BRATISLAVA UNIVERSITY OF ECONOMICS AND BUSINESS

FACULTY OF ECONOMICS AND FINANCE

SELF-REPORT OF DISSERTATION

Ing. Margaréta Pauchlyová

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Self-report of Dissertation

The Impact of Behavioral Factors on the Price of Non-rival Intangible Assets in Auctions

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Submitted by: Ing. Margaréta Pauchlyová
Department of Finance of the Faculty of Economics and Finance, EUBA

Supervisor: doc. Ing. Jana Péliová, PhD.
Department of Finance of the Faculty of Economics and Finance, EUBA

Reviewers: doc. Ing. Maroš Servátka, PhD.
The Faculty of Economics and Finance, EUBA

Ing. Tomáš Miklánek, M.A., PhD.
The Faculty of Business Administration, VŠE Prague

doc. Ing. Tomáš Želinský, PhD.
Faculty of Economics, TUKE

The self-report was distribute on.....

The dissertation defence takes place on ..... at ..... o´clock at the Faculty of Economics and Finance, EUBA, Dolnozemská cesta 1, 852 35 Bratislava, before the dissertation defence committee in the doctoral study programme Finance, field of study Economics and Management, appointed by the Dean of the Faculty of Economics and Finance, EUBA.

doc. Ing. Jana Péliová, PhD.
chairwoman of the Doctoral Study Subcommittee 1.2 Finance

1. An Overview of the current status of the issues addressed in the dissertation at home and abroad

The dissertation addresses the problem of price formation and value discovery for non-rival intangible assets, with particular attention to data and digital goods traded in auction environments. It therefore builds on two connected areas of literature: auction theory and the economics of intangible and digital assets. Classical auction theory, rooted in the foundational work of Vickrey (1961) and formalized further by Myerson (1981) and Milgrom and Weber (1982), demonstrates that appropriately designed institutions can induce participants to reveal their private valuations and thus enable efficient allocation. The Vickrey second-price auction, in which the highest bidder wins but pays the second-highest bid, is a canonical example: truthful bidding is a weakly dominant strategy, and the mechanism achieves allocative efficiency under independent private values. Despite these theoretical virtues, experimental evidence consistently documents deviations from truthful bidding. Kagel, Harstad, and Levin (1987) and Cox, Roberson, and Smith (1982) report systematic overbidding in second-price auctions, a finding replicated across multiple laboratory settings. More recently, Masuda et al. (2022) show that truth-telling rates in multi-unit Vickrey auctions are below 50% even after subjects receive explicit advice about the dominant strategy. The principal behavioral explanations include failure to understand incentive compatibility (Masuda et al., 2022), joy of winning (Cooper and Fang, 2008), spite (Andreoni et al., 2007), and optimism bias (Georganas et al., 2017). These findings raise practical questions about the reliability of auction mechanisms as tools for value discovery. The growing importance of digital goods and data markets has introduced a new dimension to this question. Unlike tangible goods, non-rival digital assets can be reproduced at near-zero marginal cost, effectively eliminating the scarcity that traditional auction theory treats as essential for competitive pricing (Goldberg and Hartline, 2001; Jones and Tonetti, 2020). The absence of scarcity creates what Goldberg and Hartline (2001) identify as a potential for price collapse: if all participants expect to receive the good, the incentive to outbid competitors weakens, and equilibrium bids may converge toward zero. This challenge is compounded by the

characteristics of data as an economic good. Veldkamp (2023), Pei (2020), and Ruan (2019) describe data as simultaneously non-rival, indefinitely reusable, and difficult to value prior to use, an experience good in the sense of Nelson (1970). Moody and Walsh (1999) examine the limitations of conventional valuation approaches (cost-based, utility-based, and market-based) as applied to information goods such as data, and conclude that each fails in important respects. The result is a market characterized by asymmetric information, context-dependent valuations, and limited pricing benchmarks. These factors make auctions potentially attractive as value discovery mechanisms for data, but also highlight the risk that standard auction formats will fail in the absence of meaningful scarcity.

The Random Sampling Optimal Price (RSOP) mechanism, introduced by Goldberg et al. (2006), addresses this failure directly. RSOP was developed for unlimited-supply settings in which the seller does not know the demand distribution. Its key principle is to separate price formation from allocation. Bids are randomly divided into two subsets. Each subset is used to calculate a revenue-maximizing price that is then applied to the other subset. Since a bidder's own bid does not determine the price that the bidder faces, truthful bidding is theoretically a dominant strategy. At the same time, the mechanism uses actual market bids to estimate prices, which makes it suitable for markets where demand is unknown and heterogeneous. RSOP can be interpreted as a hybrid between market-based price discovery and posted-price logic. Like a posted-price mechanism, it offers buyers a take-it-or-leave-it price. However, unlike ordinary posted pricing, this price is not imposed externally but learned from another sample of bids. This feature is particularly relevant for data markets and other non-rival digital goods because the seller can use the mechanism to infer demand without needing prior information about the full valuation distribution. RSOP therefore addresses two linked challenges: it attempts to prevent price collapse in unlimited-supply environments and, at the same time, to preserve incentives for truthful revelation of valuations.

