WHAT DRIVES COST EFFICIENCY? EVIDENCE FROM SLOVAK PUBLIC PROCUREMENT

ANALYSING CONTRACTUAL, INSTITUTIONAL, AND POLITICAL DETERMINANTS OF PROCUREMENT SAVINGS (2009-2023)

By

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AUTHOR'S DECLARATION

I, undersigned, **Gabriella Gunárová**, candidate for an MA degree in International Public Affairs declare herewith that the presented thesis titled "What Drives Cost Efficiency? Evidence From Slovak Public Procurement: *Analysing Contractual, Institutional, And Political Determinants of Procurement Savings (2009-2023)*" is exclusively my own work, based on my research and only such external information as properly credited in notes and bibliography. I declare that no unidentified and illegitimate use was made of the work of others, and no part of the thesis infringes on any person's or institution's copyright.

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ABSTRACT

This thesis investigates the key determinants of cost efficiency in Slovak public procurement, focusing on the probability and the extent of savings. Drawing on a comprehensive dataset of procurement contracts awarded between 2009 and 2023, the analysis explores how endogenous factors (e.g. bidder count, procurement type, procurement type, funding source) and exogenous factors (institutional quality, corruption risk, election timing) influence procurement outcomes. Methodologically, this thesis combines machine learning (random forest) with traditional econometric models (logit and OLS regression).

The results show that procurement efficiency is driven by a complex interplay of factors. Framework agreements substantially reduce the probability of savings, while high institutional quality and EU funding increase it. The number of bidders emerges as the most important predictor of the extent of savings, although the effect is non-linear.

This thesis contributes to the literature by integrating both endogenous and exogenous determinants into the analysis of Slovak public procurement and underscores the need for enhancing real competition, reducing administrative complexity, yet promoting transparent procurement practices.

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LIST OF ABBREVIATION

EU – European Union

OECD – Organization for Economic Co-operation and Development

PPO – Slovak Public Procurement Office

CRI – Corruption Risk Indicator

WGI – Worldwide Governance Indicators

Coc – Control of Corruption Indicator

EQI – European Quality of Government Index

1 INTRODUCTION

Public procurement refers to the process by which governments acquire goods, services, and construction work. Alongside grants and social transfers, it represents one of the principal mechanisms for allocating public funds and accounts for a substantial share of government expenditure (UNODC 2019). Across EU countries, public procurement averages approximately 14% of GDP annually (European Commission 2023). **In Slovakia, it represents an estimated 10-15% of GDP annually and around 20-30% of total public spending** (OECD 2021; 2021b, 2015), highlighting its central role in the allocation of public resources.

The core objective of public procurement is to ensure **efficient, transparent, and equitable use of public resources.** Given the sheer volume of public spending it represents, it is a strategic policy instrument that can enhance value for money, promote fiscal responsibility, and improve the quality of public service delivery. When governed transparently and effectively, it strengthens democratic legitimacy, fosters trust in institutions, and contributes to broader societal outcomes such as environmental sustainability, innovation, job creation, and support for small and medium-sized enterprises (OECD 2015; 2021; Fazekas and Blum 2021; Transparency International 2024). As such, public procurement is not merely a technical or administrative procedure but **a critical instrument of governance and development**.

However, the transformative potential of public procurement is frequently undermined by inefficiencies in practice. These inefficiencies are generally categorized as either **active misallocation – corruption – or passive waste stemming from poor procurement design and management** (Bandiera, Prat, and Valletti 2009). Due to the significant concentration of public funds, procurement is considered one of the most corruption-prone areas of government activity (OECD 2022; Abdou, Basdevant, and Fazekas 2022). Corruption in procurement involves the deliberate abuse of public office for private gain through bribery, favoritism, or

unjustified restriction of competition to steer contracts toward preferred bidders (Fazekas and Kocsis 2020, 1), often resulting in inflated prices or poor-quality outcomes (Rose-Ackerman and Palifka 2016). In contrast, passive waste refers to inefficiencies caused by mismanagement, limited administrative capacity, weak oversight, or poor incentive structures, rather than criminal intent. Yet, it can be equally costly and more difficult to detect, as it arises from legal but economically inefficient procurement decisions (Bandiera, Prat, and Valletti 2009).

In empirical research, **procurement efficiency is commonly assessed in terms of the cost savings achieved during the procurement process** (Kuhlman, Johnson 1983; Iimi 2006; Gavurova et al. 2018; Grega et al. 2019; Hanák and Muchová 2015; Tkacova et al. 2017). Specifically, in the absence of implementation data, efficiency is measured by examining the **variance between the estimated contract price and the final award price**, expressed as a ratio (Gavurova et al. 2018; Grega and Nemec 2015; Tkacova et al. 2017; 2022). A ratio below one indicates that savings were achieved, whereas a ratio above one reflects *overpayment* (Tkacova et al. 2017, 372) or *overprice* (Gavurova et al. 2017, 30; Grega and Nemec 2015, 59).

Recent scholarship has increasingly explored the underlying drivers of final price variation in public procurement, as understanding these factors is crucial for diagnosing inefficiencies and informing more efficient procurement policies. **Contracts that result in significant overpricing or that exhibit no variation from the estimated value are typically considered inefficient**, as they fail to deliver expected savings and may indicate deeper systemic deficiencies (Gavurova et al. 2017, 32). Understanding what shapes price outcomes, and thus when, why, and under what conditions savings occur, is therefore essential for enhancing procurement efficiency and reducing public spending waste.

Slovakia offers a particularly relevant context for such analysis, given the scale of public procurement within its economy and persistent concerns about inefficiency, corruption, and waste. The procurement system is governed by Act No. 343/2015 Coll. on Public Procurement,

which regulates how public institutions acquire goods, services, and works. It establishes a tiered framework of procedures based on contract value and contracting authority type, with stricter requirements for higher-value contracts. These thresholds are frequently revised, typically as part of broader reform efforts aimed at simplifying, reducing administrative burdens, and improving efficiency.

Despite repeated reforms, the Slovak public procurement system exhibits inefficiencies, with research showing that **around 40% of contracts fail to generate savings**, highlighting systemic shortcomings contributing to the waste of public funds (Gavurova et al. 2017, 32). Scholars attribute these inefficiencies to excessive bureaucracy, frequent legal changes, and a compliance-driven administrative culture (Nemec, Grega, and Orviska 2020; Tkacova et al. 2022). These factors reduce procurement to a procedural formality, fostering passive waste and disincentivizing savings (Grega et al. 2019). In combination with persistent concerns over transparency and integrity, these structural challenges undermine the overall effectiveness of the system (Gavurova et al. 2018, 25) and pose a significant policy challenge.

While scholarly attention to public procurement has grown, several shortcomings persist in the Slovak context. Much of the existing literature focuses narrowly on sectoral cases, draws on outdated or limited datasets, or examines only a narrow set of factors internal to the procurement process. The broader political, institutional, and economic context in which procurement operates is commonly neglected. As a result, the understanding of what drives final price variation remains partial and fragmented.

This thesis seeks to address these gaps by investigating the determinants of cost efficiency at the award stage in Slovak public procurement. Specifically, it examines how a combination of endogenous factors (procedure type, contract characteristics, and bidder participation) and exogenous variables (institutional quality, political cycles, and macroeconomic conditions) shape final price outcomes. The central question guiding this research is: ***What are the key***

determinants of cost efficiency in Slovak public procurement contracts and how do endogenous and exogenous factors influence the extent of final savings?

To answer this question, this thesis adopts a multi-step methodological strategy combining machine learning models with traditional econometric methods. Drawing on a comprehensive dataset covering over a decade (2009-2023), this study offers a unique, cross-sectoral analysis of procurement outcomes grounded in both quantitative rigor and policy relevance, offering a more robust and generalizable assessment than prior studies.

This thesis is structured as follows. The next section reviews key empirical research on procurement efficiency and cost savings, highlighting relevant findings and gaps in the literature. The subsequent section outlines the research design, data collection, and empirical strategy. This is followed by the presentation of the main analytical results. The discussion section then interprets these findings in the context of broader academic and policy debates. Finally, the conclusion summarizes the key insights and outlines their implications for policy and future research.

2 LITERATURE REVIEW

This chapter synthesizes international and Slovak research on the determinants of procurement efficiency, with a particular focus on cost savings. It distinguishes between **endogenous factors**, internal to the procurement process or contract design, and **exogenous factors**, encompassing broader political, institutional, and economic conditions. The chapter highlights key variables and identifies gaps relevant to the Slovak context.

2.1 ENDOGENOUS FACTORS

Endogenous factors refer to procurement-specific elements such as bidder number, procedure types, the use of digital tools, subcontracting, funding source, and framework agreements. These shape internal procurement dynamics and influence price outcomes.

2.1.1 Competition and Market Access

The level of competition, typically measured by the number of bidders, **emerges as one of the most robust and widely cited predictors of procurement efficiency and cost savings** (Kuhlman, Johnson 1983; Rose-Ackerman 1999; Gómez-Lobo and Szymanski 2001; Gupta 2002; Iimi 2006; European Commission 2008; Pavel 2010; Soudek and Skuhrovec, 2016, Androniceanu 2017). High bidder participation is consistently linked to lower final prices, improved quality, and stronger procedural integrity (Kuhlman and Johnson 1983; Gómez-Lobo and Szymanski 2001; Gupta 2002; Androniceanu 2017). Conversely, limited competition weakens procurement outcomes and increases the risk of collusive behavior and cost inefficiency (Rose-Ackerman 1999; Gupta 2002; Albano et el., 2006). Nonetheless, **the relationship between bidder count and efficiency is not strictly linear.** Studies report **diminishing marginal returns**, with optimal competition generally reached in tenders

attracting around six to nine bidders (Brannman, Klein and Weiss 1987; MacDonald, Handy and Plato 2002; Gupta 2002; Li and Zheng 2006).

Slovak data reflect similar trends, showing a positive association between the number of bidders and achieved savings, with diminishing returns observed after approximately six bidders (Grega and Nemec 2015, 550; Gavurová et al. 2017, 37). However, anomalies persist in some tenders, **three or four bids yielded less savings than two, possibly due to collusion or strategic bidding** (Gavurová et al. 2017; Hanák and Muchová 2015). Moreover, Slovak public procurement is characterized by **persistently low competition across all sectors** (Grega et al. 2019, 57; Tkáčová 2022; Grega et al. 2019) limiting cost savings potential and increasing the vulnerability to distortion.

The selected **procurement procedure** influences the potential level of competition. Open procedures, which allow fully unrestricted access to tenders (Nemec, Ďurovičová, and Kubák 2023), are typically associated with higher transparency, broader accessibility, increased bidder participation, and greater cost savings (Gómez-Lobo and Szymanski 2001). While some studies report significant price reductions under open procedures (Soudek and Skuhrovec 2016), others find insignificant (Tkacova et al. 2022; Grega and Nemec 2015) or even negative effects (Džupka, Kubák, and Nemec 2020). These inconsistencies likely reflect sectoral differences or interactions between procedure type and bidder count. While some scholars argue that openness matters more for enabling broader market access and expanding the **pool of potential competitors** (Plaček et al. 2020; Guvarová et al. 2017), others argue that **direct competition**, measured by the number of bids, has a more substantial impact on outcomes than the procedure type itself (Kuhlman and Johnson 1983; Gilley and Karels 1981). This thesis accounts for this complexity by modeling interaction effects between procedure type and bidder number.

2.1.2 Contract Design and Incentive Structure

Beyond competitive access, several procurement design features also influence the final price by altering risk allocation, administrative burden, and the motivation to minimize costs.

Electronic auctions (e-auctions) are widely promoted for enhancing cost efficiency, transparency, and integrity by promoting price-based competition and mitigating the opportunities for favoritism through their standardized digital format (Soudry 2004). Although evidence remains mixed, studies highlight their cost-saving potential, especially with multiple bidders (Grega et al. 2019, Murray Švidroňová and Nemec 2016; Mikušová Meričková and Stejskal 2014). However, single-bid e-auctions risk overpricing (Grega et al. 2019), and some research reports no significant or even negative effects (Tkacova et al. 2022; Grega and Nemec 2015). Overall, **efficiency gains from e-auctions appear to depend on bidder participation and broader market conditions.** This thesis includes an e-auction to test its direct effect as well as interaction with bidder count to assess its contribution to savings.

The role of **subcontracting remains contested.** It is often associated with greater complexity, coordination costs, and opportunities for cost inflation along subcontracting chains. While Tkáčová et al. (2022) found that non-subcontracted contracts in Slovakia yield 11.6% higher savings on average, Gavurová et al. (2017) report a 4.4% increase when subcontractors are present. Lower savings are typically observed in subcontracted **construction and infrastructure projects** (Tkáčová et al. 2022; Hrdlička 2009; Pavel 2010), likely due to greater complexity and coordination demands. These divergent findings suggest sector-specific effects.

