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Impact of Technology on Corruption

A study of impact of e-procurement on prices of various government purchases

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Abstract

Corruption is a challenge that can restrain a country's development, and there have been many initiatives to address this severe global phenomenon. Given the increasing role of technology in an interconnected world, many leading experts suggest that this same technology can be a powerful tool to improve government transparency and accountability, which will, in turn, hamper corruption.

This thesis aims to study the relationship between the use of technology and its impact on corruption. Being inspired by other studies that assess how e-governments helped to tackle corruption, we focused on how e-procurement reforms in the public sector affected the level of corruption in Ukraine. Since corruption itself is a complex phenomenon that is hard to measure, we conducted our assessment through measuring the impact of e-procurement on prices and competition. Additionally, we will elaborate on how this impact varies among different government purchases depending on the complexity of the purchase.

We find that ProZorro (an e-procurement solution in Ukraine) had a positive impact on reducing the prices for government purchases overall. Just as we expected, there was a stronger impact on prices and competition among goods, compared to services and works since ProZorro implementation. However, when we analyzed the impact on specific purchases, we did not find consistent results that the impact is stronger for simple purchases (natural gas, among others) compared to complex purchases (road repairs, engineering consulting). Furthermore, contrary to our expectation we found a decreasing reduction in price over time when analyzing monthly data.

Our findings suggest that although ProZorro did have a significant impact on reducing the prices of purchases, however, those numbers will not be taken at face value because of the way of calculating the estimated market data. Despite that weakness in the empirical validity of our price reduction indicator, we have seen enough signs of indirect positive effects of ProZorro, which are hard to quantify. Among those benefits are increased use of ProZorro in the media to expose corruption, and push for other reforms inspired by ProZorro's success.

Given the results of the study, we emphasize the importance of non-price evaluation criteria such as quality of the bidder. Furthermore, there is a need to complement public procurement reforms with additional and useful institutional reforms, especially within judicial and law enforcement to have tangible results. The impact of transparency and accountability provided by ProZorro, should not be taken for granted by the government in Ukraine, and they should take actions against those involved in the crime.

Acknowledgements

We wrote this thesis as a part of our Master of Science in Economics and Business Administration at the Norwegian School of Economics (NHH).

The topic initially arose from witnessing high levels of fraud and corruption in the government sector in Tajikistan (the home country of one of the authors), including in public procurement, which is a significant proportion of a country's GDP. Like many other emerging economies, Tajikistan has been held back economically due to endemic corruption which is especially prevalent in the public sector. Further inspiration to write about this topic came while taking a course at NHH *Corruption, Incentives, Liabilities and Disclosure* with Tina Søreide, where she emphasized the causes and consequences of corruption in public procurement. Additionally, as part of the course, we had an excursion to Tbilisi, Georgia, which is known for having one of the most successful anti-corruption reforms in the world. In Georgia, we saw how the government utilized technology to fight petty corruption. We believe our findings will contribute to the policy debate of how to effectively employ technology to fight corruption in the public sector.

The work has been challenging, exciting, and deepened our understanding of the theme and helped us develop our analytical skills further. We want to give special thanks to Tina Søreide who provided us with excellent support and was an engaged supervisor, always pushing us forward to think critically and challenge established thoughts on the topic. We wrote the thesis with support from the Norwegian Centre for Taxation and Centre for Ethics and Economics at NHH, for which we are very grateful. We wish to thank ProZorro PR Manager Larysa Luzinska and former International Cooperation Coordinator Yuri Bugay, Project Manager at TI Ukraine Segiy Pavluik and Oleksa Stepanuik from Center for Excellence in Procurement for their willingness to share insights, valuable directions, and providing valuable data. We direct a thank to the inspiring people we met in Kyiv that gave us more profound insights from their respective areas, especially we want to mention Sviatoslav Abramov from CoST Ukraine, Fredrik Arthur and Petter Buck from the Norwegian Embassy in Kyiv.

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Acronyms

API	Application Programming Interface
CPV	Common Procurement Vocabulary
CCI	Corruption Control Index
CPI	Corruption Perception Index
e-GP	e-Government Procurement
EGDI	E-Government Readiness Index
EC	European Commission
EU	European Union
GPA	Government Procurement Agreement
G2B	Government to Business
G2C	Government to Citizen
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IV	Instrumental Variable
MDG	Millennium Development Goals
NEFCO	Nordic Environment Finance Corporation
NHH	Norwegian School of Economics
OECD	Organization for Economic Cooperation and Development
PA	Principal Agent (theory)

SME	Small and Medium-sized Enterprises
UAH	The hryvnia, Ukrainian Currency
TI	Transparency International
UN	United Nations
UNODC	United Nations Office on Drugs and Crime
WDI	Web Development Index
WTO	World Trade Organization

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1. Introduction

1.1 Motivation and purpose

Scholars have identified corruption as one of the most significant obstacles to bridging the rising income gap between industrialized and developing nations. Many stakeholders, including governments, private businesses, and civil society organizations agreed to put the fight against corruption as the most crucial goal in their agendas. Transparency International (TI) notes that the United Nations Millennium Development Goals (MDG) will not be achieved without reducing corruption around the world (TI, 2005). Despite the optimistic promises, ambitious goals, and anti-corruption reforms lead by politicians; corruption is a very complex phenomenon that is a lot harder to eradicate in practice. At the same time, the role of technology in today's world has been growing exponentially, and almost every aspect of our lives has been affected by a digital revolution. This growth in technology has made a range of new tools and techniques available, that can be used to fight corruption more effectively.

When looking for anti-corruption solutions, transparency and accountability are essential factors that need to be improved. Technology can be a crucial enabler for providing more transparency; first, by making transactions visible, which allows closer monitoring by the public, and second, by reducing human interaction between interested agents, which usually causes corruption in the first place (World Economic Forum, 2016). While the private sector has already reaped the benefits of digitalization, many governments still do not fully utilize ICT tools to enhance their efficiency and eradicate unnecessary costs. While in many industrialized nations, governments mostly try to use technology to offer more innovative and convenient solutions for citizens and businesses for efficiency gain, in other countries that face significant challenges with functioning institutions, we can see technology as a tool to reduce corruption through greater transparency and integrity in the public sector. Many private companies have achieved significant gains in efficiency and corruption prevention when utilizing technology. Consequently, many governments are also implementing what is now known as e-government initiatives to achieve progress with that respect. Among e-government systems, the most popular initiatives are focused on digitizing government-to-business (G2B) or government-to-citizen (G2C) services. Among other examples of technology being used to fight corruption is the use of advanced analytics to detect and prevent fraud in the public sector. Examples of using sophisticated data analysis tools are prominent in the private sector and

include Deloitte Analytics solutions such as Dynamic Review that can identify and detect patterns of anomalous behaviors hidden deep in large data sets (Deloitte, 2017). Technological advancements that provide complete anonymity have also lead to an increase of whistleblowing and investigative journalism activities that expose corruption, even at an international level.

In this thesis, we will investigate how technological advancements in the form of e-government solutions can help to reduce corruption. We will clarify mechanisms through which technology can reduce corruption through an example of implemented electronic public procurement in Ukraine in 2015. We focused on Ukraine for this study for several reasons, including the availability of data, lack of other studies evaluating e-procurement reforms, and because Ukraine is at the forefront of the fight against corruption. We will explain additional reasons why we focused on Ukraine in Chapter 6.

It is well known that for governments and other public institutions to carry on their activities and complete their duties and responsibilities towards their citizens, they must purchase goods, services, and works in the market. The process of purchasing goods and services by government agencies and state-owned enterprises is known as *public procurement* (OECD, 2016). Given the problem of corruption in public procurement, scholars have proposed electronic procurement or e-government procurement has as a useful tool that can help prevent corruption that occurs at the administrative level of public procurement. As it is hard to measure corruption itself, we focus on how public e-procurement affects prices of government purchases instead. Given how many governments have been recommended to pursue technological solutions, there is an increasing need to share best practices with regards to the assessment of technological innovations in e-government (Basel Institute on Governance, 2017). We, therefore, believe that it is necessary to carry out further research on the impact of e-government solutions on corruption.

1.2 Research questions

As mentioned above, there are different ways to use technological advancements to fight corruption. One of the suggested methods is e-government because the problem of corruption is especially widespread in the government sector. The definition of e-government varies across the spectrum depending on the field where it is defined. However, the unifying aspect of all different definitions of e-government is that they all encompass the utilization of

information technologies for the improvement of efficiency of traditional government functions and services. Conventionally, citizens associate e-government with a platform that consists of several electronic applications, including performing essential government services for its citizens online, which we also know as G2C (government to consumers). Examples of those services can be giving out licenses, permits, identification documents, and even the ability for citizens to file their taxes online. In this thesis, we want to focus on digitalization of a vital government function, public procurement, which is used the most by Small and Medium-sized Enterprises (SME). Therefore, this type of service by the government is known as G2B service (government to business).

As noted by major multilateral organizations, including the OECD and the World Bank, public procurement remains the government activity most vulnerable to waste, fraud, and corruption due to the size of the financial flows involved (OECD, 2016). Thus, to mitigate corruption risks, several governments have implemented electronic procurement systems, known as e-procurement which has been successful in some cases, but less so in others. Given the ever-increasing role of digital breakthroughs and strong encouragement to implement e-procurement by all prominent multilateral organizations, including the World Bank, OECD, and UN, this study will analyze and further assess the impact of e-procurement on corruption in Ukraine. We believe it is essential to examine the mechanisms through which e-procurement solutions can help governments to reduce unnecessary costs through reducing corruption and improving efficiency and transparency. Our thesis aims to answer following research questions:

To what extent do implemented e-procurement solutions benefit the public sector in terms of reducing corruption?

Do implemented e-procurement solutions have the same effect on the public sector's purchases across goods, services, and works?

While those are the two central questions for our research, we organized the thesis as follows. Chapter two *Corruption in governments* and three *Corruption in procurement* will discuss and elaborate on the formal and phenomenal definition of corruption, including its relevance in the public procurement sector, and the increasing role of technology as an instrument to fight corruption. In Chapter four, *Theory and hypothesis* we explain the economic theory of how technology, in an example of e-procurement, can decrease corruption risks in public sector. In the same chapter, we outline our hypotheses about the impact of e-procurement on prices

and competition as we believe those indicators reflect the best available proxies of corruption level given the nature of our study and the data available. Chapter five reviews empirical literature about previous studies assessing the link between technology, e-government, and corruption. Chapter six describes why we chose Ukraine as an interesting case study and data that will be used to conduct our impact assessment. Chapter seven and eight will present results and discuss potential explanations and limitations of our findings. Finally, in Chapter nine, we conclude the thesis and discuss its policy implications.

2. Corruption in governments

2.1 Define corruption

Corruption is a complex phenomenon and a significant problem that scholars in social science have addressed differently. Rodriguez et al. (2005); Sandholtz and Koetzle (2000) have a broad definition of corruption in a nation: *The abuse of public power for private benefit*. The previous is a widely used definition; it is also the definition used by TI. However, it is worth noting that there are different approaches to understand this phenomenon, which often depends on whether lawyers, economists, or anthropologists have studied and defined it.