The dissertation compares RSOP with a modified Vickrey auction. This comparison is theoretically meaningful because both mechanisms have

incentive-compatible properties, but they differ in how prices are determined and how allocation works. The Vickrey auction is a benchmark mechanism in which the price is based on bids in the same auction. In its multi-unit version, multiple winners may receive identical units and pay a uniform price. RSOP, by contrast, determines the price for each bidder from an independent subset of bids. The central distinction is therefore between endogenous price formation within the same auction and price formation based on an independent sample. This distinction is important for understanding whether a mechanism can perform well when goods are non-rival and supply is effectively unlimited. Ausubel (2004) demonstrates that uniform-price auctions, relevant to the multi-unit Vickrey format used in this dissertation, can suffer from demand reduction, where bidders strategically understate their willingness to pay for marginal units. Back and Zender (1993) document similar findings in Treasury bond auctions. The experimental literature (Kagel and Levin, 1993) confirms that deviations from dominant strategies are persistent even in repeated settings, though learning does occur. Smith (1962) and subsequent work show that markets converge toward competitive equilibrium over time, but convergence is neither automatic nor complete.

Domestically, the literature on experimental economics and auction design is less developed than internationally, and direct comparisons in the Slovak or Central European context are limited.

The current state of knowledge thus suggests that standard auction mechanisms are powerful tools for value discovery under scarcity, but their performance is less clear in non-rival settings. The literature on data and digital goods shows that these assets are difficult to price because of non-rivalry, near-zero marginal costs, heterogeneous valuations, information asymmetry, and experience-good characteristics. The literature on auctions shows that incentive-compatible mechanisms can theoretically elicit truthful valuations, but experimental evidence indicates that actual bidding behaviour may deviate from theoretical predictions. The unresolved issue is whether an auction mechanism designed for unlimited supply, such as RSOP, can perform better than a modified Vickrey benchmark in eliciting truthful bids and generating seller revenue. This dissertation addresses this issue and provides one of

the first controlled laboratory tests of the RSOP mechanism in the context of non-rival intangible assets through a within-experiment comparison to a calibrated multi-unit Vickrey auction.

2. Aim and focus of the dissertation

The primary aim of this dissertation is to examine how auction format affects bidder behavior and seller revenue in markets for non-rival intangible assets: goods that can be supplied at near-zero marginal cost and in effectively unlimited quantities. The thesis focuses specifically on the Random Sampling Optimal Price (RSOP) mechanism and compares it to a modified multi-unit Vickrey auction as a theoretically well-established benchmark.

The research is motivated by a practical and theoretical gap: standard auction formats, designed around the assumption of scarcity, may fail to function effectively when selling non-rival digital goods. Price collapse, reduced competitive pressure, and strategic manipulation are all potential concerns. The dissertation examines whether the RSOP mechanism, which was designed theoretically to address these concerns, delivers on its promises under actual behavioral conditions.

The research focuses on two main dimensions. The first dimension is bidding behaviour, especially the extent to which participants bid truthfully. Truthful bidding is understood as a situation in which the submitted bid corresponds to the bidder's induced private value. The dissertation measures deviations from truthful bidding by comparing submitted bids with assigned values. The second dimension is seller revenue, defined as the product of the market-clearing price and the number of winning bidders in a given auction round.

The dissertation formulates two main research questions:

RQ1: Do bidders deviate more from truthful bidding in the Vickrey auction than under the RSOP mechanism?

RQ2: Does RSOP yield higher seller revenue than the Vickrey mechanism?

The first research question addresses whether the auction format influences bidding accuracy. Although truthful bidding is theoretically optimal in both mechanisms, previous experimental literature documents systematic deviations from truthful bidding, especially in Vickrey auctions. These deviations may result from misunderstanding of the

mechanism, behavioural biases, or strategic uncertainty. The RSOP mechanism differs from the Vickrey mechanism because the price faced by a bidder is determined by bids submitted in an independent partition of the market. This feature may reduce perceived opportunities for strategic manipulation and may support more truthful bidding.

The second research question addresses whether the auction format affects revenue outcomes. In markets with unlimited or near-unlimited supply, standard auction formats may generate weaker competition and lower prices. RSOP was designed for digital goods and unlimited-supply markets, where the seller does not know the distribution of bidder valuations. It uses submitted bids to estimate a revenue-maximizing price without requiring prior information about demand. The dissertation therefore examines whether this mechanism produces higher seller revenue than the modified Vickrey benchmark.

On the basis of the theoretical and experimental literature, the dissertation formulates three hypotheses:

H1: The magnitude of bids' deviation from induced values is greater in the Vickrey auction than in the RSOP mechanism.