The impact of **EU funds** on savings generation is a recurring theme in Slovak literature. Multiple studies report that **EU-funded contracts tend to generate 1.5% to 6.6% lower cost savings compared to those financed from national sources** (Tkačová et al. 2022, 106; Džupka, Kubák, and Nemec 2020, 9; Grega and Nemec 2015, 550).

Finally, the use of **framework agreements** represents another critical dimension of procurement design with implications for cost efficiency. While they intend to streamline procurement, reduce administrative burdens, and facilitate quick contract awards (OECD 2020), **their cost efficiency remains debated**. Džupka, Kubák, and Nemec (2020) found framework contracts to be around 10% more expensive, whereas Nemec, Ďuricová, and Kubák (2023) reported notable savings in the healthcare sector. These discrepancies likely reflect sector-specific dynamics. This thesis addresses the issue by including framework agreement usage and controlling for sectoral variation to enable a more nuanced analysis of their cost-saving potential.

2.2 EXOGENOUS FACTORS

While endogenous determinants are crucial, a growing body of literature highlights the influence of exogenous, systemic factors in shaping procurement outcomes (Catalão, Cruz, and Sarmento 2023; Plaček et al. 2020). These include **institutional quality, political dynamics, and broader economic conditions,** which shape the broader environment in which procurement decisions are made.

2.2.1 Institutional factors

A growing body of research emphasizes that **institutional quality**, reflected in **corruption levels, government accountability, efficiency,** and the **rule of law**, plays a critical role in public procurement efficiency (Catalão, Cruz, and Sarmento 2023; Nemec, Ďurovicová, and Kubák 2023; Plaček et al. 2020; Bauhr et al. 2020; Bandiera, Prat, and Valletti 2009). **Stronger institutions are linked to reduced overpricing and improved cost efficiency**. For example, a one-unit improvement in the World Bank's Control of Corruption (CoC) indicator is associated with a final price reduction (Plaček et al. 2020; Nemec et al. 2023). Accountability

and the rule of law reduce overpricing (Catalão, Cruz, and Sarmento 2023), underscoring institutional quality and governance as a key determinant rather than a background factor.

However, much of this literature relies on perception-based indicators such as CoC, which reflect aggregated expert and public opinion rather than actual procedural corruption risk. To address this, **this thesis employs a contract-level Corruption Risk Index (CRI)** based on observable red flags, providing a more objective, data-driven measure of corruption risk in public procurement (Fazekas and Kocsis, 2020). Moreover, given the single-country focus of this thesis, national-level indicators like the World Governance Indicators (WGI) are replaced with **the European Quality of Government Index (EQI),** which offers finer granularity in capturing governance quality, specifically public service quality, impartiality, and corruption, allowing for a more precise inclusion of institutional variables.

2.2.2 Political factors

Political dynamics, particularly **electoral cycles**, also shape procurement outcomes. According to public choice theory, politicians often **prioritize short-term electoral gains over long-term efficiency**, increasing transaction costs and inefficiencies (Mueller 2003). Catalão, Cruz, and Sarmento (2022) show that contracts awarded during election years are associated with overpricing, attributing this to fast-tracking projects ahead of elections, resulting in relaxed oversight and cost underestimation. This thesis tests whether procurement during Slovak parliamentary election periods is associated with reduced cost efficiency.

2.2.3 Economic factors

Macroeconomic factors like **GDP growth, inflation, and external shocks** influence procurement efficiency. **Inflation** raises input costs and lowers supplier margins, discouraging competition and driving up prices, while higher **GDP** growth is linked to reduced overpricing (Catalão, Cruz, and Sarmento 2023). Crises such as **COVID-19** have shifted procurement

priorities toward speed over efficiency and transparency. During the pandemic, Slovakia's PPO adopted emergency, often less transparent, procedures like direct negotiations (OECD 2020). Though necessary, such emergency measures often lead to inefficiencies due to poor resource management, political interference (Buor 2019), vague guidelines (Balaeva et al. 2020), and opaque processes (Tkacova 2022; Kubák, Nemec, and Vološin 2021).

The literature on public procurement efficiency highlights the influence of both endogenous and exogenous factors. Among endogenous drivers, bidder participation is consistently linked to cost savings. Procedure type and e-auctions exert mostly indirect effects by expanding bidder participation. EU-funded contracts appear less efficient while subcontracting and framework agreements show mixed effects. Exogenous factors such as institutional quality, political cycles, and economic context are increasingly recognized as important, yet remain underexplored in Slovakia. This thesis addresses those gaps by including contract-level corruption risk indicators and regional institutional quality measures.

Based on the existing literature, this thesis investigates the following hypotheses using a comprehensive dataset of Slovak public procurement contracts:

- **H1 (Competition):** Contracts that attract a higher number of bidders are (a) more likely to generate savings, and (b) associated with greater savings.
- **H2 (EU Funding):** Procurement contracts financed by EU funds are (a) less likely to generate savings, and (b) associated with lower savings, compared to those funded from national sources.
- **H3 (Framework Agreements):** Contracts awarded under a framework agreement are (a) less likely to generate savings and (b) associated with lower savings compared to those awarded through classical procedures.
- **H4 (Corruption Risk / Integrity):** Contracts with higher Corruption Risk Index (CRI) scores are (a) less likely to generate savings and (b) associated with lower savings.

- **H5 (Institutional Quality):** Contracts with higher scores of quality and impartiality of public services are (a) more likely to generate savings and (b) associated with greater savings.
- **H6 (Electoral Cycles):** Contracts awarded during Slovak parliamentary election years are (a) less likely to generate savings and (b) associated with lower savings or higher overpricing.

The following chapters detail the methodological approach used to empirically test these hypotheses

3 RESEARCH DESIGN AND METHODOLOGY

This section outlines the research design, data sources, variable operationalization, and methodological strategy used to examine the determinants of cost efficiency in Slovak public procurement, along with key data and methods used.

3.1 DATASET DESCRIPTION

This analysis draws on contract-level data from Opentender.eu, which compiles public procurement records from EU member states. Slovak data are sourced from the national procurement system and Tenders Electronic Daily (TED), with extensive cleaning and validation applied to ensure consistency. The dataset spans 2009-2023 and includes all contracts exceeding national reporting thresholds. To account for institutional context, variables from the European Quality of Government Index (EQI) are also included.

The dataset was filtered to include only awarded contracts with both estimated and final prices, enabling the calculation of cost savings. Outliers in the dependent variable were removed using the 1.5 IQR rule. Categorical variables were factored, and missing values were handled by imputing medians for numeric fields and assigning an "NA" category for categorical variables to ensure compatibility with machine learning models. The final cleaned dataset includes 607,342 observations.

3.2 VARIABLE OPERATIONALIZATION

This section outlines how key variables are defined and measured to answer the research question: **What are the key determinants of cost efficiency in Slovak public procurement, and how do endogenous and exogenous factors influence the extent of final savings?**

3.2.1 Dependent variables

Procurement efficiency is captured using two dependent variables: the occurrence of savings and the magnitude of those savings.

Firstly, this analysis includes ***savings_achieved*,** a binary indicator, derived from the estimated-to-final price ratio and is coded as 1 if the final contract price is lower than the estimated price; and 0 if no savings are achieved. This allows for analysis of how different factors affect the likelihood of cost savings.

Secondly, ***savings*** is a continuous measure used to capture the extent of savings (see *Figure 1*). It represents the proportion of the estimated contract value saved through the procurement process, and is calculated using the following formula: $\text{Savings\%} = \left(\frac{\text{Estimated Price} - \text{Final Price}}{\text{Estimated Price}}\right) \times 100$ It encompasses a subset of observations that achieved savings (Savings% > 0), thereby focusing the analysis on measurable cost efficiency.

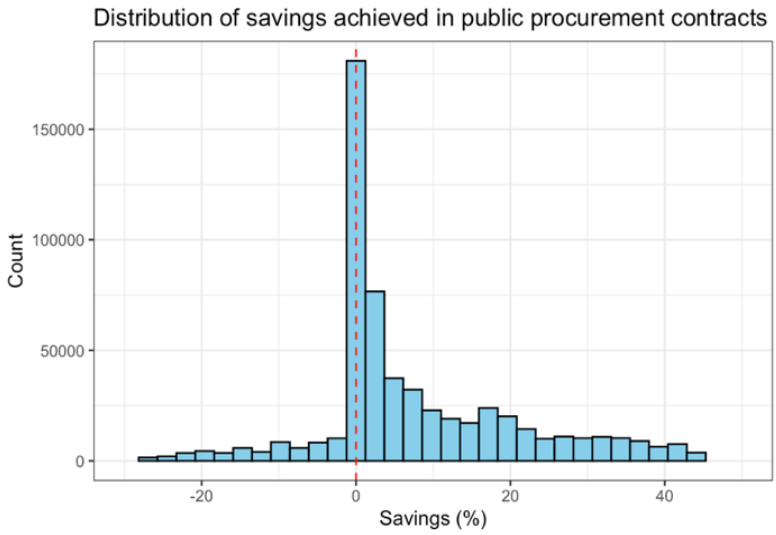

Figure 1 *Distribution of savings across the full sample*

Source: Author

Together, these two variables provide a comprehensive measure of procurement efficiency, capturing both the likelihood of achieving savings and the extent to which savings are realized when they occur.

3.2.2 Explanatory variables

The selection of explanatory variables is guided by the empirical findings from the reviewed literature and grouped into three categories: main hypothesized predictors, complementary contract-level variables, and control variables.

MAIN HYPOTHESIZED PREDICTORS

- ***The number of bidders*** is treated as a continuous variable in Random Forest models and as a categorical variable in regression models to reduce the computational burden, indicating the number of bids submitted per lot. The overall distribution of this variable across the dataset is shown in *Figure 2*.

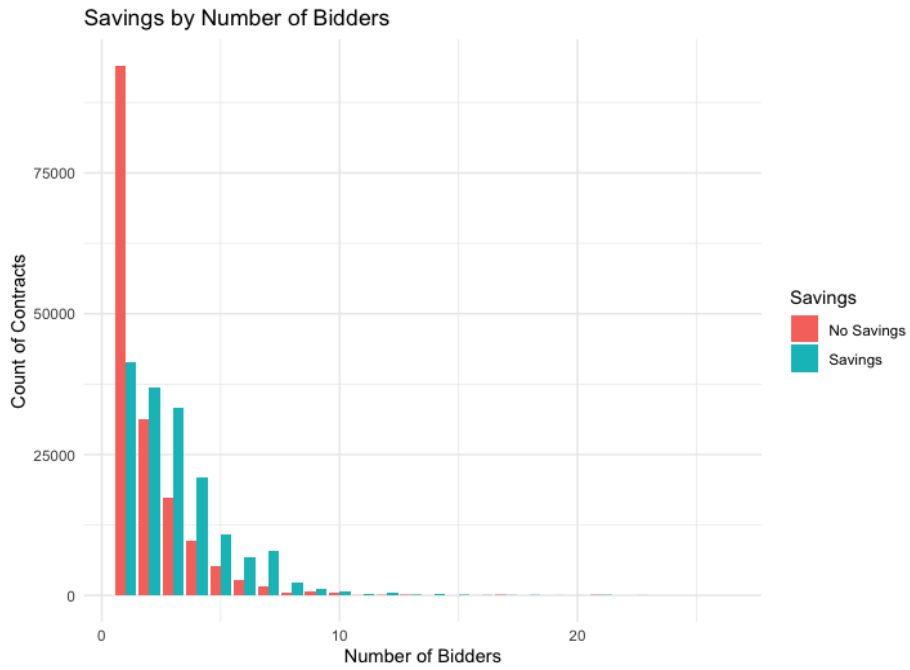

Figure 2 *Distribution of Savings by Number of Bidders*

Source: Author

- ***EU Funding*** is captured as a binary variable, coded as 1 if the contract is fully or partially financed through EU funds, with approximately 10% of contracts falling into this category.

- ***Framework agreement*** is a binary variable indicating whether the contract is part of a framework agreement (1 = yes, 0 = no).
- ***Electoral cycles*** are captured as a binary variable coded 1 if the contract was awarded during a Slovak parliamentary election year (2010, 2012, 2016, 2020, 2023) and otherwise 0.
- ***Corruption*** is measured using a composite CRI capturing procedural integrity through contract-level red flags: single bidder, published call for tenders, and procedure type. A single bidder red flag reflects no competition for the contract, which is one of the main signs of corruption in public procurement (Fazekas, Poltoratskaia, and Tóth 2023; Abdou et al. 2021). No publication of the call for tender as well as non-open procedures weakens and restricts competition, increasing the risk of corruption (Fazekas, Poltoratskaia, and Tóth 2023). CRI is calculated as an average score of these red flags, scaled from 0 to 1, with higher values indicating higher corruption risk (see *Table 1*).

