

$$\underbrace{(0.6 + 0.3 + 0.35)}_{global\ bidder's\ total\ valution} - \underbrace{(0.7 + 0.6)}_{total\ payment} = -0.05$$

This is an example of an inefficient auction outcome. The local bidders should have won both licenses for an efficient outcome as discussed above (because $0.7 + 0.6 > 0.6 + 0.3 + 0.35$

[3]It is also possible that global bidder wins one good and the local bidder wins the other good might be an efficient outcome but it is easy to check that this is not the case in this example.

).

Table 1 shows all possible outcomes, and the corresponding revenue and welfare in ij auction which helps us in calculating them ex-post. The table shows that there are four different types of inefficiency when there are only one local bidder bidding for each good. Two of the inefficient outcomes are the global bidder winning one or both goods with an ex-post loss (rows 2 and 4 in Table 1); one of them is the global bidder winning (one good) inefficiently with a profit (row 6), and the last one is the local bidders winning both goods inefficiently (row 8).[4]

In the table, b_{ij} denotes the global bidder's bid in the first auction i. We showed that b_{ij} is above his stand-alone valuation for good i in proposition 1. Also, as explained in the model section, the private valuations of each bidder is denoted by v_{ki}, for $k = G, 1, 2.., N_i$, and $i = A, B$ (G denotes the global bidder, the numbers $1, 2, \cdots$ denote the local bidders).

	License i won by	License j won by	Global bidder makes	Allocation is	Revenue is	Welfare is
1.	Global Bidder	Global Bidder	Profit	Efficient	$v_{1i} + v_{1j}$	$v_{Gi} + v_{Gj} + \theta$
2.	Global Bidder	Global Bidder	Loss	Inefficient	$v_{1i} + v_{1j}$	$v_{Gi} + v_{Gj} + \theta$
3.	Global Bidder	Local Bidder j	Profit	Efficient	$v_{1i} + v_{Gj} + \theta$	$v_{Gi} + v_{1j}$
4.	Global Bidder	Local Bidder j	Loss	Inefficient	$v_{1i} + v_{Gj} + \theta$	$v_{Gi} + v_{1j}$
5.	Local Bidder i	Global Bidder	Profit	Efficient	$b_{ij} + v_{1j}$	$v_{1i} + v_{Gj}$
6.	Local Bidder i	Global Bidder	Profit	Inefficient	$b_{ij} + v_{1j}$	$v_{1i} + v_{Gj}$
7.	Local Bidder i	Local Bidder j	Zero Profit	Efficient	$b_{ij} + v_{Gj}$	$v_{1i} + v_{1j}$
8.	Local Bidder i	Local Bidder j	Zero Profit	Inefficient	$b_{ij} + v_{Gj}$	$v_{1i} + v_{1j}$

Table 1: All possible outcomes in an ij auction, when $N_i = N_j = 1$

Table 2 shows all possible outcomes when there are more than 1 local bidders bidding for each good. In the table, since we have more than one local bidder, p_i and $\tilde{p}_i$ denote the maximum valuation and the second maximum valuation of all local bidders for good $i = A, B$, respectively.

[4] Please, refer to [MG17] for the proof that there cannot be an inefficient outcome in which global bidder wins the first item with profit but loses the second one.

	License i won by	License j won by	Global bidder makes	Allocation is	Revenue is	Welfare is
1.	Global Bidder	Global Bidder	Profit	Efficient	$p_i + p_j$	$v_{Gi} + v_{Gj} + \theta$
2.	Global Bidder	Global Bidder	Loss	Inefficient	$p_i + p_j$	$v_{Gi} + v_{Gj} + \theta$
3.	Global Bidder	Local Bidder j	Profit	Efficient	$p_i + v_{Gj} + \theta$	$v_{Gi} + p_j$
4.	Global Bidder	Local Bidder j	Loss	Inefficient	$p_i + v_{Gj} + \theta$	$v_{Gi} + p_j$
5.	Global Bidder	Local Bidder j	Profit	Efficient	$p_i + \tilde{p}_j$	$v_{Gi} + p_j$
6.	Global Bidder	Local Bidder j	Loss	Inefficient	$p_i + \tilde{p}_j$	$v_{Gi} + p_j$
7.	Local Bidder i	Global Bidder	Profit	Efficient	$b_{ij} + p_j$	$p_i + v_{Gj}$
8.	Local Bidder i	Global Bidder	Profit	Inefficient	$b_{ij} + p_j$	$p_i + v_{Gj}$
9.	Local Bidder i	Global Bidder	Profit	Efficient	$\tilde{p}_i + p_j$	$p_i + v_{Gj}$
10.	Local Bidder i	Global Bidder	Profit	Inefficient	$\tilde{p}_i + p_j$	$p_i + v_{Gj}$
11.	Local Bidder i	Local Bidder j	Zero Profit	Efficient	$b_{ij} + v_{Gj}$	$p_i + p_j$
12.	Local Bidder i	Local Bidder j	Zero Profit	Inefficient	$b_{ij} + v_{Gj}$	$p_i + p_j$
13.	Local Bidder i	Local Bidder j	Zero Profit	Efficient	$b_{ij} + \tilde{p}_j$	$p_i + p_j$
14.	Local Bidder i	Local Bidder j	Zero Profit	Inefficient	$b_{ij} + \tilde{p}_j$	$p_i + p_j$
15.	Local Bidder i	Local Bidder j	Zero Profit	Efficient	$\tilde{p}_i + v_{Gj}$	$p_i + p_j$
16.	Local Bidder i	Local Bidder j	Zero Profit	Inefficient	$\tilde{p}_i + v_{Gj}$	$p_i + p_j$
17.	Local Bidder i	Local Bidder j	Zero Profit	Efficient	$\tilde{p}_i + \tilde{p}_j$	$p_i + p_j$
18.	Local Bidder i	Local Bidder j	Zero Profit	Inefficient	$\tilde{p}_i + \tilde{p}_j$	$p_i + p_j$

Table 2: All possible outcomes in an ij auction, when $N_i = N_j \geq 2$
p_i and $\tilde{p}_i$ maximum and second maximum local bidder´s valuation for good i, $i = A, B$

4 Hypotheses

Let N_A be a finite but small number, while let N_B be a large number. As a consequence, the number of local bidders in good A is very small relative to that of good B. Let order AB denote the sequential auction in which good A is sell first and good B second. Similarly, for order BA. Theory predicts that order AB of the sequential auction should be (almost) efficient, while order BA is inefficient. In particular, order AB is more efficient than order BA. Broadly speaking, this is what we want to test with our experiment. We write our hypotheses below.

Let P_{ij} denote the proportion of efficient outcomes of the sequential auction with order ij, where $i, j = A, B$, $i \neq j$.

In line with Proposition 3, we have the following two hypotheses.

Hypothesis 1: *Having a large number of local bidders in the second auction is efficient. The claim is* $P_{AB} \approx 1$.