Although truthful bidding is theoretically a weakly dominant strategy in both Vickrey and RSOP mechanisms (Vickrey, 1961; Goldberg et al., 2006), experimental studies document persistent deviations in Vickrey auctions due to behavioral biases and misunderstanding (Kagel et al., 1987; Cox et al., 1982; Masuda et al., 2022). The key institutional difference is that under RSOP, the price faced by any individual bidder is determined by the bids of the opposing group, not by the bidder's own group. This creates a separation between individual bidding and price determination that may reduce strategic manipulation and encourage more truthful reporting.

H2: Seller revenue is higher under the RSOP mechanism than under the Vickrey auction.

Standard auction formats rely on scarcity to generate competitive revenue. Under unlimited supply, this competition weakens and prices may fall (Goldberg and Hartline, 2001). The RSOP mechanism was specifically designed to approximate optimal revenue extraction without

prior demand knowledge (Goldberg et al., 2006). Revenue under RSOP derives not from high prices per winner, but from allocating to a larger number of winners at moderate prices — a property made economically feasible by non-rivalry.

H3: Bidding behavior converges towards truthful bidding over time.

Experimental evidence suggests that repeated participation in auctions improves understanding of the dominant strategy, reducing deviations over time (Smith, 1962; Cox et al., 1982; Kagel et al., 1987; Masuda et al., 2022). The hypothesis is tested by comparing bidding deviations in early versus late experimental rounds.

3. Methodology of work and research methods

To test the research hypotheses, a controlled laboratory economic experiment was designed and conducted. Laboratory experiments are suitable for this purpose because they allow the researcher to manipulate the auction mechanism while keeping other relevant conditions constant. Compared with observational data, the experimental design makes it possible to study causal differences between mechanisms. Compared with field experiments, it provides stronger control over external factors, participant information, and the valuation environment.

The experiment was conducted at the Bratislava University of Economics and Business. Participants were university students recruited through the ORSEE online recruitment system (Greiner, 2015). All sessions were conducted in Slovak. A total of 10 sessions were run: five for the Vickrey treatment and five for the RSOP treatment, with 20 participants per session (200 participants in total). The experiment employed a between-subject design: each participant experienced only one of the two auction mechanisms. Each session lasted approximately 60 minutes and included two control questions, two unpaid practice rounds, and 30 incentivized auction rounds.

Participants were assigned private induced values at the beginning of each round. Values were drawn from a discrete uniform distribution on {0, 5, 10, ..., 100}. Bids were also restricted to multiples of five within [0, 100]. The induced value represents the resale price the experimenter would pay the participant if they won the good, ensuring that participants' optimal behavior (truthful bidding) is well-defined and independently verifiable. Valuations were assigned by computer position to fix the sequence across treatments, allowing attribution of differences in behavior to the mechanism rather than the value draw. Payoffs were calculated as the difference between the induced value and the market price, conditional on winning; otherwise payoff was zero. Earnings were denominated in Experimental Currency Units (ECU) at a rate of 1 ECU = 0.1€. Participants earned a mean of approximately 157 ECU (15.7€); those with low or negative earnings received a show-up fee of 5€. Payments were made privately in cash after each session.

Post-experimental questionnaires collected individual-level measures of financial literacy (Lusardi and Mitchell, 2011), cognitive reflection (Frederick, 2005), and risk attitudes (Blais and Weber, 2006).

Experimental Treatments

The Vickrey Treatment implements a k-item uniform-price auction. The parameter k = 8 was calibrated ex ante through numerical simulation (100,000 simulated RSOP auctions) to ensure that the expected market-clearing price was comparable across both mechanisms. The simulation showed that under the discrete uniform value distribution with n = 20 participants, the expected RSOP price is approximately 56.3 ECU. The k = 8 Vickrey auction, where the market price equals the 9th highest bid, generates an expected price of approximately 57.5 ECU, the closest match among candidate values of k. In each round, the 8 bidders with the highest bids win the good and all pay the 9th highest bid as the uniform price.

The RSOP Treatment implements a dual-price version of the mechanism proposed by Goldberg et al. (2006). In each round, participants are randomly divided into two groups. Each group's submitted bids are used to compute the revenue-maximizing price for the opposite group. Specifically, for each group, the mechanism evaluates all submitted bids as candidate price levels and selects the price p that maximizes the product of the price and the number of bidders willing to pay at least that price. This computed price is then applied to the bidders in the other group: all members of the opposing group whose bid meets or exceeds the offered price receive the good and pay that price. Group composition is randomized independently in each round.

Data Analysis Methods

The primary outcome variable for testing H1 is the absolute bid deviation $|V - b|$, where V is the induced value and b is the submitted bid. This measures the distance from truthful bidding regardless of direction. For H2, the outcome variable is total seller revenue per round, defined as the sum of all payments across winners.