Table 1 *CRI components*

Indicator	***Coding***
Single bidder	1 = one bid submitted
	0 = more than one bid submitted
Published call for tenders	1 = yes
	0 = no
Procedure type	1 = high risk procedures: approaching bidders, negotiated/negotiated without publication, outright award)
	0.5 = medium risk procedures: restricted, negotiated with publication, competitive dialogue, design contest)
	0 = low risk procedures: open

Source: Author

- ***Institutional*** **quality** is proxied using 2 variables from the European Quality of Government Index (EQI). Namely**, the quality and impartiality** of the public services delivery (see *Table 2*) are included as separate region-level continuous variables reflecting the broader

regional governance environment in which procurement takes place. Their scale is standardized with a mean of 0 (EU average) and a standard deviation of 1, where higher values reflect higher governance quality relative to the EU average. Perception of the corruption dimension is excluded, as in this analysis, corruption is measured using CRI as explained above. Because EQI is available only for selected years (2010, 2013, 2017, 2021), each contract is matched with the closest subsequent wave[1].

Table 2 *European Quality of Government Index Dimensions*

European Quality of Governance Index Dimension	***Measures the perception of***
Quality of Public Services	Effectiveness and availability of key public services such as education, healthcare, and law enforcement.
Impartiality of Services	Equality of delivery of public services to all citizens, without discrimination, favoritism, or political bias.

Source: Author, based on Charron, Dijkstra, and Lapuente (2014, 2015). Charron, Lapuente, and Annoni (2019), Charron et al. (2022); and Charron, Lapuente, and Bauhr (2024)

COMPLEMENTARY CONTRACT-LEVEL COVARIATES OF INTEREST

In addition to these core predictors, the analysis also includes a set of contract-level variables whose relationship with cost efficiency remains theoretically relevant but provides empirically mixed.

- ***Procedure type*** is a categorical variable that captures the procedure type used in the procurement process including open, restricted, negotiated with publication, negotiated

[1] For example, tenders from 2011 are matched with the 2013 EQI score, rather than the earlier 2010 wave as EQI scores capture governance quality retrospectively, reflecting perceptions and experiences accumulated over the previous years.

without publication, approaching bidders, negotiated, design contest, outright award, and competitive dialog.

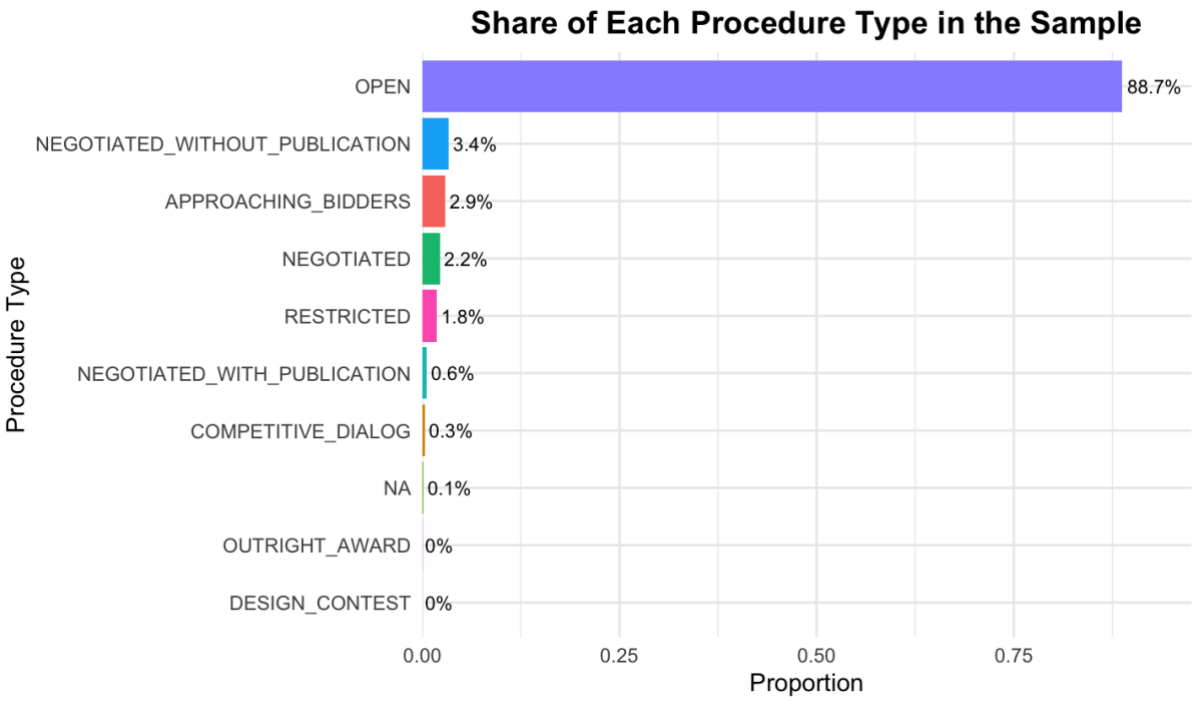

Figure 3 *The share of procurement procedure types*

Source: Author

- ***E-Auction*** indicates whether the electronic auction was used in the procurement process (yes = 1, no = 0).
- ***Subcontracting*** reflects the involvement of subcontractors in contract delivery (1 = subcontracted, 0 = not subcontracted).
- ***Supply type***, included as a categorical explanatory variable, distinguishes between three types of public contracts: goods, services, and construction work, capturing fundamental differences in market structure and complexity across these categories.

To account for potential conditional effects, interaction terms are included between (1) procedure type and number of bidders, and (2) e-auction use and bidder count.

CONTROL VARIABLES

To isolate the effects of key explanatory variables, the model includes several control variables that account for structural, temporal, and contextual differences in public procurement (See *Table 3*).

Table 3 Control Variables Description

Control Variable	***Description***	***Purpose in Model***
Award Year	Factor-coded year dummies	Controls for time-specific shocks such as legislative reforms, economic changes, or the COVID-19 pandemic.
Contract size	Natural logarithm of the estimated contract value.	Accounts for scale-related variation between small and large tenders.
Contracting authority	Categorical variable indicating the type of public buyer: national authority, national agency, regional authority, regional agency, public body, utilities	Controls for institutional variation in procurement behavior, administrative capacity, and decision-making processes.
Sector type	Categorical variable derived from CPV codes and grouped into eight categories	Controls for structural differences in procurement practices, competitiveness, and pricing dynamics across economic sectors.

Source: Author

Altogether, these variables offer a comprehensive framework to assess both the internal design and external context of procurement processes and their influence on cost efficiency.

3.3 METHODOLOGICAL STRATEGY

This thesis investigates the key determinants of cost efficiency in Slovak public procurement and how various factors influence the extent of final savings. A multi-step empirical strategy is employed, combining supervised machine learning with traditional econometric analysis to balance predictive power and interpretability.

In the first stage, a **Random Forest classifier is used to predict the probability of savings (binary variable: *savings_achieved*)**. To address the class imbalance, the majority class was downsampled, resulting in a sample of 326,970 observations. The data were split into training (70%) and testing (30%) sets. The final Random Forest model used 50 trees (ntree = 50) and 8 variables per split (mtry = 8), with error rates stabilizing after ~30 trees (see *Figure 4*). The model achieved high predictive performance: 98.52% accuracy (95% CI: [0.9845, 0.9860]) and AUC = 0.9988.

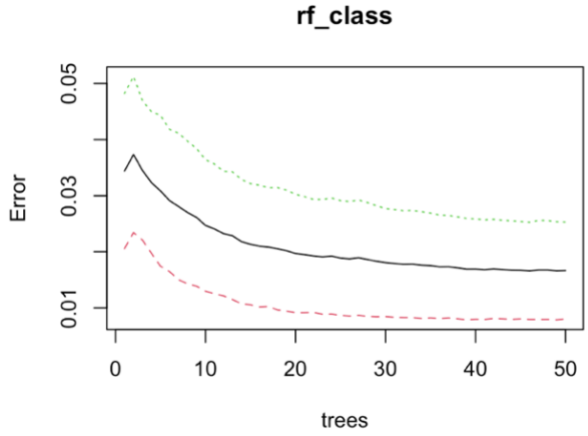

Figure 4 *Random Forest Classification Error by Number of Trees*

Source: Author

Partial dependence plots (PDPs) are used to visualize the isolated effects of each variable on the predicted probability of savings, holding other variables constant.

To enhance interpretability, a **logistic regression (GLM)** is estimated. While RF identifies variable importance, the logistic model **provides coefficient direction, statistical significance, and Average Marginal Effects (AMEs)** [2]. All theoretically relevant controls

[2] AMEs represent an average change in outcome variable for (1) a one-unit increase in continuos varibales, (2) a change from 0 to 1 in binary variables, and (3) each category relative to the reference group.

were retained (except *year* due to collinearity [3]). Multicollinearity was acceptable (VIF < 2), except for *CRI* (VIF = 4.34), which was retained. Model fit was strong ($\chi^2 = 161{,}040$, $p < 0.001$; McFadden $R^2 = 0.228$), and robust standard errors were used to address heteroskedasticity. Additional models were run by procurement type (supply, services, construction).

In the second stage, a **Random Forest regression** is applied to contracts with non-zero savings (n = 444,737) **to predict the *extent* of savings.** Using the same 70/30 train-test split, 50 trees, and *mtry* = 9, the model achieved excellent fit: MSE = 4.6, MAE = 0.673, and $R^2 = 0.983$ (see *Figure 5*). PDPs again visualize the effects of individual predictors on savings

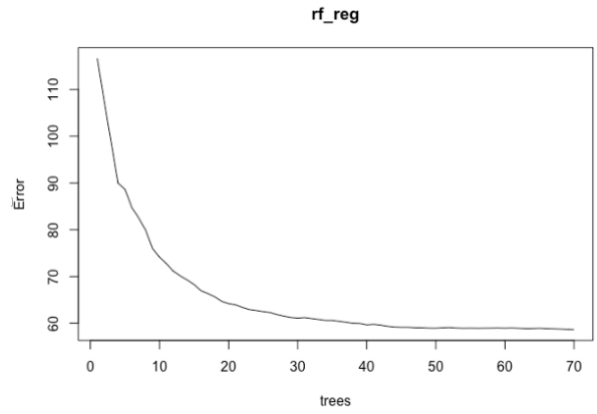

Figure 5 *Random Forest Regression Error by Number of Trees*

Source: Author

magnitude.

To support interpretation and validate RF findings, an **Ordinary Least Squares (OLS)** regression is also estimated. While more restrictive, OLS offers **clear coefficients for the direction, magnitude, and significance of each predictor.** Diagnostics indicated heteroskedasticity, non-normal residuals, and no autocorrelation; thus, robust standard errors

[3] Time trends are thus partially captured by other variables.

were used to ensure valid inference. Multicollinearity was low overall, though *CRI* had a moderate GVIF of 4.09.

This mixed-method strategy enables a robust and policy-relevant assessment of procurement efficiency by capturing both the probability and extent of cost savings. The combined use of machine learning and regression enhances both explanatory power and robustness through methodological triangulation.

3.4 LIMITATIONS

While the multi-method approach employed in this thesis offers a robust analytical framework, several limitations must be acknowledged. First, the analysis relies on secondary **administrative data** from Opentender.eu, which, despite validation, ultimately depends on the accuracy and completeness of reporting by contracting authorities. Second, using the estimated contract price set by procurers, as opposed to independent market benchmarks (Grega and Nemec 2015), may introduce bias if estimates are strategically inflated or inaccurate (Tkáčová et al. 2022). Nonetheless, the **estimate-to-final price ratio** remains a widely used and practical proxy for assessing cost deviation in procurement research (Gavurová et al. 2017, 2018; Grega and Nemec 2015; Tkáčová et al. 2017, 2022; Nemec, Ďuricová, and Kubák 2023).

Methodologically, Random Forest models capture complex, non-linear patterns but lack transparency and statistical inference. In contrast, OLS and logistic regressions offer interpretability but rest on assumptions like linearity and homoscedasticity, which, if violated, can distort estimates. Moreover, model validity depends on complete specification. **Unobserved factors** such as political favouritism, institutional capacity, or informal networks may bias results.

Despite these constraints, the combination of machine learning, traditional econometrics, and robustness checks provides a balanced and empirically grounded assessment of procurement efficiency in Slovakia.

4 EMPIRICAL ANALYSIS AND FINDINGS

As demonstrated in *Figure 6*, a substantial share of Slovak public procurement contracts – **73.7% resulted in some level of savings**, while 13.6% matched the estimated price exactly and 12.7% were overpriced. There are two key perspectives that were considered when assessing savings: **the probability of achieving savings, and the extent of those savings if they occur**. The following results illustrate how the selected factors drive variation across both dimensions, drawing on Random Forest and regression models (see **Appendix 1** & **Appendix 2** for details).