One can define corruption as a legal term, which emphasizes that there is a robust legal liability for conducting corruption. Thus, in a legal context corruption can, among other definitions, be defined as *an act of an official or judiciary person who unlawfully and wrongfully uses his station or character to procure some benefit, contrary to duty and right of others* (Black's Law Dictionary, 2007). If we look at the specific case of Ukraine, the law of Ukraine No. 1700-VII also defines corruption in the sections "On Preventing Corruption" and "Anti Corruption Law." This law became fully effective the 26th of April 2015 and includes the full anti-corruption legislation with administration offenses and criminal code. However, none of the mentioned laws in Ukraine establishes the liability for corruption offenses for the officers and employees in a company, neither, crimes committed by agents or other third parties. Even if these actors commit crimes to especially obtain, keep, or gain a business advantage for the company, they cannot be held liable (Global Legal Insights, 2017). What the Ukrainian government defines as corruption is therefore relatively narrow and does not cover the broad problems mentioned in the above sections. Scholars within the law have also stated that the legal definitions of corruption can be limited, therefore, in this study we will not use the narrow legal definition but instead focus on corruption as a phenomenon in the public sector. We believe corruption in the public sector is a form of corruption that can have one of the most harmful consequences, and that one, therefore, should address corruption in this sector first and then continue to tackle corruption in other sectors.

Søreide (2016) describes corruption as a *trade in decisions that should not be for sale.* This trade in decision is visualized in Figure 1, inspired by and simplified from an illustration by Søreide (2016). She presents a government institution or authorities that have an aim, Aim X in the figure, and a public official that is a decision-maker. The decision-maker can deviate

from the authority's aims. This deviation represents some 'cost' that the decision-maker will get compensated for by a personal benefit for the decision-maker, line A. Benefits can be tangible, for example, monetary compensation, or intangible like a service, change of power or something else the decision-maker would value. The principal-agent theory can also describe this relationship and will be elaborated further in Chapter 4.

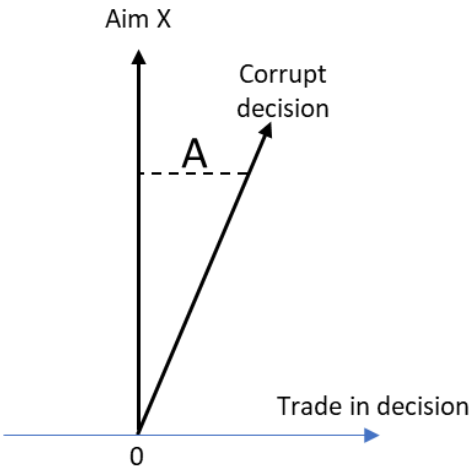

Figure 1. Corrupt acts – trade in decision that should not be for sale

From our definition, we can see that corruption, even within public sector can be an inclusive and vague term. Therefore, we want to elaborate on different forms of corruption. Søreide (2016) describes four different forms of corruption that will be useful to separate for the clarity of discussion; these are extortive corruption, bribery, collusive corruption, and negligence, and some of them we will explain in detail below.

Bribery is the offer or transfer of bribes and therefore is considered a more act-specific than the more character-describing 'corruption' (Søreide, 2016). For example, a bribe can be a monetary amount to influence a government decision. A more indirect form of corruption is *negligence.* This form describes an avoidable danger and the failure of detecting and differing from it. It imposes an increased risk of corruption that the activity can manifest. Negligence includes 'corruption fuelling' activities. For example, one can execute public procurement without transparency and external controls and thereby fail to avoid obvious dangers of corruption. It can also be government officials skipping controls or 'looking the other way' in their duties.

We can separate *extortive corruption* from the other forms with its asymmetrical allocation of bargaining power. If a government official demands a bribe for letting a citizen escape a fine

even though there was no crime committed and the citizen has no way to prove it, this would be extortive corruption. The government official can also misuse their power to demand a bribe for a service that would typically be at a lower cost or no cost at all. In these examples, the citizen has less bargaining power than the official. On the other hand, we have *collusive corruption,* which is a result of an agreement, because they distribute the bargaining power more or less equally. The parties involved collaborate to get a joint benefit at the expense of society. This form has more blurry boundaries as it can come close to lobbying. An example of collusive corruption is a business manager affecting a minister's decision on industry regulations or awarding a state contract by offering the minister a personal benefit. Collusive corruption is prevalent in public procurement as well when procuring authorities collude with suppliers regarding government purchases.

2.2 Risk areas

Corruption, as defined above, will be conditioned on circumstances that allow the players to abuse their power or a trade to happen. Thus, Søreide (2016) mentions four criteria that need to be in place for a corrupt action to happen. Firstly, the decision-maker needs to be in control of some value, monetary or non-monetary. Secondly, the decision maker must have discretionary authority to make decisions. Furthermore, the offer should surpass the total cost of the biased decision, including the risk of detection and the cost of reaction, plus moral cost. Lastly, there must be trust in a counterpart willing to enter the deal and not raise any alarms.

These four criteria help to identify risk areas. To develop this further, we can look at which category of monetary and non-monetary values imposes a high risk of corruption. Søreide (2016) presents a framework for categorizing corrupt distortions that can be used to analyze these values which we visualize in Table 1. The framework has two dimensions: type of value-allocation and degree of value scarcity. The allocation can be 'qualification-steered' or 'available for all.' Søreide and Rose-Ackerman (2016) describe the assessment of qualifications for benefits as a significant part of an official's discretionary authority to apply other criteria than the ones stated in a directive or law to allocate the benefit. According to that model, we can categorize scarcity as 'limited' or 'plenty.' Therefore, demand for a limited value, according to Søreide and Rose-Ackerman (2016), determines the equilibrium price, both legally and illegally paid.

		Type of allocation	
		Qualification-Steered	Available for all
Degree of scarcity	Limited	A	B
	Plenty	C	D

Table 1. Categorizing corrupt distortions

In this study, we are primarily focusing on public procurement, and we want to see where it fits into the given model. We know that the government awards procurement contracts to firms that are assessed on specific criteria to see whether they are eligible to receive the contract or not. According to the description above, this makes allocated procurement contracts qualification-steered. We also assume that the government has a limited budget for procurement purchases. These two characteristics make the contracts fall into category A, limited and qualification-steered. According to Søreide (2016), this is the category with the most dramatic consequences. The category also has a high risk of corruption as a distortion of both allocations and prices can happen. Also, an assessment of the tendering firm's integrity can lead to debarment when this is not sufficient. The official does now have another opportunity to execute discrete power, namely by excluding some firms from tendering. Hjelmeng and Søreide (2014) criticise the EU Procurement Directive of 2014 for allowing for precisely this form of corruption by giving the public official too much power in the debarment decision.

2.3 Corruption and technology

The growth of information technology has already caused significant economic, political and social changes across many countries. Its impact has been noted in the government sectors as well as many governments started realizing the potential benefits of technological advancements being an excellent tool to improve their service to citizens. Given that technological advancements make it logistically easier for governments to be more accountable and transparent, many activists, political leaders and experts in the field of corruption highlight its importance when fighting corruption. By facilitating the flow of information between government institutions and citizens, new technologies can promote

transparency, accountability and civic participation (Chene, 2012). Furthermore, Wickberg (2013) in U4 Expert Answer brings examples of how ICTs have been successful to reduce corruption in following ways:

1. ICTs for reporting, when technology makes it easy to report incidents of bribery through new channels. Websites, where citizens can report on bribery and petty corruption, such as "*I, Paid A Bribe"* that has been initiated in India and has been launched in other countries as well.

2. ICTs for monitoring, when online tools are increasingly being used to monitor budgeting, government activities and expenses and even political contributions to politicians.

3. ICTs and specifically social media such as Facebook and Twitter have been actively used to campaign and mobilize people to put pressure on politicians exposed in corrupt deals.

4. ICTs to improve citizen or business to government interaction, which is known as E-government. As mentioned above, this research will focus mainly on this type of technological impact because many countries increasingly use e-governments. In fact, multilateral institutions such as the UN and World Bank have recommended that governments across the world use e-government to serve their citizens better and reduce rampant corruption.

There is a considerable amount of research that focuses on the link and relationship between e-government initiatives and whether it contributes to reducing corruption. For example, Oye (2013) points out how e-government has reduced the administrative corruption and improved transparency in service delivery in African countries. We will have a more detailed discussion, of weaknesses of previous studies that assess this relationship in Chapter 5 of this thesis. Being motivated by those findings, we have collected data from the UN and TI to show the correlation between the level of technology and corruption. Figure 2 shows that there is a strong positive correlation between the ranking of a country's e-government and the Corruption Perception Index (CPI) in 2016[1]. On the vertical axis, we have a CPI, which is an

[1] CPI data for 2016 is collected from Transparency International website

annual ranking of 190 countries by TI since 1996 that has been determined by expert assessments and opinion surveys. Although the CPI score is criticised by Søreide (2016) who notes that TI does not assess each country in an exactly same way, it is still the most commonly used proxy to compare country-level corruption. The E-Government Readiness Index (EGDI)[2] on the horizontal axis is a composite measure of the capacity and willingness of countries to use e-government for ICT-led development, which is measured by the UN Department of Economic and Social Affairs. Based on our analysis of other indicators, we found that the CPI and the EGDI are suitable proxies to measure the level of corruption and technology used by governments, despite their shortcomings. Essentially, Figure 2 says that the countries that have the lowest CPI score (highest corruption levels) tend to be ranked quite low in terms of EGDI. To avoid further confusion, it is worth noting that further away from the zero position a country is on the horizontal axis, the lower it is ranking in terms of EGDI.

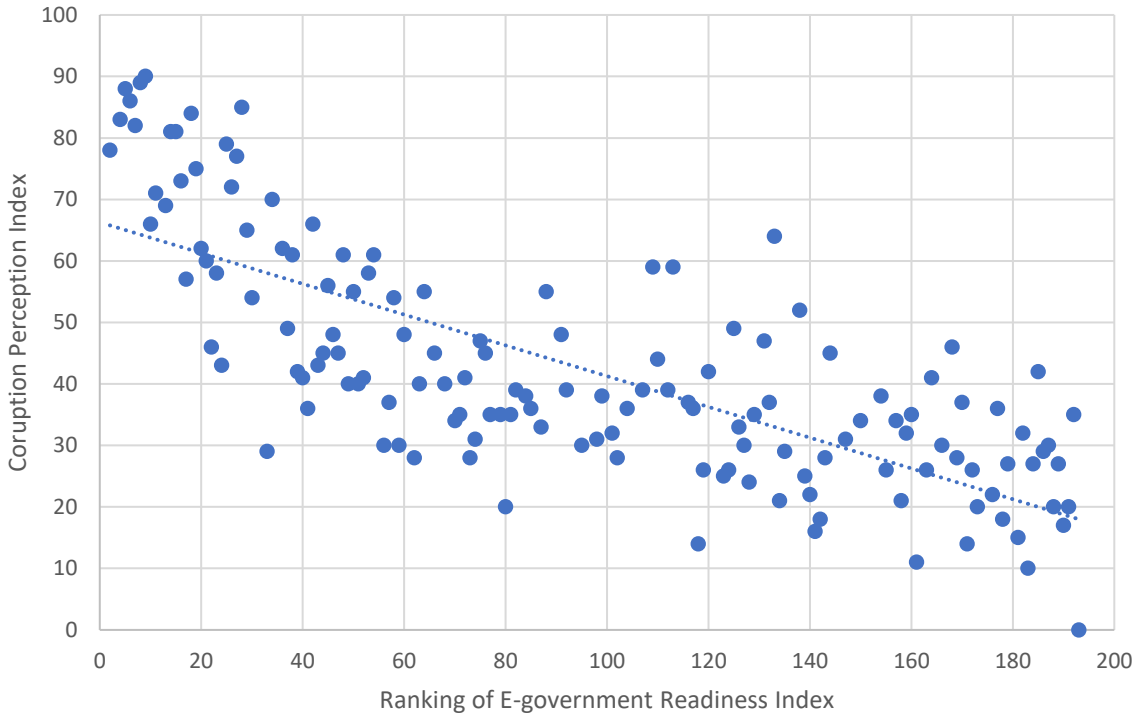

Figure 2. Relationship between CPI and ranking of EGDI in 2016

There is little reason to doubt that even if we use other indexes to measure the level of technological capacity of the country, such as CCI and ICT Development Index, the results

[2] The index rates the performance of national governments relative to one another by averaging three other indices: the Online Service Index, the Telecommunication Index and the Human Capital Index.

will show a similar trend of more technologically advanced governments having lower levels of corruption. For the same reasons countries with the lowest CPI score happen to be in the top of either the Web Development Index (WDI) or the Open Data Index (Granickas, 2014). Despite that seemingly simple correlation, the relationship above does not tell us anything about causality, and therefore we will address the endogeneity problems in those kinds of studies in Chapter 5. Many studies argue empirically that the use of e-government reduces corruption. However, as the World Bank (2016) notes, e-government initiatives have a varying impact and have been less useful in solving government failures associated with rent-seeking. Therefore, there is a need for further research. In fact, the same World Bank report also mentions that even in countries with high level of e-government, there is a high failure rate of complex systems that are intended to automate the government processes. Finally, when assessing the role of technology, it is crucial to mention that one of the most significant initiatives in e-government package of solutions has been the introduction of e-procurement. Public procurement is known to be most significant and most vulnerable to corruption in the public sector, which is why it is the focus of this thesis.