Non-parametric methods were used as primary tests, as the distributional assumptions required for parametric tests cannot be reliably assumed. The Mann–Whitney rank-sum test was used for between-treatment

comparisons of bid deviations (H1) and revenue (H2), and the Wilcoxon signed-rank test was used for within-subject convergence analysis (H3). A matched-pair robustness check was conducted by pairing observations with identical induced values across treatments, yielding 600 matched cells. This design controls for the valuation environment at the level of individual cells and provides a direct comparison of mechanism performance under identical conditions. Quantile regression was used to examine the treatment effect across the distribution of deviations, testing whether RSOP reduces deviations more at the extremes than at the center of the distribution. OLS regressions with subject-level and session-level clustered standard errors were estimated to control for observable individual characteristics (gender, CRT score, financial literacy, risk tolerance) and assess whether treatment differences are attributable to pre-existing heterogeneity between groups. A behavioral type classification was also employed, categorizing participants as truthful bidders, underbidders, overbidders, or noisy bidders based on their median signed deviation. The combination of non-parametric tests, regression methods, matched-pair analysis, and qualitative self-report data provides a multi-method evaluation of the research hypotheses. Each method addresses a different dimension of the question: non-parametric tests assess statistical significance, regression models control for confounding variables, matched pairs provide causal attribution, and qualitative data explain the behavioral mechanisms behind the observed patterns.

4. Structure of the dissertation

The dissertation is organized into five chapters, preceded by an introduction and followed by a conclusion, a reference list, and appendices.

The Introduction presents the motivation for the study, identifies the core research problem (price discovery in markets for non-rival digital goods) and outlines the research approach.

Chapter 1, Theoretical Background and Literature Review, provides the conceptual foundation for the dissertation. Section 1.1 introduces auctions as institutions for price discovery, traces the development of auction formats from early oral auctions to modern digital mechanisms, and discusses the theoretical properties of the four classical formats (English, Dutch, first-price sealed-bid, second-price sealed-bid). Section 1.1.1 provides a detailed formal treatment of the Vickrey auction, including the incentive-compatibility proof and the multi-unit extension that is used as the baseline treatment. Section 1.2 turns to pricing in markets with unlimited supply, beginning with a discussion of the economic characteristics of intangible assets and data (Section 1.2.1) and reviewing the main pricing mechanisms applicable to such markets: posted pricing, reserve pricing, all-pay auctions, and random sampling mechanisms (Section 1.2.2). Section 1.2.3 presents the RSOP mechanism formally, including its revenue guarantee, incentive properties, and a detailed illustrative example.

Chapter 2, Research Objectives, translates the theoretical discussion into specific research questions and testable hypotheses. The three main hypotheses concerning bidding deviations (H1), seller revenue (H2), and learning dynamics (H3) are stated and grounded in the existing literature.

Chapter 3, Methodology and Data, describes the experimental design, the implementation of both treatments, the calibration of the Vickrey parameter k, the experimental procedure, the post-experimental questionnaires, and the data analysis strategy. This chapter explains the rationale for design choices, including the between-subject structure, the discrete value distribution, and the parameterization approach.

Chapter 4, Results, presents the empirical findings organized around the three hypotheses and supplementary analyses. Section 4.1 provides descriptive statistics. Sections 4.3 through 4.5 test the main hypotheses. Sections 4.6 through 4.9 report the robustness check, determinants of bidding accuracy, bidder type classification, and qualitative analysis of bidding strategies.

Chapter 5, Discussion, interprets the results in relation to the research questions, situates the findings within the existing literature, and discusses the mechanism-level explanations for the observed patterns. The chapter also identifies the limitations of the study and suggests directions for future research.

The Conclusion summarizes the main contributions, both theoretical and practical. The References section includes all cited works. Appendices A–D contain the experimental instructions, the post-experimental questionnaire, the full regression tables, and additional figures.

5. The results of the work

Descriptive Statistics

The experiment involved 200 participants (100 per treatment) across 10 sessions (5 per treatment), each completing 30 auction rounds, producing 6,000 individual observations per treatment. Summary statistics confirm that the two treatment groups were broadly balanced on pre-experiment characteristics: age, CRT scores, financial literacy scores, and risk attitudes did not differ significantly between treatments in the balance covariate analysis (Table 9 in the dissertation). One exception was gender composition: more women participated in the RSOP sessions. This imbalance was accounted for in the regression analyses.

Average market prices differed between treatments: the mean market price was 63.90 ECU (SD = 10.18) in the Vickrey treatment and 56.47 ECU (SD = 10.01) in the RSOP treatment. By design, the number of winners per round was fixed at exactly 8 in the Vickrey treatment, while under RSOP it varied substantially (mean = 11.09, SD = 2.50, range = 3–18), reflecting the variable allocation property of the mechanism.

H1: Bidding Deviations

Hypothesis 1 proposed that absolute bid deviations (the distance between the submitted bid and the induced private value) would be smaller under RSOP than under the Vickrey mechanism. Table 10 in the dissertation reports that mean absolute deviations were 18.74 ECU under Vickrey and 16.89 ECU under RSOP. The Mann–Whitney rank-sum test rejects the null hypothesis of equal distributions at the 10% significance level ($p < 0.10$), providing weak but directionally consistent support for H1.