Hypothesis 2: *Having a large number of local bidders in the first auction, relative to that number in the second auction, is inefficient* *with a positive probability*. *The claim is that* P_{BA} *is significantly less than* 1.

As a consequence of the previous hypotheses, we have

Hypothesis 3: *Selling the good with fewer bidders first, and the good with large bidders* *second is better at obtaining efficient outcomes. That is,* $P_{AB} > P_{BA}$.

We take advantage of the experimental approach to study a question related to revenue. Let R_{AB} be the revenue obtained from the sequential auction with order AB. Similar notation applies to R_{BA}.

Question 4: *Is selling the good with fewer bidders first, and the good with large bidders second better at obtaining higher revenue or not? In other words, we wonder whether* $R_{AB} > R_{BA}$.

5 Experimental Design

Our aim is to analyze the order of selling two goods when there are different number of (local) bidders participating in each leg of a second-price sequential auction. In order to test the hypotheses stated in Section 4, we follow the theoretical model, and consider $N_A = 1$ and $N_B = 1000$. That is, the number of local bidders for good A is one and the number of local bidders for good B is 1000. There is one global bidder who bids for both goods sequentially, one good first and then the other. The global bidder is played by human subjects and the local bidders played by the computers. That is why local bidders are sometimes named bots or robots. Following theory, the robots will bid its valuation truthfully in both goods of the sequential auction.

5.1 Experimental treatments

It is a between subject design, with Treatment AB and Treatment BA, which refer to the sequential auctions with orders AB and BA, respectively. Hence, in Treatment AB, the global bidder faces one local bidder in the first leg (auction for good A) of the sequential auction while facing 1000 local bidders in the second leg (auction for good B). The global bidder is played by human subjects and they know that they face local bidders played by the computers. In Treatment BA we reverse the order of selling the goods. Hence, the global bidder faces 1000 local bidders in the first leg (auction for good B) while facing one local bidder in the second leg (auction for good A). In each treatment, every participant plays 20 rounds. Since we are interested in mature (learned) behavior of bidders, we had determined in advanced to utilize only the last 10 rounds.

5.2 The valuations

The valuations of the global bidder will be drawn from a uniform distribution on the support $[0; 100]$ for the first and second leg of the auctions at the beginning of the sequential auction. The valuation of the local bidders will also be drawn (independently) from the same distribution before each leg of the sequential auction. Thus, for each round of a sequential auction, we generate a vector of valuations with dimension 1003, two for the global player and 1001 for the local players. We use the synergy factor of $\theta = 50$ which is common knowledge. The global bidder (human subject) will determine its first leg bid after learning his valuations for both objects, the synergy factor and how many local bidders its facing in both auctions. Then, she will learn if she won the first auction or not. After that, she will determine its second leg bid. At the end of the round, the global bidder will learn the auction outcome, the price paid by the winner, and her payoff. Subjects never directly learn the valuations of others. At the end of each round, the bidders receive an update of their payoffs.

In order to compare the treatments, a unique matrix of random numbers with dimension 20×1003 is generated, which is used in both treatments. Each row contains the valuations of all the players (global and local) for the corresponding round. If we identify each row with $(v_{GA}, v_{GB}, v_{1A}, v_{1B}, v_{2B}, \cdots, v_{1000B})$, the first and second columns contain the valuations of good A and good B for the global player, the third column the valuations for good A for the robot, and from columns 4 up to 1003 contains the valuations for good B for the 1000 robots. In each session, each global bidder plays the 20 rounds with the valuations given by the same matrix of dimension 20×1003. That is, the same matrix is used throughout each treatment.

Bidder's valuations are expressed in Experimental Currency Unit (ECU) as usual. The exchange rate is 4 ECU for 1 PEN (PEN is the international code for the local currency in Peru, called Peruvian Sol). The bids in ECU can be anything between [0; 500] and it need not to be an integer. If there is a tie, the computer chooses the winner with equal probability among the same bid owners.

5.3 The payoffs of the sequential auction

The payoff of a global bidder, payoff_G, is given by the sum of his payoffs from auction of goods A and B, denoted by payoff_{GA} and payoff_{GB}, respectively.

$$\text{payoff}_G = \text{payoff}_{GA} + \text{payoff}_{GB},$$

For the sake of concreteness, let us define the payoffs for the order AB. The global bidder's payoff from auction of good A depends on whether she wins that auction.

$$\text{payoff}_{GA} = \begin{cases} 0 & \text{if losses good A} \\ v_{GA} - p_A & \text{if wins good A} \end{cases}$$

We recall that p_i denotes the maximum valuation of local bidders for good $i = A, B$. Thus, p_i is the price that the global bidder pays if she wins good i. The global bidder's payoff form auction of good B depends on whether she wins auctions for goods A and B. In particular, if she wins both legs of the sequential auction, her payoff includes the synergy factor θ. Indeed,

$$\text{payoff}_{GB} = \begin{cases} 0 & \text{if losses both goods A and B} \\ v_{GB} - p_B & \text{if losses good A and wins good B} \\ v_{GB} - p_B + \theta & \text{if wins both goods A and B} \end{cases}$$

Consequently, the global bidder's payoff from the sequential auction of order AB is given by

$$\text{payoff}_{G} = \begin{cases} 0 & \text{if losses both goods A and B} \\ v_{GA} - p_A & \text{if wins good A and losses good B} \\ v_{GB} - p_B & \text{if losses good A and wins good B} \\ v_{GA} - p_A + v_{GB} - p_B + \theta & \text{if wins both goods A and B} \end{cases}$$

The global bidder's payoff from the sequential auction of order BA is defined in a similar manner, just replacing A with B and viceversa.

On the other hand, since the local players (robots) bid their valuations truthfully, their payoffs are zero if they lose the auction, and it is their valuation minus the second highest bid among all the players (which is either the global bidder's bid or other robot's bid).

At the end of the experiment there are 20 payoffs for a global bidder, one for each round. In order to avoid wealth effects, we determine the *valid payoff* by choosing one of the rounds randomly, with every round having the same probability. Of course, participants know this rule before the experiment begins.

Clearly, the participants (global bidders) might have negative payoffs, as shown in the example given in Section 3. In theory, they are supposed to face an actual loss of their own money. In our experiment, we mimic it by introducing a previous stage in which global bidders earn money.

5.4 Earned wealth and overall earnings

Following [Jac+09], before the experiment on the sequential auction begins, we introduce a previous stage. Global bidders earn money by answering 8 questions of general culture, at the level of preparation for college entrance.[5] Each question has four choices among which one is correct. If they answer correctly 6 or more questions, they earn 20 ECU; otherwise, they earn only 4 ECU. The limit time for this stage was 12 minutes.

The overall earnings of a global bidder is based on the resulting sum of three components: the valid payoff of the sequential auction, the earned wealth of the multiple-choice questionnaire and the show-up fee (5 PEN). The actual earnings they obtain is the sum of the three components unless it is less than 5, in such a case they obtain 5 PEN. Thus, the earnings of a global bidder is at least the show-up fee for sure.