3. Corruption in procurement

3.1 Public procurement as a high-risk area for corruption

Procurement itself is an ancient phenomenon that has existed in one form or another throughout the history. Callendar (2003) briefly summarized the history of procurement practice being originated 2800 years ago, which included procurement practices of Roman armies back in 215 BC and supplier management principles that were suggested by King Gustavus in the sixteenth century. Nowadays, public procurement is an important mechanism that helps the government to perform its functions, and given an ever-increasing role of public procurements, there are many mechanisms on the paper to ensure an effective process. Unfortunately, those established mechanisms fail to reach their goals because corruption and inefficiency in public procurement is a common problem in almost every country in the world.

When analyzing procurements, it is worth noting that modern public procurement is a quite complicated process that involves various stakeholders interacting in a multi-stage process, which makes it more likely to be prone to corruption. The general stages of public procurement are depicted in Figure 3 below and consist of the main stages such as contract development, bidding processes, and contract management. The first stage starts with the identification of needs, which is determined at higher political level by parliament or an executive branch of government, followed by further administrative procedures conducted by public procurement officials.

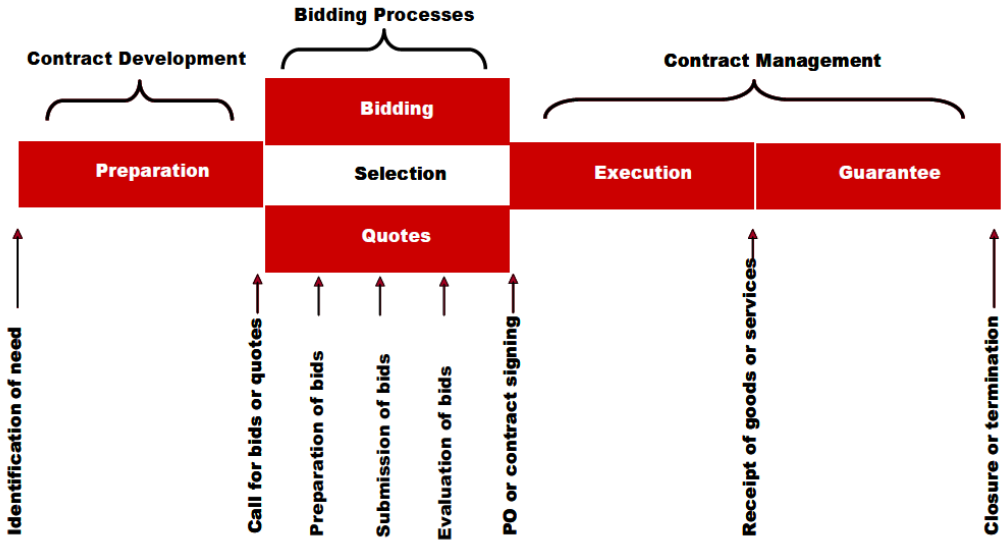

Figure 3. General stages of public procurement (Schapper, 2007)

To simplify the core problem of public procurement, one should consider how the American economist Milton Friedman defines four ways of spending money. First, he explains that a person can spend his or her own money on her-/himself. If this is the case, the person is cautious and try to get the best cost and quality combination possible. Second, the person can spend his or her money on somebody else; then he or she would most likely not be so concerned about the quality but will know the cost very well. Third, the person can spend someone else's money on him-/herself; this will make the person very concerned about the quality, but not the price. Lastly, the person can spend someone else's money on someone else, and both the concern of quality and cost will disappear. In his own words:

"(…) Finally, I can spend somebody else's money on somebody else. And if I spend somebody else's money on somebody else, I'm not concerned about how much it is, and I'm not concerned about what I get. And that's government. And that's close to 40% of our national income." (Friedman, 2004)

The carelessness of quality and cost that Friedman points at in the government underlines the problem of public procurement corruption and inefficiency in the form of public procurement where authorities as intermediaries, act on behalf of the citizens. To ensure proper governance and service delivery to its citizen's public procurements by governments need to be well designed to prevent fraud, waste, and corruption. Corruption can arise at any stage of the procurement processes that are mentioned in Figure 3. It can take place through violations of ordinary procurement rules or misuse of legal authorization for discretionary decisions (Schultz & Søreide, 2016). According to OECD (2016), the volume of public procurement in OECD countries is estimated to be 29% of government expenditure, amounting to 4.2 trillion euros in 2013. Thus, public procurement is one of the most significant areas of government expenses. Furthermore, up to 20-25% of the procurement budget is drained through corruption globally (OECD, 2016). Based on those numbers and expert analysis on corruption risks in public procurement, there is a commonly agreed idea that public procurement is one of the areas most prone to the risk of corruption, which needs to be prioritized by governments

globally. Thus, following Figure 4 from the OECD Foreign Bribery Report (2014), one can see that astonishing 57% of bribes were given to obtain a public procurement contract.

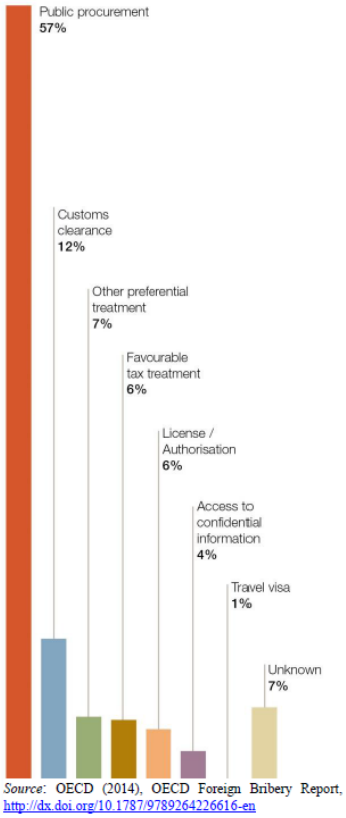

Figure 4. Purpose of the bribes according to OECD survey

Most of the advanced economies have a significant amount of public procurement as a share of GDP. In fact, the share of public procurement to GDP varies from 8% in Switzerland to 21% in the Netherlands (OECD, 2016). Although there are reports, such as the one conducted by PwC that measure direct costs of corruption and estimated to be between 1.4 and 2.2 billion euros in 8 EU member states (Hoskens et al., 2013), we doubt their reliability due to disagreements on the ways to measure corruption costs among the scholars. Despite the difficulties in measuring the actual monetary costs of corruption, we should not underestimate the importance of efficient and corruption-free public procurement as an instrument to help any country to overcome its socio-economic challenges. Thus, Jeremy Douglas, the Regional Representative of UNODC for Southeast Asia and the Pacific, highlighted that *"managing corruption risks in public procurement is one of the urgent priorities for the region to promote sustainable development"* (Beth, 2017).

The devastating consequences of corruption in public procurement, which has become one of the most severe obstacles for development, can be illustrated in the simple example of a school

that is being built by a firm that won government contract unfairly. Because of that, the firm responsible for building the project will charge a higher price and might even build a lower-quality school if the contract was awarded to the best firm (Davoodi & Tanzi, 1997). As Søreide (2002) states, corruption in public procurement makes officials purchase goods and services from the best briber instead of choosing the best price-quality combination.

When researching corruption within public procurement, we can distinguish between two levels of corruption. The two levels are *political* or *high* level on the one hand and *administrative* or *bureaucratic* on the other hand. According to Davoodi and Tanzi (1997), *political corruption* takes place in the phase where the budget is prepared, and this is when the political decision is to be made. When corruption takes place in the execution of the planning, it will be *bureaucratic corruption*. As political corruption is perceived as more complicated and harder to identify or measure we want to focus on how e-government technology solutions such as e-procurement can help to reduce administrative or bureaucratic corruption in public procurement. Despite these distinctions, it is worth to note that one cannot draw a strict line separating those two forms, since there are many instances of corruption in public procurement have elements of political and administrative violations and most often they have strong links between each other.

3.2 Electronic procurement

There are several definitions of *e-procurement.* The World Bank (2003) defines it as the use of information technology (especially the internet) by governments in conducting their procurement relationships with suppliers for the procurement of works, goods, and consultancy services required by the public sector. Other definitions focus on the fact that handling of all procurement processes should be fully electronic, whereas the EU offers a similar definition as the World Bank, but includes public sector organizations in addition to governments as well (European Commission, 2008). Additionally, Lindskog and Wennberg (2002) define e-procurement as the use of web-based technology to support key procurement process:

1. Requisitioning

2. Sourcing

3. Contracting

4. Ordering

5. Payment

This definition lacks strategic focus, and the concept of value for money because procurement is not only an operational process within the organization; it has become a strategic source to support the long-term goals (Carr & Ellram, 1994). Even though the definitions of public e-procurement vary depending on experts of which angles study it, there is a general compromise that it can be studied from four disciplinary streams. Those are Information Systems/E-Commerce, Public Procurement, Supply Chain, and E-Government as shown in Table 2 (Vaidya & Campbell, 2014). While e-procurement is described differently across various academic disciplines, we believe the definition by Vaidya & Cambell (2014) to be most suited for this research because it covers all the important aspects of it:

"Public electronic procurement is the use of the internet based inter-organizational information system, which automates and integrates any part of the procurement process in order to improve the efficiency and quality in public procurement and to promote transparency and accountability in the wider public sector."

Information Systems/ E-Commerce	**Public Procurement**	**Supply Chain**	**E-Government**
Description (enabler)	Action (process outputs)	Action (operational outcome)	Action (strategic outcome)
The use of the internet-based inter-organizational information system	Automates and integrates any part of the procurement process	Improves efficiency and quality in supply chain	Promotes transparency and accountability in the broader public sector

Table 2. Four academic disciplines related to public e-procurement

3.3 E-procurement gains

There is an enormous amount of benefits of e-procurement. Therefore, we need to discuss each of them as a useful tool to reduce corruption in the public sphere. Below is a list of the three

significant benefits of e-procurement and their implications that have been identified by policymakers and experts:

1. Lower entry-barriers. Suppliers have fewer barriers to submit a bid; more suppliers imply more competition for government contracts, which can lead to significant savings of taxpayers' money. Furthermore, the use of e-auctions for procurement of goods, services, and works, can also lead to a higher number of bidders, which again should result in lower prices for government purchases.

2. Greater transparency and improved accountability. E-procurement systems make it much easier for the public and suppliers to access information about the volume of contracts, awarded prices and disclosure of all other relevant information to the deal. The monitoring tools, and readily available information help to build trust in the system. Greater transparency and improved accountability are crucial for potential suppliers because the government lets them know that the rules of the games are fair, and the best supplier will win the contract without having any additional channel of influence.