Importantly, the difference between mechanisms is not uniform across the distribution. Both mechanisms exhibit systematic overbidding as the dominant behavioral pattern, with negative mean signed deviations indicating that bids exceed induced values on average. However, the interquartile ranges and the distribution tails differ: the Vickrey treatment contains more extreme overbidders, while RSOP shows more consistent small overbidding. Quantile regressions indicate that the treatment effect is larger at the upper quantiles of the absolute deviation distribution (Q75

and Q90), but none of the quantile coefficients reach conventional statistical significance.

The matched-pair robustness check provides the clearest evidence. In 54.5% of 600 matched cells (paired by identical value-round combinations across treatments), RSOP yields smaller deviations than Vickrey; in 41% of cases Vickrey performs better; and 4.5% show no difference. The mean matched-pair difference (RSOP minus Vickrey) is -1.80 ECU (median -2.00 ECU), and a Wilcoxon signed-rank test confirms statistical significance ($z = -4.40$, $p < 0.001$). Additional robustness regressions controlling for gender, CRT score, financial literacy, and risk tolerance yield a consistently negative RSOP coefficient (approximately -1.87 ECU), though not statistically significant at conventional levels in mean-based regression. The treatment difference remains significant in a Mann–Whitney test restricted to the second half of the experiment (rounds 16–30), indicating that the result is not driven by early-round confusion.

H2: Seller Revenue

Hypothesis 2 proposed that RSOP would generate higher seller revenue than the Vickrey mechanism. This hypothesis is strongly supported. Seller revenue per round was substantially higher under RSOP across all sessions. Table 12 and Table 13 in the dissertation report session-level and round-level revenue statistics. The Mann–Whitney test comparing session-level revenues (five sessions per treatment) is significant ($p < 0.05$). The revenue advantage of RSOP is not explained by higher prices, average prices are in fact lower under RSOP than under Vickrey. Rather, it is driven by the variable allocation property: RSOP allocates the good to substantially more winners per round (mean = 11.09 vs. 8.00), and revenue from 11 winners at approximately 56 ECU exceeds revenue from 8 winners at approximately 64 ECU. This is consistent with the theoretical design objective of RSOP (Goldberg et al., 2006), where revenue derives from broad allocation at a price discovered from an independent sample rather than narrow allocation at a high competitive price.

H3: Learning and Convergence

Hypothesis 3 proposed that bidding behavior would converge toward truthful bidding over time. Evidence for learning differs sharply between treatments. Under RSOP, the mean absolute deviation declines from 18.55 ECU in the first five rounds to 13.59 ECU in the last five rounds; the Wilcoxon signed-rank test confirms this decline is statistically significant ($z = 3.467$, $p < 0.001$). In the RSOP treatment, 66% of participants show a decrease in deviations from early to late rounds. Under Vickrey, the corresponding decline (from 19.23 to 18.19 ECU) is not statistically significant ($z = 0.774$, $p = 0.439$), with the proportions of participants showing increasing and decreasing deviations nearly equal (44% vs. 47%). H3 is therefore supported for RSOP but not for Vickrey.

Behavioral Type Classification

Participants were classified into behavioral types based on their median signed deviation across all rounds: truthful bidders (median absolute deviation = 0), underbidders (median signed deviation $b - V < 0$, i.e., bids below value), overbidders ($b - V > 0$), and noisy bidders (median signed deviation zero but positive absolute deviation). Overbidding is the most common behavioral pattern in both treatments (57% Vickrey, 60% RSOP). However, the distribution of types differs significantly between treatments (chi-square test, $p = 0.04$). RSOP has a substantially higher proportion of truthful bidders (11% vs. 3%, Fisher exact $p = 0.049$) and a lower proportion of underbidders (18% vs. 31%, $p = 0.048$). The share of overbidders does not differ significantly ($p = 0.774$).

OLS regression

The dissertation also estimates OLS regressions of mean absolute bid deviation on the treatment indicator and participant characteristics. Across specifications, the RSOP coefficient remains negative, indicating lower deviations under RSOP. The coefficient is statistically significant only in the specification controlling for gender, and it loses significance after adding the full set of controls. However, the direction of the coefficient remains stable. The results also show that higher Cognitive Reflection Test scores are significantly associated with smaller bid deviations, suggesting that more cognitively reflective participants bid closer to induced values. Financial literacy and DOSPERT financial risk

tolerance do not show statistically significant relationships with bidding accuracy

Qualitative Analysis

Post-experimental open-ended responses reveal that participants anchor bids primarily to their induced resale value. The most common strategy types are: (i) bid exactly the resale value; (ii) bid slightly below the resale value (typically by 5 ECU) to secure profit while remaining competitive; (iii) overbid to increase winning probability; (iv) use intuition without a systematic rule; and (v) threshold strategies where participants bid 0 or 100 depending on whether the resale value exceeds a self-assessed price threshold. Learning is documented qualitatively: many participants report that they initially experimented with different strategies and gradually converged to a more stable rule as they learned the price dynamics of the market. This pattern is more pronounced in the RSOP treatment, consistent with the convergence finding for H3.