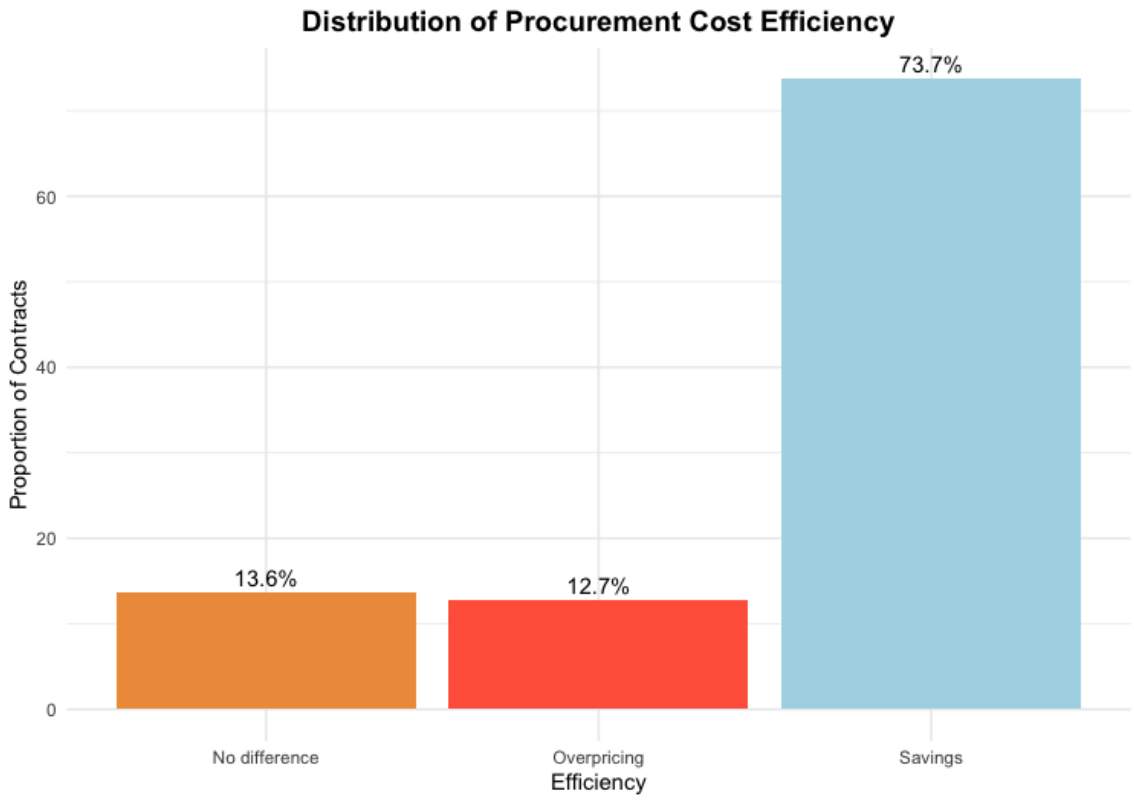

Figure 6 *Distribution of Procurement Cost Efficiency*

Source: Author

4.1 ANALYSING THE PROBABILITY OF ACHIEVING SAVINGS

As a first step of the analysis, the Random Forest classifier was used to identify **the most important variables influencing the probability of savings generation in public procurement.** As illustrated in *Figure 7*, the most important predictors[4] include **framework agreement (H3a), quality of public services indicator (H5a), EU funding (H2a), impartiality of public services indicator (H5a)**, and subcontractor presence. In contrast, several variables such as procedure type, use of e-auction, **bidder count (H1a), elections (H6a), and CRI (H4a)** demonstrated little to no predictive importance in the model.

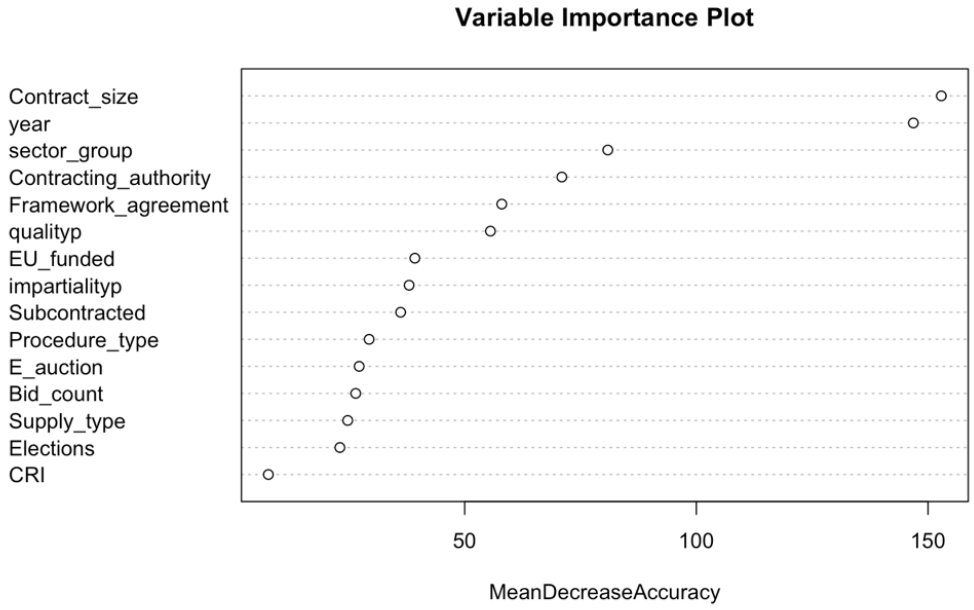

Figure 7 *Random Forest Classifier Variable Importance Plot*

Source: Author

[4] Year, contract size, sector group, and contracting authority are included as control variables to account for time-fixed effects, scale-related variation, and institutional heterogeneity, respectively. While their predictive contributions are reported for completeness, they are not the focus of interpretation.

Among all factors, the **framework agreements variable emerged as the most important predictor of procurement savings.** PDP analysis shows that contracts awarded under framework agreements are substantially less likely to generate savings than those awarded through classical procedures (see *Figure 8*). This is further confirmed by the logit model where framework agreements exhibited the strongest average marginal effect (AME) among all explanatory variables. Specifically, such contracts were associated with a **60 percentage points lower probability of achieving savings compared to classical contracts,** on average. This aligns with the observed distribution of data, wherein less than 8% of framework agreement contracts resulted in any cost savings. **These findings provide strong support for H3a.**

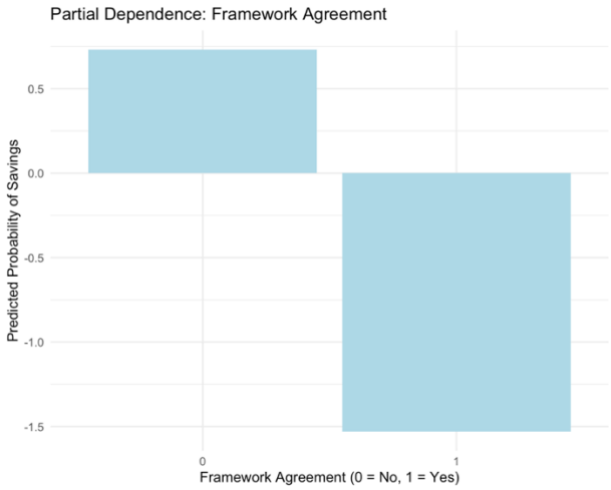

Figure 8 *Partial Dependence of Savings on Framework Agreement*

Source: Author

Another highly important set of predictors relates to **institutional quality**, particularly the perceived **quality and impartiality of public services**. Both indicators show nonlinear negative relationships with procurement savings, suggesting **that weaker institutional performance is associated with a lower probability of achieving savings**. For perceived quality, the predicted probability of achieving savings declines substantially with lower scores, but this effect weakens beyond - 0.6 points, (see *Figure 9*). Perceived impartiality shows a

similar, but more gradual pattern between impartiality and procurement inefficiency, yet **non-linearity is present** (see *Figure 10*). The AMEs from the logit model show that perceived quality is associated with a 12.2 percentage points increase in savings probability, while a similar increase in impartiality corresponds to a 3.6 percentage point increase[5]. Despite the nonlinear patterns observed, a stronger (less negative) score of institutional quality is positively associated with achieving savings, **thus lending support to H5a.**

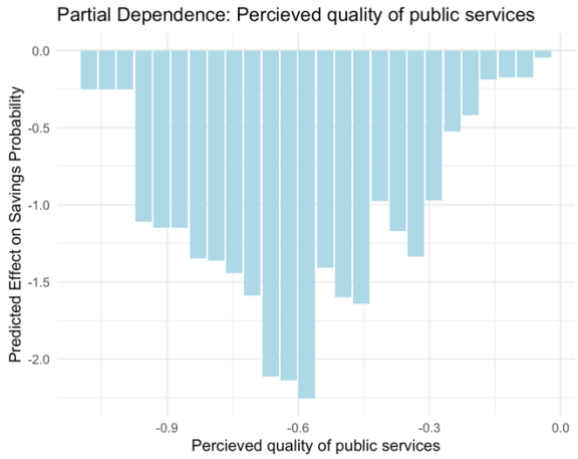

Figure 10 *Partial Dependence of Savings on the Quality of Public Services*

Source: Author

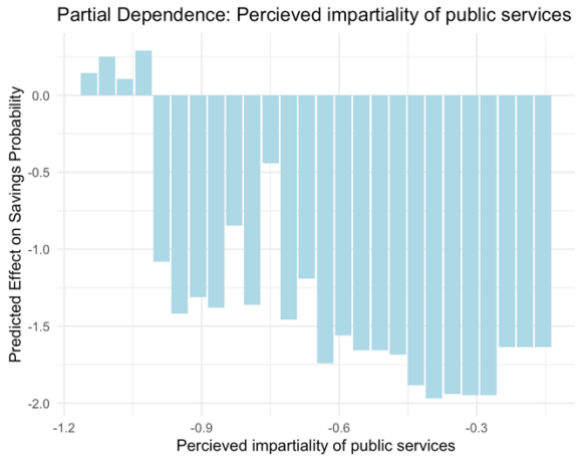

Figure 9 *Partial Dependence of Savings on the Impartiality of Public Services*

Source: Author

Figure 11 shows that contracts financed through **EU funds are associated with a much higher predicted probability of savings.** Consistent with PDP findings, the AME of EU funding shows a 4.5 percentage points increase in the probability of generating savings in contracts that are financed through EU funds compared to nationally financed contracts. **These findings contradict H2a.** The only exception is construction work contracts, which exhibit a 2.5 percentage point lower probability of savings when funded by the EU.

[5] Given that both variables are continuous and standardized around negative values, this suggests that moving from regions with the lowest institutional performance to those with the highest leads to substantial improvements in procurement efficiency.

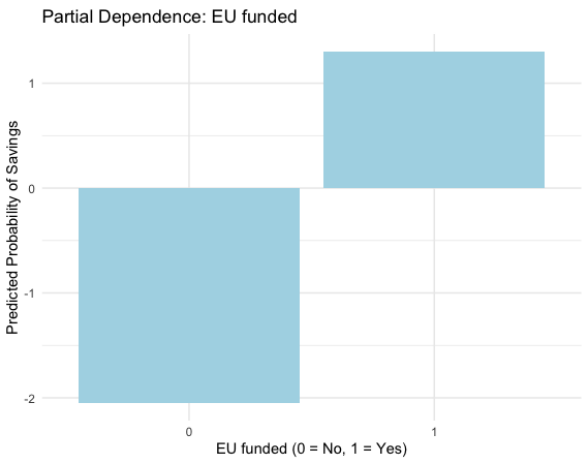

Figure 11 *Partial Dependence of Savings on the Source of Funding*

Source: Author

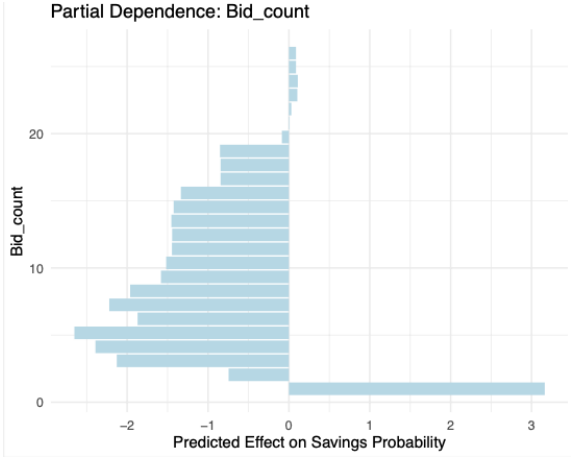

Figure 12 *Partial Dependence of Savings on the Number of Bidders*

Source: Author

Although the **number of bidders** ranks relatively low in the variable importance, the PDP (see *Figure 12*) still provides valuable insights into how competition affects the probability of savings. The plot reveals a non-linear association and a surprising insight that single-bidder contracts exert the highest probability of achieving savings. This likely reflects a conditional relationship, where single-bid contracts frequently co-occur with other characteristics that improve procurement outcomes[6]; rather than imply that low competition is inherently more efficient. The AME indicates that **increasing competition is associated with a higher probability of savings**, with contracts attracting 10 or more bidders associated with an 18 percentage points increase in the probability of savings compared to single-bid contracts. Interestingly, contracts with **two bidders are associated with 2.2 percentage points lower probability of achieving savings than single-bid contracts**, with the PDP showing a similar **downward trend for contracts with two to five bidders**. Overall, while the relationship is