5.5 Experimental subjects

The experiment was conducted in the laboratory LEEX-PUCP of Pontifical Catholic University of Peru (PUCP).[6] It involved a total of 64 students, 34 and 30 for treatments AB and BA, respectively. To have full control of the experiment, we run it in six sessions. Including the show up fee of 5 PEN, the average earnings of a student was 15 PEN, with the minimum of 5 PEN and a maximum of 30 PEN.[7] The experiment was programmed in oTree ([CSW16]), and the recruitment process at LEEX was done via the system ORSEE ([Gre15]). The Ethics Board at PUCP provided formal approval for conducting this study, and at the day of the experiment each student was asked whether they agree to participate. Informed consent was obtained from all subjects.

6 Results

We emphasize that students played 20 rounds in total. For the statistical analysis, we considered only the last 10 rounds, as the first 10 are considered as part of the training

[5] The alternative way to do this is to give windfall money to the participants. The earned approach that we apply to this experiment is to generate incentives for more sincere bidding, as found in [Jac+09].

[6] At LEEX, we are very grateful to Joan Miranda and Andrea Ulloa for research assistance.

[7] We recall that PEN is the international code for the local currency in Peru. To give a sense of the numbers, it is worth pointing out that a lunch menu on campus PUCP is around 10 PEN.

process. Of course, student were not aware of this. We have 340 and 300 observations for Treatment AB and Treatment BA, respectively. A plot of the bids and valuations of all the participants can be seen in the Appendix A.

Before providing the details, we summarize our findings. Regarding efficiency, we have three results. Firstly, we do not find evidence that Treatment AB is close to efficiency 100%, as claimed in **Hypothesis 1**; the estimate value of efficiency is 70%. Secondly, we find strong evidence that inefficiency is greater than zero in Treatment BA, as predicted by theory in **Hypothesis 2**; the estimate value of inefficiency is 44%. Thirdly, we find strong evidence that Treatment AB is more efficient that Treatment BA, as stated in **Hypothesis 3**; the estimate difference in efficiency is 14.33%.

Regarding revenue, we do not find evidence that Treatment AB generates more revenue than Treatment BA. Hence, the answer to **Question 4** is negative. Indeed, the revenue estimates are, respectively, 131.65 ECU and 132.11 ECU, which are very close to each other.

Next, we present the details of the results, including the statistical tests.

Result 1 The efficiency of Treatment AB is statistically significant greater than 65% but not greater than 90%.

We assume first that the null hypothesis is $P_{AB} = 90\%$, and we want to show that the alternative $P_{AB} > 90\%$ holds.[8] There is no evidence to reject the null hypothesis (the p-value is approximately 1). On the other hand, we also test the null hypothesis $P_{AB} = 65\%$ against the alternative $P_{AB} > 65\%$. In this case, there is evidence in favor of the alternative (the p-value is approximately 0.03).

Certainly, this result does not coincide with the theoretical prediction stated in Hypothesis 1. However, we point out that this is the usual case in experimental results in auctions in which the theoretical prediction is efficiency 100%. For instance, [Jac+09] find an estimate of 61.1%.

Result 2 The inefficiency of Treatment BA is statistically significant greater than 35%. Hence, it is significantly greater than zero.

Let us assume that the null hypothesis is $(1 - P_{BA}) = 35\%$ and the alternative is $(1 - P_{BA}) > 35\%$. We reject the null hypothesis in favor of the alternative $(1 - P_{BA}) > 35\%$ (the p-value is 0.00044).

[8] We note that we cannot test the null hypothesis $P_{AB} = 100\%$, the tests of proportions are designed for $0 < P_{AB} < 1$. That is why we perform these tests.

Hence, there is strong evidence in favor of Hypothesis 2 predicted by the theoretical model.

Result 3 The efficiency of Treatment AB is statistically significant greater than that of Treatment BA.

In the inference statistics the null hypothesis is $P_{AB} = P_{BA}$, and the alternative $P_{AB} > P_{BA}$. As the p-value is 0.0066, we find strong evidence in favor of the alternative hypothesis. In addition, we note that the estimate difference in efficiency is 14.33%.

Hence, there is strong evidence in favor of Hypothesis 3 implied by the theoretical model.

Result 4 The revenue of Treatment AB is not greater than that of Treatment BA. Furthermore, we cannot find evidence against $R_{AB} = R_{BA}$.

The null hypothesis is $R_{AB} = R_{BA}$ and the alternative is $R_{AB} > R_{BA}$. We cannot reject the null hypothesis (the p-value is 0.61). Hence, we do not find evidence to provide a positive answer to Question 4. Further, we have considered the null hypothesis $R_{AB} = R_{BA}$ and the alternative $R_{AB} \neq R_{BA}$. Again, we cannot reject the null hypothesis (the p-value is 0.77). Thus, the results of the experiment are consistent with $R_{AB} = R_{BA}$.

7 Conclusion

The goal of this research is to study, via an experiment, whether the order of sale of two goods has an impact on the efficiency of a sequential auction. We design an experiment with one global bidder that faces 1 and 1000 local bidders, in auctions A and B, respectively. According to theory, when there is one good B with a large numbers of local bidders relative to that of good A, a sequential auction with order AB is more efficient than order BA. Our experimental results are consistent with such a theoretical implication. In addition, our experiment shows that order BA of the sequential auction is highly inefficient, as predicted by theory. Further, based on our experiment we estimate the probability of an efficient outcome to be close to 70%, but the theoretical prediction is close to 100%. Overall, the bottom line is that the order of sale of the two goods matters for efficiency outcomes.

Although we do not have a theoretical result for revenue, we have taken advantage of our experimental design to study whether the order of sale has an effect on revenue. Our experimental results show no compelling evidence to reject the (null) hypothesis that both orders generate the same revenue. That is, when it comes to revenue, it seems that the order of sale does not matter.

References

[McM94] J. McMillan. "Selling Spectrum Rights". In: *Journal of Economic Perspectives* 8 (1994), pp. 145–162.

[KR96] V. Krishna and R. W. Rosenthal. "Simultaneous auctions with synergies". In: *Games and Economic Behavior* 17 (1996), pp. 1–31.

[Sil05] D. G. De Silva. "Synergies in recurring procurement auctions: an empirical investigation". In: *Economic Inquiry* 43.1 (2005), pp. 55–66.

[GX07] H. Gunay and X.Meng. "Predatory Bidding in Sequential Auctions". In: *Economics Bulletin* 4.12 (2007), pp. 1–5.

[Jac+09] N. Jacquement et al. "Earned wealth, engaged bidders? Evidence from a second-price auction". In: *Economics Letters* 105 (2009), pp. 36–38.

[CL12] K. Chernomaz and D. Levin. "Efficiency and synergy in a multi-unit auction with and without package bidding: An experimental study". In: *Games and Economic Behavior* 76 (2012), pp. 611–635.

[LPV12] K. Leufkens, R. Peeters, and M. Vorsatz. "An experimental comparison of sequential first- and second-price auctions with synergies." In: *The B.E. Journal of Theoretical Economics* 12.1 (2012).