6. Conclusion

The dissertation addresses the problem of price discovery and revenue generation for non-rival intangible assets, with particular emphasis on data and digital goods. These assets differ from traditional rival goods because they can be supplied to multiple buyers at negligible marginal cost. This weakens the role of scarcity, which is central to standard auction mechanisms. In such environments, the main challenge is not simply to allocate a scarce object to the highest-valuing bidder, but to design a mechanism capable of eliciting willingness to pay and generating revenue when the good can be allocated broadly.

The dissertation compares two auction formats: the Random Sampling Optimal Price mechanism and a modified k-item Vickrey auction. The aim is to examine how these mechanisms affect bidding behaviour, seller revenue, and learning in a non-rival goods environment. The analysis is based on a controlled laboratory experiment with induced private values, repeated auction rounds, and two treatment groups. The empirical strategy combines non-parametric tests, quantile regression, matched-pair robustness checks, OLS regressions, behavioural classification, and qualitative analysis of participants' reported strategies.

The results provide evidence in favour of RSOP, although the strength of the evidence differs across outcome dimensions. The strongest result concerns seller revenue. RSOP generates substantially higher revenue than the modified Vickrey auction. This revenue advantage is consistent across sessions and rounds and is statistically significant. Importantly, the higher revenue is not caused by higher transaction prices. Average prices are lower under RSOP than under Vickrey. Instead, RSOP generates higher revenue by allocating the good to more winners. This result is particularly relevant for non-rival goods, where broader allocation does not imply higher marginal cost.

The evidence on bidding accuracy is weaker but still informative. Bid deviations from induced values are smaller under RSOP on average, and the main non-parametric test provides weak statistical support for this result. Median deviations are identical across treatments, which indicates that typical behaviour is similar. However, Vickrey contains more extreme deviations, while RSOP performs better in matched-pair

comparisons and in later rounds. The results suggest that RSOP may reduce some large bidding errors, but it does not fully eliminate deviations from truthful bidding.

The dissertation also finds partial evidence of learning. Under RSOP, bidding deviations decrease significantly from the early to the late rounds, indicating convergence toward more truthful bidding. Under Vickrey, the decrease is smaller and not statistically significant. This suggests that RSOP provides a more favourable environment for learning and behavioural adjustment. Nevertheless, even under RSOP, participants do not fully converge to truthful bidding. Behavioural factors, heuristic decision-making, and imperfect understanding remain important.

The theoretical contribution of the dissertation lies in connecting auction theory, the economics of data, and experimental evidence. The dissertation contributes to the literature by examining the empirical performance of RSOP in a controlled laboratory setting for non-rival intangible assets. The mechanism has strong theoretical properties, but experimental evidence on bidder behaviour under RSOP is limited. By comparing RSOP with a modified Vickrey benchmark, the dissertation provides evidence on how different price-determination rules affect value elicitation, revenue, and learning.

The practical contribution of the dissertation concerns the design of pricing mechanisms for digital goods and data-based assets. The findings suggest that when marginal costs are close to zero and the good can be allocated to multiple buyers, revenue may be improved by mechanisms that combine market-based price discovery with broad allocation. RSOP appears to be better suited than the tested Vickrey benchmark for such environments because it can generate higher revenue through a larger number of transactions. This is relevant for digital marketplaces, data markets, and other settings where sellers face heterogeneous buyers but lack reliable prior information about demand.

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9. Summary

This dissertation examines the properties of the Random Sampling Optimal Price (RSOP) mechanism, a theoretically motivated approach to pricing non-rival digital goods, in a controlled laboratory economic experiment. The study is motivated by the observation that standard auction formats, which rely on scarcity to generate competitive bidding, may fail to function effectively in markets for digital goods such as data, where supply is effectively unlimited and marginal costs are near zero. The dissertation compares the RSOP mechanism to a calibrated multi-unit Vickrey auction (an 8-item uniform-price auction) across 10 experimental sessions with 200 participants and 30 auction rounds per session. The experimental design holds the valuation environment constant across treatments, assigning private induced values from a discrete uniform distribution on {0, 5, 10, ..., 100} ECU and fixing value sequences by participant position. The Vickrey parameter $k = 8$ was calibrated through numerical simulation to ensure comparable expected market-clearing prices across both mechanisms.