[6] 30% of all contracts received only a single bid

non-linear, the findings affirm that higher levels of competition are generally associated with greater procurement efficiency **confirming H1a.**

The RF model assigned negligible predictive importance to the election-year variable. Despite the PDP (see *Figure 13*) suggesting a **lower predicted probability of achieving savings during election years**, this pattern is not corroborated by the logistic regression results. The AME indicates that, on average, contracts awarded during election years are associated with a 1.8 percentage point higher probability of generating savings compared to other periods in the electoral cycle. The direction and magnitude of the effect also vary across contract types, suggesting the influence of context-specific dynamics. Although the **regression analysis rejects H6a, taking other models into consideration, the effect of the election year on savings generation should be interpreted with caution.**

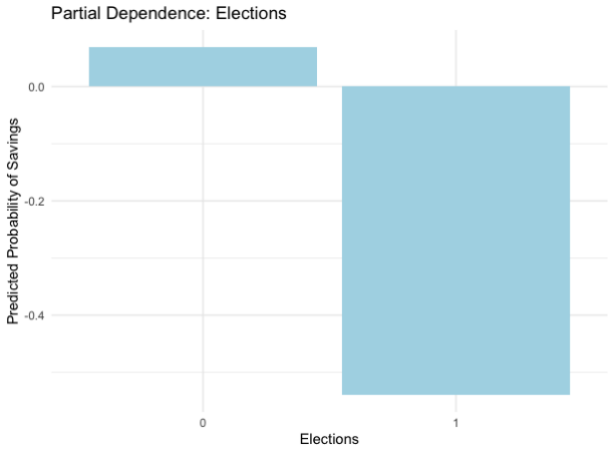

Figure 14 *Partial Dependence of Savings on the Election Year*

Source: Author

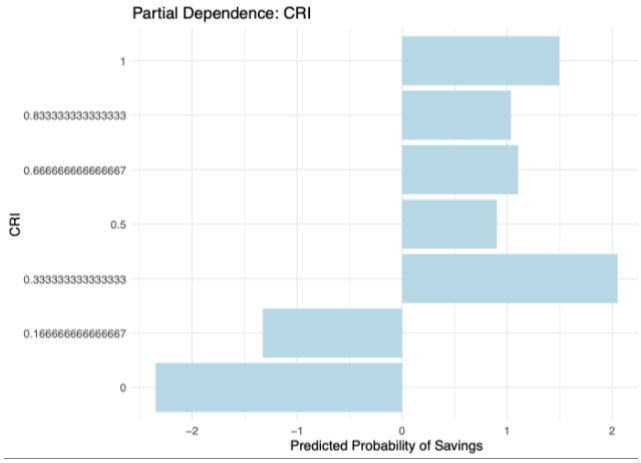

Figure 13 *Partial Dependence of Savings on the Corruption Risk Index score*

Source: Author

The **CRI ranks as the least important variable in the Random Forest model**, suggesting it has minimal predictive value for the probability of savings. The PDP further reveals a counterintuitive pattern, with higher CRI scores associated with a higher predicted probability of savings likely reflecting interactions with other variables. In contrast, logistic

regression shows a significant negative effect: contracts with a **CRI of 1 are 37.3 percentage points less likely to yield savings than those with a CRI of 0**. While the **regression result supports the H4a** expected negative relationship, the overall evidence with RF and PDP remains inconclusive.

Among the complementary factors (see **Appendix 3** for PDPs), **subcontracting** is generally associated with a **4.6 percentage point higher probability of saving**, though, in construction contracts, it reduces the likelihood of savings by 12.2 percentage points. Supply type also matters: **supply contracts are the most cost-efficient**, while services and construction works are associated with 7.6 and 14.8 percentage points lower probabilities of savings, respectively. Procedure type shows that **open procedures are most efficient**, while restricted and bidder-approached procedures are least likely to generate savings. Interestingly, **e-auctions are associated with a 15.5 percentage point lower probability of savings**, suggesting limited cost-efficiency in practice.

In summary, combining machine learning and logistic regression allowed for both accurate prediction and nuanced interpretation of savings drivers. Framework agreements and institutional quality, level of competition, and CRI showed expected effects aligned with H1a, H3a, H4a, and H5a. The evidence for EU funding (H2a) and election timing (H6a) contradicted expectations, However, CRI (H4) and election timing (H6a) should be interpreted with caution due to inconclusive results across methods.

4.2 EXPLAINING THE EXTENT OF SAVINGS

In the second stage of the analysis, the RF regression model was used to identify the **most important determinants of the extent of savings in public procurement contracts** (see *Figure 15*). The model indicates that the **number of bidders (H1b)** is the most important predictor of the extent of generated savings. Other important predictors include quality and impartiality of public services **(H4b),** and supply type, with the rest of the indicators exhibiting substantially lower importance in the model's accurate prediction of generated savings.

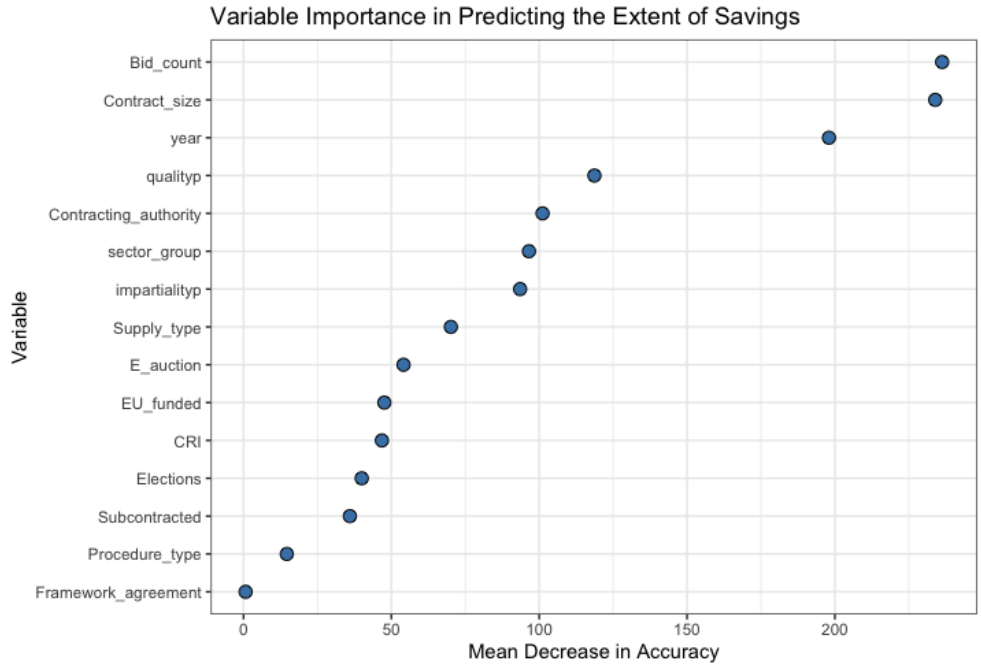

Figure 15 *Random Forest Regression Variable Importance Plot*

Source: Author

While the **number of bidders** showed low importance in predicting whether savings are achieved, it is the **key factor in predicting the extent of savings**. The PDP shows a clear upward trend in savings up to about seven bidders, with a peak around 15, followed by diminishing returns (See *Figure 16*). These patterns are supported by the OLS regression, which

indicates that **each additional bidder is associated with an average increase in savings of approximately 2.7%,** with contracts attracting 10 or more bidders associated with approximately 19% higher savings compared to single-bidder contracts, **confirming H1b.** Interestingly, OLS results also show that **contracts attracting two or three bidders result in approximately 3% less savings than single-bidder contracts.**

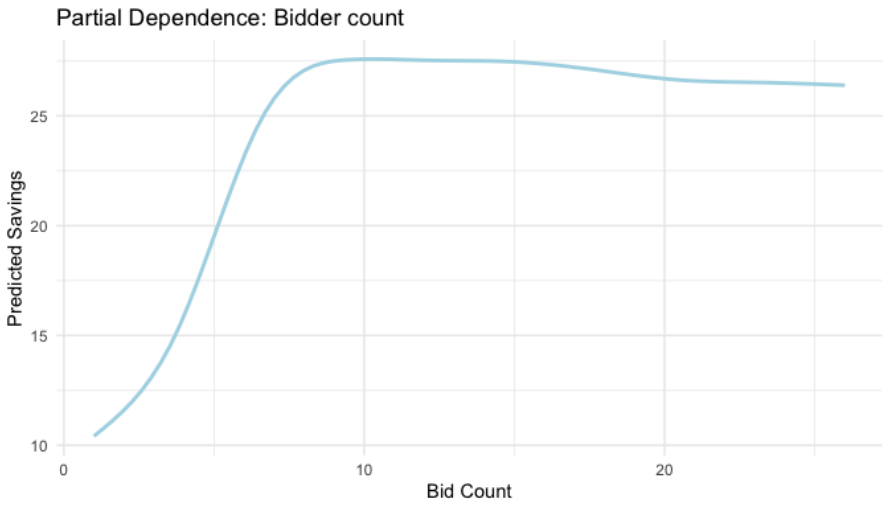

Figure 16 *Partial Dependence of the Extent of Savings on the Number of Bidders*

Source: Author

The PDPs for perceived **quality and impartiality of public services reveal no clear positive relationship with predicted savings.** OLS results further show that both indicators are significantly negatively associated with savings: **a one-unit increase in quality corresponds to a 1.9% decrease, and in impartiality to a 1.6% decrease in savings**[7]. These findings suggest that institutional quality may influence procurement outcomes in context-

[7] Given that both variables are continuous and standardized around negative values, this suggests that moving from regions with the lowest institutional performance to those with the highest is associated with a decrease in savings.

specific or non-linear ways rather than through a consistently positive effect. **Overall, the evidence does not support H5b.**

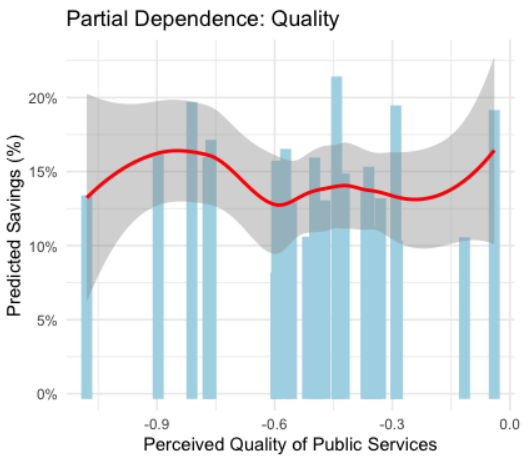

Figure 18 *Partial Dependence of the Extent of Savings on the Perceived Quality of Public Services*

Source: Author

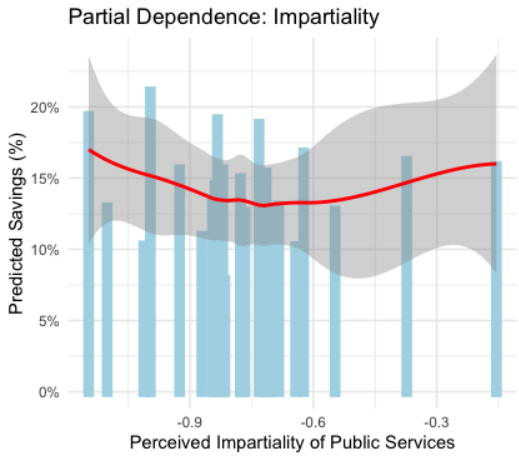

Figure 18 *Partial Dependence of the Extent of Savings on the Perceived Impartiality of Public Services*

Source: Author

The PDP indicates that **EU-funded contracts are associated with lower predicted savings** (see *Figure 19*). Regression results suggest that, on average, contracts financed through EU funds achieve **4.5% lower savings** compared to those funded from national sources, **confirming the expectations of H2b.**

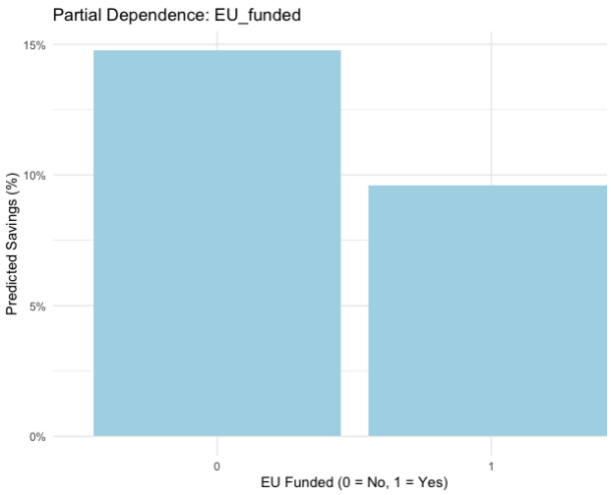

Figure 20 *Partial Dependence of the Extent of Savings on the Funding Source*

Source: Author

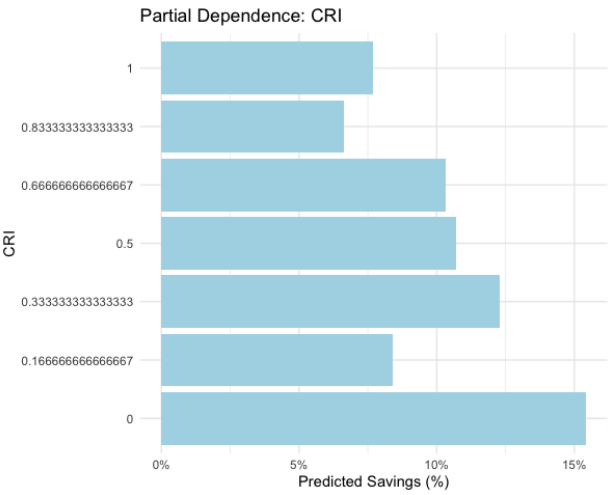

Figure 19 *Partial Dependence of the Extent of Savings on the Corruption Risk Indicator*

Source: Author

The PDP shows a **steady decline in predicted savings as the CRI increases**, suggesting that contracts flagged with more corruption risk indicators tend to achieve significantly lower cost savings (see *Figure 20*), **confirming H4b**. This pattern is reinforced by the OLS results, which show that **contracts with the highest CRI scores yield, on average, 6.6% lower savings compared to those with the highest integrity.**

Observed trends from the PDP indicate that **contracts awarded during election years tend to achieve slightly lower savings.** Specifically, average savings are about 0.5% lower compared to non-election years. **This offers modest support for H6b**.