3. Savings in administrative and human labor costs. Automating complex procurement processes usually, lead to efficiency gains. An audit of the introduction of the electronic process in Australia's Department of Natural Resource and Environment shows that because of e-procurement, 8 of the 15 steps were simplified, which resulted in substantial cost savings for the government (Auditor General, 2003). Furthermore, the increased efficiency is also supported by Egbu et al. (2004) who revealed that through the implementation of an e-procurement system, a steel supplier was able to carry out a multi-million-pound project with only 20% of the staff the company would usually have used.

In theory, the benefit of e-procurement seems to be clear. However, with this thesis, we want to quantify and examine some of these benefits to see whether there is an actual tangible outcome in the form of reduced prices and increased competition. The next section will elaborate more on the economic theory behind a corrupt act, how we would expect the price of purchases to behave under certain conditions, and it will end with the two hypothesis we must use to answer our research question.

4. Theory and hypothesis

4.1 Principal-agent theory

Corruption can disturb market mechanisms and slow down economic development. When the officer in public procurement chooses the best briber instead of the best qualified or best price-quality combination, it can result in high prices, and low quality (Søreide, 2002). There are plenty of corruption risks, which were explained in Chapter 2.2 and they are applicable in public procurement as well. Even when assuming the participants of procurement are honest actors, economic theory suggests that there is a high risk of collusion between procurers and suppliers due to economic incentives.

A well-known economic theory referred to as the principal-agent theory, can be used to explain corruption that occurs in the government, including in public procurement. A central aspect of this theory is an assumption of information asymmetry, which permits misalignments in interests to influence government decisions. According to Eisenhardt (1989), the principal-agent problem, also known as agency problem states that when one person or entity (i.e., the agent) makes decisions on behalf of someone else (i.e., the principal), that person faces a dilemma. This dilemma always existed because agents are motivated to act in their own best interests, which might be contrary to principals' interests. Even if the principal in the form of government is benevolent, there is a high risk of abuse of power because most of the principal's work is delegated to agents, who are motivated to act in their self-interest. This interest was also illustrated in Figure 1 in Chapter 2.1.

In the context of our theme, procuring entities that oversee, and award government contracts are agents, whereas the government itself is the principal. The agent is acting on behalf of the principal, and the principal cannot monitor everything the agent does. This monitoring problem creates an information asymmetry, where the agent has more information on his/her actions than the principal. In the procurement setting, the government cannot control whether the procurement entity is acting trustworthy when it comes to spending public funds appropriately and efficiently. This principal-agent problem is well explained by Aidt (2013) in the case of tax collectors and the government, which is very similar to the relationship between public procurement officials and the government. We will, therefore, shift the example by Aidt (2013) to this setting: There are three players; a public procurement official (agent), the government (principal), and a firm. The agent must procure a specific good on

behalf of the principal to satisfy citizen's government-provided services. The firm is willing to pay the agent a bribe, so the agent purchases those goods from that particular firm, instead of buying it from the best firm in the markets. The agent or procurement entity is willing to take a chance by accepting the bribe and circumvents the procurement policies to award a contract to a firm that gave him or her a bribe. It is worth stating that he is only willing to do so if the expected gain, is larger than the return to honest procurement. This theory can be shown by the following formulas:

$$Expected\ gain\ of\ agent = (1-p)(w+b) + p(w_0 - f)$$

$$Expected\ gain\ \ of\ a\ firm = \ \pi - pg,$$ where

p	Probability of discovery
w	Wage of the agent in the public sector
w_0	Wage agent can get in private sector
b	The bribe
f	Fine imposed if caught
g	Legal sanctions for the firm
π	Firm profit from the corrupt act

The result of getting caught *(p)*, will be a fine and the agent losing the job in the public sector, whereas the firm will get legal sanctions (*g)*. We assume the agent has no bargaining power, thus, the bribe (*b)* is decided by the firm and should be lower than the companies gain by the corrupt act. The agent accepts the bribe only if the expected gain by committing a corrupt action for a bribe is larger than honest procurement.

$$b \leq \pi - pg$$

$$(1-p)b + p(w_0 - w - f) > 0$$

In the example above some of the decisive factors are clearly out of the agent's and firm's control; the wage of a public official, the probability of getting caught which is determined by the monitoring system, and the consequences of getting caught represented by the fine and

legal sanctions. Thus, the government can improve its institutions and build proper mechanisms that will affect wage (*w)* and the probability of being caught (*p).* That, in turn, will reduce incentives for agents and firms to collude. When firms cannot collude, there is no additional bribe given to procurers, the tender is awarded to the best bidder with the lowest price, and therefore the final price paid for a government purchase should decrease.

There have been already other studies that focused on measuring the impact of a public wage increase on corruption. Therefore, in our instance, we are focusing on technology such as e-procurement used as a tool for governments to increase the probability of discovery of dishonest practice in public procurement. E-procurement centralizes public procurement processes and makes it easier for the principal to monitor agent's actions at low cost. It does so through giving the public access to all public procurement information. This high level of monitoring should, in theory, make procurers and firms less likely to engage in corrupt activity, assuming the new system reduces information asymmetry between principal and agent. Although a complete information asymmetry is nearly impossible to achieve, e-procurement enhances transparency and accountability significantly, which in turn should minimize information asymmetry between the government, public procurers, and suppliers.

Furthermore, awarding big contracts to certain suppliers over others due to bribery also affects the market and agents in the private sector. Therefore, competing suppliers should be incentivized to report suspected collusion if they have easy access to information through e-procurement. In fact, many e-procurement solutions have designated portals, which make it easy for any relevant stakeholders to report suspicious activity real time. This reporting should reduce the cost of monitoring for governments because now everyone, including the private market players, can monitor for potential violations. As noted by Mookherjee and Png (1992), it is more cost-efficient for government to rely on those reports to decide when to start investigation rather than to conduct random investigations. If the principal becomes better at investigating a suspected corruption, *p* will increase, and agents and suppliers are less likely to be involved in the corrupt activity, which should, in turn, affect the prices and competition among government purchases.

E-procurement helps to reduce the problem of information asymmetry between the governments, procuring entities, and firms. That combined with several other benefits mentioned in Chapter 3.3, should result in a decrease in prices paid for government purchases over time. Although the reduction of prices might be due to increased competition and

improved market conditions, one can also claim that increased competition and reduced prices are consequences of a reduction in corruption as well.

4.2 E-procurement impact on various purchases

Although our initial research question focuses on the impact on corruption, we are aware of the links between corruption, prices, and competition. Therefore, in this study, we explore the impact of e-procurement on prices and competition instead. Furthermore, we argue that e-procurement will have a varying impact depending on the complexity of the type of purchase. We believe that the more complex the goods, services, and works that government purchases, the more challenging it is for the principal to detect collusion in public procurement. The varying impact occurs mainly because of lack of sufficient knowledge about the costs of the purchases, challenges of estimating the actual market price and difficulties of having objective criteria to assess whether procurers have evaluated bids solely on market principles. The primary motivation behind focusing on differences in the impact on prices among various purchases is that previous studies have only assessed the e-procurement or e-auction on prices overall without taking into consideration the differences in the types of purchases. All the studies that focus on the relationship between price and e-procurement will be elaborated in detail in Chapter 5 of this thesis. This study, on the other hand, understands the complex nature of government purchases and therefore focuses on those differences when assessing the impact of e-procurement.

The challenges concerning estimating the market price of complex purchases are noted by George Moody-Stuart (1997) who calls it *mystification* and claims that the more high-level technology involved, the more attractive the project will be to the potential beneficiaries and this kind of mystification reduces the risk of being criticized for paying too much. Although this notion has been debunked by one of our interviewees Larysa Luzinska who said that competitors of the firm have a necessary expertise required to tell whether the awarded price reflects the market price. In the case of more straightforward purchases, e-procurement monitoring makes it easier for any member of the public to compare the contract terms with market prices. That, in turn, pressures stakeholders to not engage in a dishonest practice which will result in obviously overinflated prices for purchases. The easily availiable comparison is not the case for more complex purchases, where procurers have the higher discretionary

authority and more tools to manipulate the outcome of the tender. Therefore they might still be willing to collude despite e-procurement.

There are other scholars, who highlight the importance of the differences between various forms of government purchases. Rose-Ackerman (1999) summarizes that corruption is more common in a category of public goods than others because of differences in procedures and characteristics of final goods and services that are being purchased by the government. Furthermore, she groups purchases into four main categories, which include purchasing *standard goods* sold in open markets, purchases of *specialized research and development product, customized goods or services* and purchase of *complex special purpose projects* such as dams and bridges. Although Rose-Ackerman (1999) acknowledges that there are mechanisms in the case of standard goods and services, International Competitive Bidding for projects funded by the World Bank, there are still many corruption challenges with complex projects. Thus, purchases of more advanced goods, services, and especially works need stricter requirements and more complex procedures, which in turn make it relatively easier for procurers to cover their wrongdoings even after introducing e-procurement. As a result, we believe that the impact of e-procurement affects corruption through price reduction to a lesser extent on more advanced purchases.

4.3 Hypothesis

Based on the above mentioned economic theory and the mechanisms through which e-procurement can impact the prices, we can propose our hypotheses. Moreover, following up on the discussions of potential benefits of e-procurement, we provide a summary of all the arguments that support our hypotheses in this section.

E-procurement's benefits, such as higher transparency and accountability, easier access for firms to participate and complain about the process, and monitoring tools that empower the public, make it more likely for e-procurement to have a positive impact by reducing the prices paid for public procurement purchases. Additionally, this reduction in prices varies depending on the type of purchase. Although we have already discussed in Chapter 4.2 the reasons why the impact would be lesser for more advanced purchases, some can argue the opposite, claiming that the impact is stronger for more advanced purchases. The opposing camp can claim that even before e-procurement, the purchases of simple goods and services have been competitive enough due to the nature of purchases. According to opposing view, an

introduction of e-procurement could affect more advanced purchases to a higher degree. Nevertheless, based on the theory and existing literature about the links between e-procurement and corruption, through an impact on price and competition, we came up with following hypotheses:

Hypothesis 1: E-procurement reduces the prices of public procurement over time.

This first hypothesis aims to investigate the first part of our research question: *to what extent do implemented e-procurement solutions benefit the public sector in terms of reducing corruption.* As already argued, we use the price as an indicator of transparency and competition which again can be connected to the level of corruption because corruption as a phenomenon is hard to measure or quantify. We assume the adaptation and on-boarding process of an e-procurement solution will be gradual in public procurement. This hypothesis will test if the system will gradually introduce more competition and transparency (as in control functions) in the procurement process and leads to the tenderers adjusting their prices accordingly.

Hypothesis 2: The more advanced the public procurement purchases are, the weaker is the impact of implemented e-procurement solution on the price of those purchases.

The second hypothesis is aiming at the second part of our research question: *do implemented e-procurement solution have the same effect on public sector's purchases across goods, services, and works?* We assume goods correspond to less advanced purchases and services and works to more advanced purchases. The effect of implementing an e-procurement solution is expected to have a weaker impact on the more advanced purchases because they typically require more complicated procedures and price estimations. As a result, there is more subjectivity to the process which prevents e-procurement to have an equally strong impact as in case of simpler purchases. In case of more advanced purchases, there is stronger information asymmetry and therefore higher risk for corruption than for simpler purchases where information asymmetry can be solved through technology.