[FB13] J. T. Fox and P. Bajari. "Measuring the Efficiency of an FCC Spectrum Auction". In: *American Economic Journal: Microeconomics* 5.1 (2013), pp. 100–146.

[FLE15] E. Filiz-Ozbay, K. Lopez-Vargas, and Ozbay E. Y. "Multi-object auctions with resale: Theory and experiment". In: *Games and Economic Behavior* 89 (2015), pp. 1–16.

[Gre15] B. Greiner. "Subject pool recruitment procedures: organizing experiments with ORSEE". In: *Journal of the Economic Science Association* 1.(1) (2015), pp. 114–125.

[CSW16] D. L. Cheng, M. Schonger, and C. Wickens. "oTree - An open-source platform for laboratory, online and field experiments". In: *Journal of Behavioral and Experimental Finance* 9 (2016), pp. 88–97.

[MG17] X. Meng and H. Gunay. "Exposure problem in multi-unit auctions". In: *International Journal of Industrial Organization* 52 (2017), pp. 165–187.

[PS19] M. Pagnozzi and K. J. Saral. "Efficiency in auctions with (failed) resale". In: *Journal of Economic Behavior and Organization* 159 (2019), pp. 254–273.

[GM22] H. Gunay and X. Meng. "Different number of bidders in sequential auctions". In: *Hitotsubashi Journal of Economics* 63 (2022), pp. 72–85.

A Participants: bids and valuations

A.1 Treatment AB: bids and valuations for good A

In the figure below, we have a panel of 34 plots, one for each participant identified by a label. In each plot, we have the valuations (black line) and the corresponding bids (color line) for the 20 rounds.

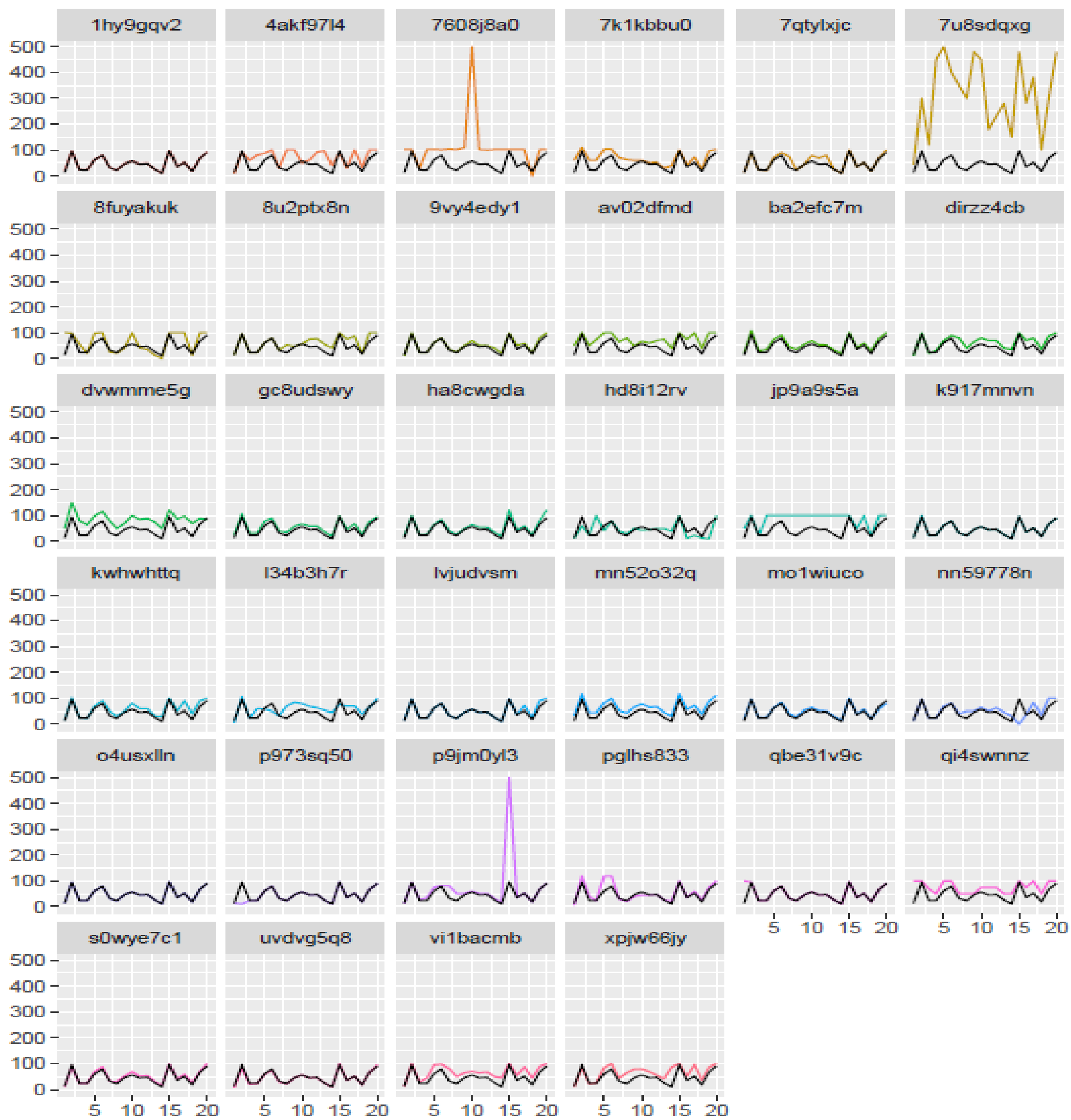

Figure 1: Treatment AB: bids and valuations for good A

A.2 Treatment AB: bids and valuations for good B

In the figure below, we have a panel of 34 plots, one for each participant identified by a label. In each plot, we have the valuations (black line) and the corresponding bids (color line) for the 20 rounds.