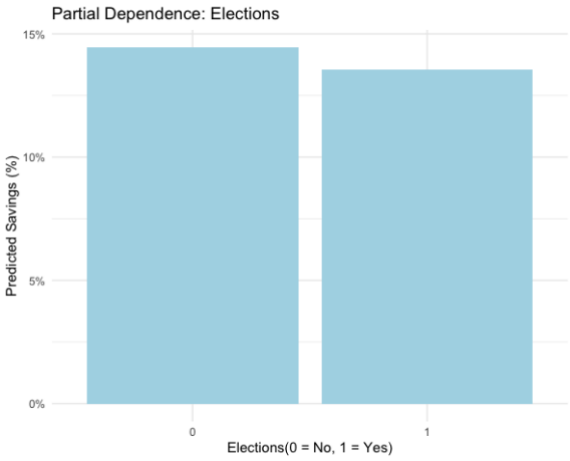

Figure 21 *Partial Dependence of the Extent of Savings on the Election Year*

Source: Author

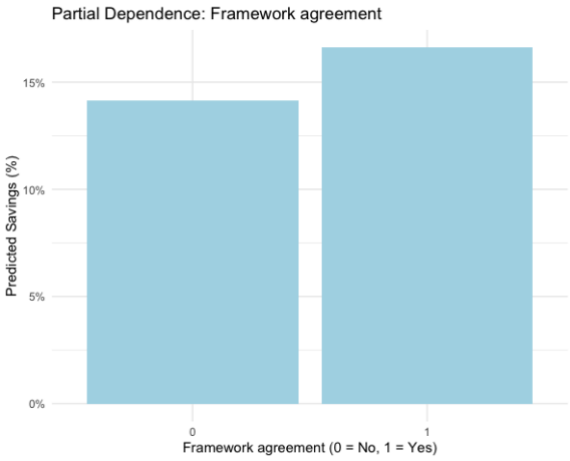

Figure 22 *Partial Dependence of the Extent of Savings on Framework Agreement*

Source: Author

The PDP shows a slight increase in predicted savings for contracts awarded under **framework agreements.** This contrasts with the earlier classification results but is supported by the OLS regression, where framework agreements are significantly positively associated with the extent of savings, suggesting that **contracts awarded under framework agreements yield, on average, 2.4% higher savings relative to classical contracts**, with the highest savings achieved in construction contracts (8.4%). **These findings reject H3b.**

Complementary factors show meaningful variation in their relationship with procurement savings (see **Appendix 4** *for PDPs*). Supply type significantly affects outcomes, with **construction work associated with the highest savings**, followed by services, while supplies perform the least efficiently. **E-auctions are generally linked to lower savings (- 1.6%)**, especially in high-competition contexts, though they appear more effective in low-bidder settings. **Subcontracting exhibits mixed effects**: it slightly reduces savings overall (-0.9%), particularly in construction and services, but increases savings in supply contracts. Procedure type also shapes savings outcomes. **Open and negotiated publication procedures are associated with the highest savings**, while restricted and non-publication procedures yield lower outcomes; however, the combination of an open procedure and a single bidder yields lower savings than many other combinations of procedures involving higher bidder counts.

5 DISCUSSION AND POLICY IMPLICATIONS

The analysis revealed that to fully understand procurement efficiency, it is important to examine not only whether savings occur, but also what determines their extent. This research's dual focus on both the probability and the magnitude of savings provides new insights into the complex dynamics of procurement efficiency, highlighting that the drivers of savings are not uniform across outcomes, nor are they always aligned with theoretical expectations.

Competition level, defined by the number of bidders, emerges as a robust predictor of cost savings. Results provide support for both hypothesized effects in *H1: Contracts that attract a higher number of bidders are (a) more likely to generate savings and (b) associated with greater savings.* While bidder count had relatively **low predictive importance for the probability of savings** in the Random Forest classifier, it was the **most influential factor in explaining the extent of savings.** Each bidder is associated with an average 2.7% increase in savings. This aligns with earlier research estimating that each additional bidder yields a 2.6% to 2.9% increase in achieved savings, on average (Grega and Nemec 2015, 550; Gavurova et al. 2017, 37). Moreover, this analysis confirms the non-linear nature of the relationship between competition and savings, revealing diminishing returns to competition. The models suggest that optimal competition is reached at seven bidders, echoing findings from prior research that indicate diminishing benefits after six to eight bidders (Gupta 2002; Gavurova et al. 2017).

At the same time, **the findings challenge the simplistic assumption that more bidders automatically lead to better outcomes**. Specifically, contracts attracting two to five bidders are associated with approximately a 2% lower probability of savings than single-bid contracts, and contracts with two or three bidders yield, on average, 3% lower savings relative to contracts with only one bidder. This counters the intuitive expectation that additional bidders inherently enhance competition and reduce prices. However, they are consistent with patterns observed in

the literature, which point to strategic bidding or otherwise distorted competition (Gavurova et al. 2017). Androniceanu (2017) notes that in a perfectly competitive environment, greater competition reduces prices, increases productivity, and curbs monopolistic behaviour and corruption. Therefore, under undistorted conditions, savings should increase with each additional bidder, particularly within the one to eight bidder range (after which diminishing returns are expected). Thus, the **findings possibly indicate distortion of competition in tenders with low bidder coun**ts, which is a particularly relevant finding in the Slovak context, where **public procurement markets continue to attract very low numbers of bidders** (see *Figure 23*). On average, supply contracts draw just two bidders, service contracts two to three, and construction works around five - a pattern consistent with previous research (Grega et al. 2019).

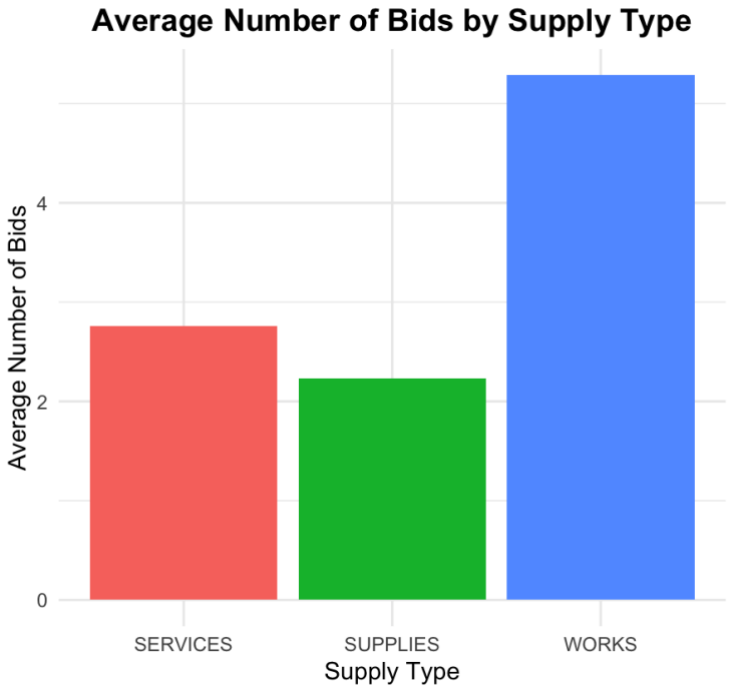

Figure 23 *Average Number of Submitted Bids per Supply Type*

Source: Author

Connected to competition, **procedure type** also plays a critical role in shaping savings outcomes. Open procedures, while associated with greater transparency and broader market access, only lead to cost efficiency when accompanied by real competition. This supports

claims in the literature that procedural openness is valuable primarily because it expands the pool of potential competitors, thereby setting the stage for more effective bidding (Soudek and Skuhrovec 2016, 16; Gavurová et al. 2017). Yet, the findings reveal that open procedures with only one or two bidders often yield lower savings than less transparent procedures with more bidders, indicating that **actual competition (number of submitted bids) is the more decisive factor.** This aligns with arguments by Kuhlman and Johnson (1983) and Gilley and Karels (1981), who emphasize that real bidding pressure has a greater impact on procurement outcomes than the formal opportunity to compete. Overall, the results underscore that **while openness of the procedure is closely connected to competition, it is the realization of that competition through higher bidder participation that ultimately drives procurement efficiency.**

Given that **open procedures account for approximately 89% of Slovak public procurement procedures,** the potential competition is widespread. **Yet, the persistent lack of robust competition points to the presence of deeper systemic barriers that hinder market engagement.** These likely include high administrative burden and difficult-to-navigate frequently amended legislation that increases transactional costs and deters participation, corruption and other unethical behaviour, as outlined by Nemec, Grega, and Orviska (2020). To address this, policymakers could consider simplifying procurement procedures to reduce participation barriers; however, such reforms must be carefully designed to avoid weakening transparency, mitigate the risk of fraud, and ensure clarity in an already complex and ever-evolving procurement framework.

Findings on **EU funding** reveal a complex relationship and somewhat contradictory relationship with procurement efficiency. Results provide partial support for *H2: Procurement contracts financed by EU funds are (a) less likely to generate savings, and (b) associated with lower savings, compared to those funded from national sources.* While EU-financed contracts

are more likely to result in savings the extent of those savings tends to be lower compared to nationally funded tenders. Plaček et al. (2020, 6) argue that EU-funded contracts may be more susceptible to overpricing, as **EU funds are perceived as less scarce or limited than national resources resulting in weaker incentives to minimize and control costs** when EU money is involved. From a policy perspective, these findings underscore the need to strengthen cost-control mechanisms in EU-funded procurement. Greater coordination between national and EU oversight bodies, clearer guidelines, and targeted audits could help align the incentives of national implementers with the efficiency and transparency goals of the EU funding framework.

The impact of **framework agreements** on procurement savings appears mixed, offering only partial support for *H3: Contracts awarded under a framework agreement are (a) less likely to generate savings and (b) associated with lower savings compared to those awarded through classical procedures*. The results strongly confirm H3a – framework agreement contracts are **substantially less likely to generate savings**, likely reflecting the lack of price renegotiation typical of long-term arrangements. On the other hand, the relatively few contracts that do achieve savings under these arrangements often report higher-than-average reductions, particularly in construction work contracts. This suggests that while framework agreements may suppress competitive incentives at the point of contract award, they may generate efficiency gains through reduced transaction costs. This duality complicates the assumption that framework agreements are inherently less cost-efficient. Instead, the findings point to context-dependent efficiency, contingent on supply type. From a policy standpoint, these results highlight the shortcomings of generalization and emphasize the need for selective application of framework agreements, informed by sector-specific benchmarks and strong oversight and audit of the implementation, to ensure that their administrative convenience does not come at the expense of value for money.