5. Empirical literature

5.1 Macro-studies

Most of the previous studies that aim to assess the relationship between technology and corruption are cross-country studies conducted on a macroeconomic level. As mentioned in Chapter 2.3, most of the studies fail to address significant econometric challenges, while assessing the relationship between the level of technological development and corruption. Although they do find that higher technological advancement in government is strongly correlated with the lower level of corruption, many of those studies fail to bring sufficient reasons to believe that there is no endogeneity problem present in their methodology.

There is an attempt to address endogeneity problem by Andersen (2007) through the introduction of an instrumental variable (IV) for e-government. His IV is the percentage of land area in the tropics, which affects the level of technology (dependent variable) and does not affect corruption (independent variable). As a result, the author finds that countries that have invested more in e-government have also seen more significant reductions in levels of corruption. Despite using IV, critics can still claim that it could be the initial low level of corruption that encouraged the governments to invest in ICT. That raises questions about the reversed causality problem in the study conducted by Andersen (2007).

Another cross-sectional study by Lupu and Lazar (2015) explore the relationship among EU and non-EU members and found that EU accession has reduced corruption with e-government, but again failed to show the causal effect of e-government on corruption. Most of those cross-country studies use accepted macro-indicators that show the perception of corruption in the country, such as the commonly used CPI index published by TI. As was mentioned before, many scholars in the field of corruption have criticized this index because it is determined by a narrow group of expert assessments and opinion surveys that could be biased. They have attacked the reliance of CPI on the opinions of a small group of experts and businesspeople. For example, Alex Cobham, from the Centre for Global Development, says that CPI *"embeds a powerful and misleading elite bias in popular perceptions of corruption"* and therefore can lead to inappropriate policy responses. (The Guardian, 2013)

Given how many factors influence corruption and complexities related to the reliable measurement of the magnitude of corruption, with endogeneity problem being especially hard to control at the macro level, this study will focus on a case study instead.

5.2 Case studies

Beside cross-country studies, there are also papers that focus on the specific case in the country, where e-procurement solutions have been implemented. One of the strengths of using a case study as a method of research is that it allows authors to explore more in-depth the causal mechanisms. Furthermore, it lets the researcher address the complexity of the relationship analyzing all the aspects of the case within the micro-level. In one of those studies where the case of Estonia has been used, Karv (2015) assesses explicitly how e-government reduces the corruption levels through increased transparency, better accountability, the disappearance of middleman, and bridging the gap between public workers and citizens. Like other studies, the author fails to bring enough justification to explain that those changes happened solely due to e-government and not because of other factors, such as significant post-transition reforms supported by EU to make Estonia its member state.

Another study, which is more relevant to our research, focuses on measuring the impact of e-procurement on infrastructure provisions in India and Indonesia. Lewis-Faupel et al. (2014) did not find in their impact assessment that e-procurement reduces prices paid by the government, but did find that it is associated with quality improvements. Authors of the study used the difference-in-difference method to compare states in India, where e-procurement has been introduced to the ones where it was not introduced. Criticism of their methodology says that adoption of e-procurement in some states in India was not randomly assigned. Consequently, it raises a question about inherent differences in the form of institutions or leadership in those states that lead to the outcome authors reached.

Studies that aim to find a correlation between e-procurement and corruption use different kinds of data to measure correlation. For example, Neupane et al. (2014) collected their data through conducting face-to-face field surveys with government agencies and e-procurement organization staff members in Nepal, where public e-procurement was introduced in 2008. This study explored three independent variables: a monopoly on power, information asymmetry, transparency, and accountability. Using partial least squares methods, Neupane et al. (2014) assessed perceptions of 46 government officers on the potential of public e-

procurement to reduce corruption. Their findings suggest that the intent-to-adopt e-procurement has a positive and significant relationship with independent variables mentioned above. However, we want to point out that their data might not be as objective as it should be due to their methodology that solely relies on collected information from interviewing and surveying e-procurement authorities, who could be biased when evaluating their own program. That bias aside, their study does not bring any evidence regarding the impact of e-procurement post implementation and focuses on the factors that can encourage the initial use of e-procurement for government agencies. It is a widely recognized problem that many e-procurement initiatives have been evaluated by the parties that are interested in showing its positive impact and therefore might not be as objective, given their goals.

There are additional studies that focus on factors that influence the final price of government purchases through public procurement. One of those factors is competitiveness, and Grega and Nemec (2015) found using regression analysis that with every additional competitor, there is 2.63% increase in savings in public procurement in Slovakia. However, their study only focuses on the relationship between e-procurement and its effect on price and competition in auctions. Furthermore, they assess the impact based on the source of financing of tender and other factors and do not explore the role of corruption in achieving changes in price or competition levels. There are also studies showing the positive impact of auction markets, including for government contracts. Brannman et al. (1987) found out that the probability of the coordination (tacit or explicit) between sellers decreased when the number of potential sellers increased. However, since their research is quite old, it does not cover the implications of auction markets within e-procurement, which is a relatively recent phenomenon.

Apart from the limited number of studies that assess the impact from e-procurement on the price of specific homogeneous goods, we could not find any papers that focus on the impact of e-procurement on various kinds of purchases by the public sector. Consequently, our thesis aims to fill the gap by assessing the impact of e-procurement on goods, services, and works, and further elaborate on possible reasons for those differences. After evaluating advantages of various methods, including cross-country analysis, we chose to focus on a specific case of e-procurement reforms in Ukraine to assess the research question in this thesis.

6. Data and empirical method

6.1 E-procurement in Ukraine

We want to explore the causal link between e-procurement and corruption and will focus on the case of Ukraine, where e-procurement reform was considered a relative success. Following the Ukrainian revolution of 2014, which resulted in the overthrowing of the corrupt government of Viktor Yanukovich, a group of inspired and motivated business and civil community leaders were interested in changing Ukraine. Knowing that the most common form of corruption exists when government purchases goods and services, they launched an initiative, which became the catalyst for public procurement reforms. With the support of international donors, the activists created a platform called ProZorro that digitalized the process of public procurement through an online system and collaboration environment that ensures an open access for tenders in Ukraine. Before ProZorro was established, the state of public procurement in Ukraine was poor. Half of the tenders were non-competitive, and negotiation with only one supplier was the most frequently used procedure (Marín, 2017). Enormous amounts of public funds were spent on low-quality infrastructure projects, and in some instances, the built roads, bridges and government buildings were not usable. According to the Ministry of Economic Development, Ukraine was losing 2 billion US dollars or 2.2% of GDP per year due to different corruption schemes and inefficiency in the public procurement sphere (Marín, 2017).

Interestingly, Ukraine is one of the few countries in the world, where a volunteer-initiated effort resulted in the complete reformation of state-owned enterprises that administered public procurement nationally. It was initially started by civil society and business activists and later was institutionalized by politicians and the government, in that sense, ProZorro implementation is a unique example of the bottom-up approach to innovation and reform. While the pilot program launched in February 2015 only included sub-threshold procurements by the Defence Ministry, other government entities gradually have been recommended to conduct their below-threshold procurements via the new platform. After receiving positive feedback by those procurers about the new system, the Ukrainian parliament passed a new law "On Public Procurement," and from August 2016 ProZorro became mandatory for all procurement authorities for tenders exceeding 200 thousand hryvnias (Ukrainian currency) for goods and services, and 1.5 million hryvnias for works.

The unique feature of ProZorro is its hybrid system, which implies that procurers announce tenders in a centralized database, tenderers (i.e suppliers) can bid for contracts through the website access provided by marketplaces. Thus, suppliers can choose the marketplace that best serves their needs. Figure 5 below shows the architecture behind ProZorro, which will be explained in more detail after the figure.

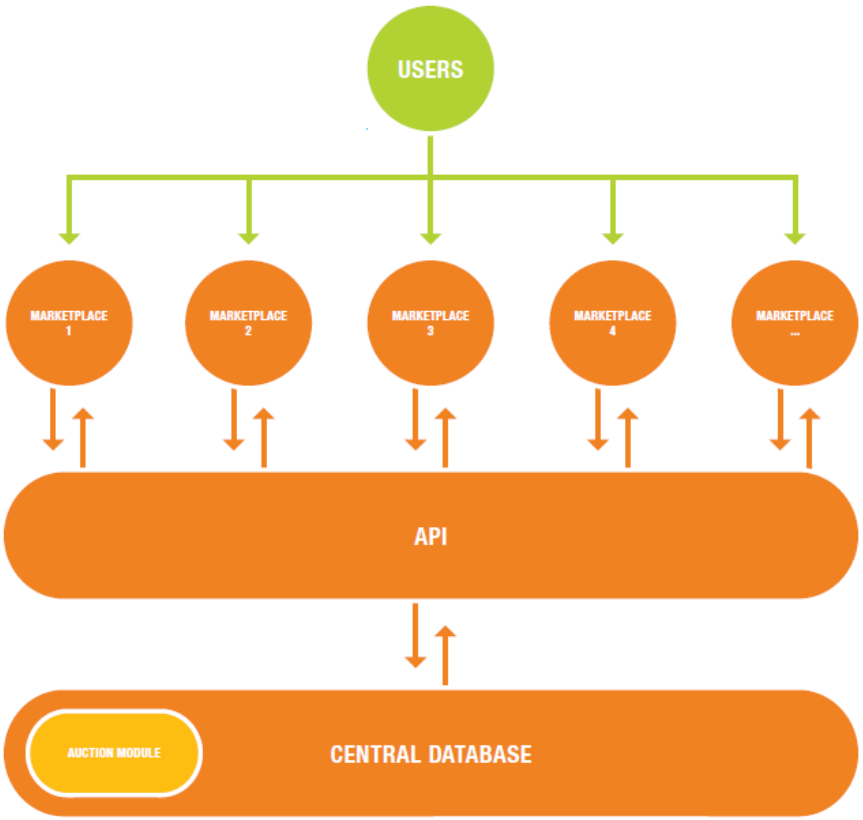

Figure 5. ProZorro architecture (Marín, 2017)

The ProZorro program is built on a central database which is connected with various marketplaces through an Application Programming Interface (API). Private marketplaces pay a fee to ProZorro and compete among themselves for suppliers, which also pay a fee to participate in the bidding procedure. This unique model establishes a competitive market mechanism that helps to cover ProZorro's maintenance and administrative expenses. In fact, the private market mechanism allows ProZorro to pay its own staff above average public wages. This should not be underestimated given that Ukraine's public sector has a lot of challenges attracting competent staff due to a wage gap with the private sector.

The implemented system also has an online portal, where the public can have access to all tender information for procurements that have been conducted through ProZorro. There is no need for the public to register an account to access necessary tools to oversee all the steps in

awarding a procurement contract, this makes it easy for the public to monitor and detect violations in real time. As Yuri Bugay, one of the early founders for ProZorro said during an interview with us (see Table 13 in Appendix) that contrary to the 22 public officials that monitored public procurement in Ukraine before, there are now potentially 44 million citizens of Ukraine that can monitor the suspicious behaviors through ProZorro. In addition, suppliers can easily complain if there has been an unfair procurement process, and their complaints get reviewed by relevant authorities.

One of the reasons, we chose to focus on ProZorro is because we believe that in the case of Ukraine it is easier to argue that the impact on prices is more likely to be caused by ProZorro and not other factors. This is the case in Ukraine because, despite all the promises to reduce corruption by the new post-revolution government, there has not been any significant change in corruption levels in Ukraine according to the international organizations like the IMF and World Bank (Polityuk & Prentice, 2017). There is a widespread opinion reflected by polls that the new Ukrainian government failed to adequately implement its promised reforms to fight corruption (Rating Group Ukraine, 2016). Ukraine's CPI score has improved only by 3 points since 2014, and the country was ranked 132th in 2016 in the same index. TI Ukraine (2016) admits that Ukraine still faces enormous challenges due to its weak institutions, excessive economic regulations, and consolidation of powers in the hands of oligarchs.