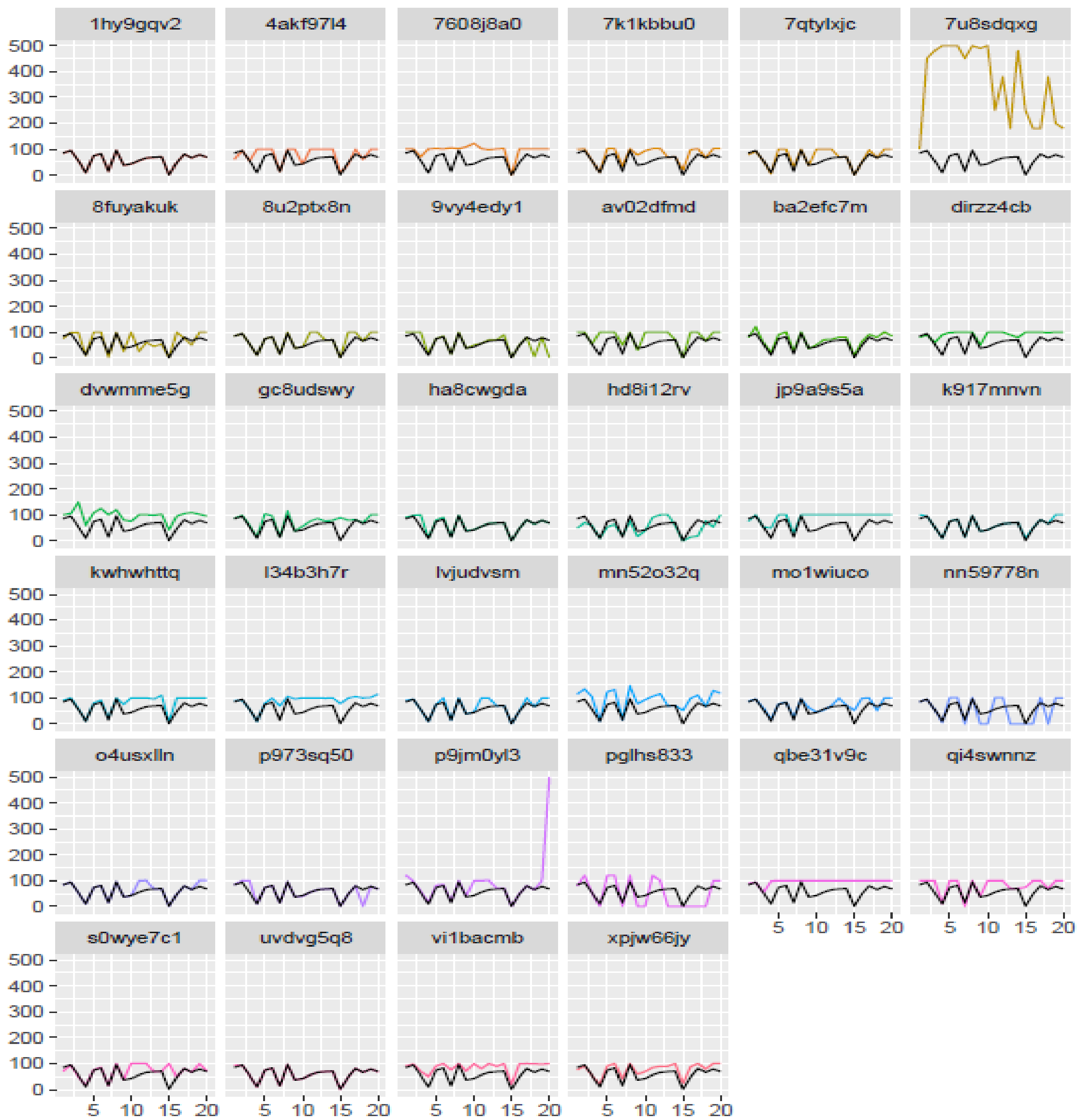

Figure 2: Treatment AB: bids and valuations for good B

A.3 Treatment BA: bids and valuations for good A

In the figure below, we have a panel of 30 plots, one for each participant identified by a label. In each plot, we have the valuations (black line) and the corresponding bids (color line) for the 20 rounds.

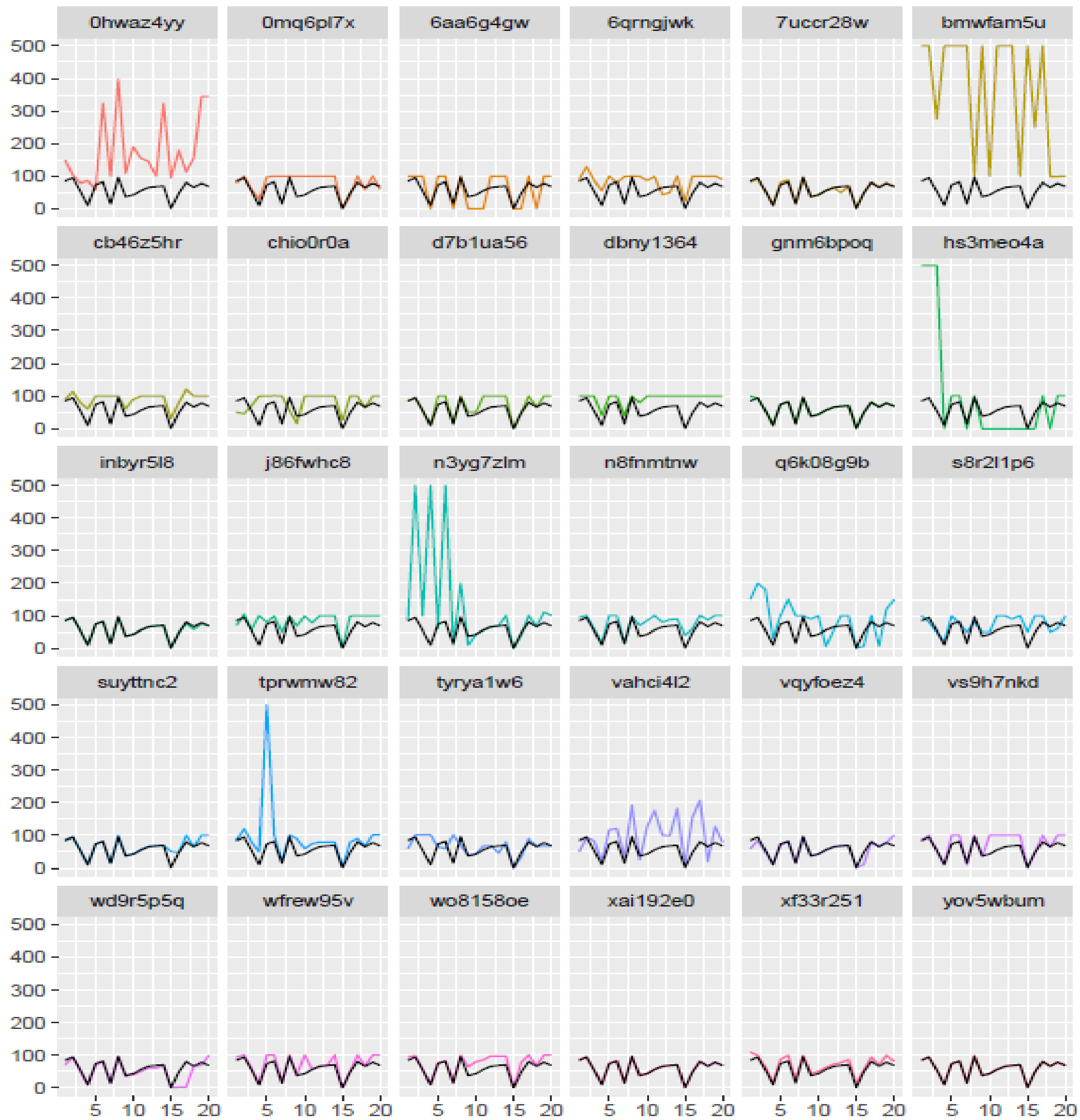

Figure 3: Treatment BA: bids and valuations for good A

A.4 Treatment BA: bids and valuations for good B

In the figure below, we have a panel of 30 plots, one for each participant identified by a label. In each plot, we have the valuations (black line) and the corresponding bids (color line) for the 20 rounds.