The findings provide support for H4: *Contracts with higher Corruption Risk Index (CRI) scores are (a) less likely to generate savings and (b) associated with lower savings,* indicating that **corruption-related risks are associated with diminished procurement efficiency in terms of both probability and magnitude of savings.** The CRI, which aggregates indicators such as single bidding, use of non-open procedures, and lack of call publication, reflects core vulnerabilities in contract integrity; thus, policy reforms should prioritize broader use of open procedures and ensure that calls for tenders are consistently published. However, as the majority of Slovak procurement contracts are already open and low bidder level persists, further gains from formal procedural reforms only are unlikely. Instead, policy should **focus on ensuring meaningful competition within open procedures by reducing administrative complexity, increasing bidder trust, and improving oversight capacities.**

The results provide limited but nuanced support for *H5: Contracts with higher scores of quality and impartiality of public services are (a) more likely to generate savings and (b) associated with greater savings.* On one hand, **higher perceived quality and impartiality of public services are linked to a greater likelihood of savings**, aligning with literature that emphasizes the role of strong institutional foundations in improving procurement performance (Plaček et al. 2020; Catalão, Cruz, and Sarmento 2023). On the other hand, their relationship with the actual extent of savings is less consistent. In other words, **better institutional environments appear linked to lower predicted savings**. This may reflect the limitations of the used indicator, which captures only the perception of selected aspects of institutional quality; rather than a true negative relationship, suggesting the need for a more robust proxy of institutional quality.

Evidence on the effect of parliamentary **election years** on procurement efficiency remains inconclusive, offering only modest support for *H6: Contracts awarded during Slovak parliamentary election years are (a) less likely to generate savings and (b) associated with*

lower savings or higher overpricing. Contracts awarded during election years appear to be associated with slightly higher probabilities of achieving savings compared to other phases of the electoral cycle. At the same time, **marginally lower average savings during election years (−0.5%) offer significant but weak support for H6.** This contrasts the expectations grounded in public choice theory and prior studies (Mueller 2003; Catalão, Cruz, and Sarmento 2022), which associate election-driven procurement with increased political discretion, weaker oversight, and inflated costs. **While the observed effects here are limited in magnitude, they underline the need for sustained transparency, institutional independence, and rigorous scrutiny of public procurement processes**, not only during election years but throughout the entire electoral cycle.

The findings reveal that procurement efficiency is driven by a complex mix of competition, institutional quality, procedural design, and political context. While bidder participation consistently increases both the likelihood and extent of savings, other factors such as EU funding, framework agreements, and institutional trust show more conditional effects. For example, framework agreements reduce the probability of savings but can yield higher savings in sectors like construction. Complementary factors matter too: construction contracts outperform others, subcontracting shows sector-specific effects, and e-auctions, though promoted for efficiency, are linked to lower savings, especially in competitive contexts. Procedure type matters less than actual competition, reinforcing that bidder engagement, rather than just openness, drives efficient outcomes. These insights highlight the need for tailored and evidence-based reforms and emphasize the importance of continuous monitoring of procurement performance to detect inefficiencies and enhance procurement efficiency.

6 CONCLUSION

This thesis has explored the drivers of procurement efficiency, defined in terms of cost savings. The central research question was: ***What are the key determinants of cost efficiency in Slovak public procurement contracts and how do endogenous and exogenous factors influence the extent of final savings?*** Drawing on a comprehensive dataset of 607,342 contracts from 2009–2023, the analysis examined contractual, institutional, and political dimensions of procurement performance.

This thesis contributes to the existing literature in three key ways. Methodologically, it combines conventional econometric models with big data methods to uncover both complex patterns and statistically interpretable relationships. Empirically, it draws on a uniquely comprehensive dataset enabling a robust and generalizable analysis. By integrating both contract-specific and exogenous variables, it offers a richer and more holistic understanding of what drives procurement savings. From a policy perspective, the findings generate evidence-based insights that can inform future reform efforts aimed at enhancing procurement efficiency, promoting transparency, and reducing the waste of public funds.

The analysis finds that framework agreements, institutional quality and EU funding appear to be the primary predictors of whether savings are achieved. Framework agreements are associated with a lower probability of savings, whereas both institutional quality and EU funding are linked to higher probability. In contrast, the level of competition, measured by the number of bidders, is the key predictor positively associated with the extent of savings. While institutional quality indicators increase the probability of achieving savings, they are surprisingly negatively associated with the extent of savings. Electoral cycles and corruption risk show limited predictive power overall, though a higher CRI is consistently linked to a lower probability and extent of savings. Electoral timing shows marginal effects in opposite directions, modestly increasing the probability but decreasing the extent of savings. Altogether,

the inclusion of exogenous variables (institutional quality, corruption risk, and electoral cycles) modestly increased the regression models' explanatory power ($\Delta R^2 = 0.05$ from a baseline of 0.22)), indicating a modest but meaningful improvement. It suggests that systemic, context- specific factors contribute to procurement efficiency, albeit less than contract-level features.

More broadly, while Slovakia performs well in terms of overall savings (73% of contracts) and openness (89% of procedures are open), the bidder participation remains low. This paradox points to underlying issues not captured in the current model. Future research should explore why high procedural openness does not translated into robust competition. Studies could qualitatively investigate firm-level deterrents, administrative complexity, or trust deficits in procurement institutions. Furthermore, the inclusion of exogenous variables improved model performance only modestly ($\Delta R^2 = 0.05$), likely reflecting the limitations of proxy indicators such as the EQI and CRI rather than a lack of substantive relevance, warranting more precise operationalization in future research. Finally, while this thesis controlled for sector and procurer type, it did not examine whether procurement dynamics differ across these categories, thus future disaggregated analyses could important variation and support more targeted policy interventions.

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APPENDICIES

Appendix 1 *Average Marginal Effects from the Logistic Regression Models*

Robust Average Marginal Effects Across Subsamples

	Dependent Variable: Savings_achieved			
	Construction (1)	Supplies (2)	Services (3)	Full Sample (4)
Bid_cat10+	0.252***	0.059***	0.029	0.180***
Bid_cat2	0.103***	-0.060***	-0.025***	-0.022***
Bid_cat3	0.035	-0.010	0.073***	0.049***
Bid_cat4	0.135***	0.046***	0.091***	0.075***
Bid_cat5	0.236***	0.010	0.045***	0.101***
Bid_cat6	0.103***	0.142***	0.113***	0.108***
Bid_cat7	0.200***	0.067***	0.131***	0.161***
Bid_cat8	0.198***	0.074***	0.256***	0.148***
Bid_cat9	0.240***	0.024**	-0.144***	0.162***
Contract_size	0.021***	0.013***	-0.010***	-0.004***
Contracting_authorityNATIONAL_AGENCY	0.066***	-0.081	-0.239***	-0.100***
Contracting_authorityNATIONAL_AUTHORITY	-0.039**	-0.079	-0.155***	-0.073***
Contracting_authorityOTHER	-0.070***	-0.063	-0.158***	-0.096***
Contracting_authorityPUBLIC_BODY	-0.079***	-0.091	-0.247***	-0.161***
Contracting_authorityREGIONAL_AGENCY	-0.043***	0.043	-0.246***	-0.056**
Contracting_authorityREGIONAL_AUTHORITY	-0.055***	-0.039	-0.163***	-0.083***
Contracting_authorityUTILITIES	-0.173***	-0.187	-0.372***	-0.249***
CRI	0.114***	-0.348***	-0.458***	-0.373***
E_auction	-0.055***	-0.063***	-0.188***	-0.151***
Elections	0.051***	-0.014***	0.035***	0.018***
EU_funded	-0.025***	0.062***	0.059***	0.045***
Framework_agreement	-0.358***	-0.396***	-0.512***	-0.597***
impartialityp	0.027***	-0.043***	0.055***	0.036***
Procedure_typeAPPROACHING_BIDDERS	0.003	0.157***	0.166***	0.188***

Procedure_typeCOMPETITIVE_DIALOG	0.033	-0.356***	-0.078	-0.358***
Procedure_typeNEGOTIATED	0.009	0.009	0.162***	0.165***
Procedure_typeNEGOTIATED_WITH_PUBLICATION	-0.869***	0.052***	0.171***	0.129***
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION	-0.108*	0.031***	0.138***	0.001
Procedure_typeRESTRICTED	-0.054***	0.062***	0.130***	0.099***
qualityp	0.295***	-0.215***	0.202***	0.122***
sector_groupConstruction	0.867***	-0.212***	-0.266***	-0.107***
sector_groupManufacturing, Goods	0.998NA	-0.078***	-0.207***	-0.073***
sector_groupNA	0.892***	0.055**	-0.295***	-0.117***
sector_groupPrimary Sector	0.998NA	-0.035***	-0.164***	-0.069***
sector_groupTransport & Logistics	0.999NA	-0.113***	-0.310***	-0.127***
sector_groupUtilities & Energy	0.998NA	-0.120***	-0.358***	-0.188***
Subcontracted	-0.122***	0.065***	0.071***	0.046***
sector_groupIT & Communication	NA	0.044***	-0.119***	0.038***
sector_groupOther Services	NA	-0.177***	-0.236***	-0.137***
Supply_typeNA	NA	NA	NA	-0.110***
Supply_typeSERVICES	NA	NA	NA	-0.076***
Supply_typeWORKS	NA	NA	NA	-0.148***
AIC	45136.01	97250.83	375605.27	545169.51
BIC	45491.18	97646.15	376038.91	545656.13
Log Likelihood	- 22530.01	-48585.41	-187762.64	-272541.75
Deviace	45060.01	97170.83	375525.27	545083.51
Num. Obs.	84678	144793	377352	607342

Note: *p<0.1; **p<0.05; ***p<0.01

Appendix 2 *OLS Regression Results*

OLS Regression with Robust Standard Errors (All Subsets)

	Dependent Variable: Savings			
	Construction (1)	Services (2)	Supplies (3)	All Types (4)
EU_funded	-3.051***	-3.042***	-5.504***	-4.374***
	(0.146)	(0.174)	(0.104)	(0.076)
Elections	1.326***	-0.140	-0.866***	-0.522***
	(0.165)	(0.124)	(0.062)	(0.051)
Procedure_typeCOMPETITIVE_DIALOG	-4.023***	-13.642***	5.300***	5.493***
	(0.702)	(0.963)	(1.218)	(1.094)
Procedure_typeNA	6.766**	-4.670*	-4.632***	0.210
	(2.935)	(2.425)	(1.000)	(0.815)
Procedure_typeNEGOTIATED	1.981***	-4.848***	0.269	0.073
	(0.185)	(0.975)	(0.391)	(0.401)
Procedure_typeNEGOTIATED_WITH_PUBLICATION		5.528***	1.491**	9.359***
		(1.022)	(0.679)	(0.645)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION	4.797***	-2.655***	-4.855***	1.102***
	(0.806)	(0.932)	(0.448)	(0.382)
Procedure_typeOPEN	1.607***	-10.470***	-0.186	3.353***
	(0.483)	(0.916)	(0.354)	(0.351)
Procedure_typeRESTRICTED	-3.199***	-7.027***	-0.472	2.381***
	(0.367)	(0.903)	(0.418)	(0.440)
E_auction	-4.788***	-3.121***	-1.165***	-1.641***
	(0.191)	(0.157)	(0.074)	(0.099)
Framework_agreement	8.457***	1.599***	0.369	2.325***
	(1.410)	(0.529)	(0.441)	(0.327)
Subcontracted	-2.287***	-3.146***	0.863***	-1.097***
	(0.141)	(0.119)	(0.130)	(0.073)
Bid_cat2	-2.955***	-6.320***	0.904***	1.208***
	(0.573)	(0.397)	(0.184)	(0.409)
Bid_cat3	-2.132***	-4.966***	1.969***	1.964***
	(0.565)	(0.380)	(0.189)	(0.412)
Bid_cat4	4.500***	-3.464***	2.235***	5.192***
	(0.568)	(0.402)	(0.201)	(0.440)
Bid_cat5	3.714***	2.255***	7.121***	6.983***
	(0.586)	(0.416)	(0.249)	(0.476)
Bid_cat6	6.788***	9.477***	11.846***	8.778***
	(0.577)	(0.446)	(0.294)	(0.498)
Bid_cat7	22.542***	3.774***	11.811***	12.704***
	(0.583)	(0.413)	(0.371)	(0.573)