6.2 Collecting data

We are focusing on data that was available in the ProZorro database. In addition to our data on procured contracts by Ukrainian authorities from the end of 2015, we have also collected qualitative information based on the interviews with various experts in Kyiv. We have interviewed previous and current ProZorro staff, researchers from Centre for Excellence in Procurement at the Kyiv School of Economics, and other international experts who provided us with their point of view, which complemented our quantitative data. The list of all interviewees and their respective positions is attached in the Appendix. Those interviewees provided us with comprehensive and valuable insight and further information on how to evaluate and assess ProZorro from various points of view, including suppliers' concerns. Unfortunately, we could not access the data for government contracts before ProZorro had been implemented, and therefore have focused our attention only on the impact of e-procurement since the launch of the program from February 2015 until November 1st, 2017,

see details on the data in the appendix. We decided to include procurements that were conducted in the system before the law "On Public Procurement" that requires all state institutions in Ukraine to use ProZorro and was approved, hence before August 2016, because some of the procurers were early adopters and used ProZorro voluntarily from the introduction of the program. All the data used in this chapter was obtained from ProZorro's two analytics modules the public and the professional (Qlik Tech International AB, 2017). Those analytic modules provided us with real-time in-depth information about the public procurement deals.

We would like to elaborate on how impact can vary depending on the type of the purchase since there is no quantitative indicator that can estimate the complexity of the purchases. Purchases are divided into three categories in ProZorro, and we assume that purchases in the category of goods will be the least complex type of purchases, followed by the categories services and works being more complex types of purchases. We argue this categorization is reasonable given that the process of purchasing the works and services requires more analysis and assessment compared to purchasing simple goods, which can be easily compared with similar goods sold in the market.

In ProZorro, government purchases are categorized according to CPV, which is a generally accepted standard, used by most European public procurement institutions. European Commission drafted CPV to standardize, by means of a single classification system for public procurement the terms used by contracting authorities and entities to describe the subject of contracts. Hence CPV divides government purchases into three main groups such as goods, services, and works. As shown in Table 12 in Appendix, CPV codification consists of a vocabulary that defines the subject of the contract and is made up of 8 digits to add further qualitative information about the purchase. Furthermore, the same table also shows which sub-categories belong to goods, services, and works. We are primarily interested in the impact of ProZorro on prices and competition levels and want to focus on how the impact of e-procurement varies among those types of government purchases.

6.3 Main sample

Our sample is comprised of all contracts that have been issued through ProZorro. As of the time of our analysis[3], the total number of tenders was almost 979 thousand, which is estimated to have a market value of 32 billion euros. The chart below shows a rough breakdown of all tenders by their share of estimated value according to their status.

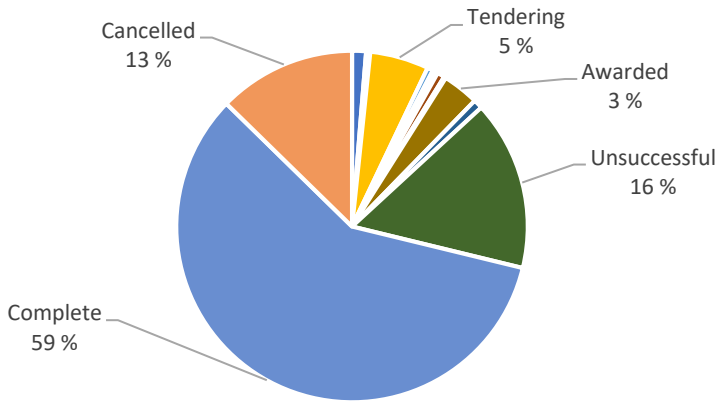

Figure 6. Tender division according to their status and estimated value

For this study, we sampled the completed contracts, which have an estimated value of 17.79 billion out of a total of 32.45 billion EUR[4]. We are focusing on the tenders that have been completed because we are interested in the outcome of such tenders. Table 3 shows descriptive statistics of all completed tenders from the launch of ProZorro until November 2017.

CPV Type	Number of Tenders (thousands)	Savings (million euros)	Number of procuring entities (thousands)	Estimated value (billion euros)	Number of bidders (thousands)
Goods	636.41	557.86	23.5	9.79	81.95
Services	205.97	126.97	16.01	2.55	50.24
Works	137.22	280.29	13.87	5.85	22.56
Total	**979.6**	**965.12**	**53.38**	**18.19**	**154.75**

Table 3. Descriptive summary statistics

[3] The data in the report has been extracted as of November 1, 2017

[4] The English version of analytics tool automatically converted the numbers to euro according to present exchange rate. (November 1st, 1 euro = 31.33 hryvnas according to XE.com)

As one can observe from Table 3, goods make up the highest shares of tenders in terms of their numbers as well as the estimated value. Although there is a higher number of tenders in the category of services than for works, the estimated value of works is higher, 2.55 compared to 5.85 billion EUR. This indicates that on average the value of tenders among works are higher because construction projects and works are costlier.

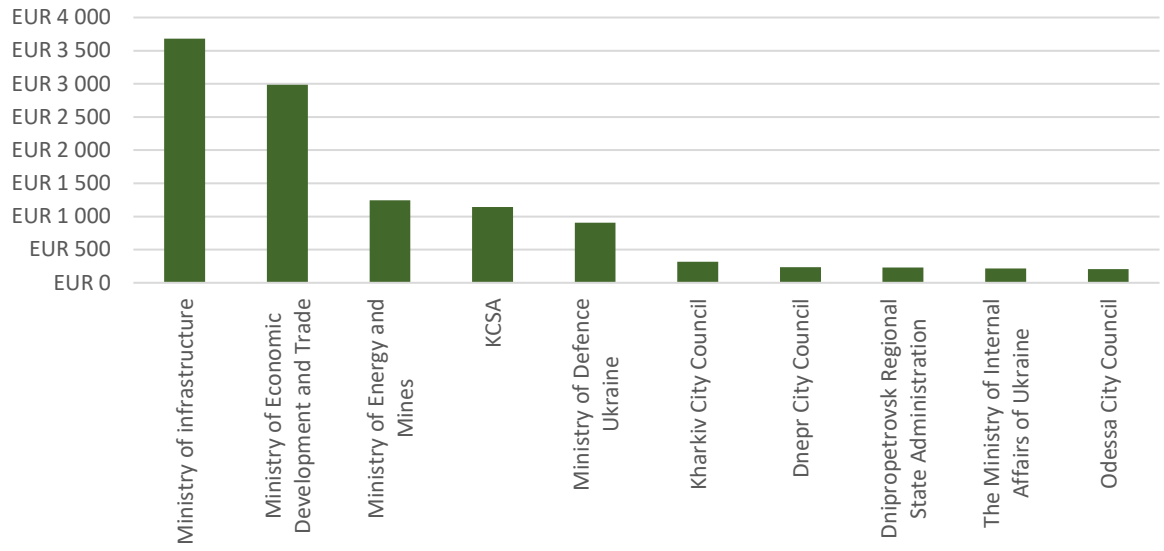

Figure 7. Top procuring entities by estimated market value of completed tenders (in millions of euros)

Figure 7 shows that most government purchases are conducted by the Ministry of Infrastructure, Economic Development, Energy, and Mines, and Kyiv City State Administration (KCSA), closely followed by other institutions. This implies that most of the public funding that has been distributed through ProZorro goes towards Ukraine's investment in the development of its infrastructure, energy projects, fostering trade, and economic as well as expenses necessary to maintain living conditions in Kyiv area.

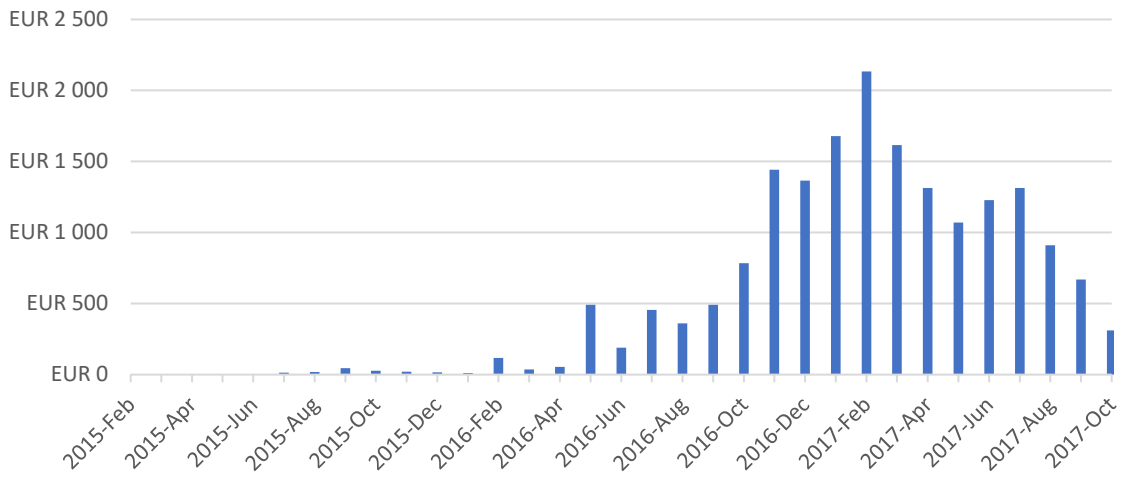

Figure 8. Estimated market value of contracts over time (EUR in millions)

As can be seen from Figure 8 which shows the estimated market value of contracts from February 2015 to October 2017, the value of all the completed contracts increases significantly over time since more procuring entities are obliged to conduct their purchases through the e-procurement system. There is a particularly noticeable increase by the end of 2016 when the law "On Public Procurement" has been passed in the Ukrainian parliament followed by a further decrease in 2017.

There are 6 types of procedures for procurements according to the Ukrainian public procurement laws. They are grouped into competitive and non-competitive types as shown in Table 4 and 5 below.

Procurement Method Type	**Number of procedures (thousands)**
Contract reporting	590.3
Negotiation	25.6

Table 4. Non-competitive procurements

Procurement Method Type	**Number of procedures (thousands)**
Sub-threshold procurements	312.8
Open tenders	63.2
Open tenders with English language publication	4.6
Negotiation procedure for defense needs	1.4

Table 5. Competitive Procurements

When it comes to geography, Figure 9 shows that the total value of contracts across Ukraine varies and one can see that the Kyiv region along with Dnipropetrovsk, Kharkiv, and Odessa regions are where most of the public funds are spent. Those are the areas where most Ukrainian people reside and are considered the most important industrial hubs that support the economy. Which can be some factors that explain the difference in the government expenses.

Figure 9. Expected value of completed contracts across different regions of Ukraine (Qlik Tech International AB, 2017)

6.4 Variables

This section will describe the variables used in this study. Most of the variables come from the publicly available ProZorro analytic modules and are listed in Table 6. We want to see how those indicators have changed over time as more suppliers and contractors have started using ProZorro. Therefore, all those variables are dependent variables, except inflation which is a control variable. We include inflation as a control variable because we expect that an increase in the rate of inflation will result in an increase in the initial prices of goods, services, and works (Sheshinski & Weiss, 1977). There are many other factors that may have affected price levels, such as ongoing conflict with the rebels in eastern Ukraine and economic embargoes imposed by Russia. Inflation is the control variable that captures the impact of all those factors in the price levels in Ukraine. For further description of the variables see the table below.