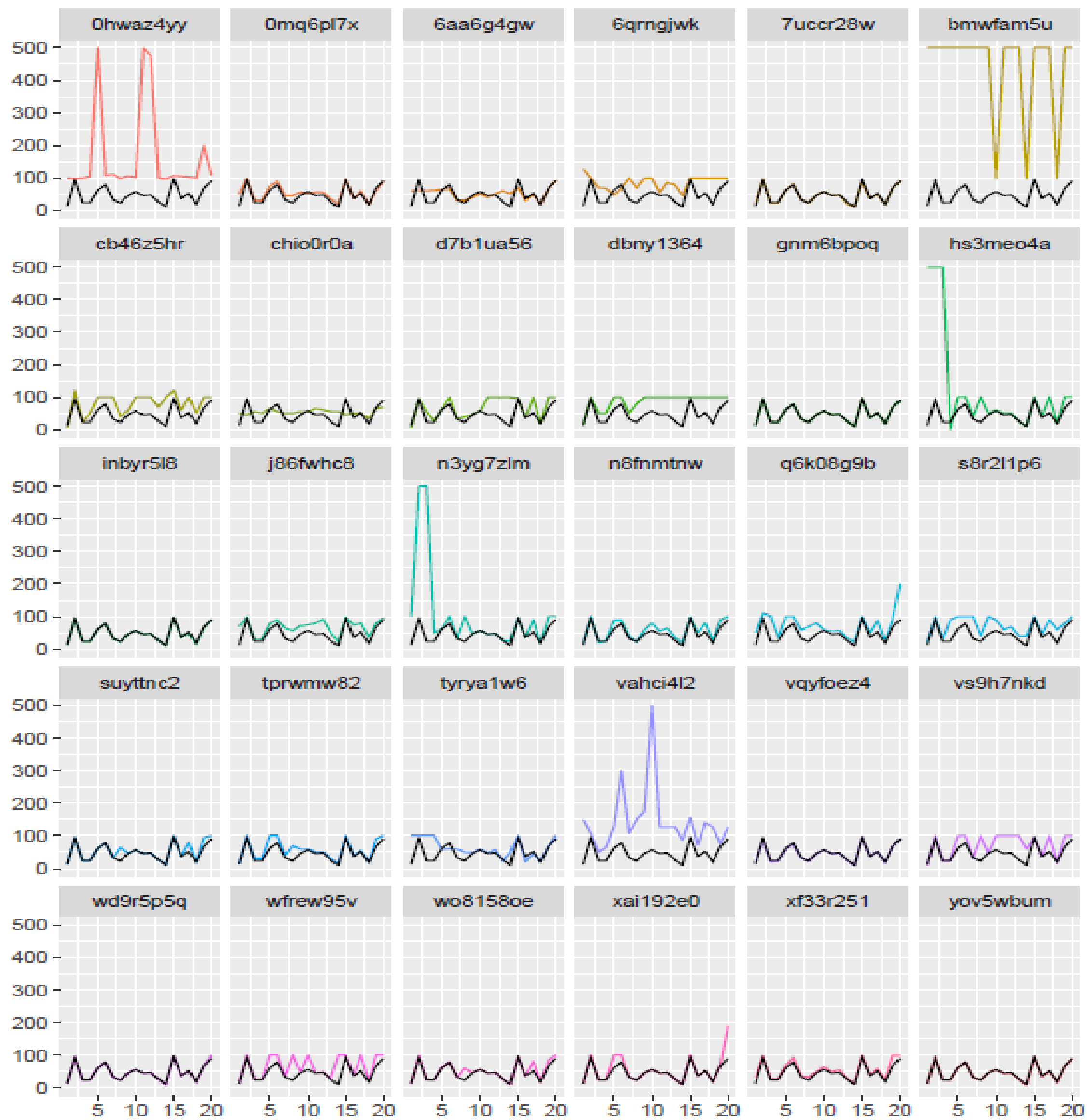

Figure 4: Treatment BA: bids and valuations for good B

ÚLTIMAS PUBLICACIONES DE LOS PROFESORES
DEL DEPARTAMENTO DE ECONOMÍA

- *Libros*

Adolfo Figueroa
2023 *The Quality of Society, Volume III. Essays on the Unified Theory of Capitalism.* New York, Palgrave Macmillan

Efraín Gonzales de Olarte
2023 *El modelo de Washington, el neoliberalismo y el desarrollo económico. El caso peruano 1990-2020.* Lima, Fondo Editorial PUCP.

Máximo Vega Centeno.
2023 *Perú: desarrollo, naturaleza y urgencias Una mirada desde la economía y el desarrollo humano.* Lima, Fondo Editorial PUCP.

Waldo Mendoza
2023 *Constitución y crecimiento económico: Perú 1993-2021*. Lima, Fondo Editorial PUCP.

Oscar Dancourt y Waldo Mendoza (Eds.)
2023 *Ensayos macroeconómicos en honor a Félix Jiménez*. Lima, Fondo Editorial PUCP.

Carlos Contreras Carranza (ed.)
2022 *Historia económica del Perú central. Ventajas y desafíos de estar cerca de la capital*. Lima, Banco Central de Reserva del Perú e Instituto de Estudios Peruanos.

Alejandro Lugon
2022 *Equilibrio, eficiencia e imperfecciones del mercado.* Lima, Fondo Editorial PUCP.

Waldo Mendoza Bellido
2022 *Cómo investigan los economistas. Guía para elaborar y desarrollar un proyecto de investigación. Segunda edición aumentada*. Lima, Fondo Editorial PUCP.

Elena Álvarez (Editor)
2022 *Agricultura y desarrollo rural en el Perú: homenaje a José María Caballero.* Lima, Departamento de Economía PUCP.

Aleida Azamar Alonso, José Carlos Silva Macher y Federico Zuberman (Editores)
2022 *Economía ecológica latinoamericana.* Buenos Aires, México. CLACSO, Siglo XXI Editores.

Efraín Gonzales de Olarte
2021 *Economía regional y urbana. El espacio importa.* Lima, Fondo Editorial PUCP.

Alfredo Dammert Lira
2021 *Economía minera*. Lima, Fondo Editorial PUCP.

Adolfo Figueroa
2021 *The Quality of Society, Volume II – Essays on the Unified Theory of Capitalism*. New York, Palgrave Macmillan.

Carlos Contreras Carranza (Editor)
2021 *La Economía como Ciencia Social en el Perú. Cincuenta años de estudios económicos en la Pontificia Universidad Católica del Perú.* Lima, Departamento de Economía PUCP.

José Carlos Orihuela y César Contreras
2021 *Amazonía en cifras: Recursos naturales, cambio climático y desigualdades.* Lima, OXFAM.