Three hypotheses are tested. H1 predicts that bidding deviations from induced values are smaller under RSOP. H2 predicts that seller revenue is higher under RSOP. H3 predicts convergence toward truthful bidding over time in both treatments. The main findings are as follows. For H1, bidding deviations are smaller under RSOP in directionally consistent and statistically significant results at the 10% level (Mann–Whitney), and confirmed by a matched-pair analysis (Wilcoxon signed-rank $p < 0.001$). The effect is modest in magnitude (approximately 1.8–2.2 ECU) and not consistently significant in mean-based regression. Overbidding is the dominant behavioral pattern in both treatments, but RSOP is associated with more truthful bidders and fewer underbidders. For H2, RSOP generates substantially higher seller revenue per round across all sessions, despite lower average transaction prices. The revenue advantage is driven by variable allocation: RSOP allocates the good to an average of 11 winners per round compared to a fixed 8 under Vickrey, and total revenue from broader allocation at moderate prices exceeds revenue from narrow allocation at high prices. For H3, learning and convergence toward

truthful bidding are documented under RSOP (Wilcoxon $p < 0.001$, decline from 18.55 to 13.59 ECU mean deviation), but not under Vickrey.

The dissertation contributes to the literature by providing one of the first experimental implementations of RSOP in the context of non-rival goods, confirming its revenue properties while documenting the behavioral limits of its incentive-compatibility guarantees. The findings suggest that RSOP may offer practical advantages over standard Vickrey-type formats in digital goods markets, particularly when the goal is revenue maximization through broad market coverage rather than high-price narrow allocation. Future research should extend this work to alternative mechanism designs.

10. Extended abstract in the Slovak language

Cieľom tejto dizertačnej práce bolo preskúmať, ako aukčný formát ovplyvňuje správanie účastníkov a výnos predávajúceho v aukciách nerivalitných nehmotných aktív. Typickým príkladom takýchto aktív sú dáta, softvér alebo digitálny obsah, ktorých ekonomický význam v posledných rokoch výrazne rastie. Na rozdiel od tradičných rivalitných aktív sa tieto aktíva vyznačujú nerivalitou, čo znamená, že ich môže súčasne využívať viacero používateľov bez obmedzenia prístupu ostatných, a zároveň ich možno reprodukovať pri takmer nulových hraničných nákladoch. Navyše, hodnota dát je subjektívna, závislá od kontextu a konkrétneho používateľa, pričom ju kupujúci dokáže často posúdiť až po ich využití. Z týchto dôvodov narážajú tradičné prístupy k oceňovaniu, založené na nákladoch, očakávaných prínosoch alebo porovnateľných trhových transakciách, na viaceré obmedzenia. V podmienkach, keď je hodnota aktíva nejasná, sa často využívajú aukcie ako nástroj na odhalenie ochoty platiť. Ani využitie aukcií však nie je v prostredí nerivalitných vylučiteľných statkov jednoznačné. Tradičné aukčné mechanizmy sú navrhnuté pre prostredia so vzácnosťou: účastníci súperia, pretože víťaz získava statok na úkor ostatných. V prípade dát, ktoré sú ľahko a lacno reprodukovateľné, účastníci predpokladajú, že statok získajú všetci, bez ohľadu na výšku svojej ponuky. Motivácia prebiehať ostatných preto klesá a výsledkom môže byť tlak na pokles cien až k ich potenciálnemu kolapsu, čo predstavuje problém pre predávajúceho. Vzniká tak potreba aukčného mechanizmu prispôsobeného tomuto špecifickému prostrediu. Mechanizmus RSOP je založený na náhodnom rozdelení účastníkov do dvoch skupín, pričom cena ponúknutá jednej skupine je odvodená z ponúk účastníkov druhej skupiny. Jedna skupina tak slúži ako zdroj informácií o trhu a poznatky získané z jej ponúk sú využité pri cenotvorbe pre druhú skupinu. Tým sa zabezpečuje, že jednotliví účastníci nemôžu priamo ovplyvniť cenu, ktorú sami zaplatia, čo podľa teórie vytvára stimuly pre pravdivé ponúkanie. Mechanizmus RSOP je v práci porovnávaný s upravenou viacjednotkovou Vickreyho aukciou, ktorá predstavuje štandardný benchmark v aukčnej teórii. Práca odpovedá na dve hlavné výskumné otázky: či sa ponuky účastníkov odchyľujú od ich skutočných hodnôt viac vo Vickreyho aukcii ako v mechanizme RSOP, a či RSOP umožňuje