Variables	**Description**	**Source**
Estimated value	Estimated market value of tender that the procurement entity announces. (in millions of euros)	BI ProZorro
Awarded price	The price offered by the supplier who ends up winning the tender because of the auction. This price is used in the contract signed with the winner of the procedure.	BI ProZorro
Savings (amount and percentage)	The difference between estimated value and price proposal of the winner of the auction. In addition to absolute value, we have also included the ratio of amount of savings to the total amount of procurement (in %)	BI Pro ProZorro
Average price reduction	By how much the awarded price has decreased compared to the estimated value for all contracts procured. (in %)	BI ProZorro
Inflation	A general increase in prices. It is calculated by the change in a consumer price index[5]. (in %)	State Statistics Service of Ukraine

Table 6. The variables of interest for this study

[5] The consumer price index (CPI) measures the rate at which the prices of consumer goods and services are changing over time (International Monetary Fund, 2014)

7. Results

In this chapter, we will show the overall impact of ProZorro on price and competition level, which is testing the first hypothesis. Then, we assess the impact separately for various types of purchases to see whether there is a significant difference in the impact on prices of goods, services, and works, which is testing the second hypothesis. Chapter 7.4 in this part is aimed to provide an additional approach to test the robustness of our analysis, by focusing on the examples of specific goods, services, and works.

7.1 Impact on overall price and savings

Initially, we want to test our first hypothesis, which states that *e-procurement reduces the prices of public procurement over time*, to see whether it can be said that the introduction of ProZorro resulted in the decrease of prices. Figure 10 displays the average price reduction in blue, the trend line for these observations in dotted blue, the percentage of savings in orange, and the trend line for the amount of savings in dotted orange. The savings peaked in August 2015 along with January and April 2016, and they dropped in May 2016. The average price reduction has a jump in April 2015 and January 2016. The trend lines are both downward sloping, showing that average price reductions and savings are decreasing over time. Thus, the impact of ProZorro is lesser at the end of 2017 (average price reduction is 15-10% and 0-5% for savings) compared to the beginning of 2015, where average price reduction is 15-20%, and savings are between 10-15%.

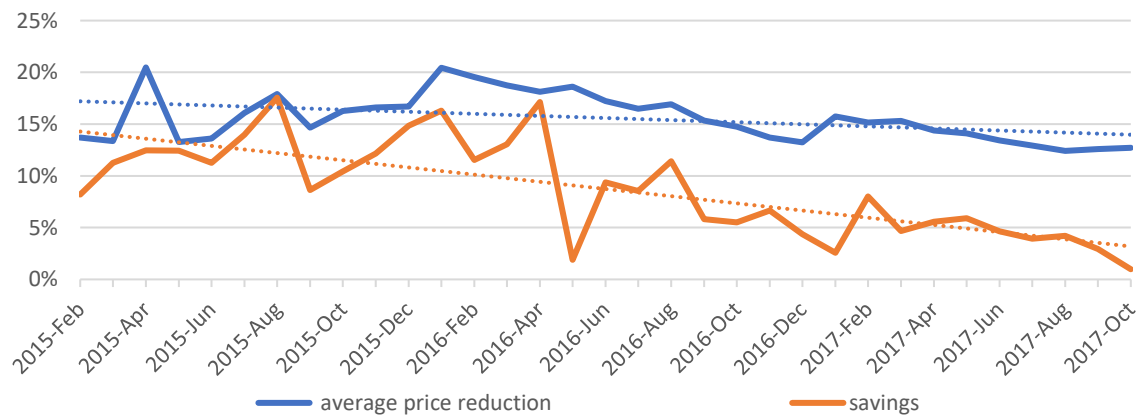

Figure 10. Price reduction and savings

Furthermore, Figure 10 shows that ProZorro had an overall positive impact on price reduction. We observe that, because of ProZorro implementation, the prices have decreased in average 15.59%, whereas the average savings is equal to 8.74% over the whole period.

We included inflation to see whether the trend from Figure 10 is the same taking inflation into consideration. Figure 11 has four lines, showing the average price reduction adjusted for inflation in yellow, the average price reduction in blue, and the inflation rate in grey. When inflation increases the average price reduction decreases, because of increased prices as we can see especially in April 2015, September 2015, April 2016, and October 2016. We can see the opposite trend when the inflation decreases and the average price reduction adjusted for inflation increases, as in October 2015, and July to August 2017. Taking into consideration that inflation did affect the slope and it is an important variable that affects price levels, we have adjusted all the average price reductions for inflation for all the remaining impact measurements.

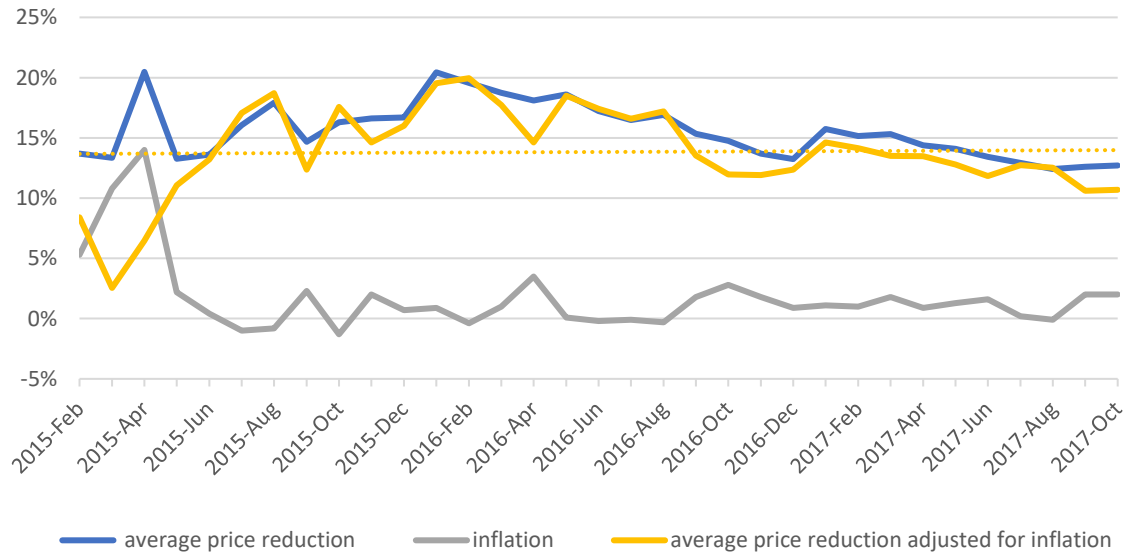

Figure 11. Price reduction adjusted for inflation

7.2 Impact on price and savings for various purchases

To test the second hypothesis, *the more advanced the public purchases are, the lesser is the impact of implemented e-procurement solution on the price of those purchases*, we analyzed the differences in the impact of ProZorro on price and savings for the three types of purchases

(goods, services, and works) separately. First, we have goods as the simplest purchase, then services, and finally, works as the most advanced (i.e., complex) purchase.

7.2.1 Purchase of goods

Figure 12 shows how the prices and percentage of savings have changed over time for goods purchased by the government through ProZorro. The blue columns display savings per month in millions of euros, read on the left y-axis. We observe that the amount of savings is gradually increasing, really picking up the pace in June, and August 2016, February 2017 before it is gradually decreasing towards October 2017. The grey line shows the percentage of savings per month, and the red line shows average price reduction. We find that the percentage of savings decreases over the time, although the volume of absolute amount savings increase over time. The same is true for an average price reduction as the orange dotted line decreases over time. This is contrary to our initial expectation that reduction in price should increase over time as more suppliers get used to bidding for contracts online and learning curve effects. Although ProZorro usage did result in the decrease of price by 16% among goods from February 2015 through October 2017, the impact is decreasing over time. Similarly, the percentage of savings was high when ProZorro has just been introduced but started decreasing as the volume of tenders grew.

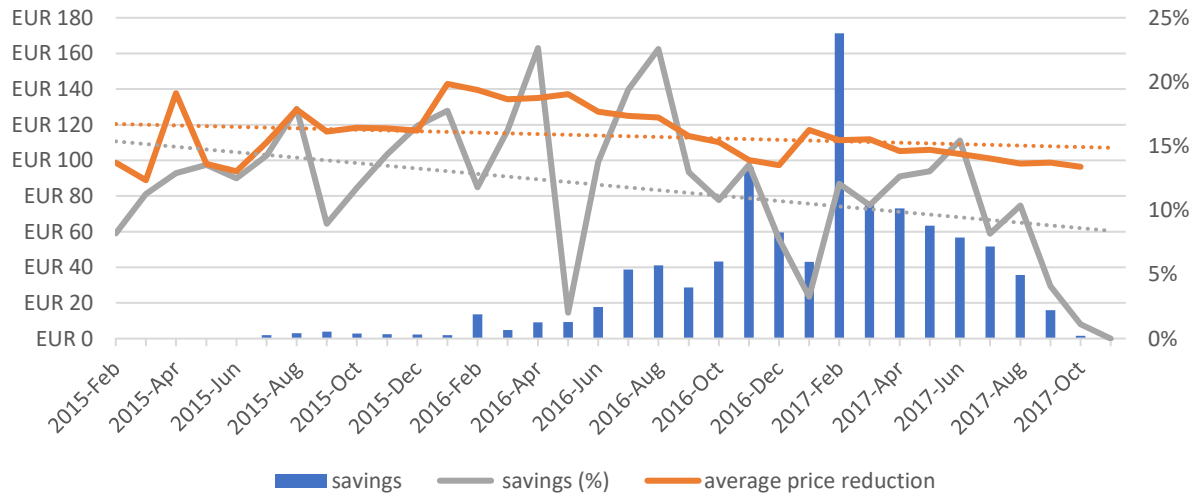

Figure 12. Savings and price reduction over time among goods (in millions of euros)

7.2.2 Purchase of services

A similar trend has been noted for the category of services. Figure 13 displays two graphs and their trend lines all connected to the right-hand side y-axis, and columns connected to the left-hand-side y-axis. From the columns showing savings, we see relative peaks in July 2016, November 2016, and April 2017, and a steady declining trend from the last peak until October 2017. Again, the trend lines for both percentage of savings (yellow) and average price reduction (blue), are declining.

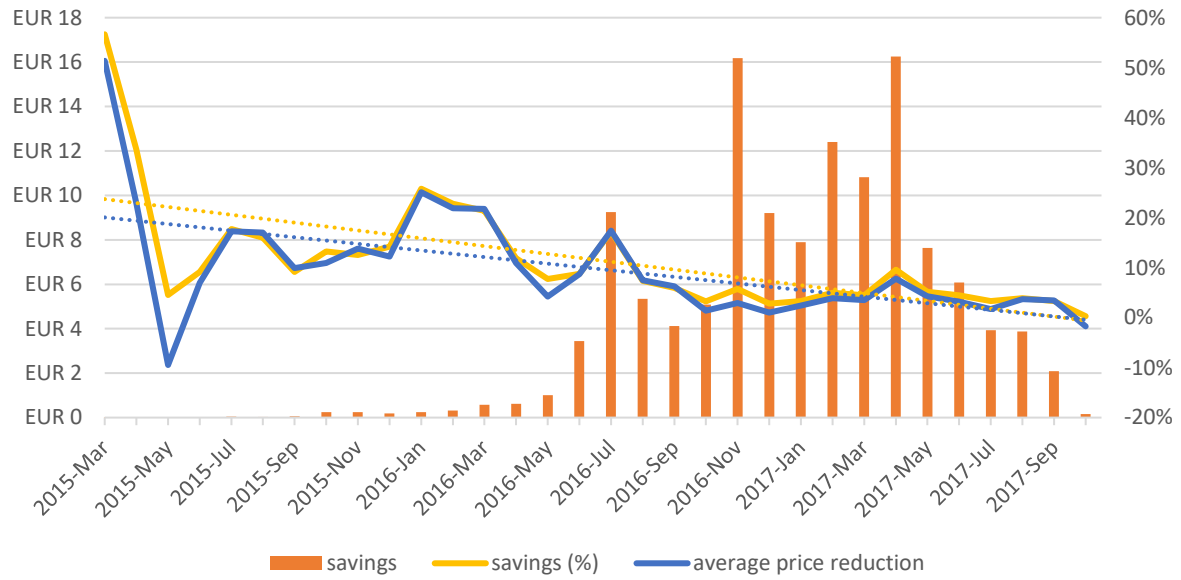

Figure 13. Savings and price reductions over time among services (in millions of euros)

The average price reduction for services has decreased from an astonishing 57% in March 2015 to 2% in October 2017. Abnormally high amounts of the percentage of savings are observed in the initial period of ProZorro. We can only speculate that high fluctuations are due to the pilot nature of the program during that period, where there have only been handful institutions using the platform on an experimental basis. On average, there was a 9.51% price reduction and 11% increase in savings over the whole period among all the completed tenders for services through ProZorro.