Alan Fairlie
2021 *Hacia una estrategia de desarrollo sostenible para el Perú del Bicentenario.* Arequipa, Editorial UNSA.

Waldo Mendoza e Yuliño Anastacio
2021 *La historia fiscal del Perú: 1980-2020. Colapso, estabilización, consolidación y el golpe de la COVID-19.* Lima, Fondo Editorial PUCP.

Cecilia Garavito
2020 *Microeconomía: Consumidores, productores y estructuras de mercado. Segunda edición.* Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

Adolfo Figueroa
2019 *The Quality of Society Essays on the Unified Theory of Capitalism.* New York. Palgrave MacMillan.

Carlos Contreras y Stephan Gruber (Eds.)
2019 *Historia del Pensamiento Económico en el Perú. Antología y selección de textos*. Lima, Facultad de Ciencias Sociales PUCP.

Barreix, Alberto Daniel; Corrales, Luis Fernando; Benitez, Juan Carlos; Garcimartín, Carlos; Ardanaz, Martín; Díaz, Santiago; Cerda, Rodrigo; Larraín B., Felipe; Revilla, Ernesto; Acevedo, Carlos; Peña, Santiago; Agüero, Emmanuel; Mendoza Bellido, Waldo; Escobar Arango y Andrés.
2019 *Reglas fiscales resilientes en América Latina*. Washington, BID.

José D. Gallardo Ku
2019 *Notas de teoría para para la incertidumbre*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

Úrsula Aldana, Jhonatan Clausen, Angelo Cozzubo, Carolina Trivelli, Carlos Urrutia y Johanna Yancari
2018 *Desigualdad y pobreza en un contexto de crecimiento económico*. Lima, Instituto de Estudios Peruanos.

Séverine Deneulin, Jhonatan Clausen y Arelí Valencia (Eds.)
2018 *Introducción al enfoque de las capacidades: Aportes para el Desarrollo Humano en América Latina*. Flacso Argentina y Editorial Manantial. Fondo Editorial de la Pontificia Universidad Católica del Perú.

Mario Dammil, Oscar Dancourt y Roberto Frenkel (Eds.)
2018 *Dilemas de las políticas cambiarias y monetarias en América Latina*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

- *Documentos de trabajo*

No. 529 External Shocks and Economic Fluctuations in Peru: Empirical Evidence using Mixture Innovation TVP-VAR-SV Models.
Brenda Guevara, Gabriel Rodríguez y Lorena Yamuca Salvatierra. Enero, 2024.

No. 528 COVID-19 y el mercado laboral de Lima Metropolitana y Callao: Un análisis de género.
Tania Paredes. Noviembre, 2023.

No. 527 COVID-19 y el alza de la inseguridad alimentaria de los hogares rurales en Perú durante 2020-2021.
Josue Benites y Pedro Francke. Noviembre, 2023.

No. 526 Globalización Neoliberal y Reordenamiento Geopolítico.
Jorge Rojas. Octubre, 2023.

No. 525 The effects of social pensions on mortality among the extreme poor elderly.
Jose A. Valderrama y Javier Olivera. Setiembre, 2023.

No. 524 Jane Haldimand Marcet: Escribir sobre economía política en el siglo XVIII.
Cecilia Garavito. Setiembre, 2023.

No. 523 Impact of Monetary Policy Shocks in the Peruvian Economy Over Time
Flavio Pérez Rojo y Gabriel Rodríguez. Agosto, 2023.

No. 522 Perú 1990-2021: la causa del "milagro" económico ¿Constitución de 1993 o Superciclo de las materias primas?
Félix Jiménez, José Oscátegui y Marco Arroyo. Agosto, 2023.

No. 521 Envejeciendo desigualmente en América Latina.
Javier Olivera. Julio, 2023.

No. 520 Choques externos en la economía peruana: un enfoque de ceros y signos en un modelo BVAR.
Gustavo Ganiko y Álvaro Jiménez. Mayo, 2023

No. 519 Ley de Okun en Lima Metropolitana 1970 – 2021.
Cecilia Garavito. Mayo, 2023

No. 518 Efectos 'Spillovers' (de derrame) del COVID-19 Sobre la Pobreza en el Perú: Un Diseño No Experimental de Control Sintético.
Mario Tello. Febrero, 2023

No. 517 Indicadores comerciales de la Comunidad Andina 2002-2021: ¿Posible complementariedad o convergencia regional?
Alan Fairlie y Paula Paredes. Febrero, 2023.

No. 516 Evolution over Time of the Effects of Fiscal Shocks in the Peruvian Economy: Empirical Application Using TVP-VAR-SV Models.
Alexander Meléndez Holguín y Gabriel Rodríguez. Enero, 2023.

No. 515 COVID-19 and Gender Differences in the Labor Market: Evidence from the Peruvian Economy.
Giannina Vaccaro, Tania Paredes. Julio 2022.

No. 514 Do institutions mitigate the uncertainty effect on sovereign credit ratings? Nelson Ramírez-Rondán, Renato Rojas-Rojas y Julio A. Villavicencio. Julio 2022.

No. 513 Gender gap in pension savings: Evidence from Peru's individual capitalization system. Javier Olivera y Yadiraah Iparraguirre. Junio 2022.

No. 512 Poder de mercado, bienestar social y eficiencia en la industria microfinanciera regulada en el Perú. Giovanna Aguilar y Jhonatan Portilla. Junio 2022.

No. 511 Perú 1990-2020: Heterogeneidad estructural y regímenes económicos regionales ¿Persiste la desconexión entre la economía, la demografía y la geografía? Félix Jiménez y Marco Arroyo. Junio 2022.

No. 510 Evolution of the Exchange Rate Pass-Throught into Prices in Peru: An Empirical Application Using TVP-VAR-SV Models. Roberto Calero, Gabriel Rodríguez y Rodrigo Salcedo Cisneros. Mayo 2022.

No. 509 Time Changing Effects of External Shocks on Macroeconomic Fluctuations in Peru: Empirical Application Using Regime-Switching VAR Models with Stochastic Volatility. Paulo Chávez y Gabriel Rodríguez. Marzo 2022.

No. 508 Time Evolution of External Shocks on Macroeconomic Fluctuations in Pacific Alliance Countries: Empirical Application using TVP-VAR-SV Models. Gabriel Rodríguez y Renato Vassallo. Marzo 2022.

No. 507 Time-Varying Effects of External Shocks on Macroeconomic Fluctuations in Peru: An Empirical Application using TVP-VARSV Models. Junior A. Ojeda Cunya y Gabriel Rodríguez. Marzo 2022.

No. 506 La Macroeconomía de la cuarentena: Un modelo de dos sectores. Waldo Mendoza, Luis Mancilla y Rafael Velarde. Febrero 2022.

No. 505 ¿Coexistencia o canibalismo? Un análisis del desplazamiento de medios de comunicación tradicionales y modernos en los adultos mayores para el caso latinoamericano: Argentina, Colombia, Ecuador, Guatemala, Paraguay y Perú. Roxana Barrantes Cáceres y Silvana Manrique Romero. Enero 2022.