dosahovať vyšší výnos predávajúceho. Na základe teoretických poznatkov a predchádzajúceho výskumu boli formulované tri hypotézy. Hypotéza H1 predpokladá menšie odchýlky ponúk od indukovaných hodnôt v mechanizme RSOP, hypotéza H2 predpokladá vyšší výnos predávajúceho v mechanizme RSOP a hypotéza H3 predpokladá, že správanie účastníkov sa v priebehu experimentu bude postupne aproximovať k pravdivému ponúkaniu. Na overenie stanovených hypotéz bol navrhnutý a realizovaný kontrolovaný laboratórny experiment na Ekonomickej univerzite v Bratislave, ktorého sa zúčastnilo 200 študentov rozdelených do desiatich experimentálnych sedení. Každý účastník bol vystavený iba jednému z porovnávaných aukčných mechanizmov. Experiment pozostával z 30 aukčných kôl s indukovanými súkromnými hodnotami (každý účastník dostal pridelenú konkrétnu peňažnú hodnotu aktíva, za ktorú mu experimentátor aktívum odkúpil späť), čo umožnilo presne merať odchýlky medzi pridelenou hodnotou a skutočnou ponukou. Na analýzu dát boli použité neparametrické testy (Mann–Whitneyov test, Wilcoxonov test), kvantilová regresia, OLS regresia a deskriptívna analýza. Robustnosť výsledkov bola overená prostredníctvom prístupu párovaného porovnania, ktorý umožňuje analyzovať rozdiely medzi mechanizmami pri zachovaní totožných experimentálnych podmienok. Výsledky naznačujú, že aukčný formát má významný vplyv na správanie účastníkov aj na výnos predávajúceho. Pokiaľ ide o prvú hypotézu, mechanizmus RSOP bol v priemere spojený s menšími odchýlkami ponúk od indukovaných hodnôt v porovnaní s Vickreyho aukciou. Rozdiel bol potvrdený na hladine významnosti 10 %, pričom párová analýza, ktorá porovnávala situácie s totožnými indukovanými hodnotami naprieč mechanizmami, poskytla silnejšiu štatistickú podporu. Výsledky OLS regresií s kontrolou individuálnych charakteristík účastníkov boli v smere efektu konzistentné, hoci koeficient nedosahoval konvenčnú hladinu štatistickej významnosti. Kvantilová regresia naznačila, že rozdiely medzi mechanizmami boli väčšie v hornej časti distribúcie odchýlok, teda predovšetkým u účastníkov s výraznými odchýlkami od pravdivého ponúkania, hoci ani tieto koeficienty nedosiahli konvenčnú štatistickú významnosť. V oboch mechanizmoch predstavovalo nadhodnocovanie ponúk najrozšírenejší vzorec správania. Klasifikácia účastníkov do behaviorálnych typov však ukázala, že RSOP vykazoval vyšší podiel

pravdivo ponúkajúcich účastníkov a nižší podiel podhodnocujúcich v porovnaní s Vickreyho aukciou, pričom tento rozdiel v rozložení typov bol štatisticky významný. Podiel nadhodnocujúcich účastníkov sa medzi mechanizmami štatisticky významne nelíšil. Najvýraznejšie rozdiely sa prejavili vo výnose predávajúceho, čo poskytuje podporu pre druhú hypotézu. Mechanizmus RSOP dosahoval vyšší celkový výnos vo všetkých experimentálnych sedeniach, a to napriek tomu, že priemerné trhové ceny boli nižšie ako vo Vickreyho aukcii. Vyšší výnos bol dôsledkom širšej alokácie aktíva medzi väčší počet víťazov. Kým vo Vickreyho aukcii bol počet víťazov pevne stanovený, v mechanizme RSOP závisel od rozloženia ponúk a mohol sa medzi jednotlivými kolami meniť. Keďže predmetom aukcie bolo nerivalitné aktívum, rozšírenie alokácie na väčší počet účastníkov nebolo sprevádzané významnými dodatočnými nákladmi. Výsledky tak naznačujú, že v prostredí digitálnych statkov môže byť širšia alokácia za strednú cenu efektívnejšia než obmedzená alokácia za vyššiu cenu. Výsledky ďalej poskytujú čiastočnú podporu pre tretiu hypotézu. Správanie účastníkov sa v priebehu experimentu vyvíjalo smerom k pravdivejšiemu ponúkaniu, avšak tento efekt bol štatisticky významný výlučne v mechanizme RSOP. V rámci Vickreyho aukcie sa pokles odchýlok medzi úvodnými a záverečnými kolami experimentu ako štatisticky významný nepreukázal. Kvalitatívna analýza odpovedí z dotazníkov naznačuje, že účastníci v priebehu experimentu postupne identifikovali stabilnejšie rozhodovacie pravidlá, pričom viacerí explicitne uviedli, že sa v počiatočných kolách učili mechanizmus a neskôr prešli na konzistentnejšiu stratégiu. Prínos dizertačnej práce spočíva predovšetkým v experimentálnom overení vlastností mechanizmu RSOP v prostredí nerivalitných digitálnych statkov, ktorý bol doposiaľ skúmaný prevažne teoreticky. Z praktického hľadiska výsledky naznačujú, že mechanizmy navrhnuté špecificky pre prostredie neobmedzenej ponuky môžu predstavovať vhodný nástroj cenotvorby a alokácie digitálnych aktív. Tieto závery sú relevantné najmä pre dizajnérov dátových trhov, prevádzkovateľov digitálnych platforiem a tvorcov regulačných politík v oblasti dátovej ekonomiky, kde absencia vzácnosti kladie osobitné nároky na výber vhodného mechanizmu cenotvorby.