Bid_cat8	13.453***	14.658***	20.352***	13.206***
	(0.594)	(0.480)	(0.699)	(0.595)
Bid_cat9	10.923***	17.001***	15.897***	15.314***
	(0.602)	(0.653)	(1.643)	(0.657)
Bid_cat10+	16.686***	10.419***	26.282***	19.279***
	(0.606)	(0.541)	(1.202)	(0.491)
sector_groupConstruction		19.871***	-2.314***	-4.304***
		(0.433)	(0.609)	(0.164)
sector_groupIT_and_Communication		6.552***	0.126	4.516***
		(0.152)	(0.624)	(0.135)
sector_groupManufacturing_Goods	-2.193	-5.034***	0.320	-1.345***
	(5.933)	(0.523)	(0.604)	(0.148)
sector_groupNA	-0.871***	-0.757	0.778	-2.987***
	(0.289)	(1.071)	(0.703)	(0.263)
sector_groupOther_Services		-0.123	9.517***	6.311***
		(0.304)	(0.626)	(0.195)
sector_groupPrimary_Sector	-2.990***	-3.894***	0.723	-3.427***
	(0.512)	(0.190)	(0.626)	(0.145)
sector_groupTransport_and_Logistics	-4.602***	-0.787***	-11.396***	-0.863***
	(0.352)	(0.195)	(0.693)	(0.160)
sector_groupUtilities_and_Energy	22.528***	2.839***	7.603***	4.390***
	(0.320)	(0.214)	(0.630)	(0.163)
Contracting_authorityNational_Agency	-3.432	-3.826	-3.626***	-5.290***
	(2.197)	(2.713)	(1.116)	(0.789)
Contracting_authorityNational_Authority	-6.295***	-5.604**	-8.064***	-6.598***
	(1.202)	(2.693)	(1.027)	(0.748)
Contracting_authorityOTHER	-6.669***	-3.362	-9.365***	-6.427***
	(1.147)	(2.693)	(1.017)	(0.745)
Contracting_authorityPublic_Body	-6.038***	-6.230**	-8.619***	-6.683***
	(1.143)	(2.693)	(1.019)	(0.744)
Contracting_authorityRegional_Agency	-5.237***	-4.861*	-11.345***	-5.615***
	(1.142)	(2.692)	(1.059)	(0.749)
Contracting_authorityRegional_Authority	-5.922***	-0.279	-8.071***	-4.507***
	(1.137)	(2.691)	(1.017)	(0.743)
Contracting_authorityUtilities	-8.298***	-5.203*	-8.987***	-6.647***
	(1.213)	(2.698)	(1.031)	(0.753)
Supply_typeNA				-2.661***
				(0.595)
Supply_typeSERVICES				-1.609***
				(0.128)
Supply_typeWORKS				4.053***
				(0.127)
qualityp	2.090***	-4.026***	-1.515***	-1.702***

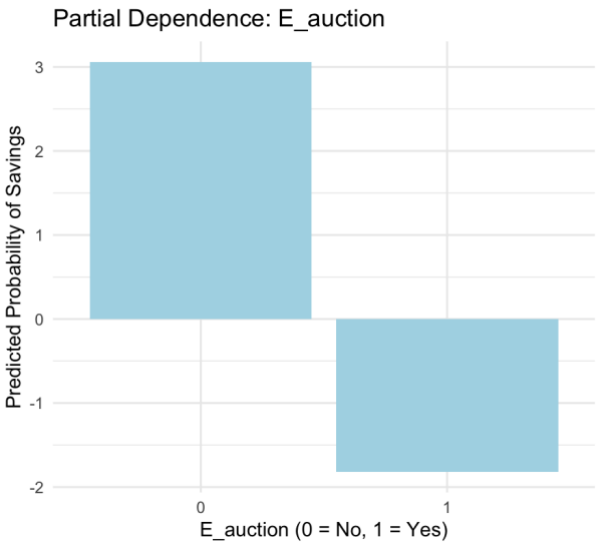
	(0.309)	(0.235)	(0.145)	(0.111)
impartialityp	-4.865***	-1.499***	-0.783***	-1.548***
	(0.279)	(0.224)	(0.154)	(0.117)
CRI	-12.693***	-19.410***	0.040	-4.609***
	(1.321)	(1.028)	(0.491)	(0.426)
Contract_size	-0.315***	-0.903***	-0.231***	-0.381***
	(0.052)	(0.031)	(0.016)	(0.014)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat2				-8.246***
				(1.318)
Procedure_typeNA:Bid_cat2				6.098*
				(3.510)
Procedure_typeNEGOTIATED:Bid_cat2				-0.732
				(0.514)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat2				-1.245*
				(0.750)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat2				3.065***
				(0.755)
Procedure_typeOPEN:Bid_cat2				-3.388***
				(0.390)
Procedure_typeRESTRICTED:Bid_cat2				-3.395***
				(0.545)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat3				-9.220***
				(1.234)
Procedure_typeNA:Bid_cat3				-10.508***
				(0.875)
Procedure_typeNEGOTIATED:Bid_cat3				0.805
				(0.527)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat3				-11.341***
				(2.929)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat3				4.990***
				(1.069)
Procedure_typeOPEN:Bid_cat3				-3.542***
				(0.394)
Procedure_typeRESTRICTED:Bid_cat3				-1.349**
				(0.536)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat4				-14.828***
				(1.149)
Procedure_typeNA:Bid_cat4				9.776***
				(0.868)
Procedure_typeNEGOTIATED:Bid_cat4				1.925***

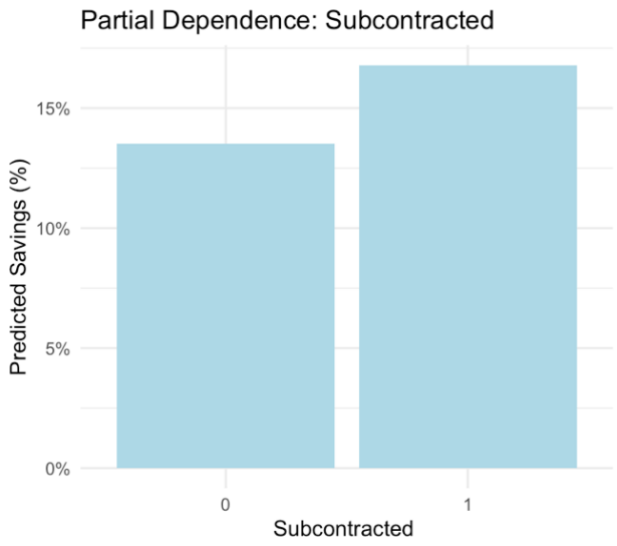
	(0.598)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat4	0.060
	(1.553)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat4	3.323
	(3.109)
Procedure_typeOPEN:Bid_cat4	-1.138***
	(0.430)
Procedure_typeRESTRICTED:Bid_cat4	-0.944
	(0.652)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat5	
Procedure_typeNA:Bid_cat5	-1.024
	(9.899)
Procedure_typeNEGOTIATED:Bid_cat5	1.669**
	(0.707)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat5	7.277***
	(0.787)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat5	6.106*
	(3.141)
Procedure_typeOPEN:Bid_cat5	-1.348***
	(0.473)
Procedure_typeRESTRICTED:Bid_cat5	-5.023***
	(0.857)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat6	
Procedure_typeNA:Bid_cat6	
Procedure_typeNEGOTIATED:Bid_cat6	4.027***
	(0.743)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat6	13.979***
	(0.865)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat6	9.598***
	(1.195)
Procedure_typeOPEN:Bid_cat6	2.173***
	(0.493)
Procedure_typeRESTRICTED:Bid_cat6	-5.989***
	(0.814)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat7	
Procedure_typeNA:Bid_cat7	-1.082
	(0.942)

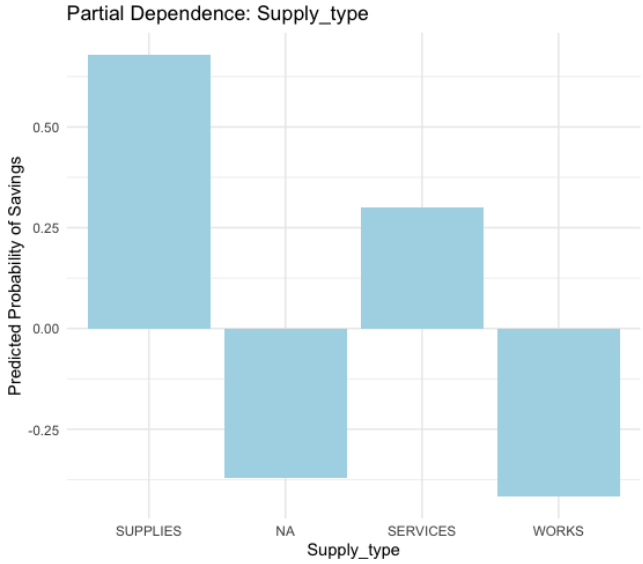
Procedure_typeNEGOTIATED:Bid_cat7	1.766**
	(0.891)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat7	24.255***
	(0.880)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat7	-16.976***
	(0.604)
Procedure_typeOPEN:Bid_cat7	6.872***
	(0.569)
Procedure_typeRESTRICTED:Bid_cat7	-4.829***
	(1.546)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat8	
Procedure_typeNA:Bid_cat8	14.051***
	(1.028)
Procedure_typeNEGOTIATED:Bid_cat8	3.255***
	(0.909)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat8	
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat8	16.446***
	(0.980)
Procedure_typeOPEN:Bid_cat8	4.231***
	(0.600)
Procedure_typeRESTRICTED:Bid_cat8	-4.410***
	(0.978)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat9	
Procedure_typeNA:Bid_cat9	
Procedure_typeNEGOTIATED:Bid_cat9	-0.504
	(1.128)
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat9	
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat9	
Procedure_typeOPEN:Bid_cat9	1.531**
	(0.714)
Procedure_typeRESTRICTED:Bid_cat9	-3.378***
	(0.914)
Procedure_typeCOMPETITIVE_DIALOG:Bid_cat10+	
Procedure_typeNA:Bid_cat10+	-12.311***
	(0.929)
Procedure_typeNEGOTIATED:Bid_cat10+	-1.043
	(0.825)

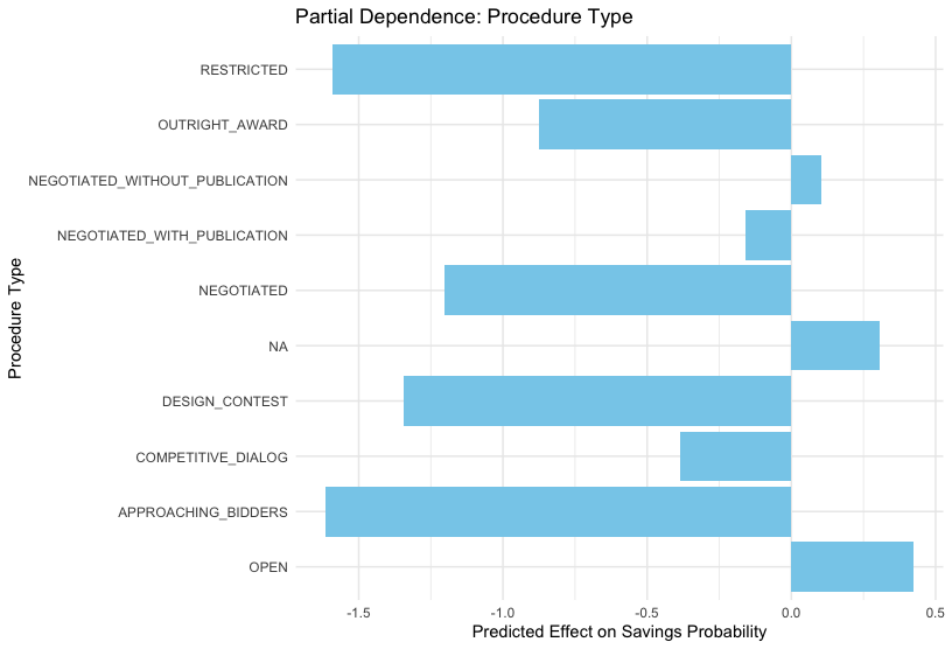
Procedure_typeNEGOTIATED_WITH_PUBLICATION:Bid_cat10+				10.754***
				(0.925)
Procedure_typeNEGOTIATED_WITHOUT_PUBLICATION:Bid_cat10+				16.736***
				(0.694)
Procedure_typeOPEN:Bid_cat10+				-0.043
				(0.548)
Procedure_typeRESTRICTED:Bid_cat10+				-3.096**
				(1.211)
E_auction:Bid_cat2				1.876***
				(0.132)
E_auction:Bid_cat3				2.108***
				(0.137)
E_auction:Bid_cat4				-5.413***
				(0.170)
E_auction:Bid_cat5				-1.541***
				(0.237)
E_auction:Bid_cat6				-2.595***
				(0.296)
E_auction:Bid_cat7				-7.083***
				(0.423)
E_auction:Bid_cat8				-3.376***
				(0.671)
E_auction:Bid_cat9				-9.833***
				(0.491)
E_auction:Bid_cat10+				-8.371***
				(0.611)
Constant	22.784***	42.222***	21.528***	20.801***
	(1.636)	(2.916)	(1.196)	(0.838)
Observations	51,459	69,333	190,255	311,315
R^2	0.522	0.253	0.094	0.226
Adjusted R^2	0.522	0.252	0.093	0.226
Residual Std. Error	10.185 (df = 51422)	11.643 (df = 69292)	12.461 (df = 190214)	12.132 (df = 311210)
F Statistic	1,562.414*** (df = 36; 51422)	585.325*** (df = 40; 69292)	490.835*** (df = 40; 190214)	874.098*** (df = 104; 311210)
Note:				*p<0.1; **p<0.05; ***p<0.01

Appendix 3 *Partial Dependence of Achieving Savings on Complementary Factors*









Appendix 4 *Partial Dependence of the Extent of Savings on Complementary Variables*