No. 504 "Does the Central Bank of Peru Respond to Exchange Rate Movements? A Bayesian Estimation of a New Keynesian DSGE Model with FX Interventions". Gabriel Rodríguez, Paul Castillo B. y Harumi Hasegawa. Diciembre, 2021

No. 503 "La no linealidad en la relación entre la competencia y la sostenibilidad financiera y alcance social de las instituciones microfinancieras reguladas en el Perú". Giovanna Aguilar y Jhonatan Portilla. Noviembre, 2021.

No. 502 "Approximate Bayesian Estimation of Stochastic Volatility in Mean Models using Hidden Markov Models: Empirical Evidence from Stock Latin American Markets". Carlos A. Abanto-Valle, Gabriel Rodríguez, Luis M. Castro Cepero y Hernán B. Garrafa-Aragón. Noviembre, 2021.

No. 501 "El impacto de políticas diferenciadas de cuarentena sobre la mortalidad por COVID-19: el caso de Brasil y Perú". Angelo Cozzubo, Javier Herrera, Mireille Razafindrakoto y François Roubaud. Octubre, 2021.

No. 500 "Determinantes del gasto de bolsillo en salud en el Perú". Luis García y Crissy Rojas. Julio, 2021.

No. 499 "Cadenas Globales de Valor de Exportación de los Países de la Comunidad Andina 2000-2015". Mario Tello. Junio, 2021.

No. 498 "¿Cómo afecta el desempleo regional a los salarios en el área urbana? Una curva de salarios para Perú (2012-2019)". Sergio Quispe. Mayo, 2021.

No. 497 "¿Qué tan rígidos son los precios en línea? Evidencia para Perú usando Big Data". Hilary Coronado, Erick Lahura y Marco Vega. Mayo, 2021.

No. 496 "Reformando el sistema de pensiones en Perú: costo fiscal, nivel de pensiones, brecha de género y desigualdad". Javier Olivera. Diciembre, 2020.

No. 495 "Crónica de la economía peruana en tiempos de pandemia". Jorge Vega Castro. Diciembre, 2020.

No. 494 "Epidemia y nivel de actividad económica: un modelo". Waldo Mendoza e Isaías Chalco. Setiembre, 2020.

No. 493 "Competencia, alcance social y sostenibilidad financiera en las microfinanzas reguladas peruanas". Giovanna Aguilar Andía y Jhonatan Portilla Goicochea. Setiembre, 2020.

No. 492 "Empoderamiento de la mujer y demanda por servicios de salud preventivos y de salud reproductiva en el Perú 2015-2018". Pedro Francke y Diego Quispe O. Julio, 2020.

No. 491 "Inversión en infraestructura y demanda turística: una aplicación del enfoque de control sintético para el caso Kuéalp, Perú". Erick Lahura y Rosario Sabrera. Julio, 2020.

No. 490 "La dinámica de inversión privada. El modelo del acelerador flexible en una economía abierta". Waldo Mendoza Bellido. Mayo, 2020.

No. 489 "Time-Varying Impact of Fiscal Shocks over GDP Growth in Peru: An Empirical Application using Hybrid TVP-VAR-SV Models". Álvaro Jiménez y Gabriel Rodríguez. Abril, 2020.

No. 488 "Experimentos clásicos de economía. Evidencia de laboratorio de Perú". Kristian López Vargas y Alejandro Lugon. Marzo, 2020.

No. 487 "Investigación y desarrollo, tecnologías de información y comunicación e impactos sobre el proceso de innovación y la productividad". Mario D. Tello. Marzo, 2020.

No. 486 "The Political Economy Approach of Trade Barriers: The Case of Peruvian's Trade Liberalization". Mario D. Tello. Marzo, 2020.

No. 485 "Evolution of Monetary Policy in Peru. An Empirical Application Using a Mixture Innovation TVP-VAR-SV Model". Jhonatan Portilla Goicochea y Gabriel Rodríguez. Febrero, 2020.

No. 484 “Modeling the Volatility of Returns on Commodities: An Application and Empirical Comparison of GARCH and SV Models”. Jean Pierre Fernández Prada Saucedo y Gabriel Rodríguez. Febrero, 2020.

No. 483 “Macroeconomic Effects of Loan Supply Shocks: Empirical Evidence”. Jefferson Martínez y Gabriel Rodríguez. Febrero, 2020.

No. 482 “Acerca de la relación entre el gasto público por alumno y los retornos a la educación en el Perú: un análisis por cohortes”. Luis García y Sara Sánchez. Febrero, 2020.

No. 481 “Stochastic Volatility in Mean. Empirical Evidence from Stock Latin American Markets”. Carlos A. Abanto-Valle, Gabriel Rodríguez y Hernán B. Garrafa-Aragón. Febrero, 2020.

No. 480 “Presidential Approval in Peru: An Empirical Analysis Using a Fractionally Cointegrated VAR2”. Alexander Boca Saravia y Gabriel Rodríguez. Diciembre, 2019.

No. 479 “La Ley de Okun en el Perú: Lima Metropolitana 1971 – 2016.” Cecilia Garavito. Agosto, 2019.

No. 478 “Peru´s Regional Growth and Convergence in 1979-2017: An Empirical Spatial Panel Data Analysis”. Juan Palomino y Gabriel Rodríguez. Marzo, 2019.

- *Materiales de Enseñanza*

No. 10 “Boleta o factura: el impuesto general a las ventas (IGV) en el Perú”. Jorge Vega Castro. Abril, 2023

No. 9 “Economía Pública. Segunda edición”. Roxana Barrantes Cáceres, Silvana Manrique Romero y Carla Glave Barrantes. Febrero, 2023.

No. 8 “Economía Experimental Aplicada. Programación de experimentos con oTree”. Ricardo Huamán-Aguilar. Febrero, 2023

No. 7 “Modelos de Ecuaciones Simultáneas (MES): Aplicación al mercado monetario”. Luis Mancilla, Tania Paredes y Juan León. Agosto, 2022

No. 6 “Apuntes de Macroeconomía Intermedia”. Felix Jiménez. Diciembre, 2020

No. 5 “Matemáticas para Economistas 1”. Tessy Váquez Baos. Abril, 2019.

No. 4 “Teoría de la Regulación”. Roxana Barrantes. Marzo, 2019.

No. 3 “Economía Pública”. Roxana Barrantes, Silvana Manrique y Carla Glave. Marzo, 2018.

No. 2 “Macroeconomía: Enfoques y modelos. Ejercicios resueltos”. Felix Jiménez. Marzo, 2016.

No. 1 “Introducción a la teoría del Equilibrio General”. Alejandro Lugon. Octubre, 2015.

Departamento de Economía - Pontificia Universidad Católica del Perú
Av. Universitaria 1801, San Miguel, 15008 – Perú
Telf. 626-2000 anexos 4950 – 4951
http://departamento.pucp.edu.pe/economia/