7.2.3 Purchase of works

Unlike the impact on goods and services, the rate of change for savings and prices is not as high among the works. This is shown in Figure 14 with columns in orange representing savings

in millions of euros, the grey line showing the percentage of savings, and the yellow graph showing the average price reduction all for purchased works, trend lines are dotted in matching colors. We observed peaks in savings in November 2016 and February 2017. For the percentage of savings and average price reduction, we saw peaks in August 2015 and January 2016. We observed that savings been 6.99% in average whereas average price reduction was 7.07% for works.

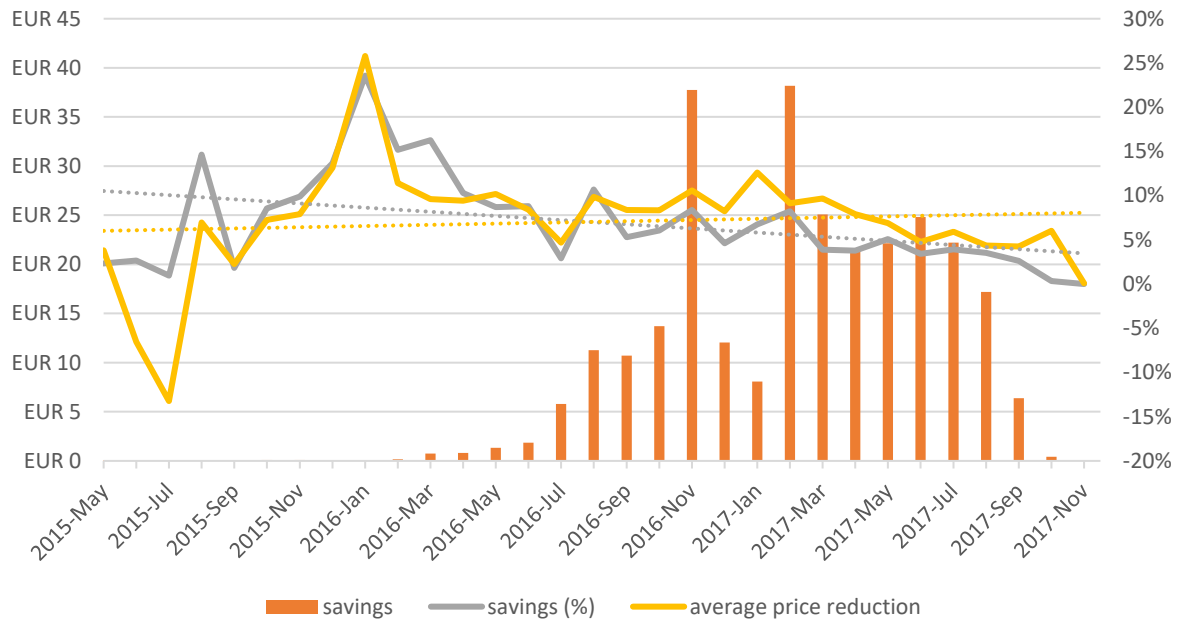

Figure 14. Savings and price reductions over time among works (in millions of euros)

7.3 Impact on competition

Rose-Ackerman (1996) states that any reform that increases the competitiveness of the economy helps reduce corrupt incentives. Reformers behind ProZorro and Ukrainian authorities declared that their goal was to foster a competitive environment through procurement reforms. First, we wanted to see the competition trend over time by comparing an average number of bids for all purchases per month and see if competition had increased over time. Second, we compared competition among goods, services, and works, in general, to see if the competition level varied among the different types of procurement purchases.

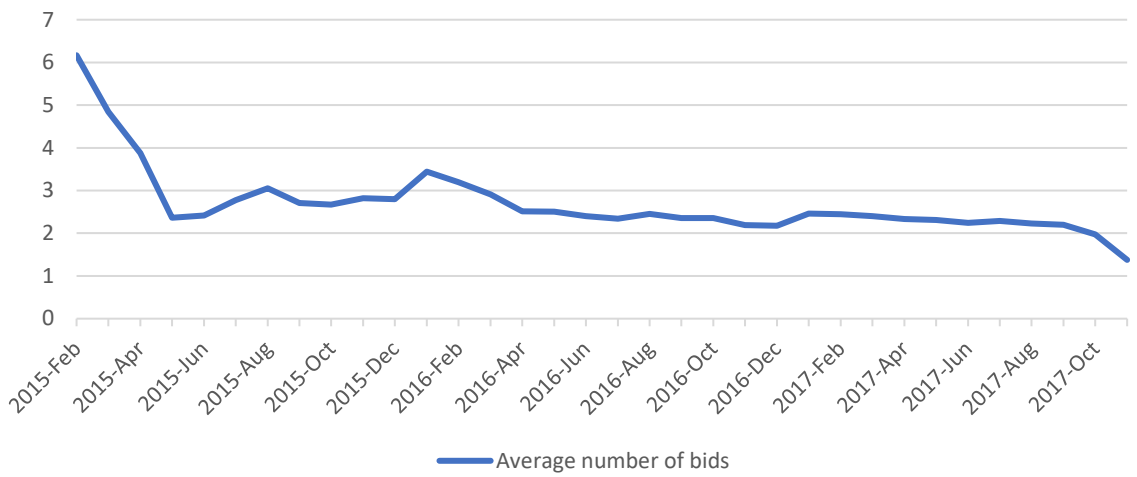

Figure 15. Average number of bids per lot

Figure 15 displays the average number of bids per lot on all purchases from February 2015 to October 2017. We see that the average number of bids is decreasing, contrary to our expectation. There is a generally accepted belief that e-procurement and ProZorro specifically made public procurement more competitive, but we did not observe that in the data. Further reasons behind this unexpected result will be discussed in Chapter 8.

Next, we want to see the ratio of competitive procedures among different types of purchases. As can be seen from Figure 16, the amount spent on competitive tenders compared to non-competitive ones (in millions of euros) is about the same among procured services, whereas among goods and works the estimated market value of competitive tenders is much higher than the estimated monetary value of non-competitive tenders. As mentioned earlier in Chapter 6.3, tenders are classified as competitive or non-competitive depending on the type of procedures used during the process of awarding the contracts.

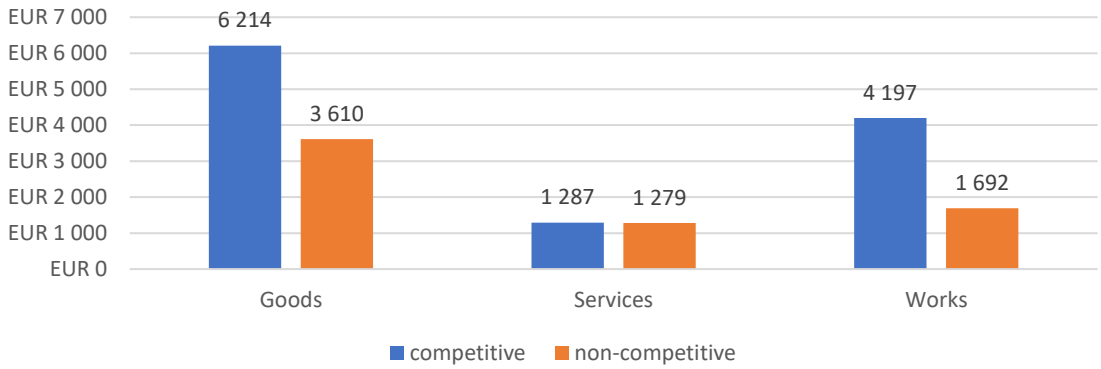

Figure 16. Amount spent on competitive and non-competitive tenders among different purchasers (in millions of euros)

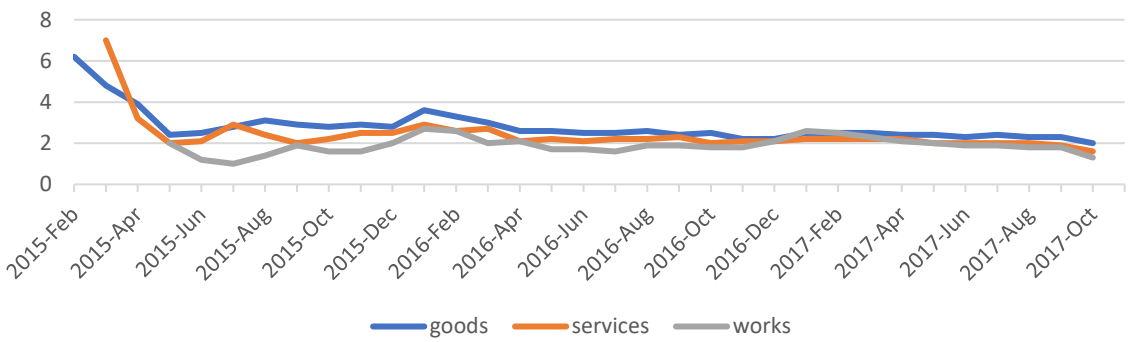

Figure 17. Average number of bids per lot among goods, services, and works

Figure 17 shows the competition trend and takes into consideration the type of purchase such as goods, services, and works. Although available data for an average number of bids for services (March 2015) and works (May 2015) starts later than for goods, we see that there is no significant difference in competition trends among the groups as the trend lines in Figure 17 nearly align.

CPV Type	Average number of bids per auction
Goods	2.48
Services	2.15
Works	1.92

Table 7. Average number of bids per auction

Table 7 shows the average number of bids per auction in the different groups of purchases over the period of our dataset. These numbers are consistent with our beliefs that claim e-procurement leads to more intensified levels of competition on simpler purchases (goods) than on more advanced purchases (works).

7.4 Additional approach

To strengthen our studies, we have tested our hypotheses by measuring the impact on price on self-selected specific examples of government purchases within each category of purchase. The two examples of goods, services, and one example of works that were chosen to be analyzed are shown in Table 8.

Goods	Services	Works
Natural gas (09123000-7)	Water distribution (65100000-4)	Road-repairs (45233142 -6)
Laser printers (30232110-8)	Civil engineering consulting (71311000-1)	

Table 8. Selected items among all the types of purchases

As can be seen in the goods category, we have intentionally chosen one relatively simple good - natural gas, which can be described as a homogenous good, despite minor differences in quality of gas from various suppliers. Furthermore, for natural gas tenders, procurers cannot add a lot of specification except the amount purchased. Then we have chosen laser printers, which we considered to be a more complex goods (or at least more complex than natural gas), because there is a lot of choices on specifications to be made in the purchase, as for example size, quality, brand, and extra functions. We have also extracted data on price reductions for two forms of services, such as water distribution which we consider to be a simpler type of service and civil engineering consulting which is a more advanced form of service. For works, we have only one example of repair works, because there was not enough data over the period of time for other kinds of work tenders.

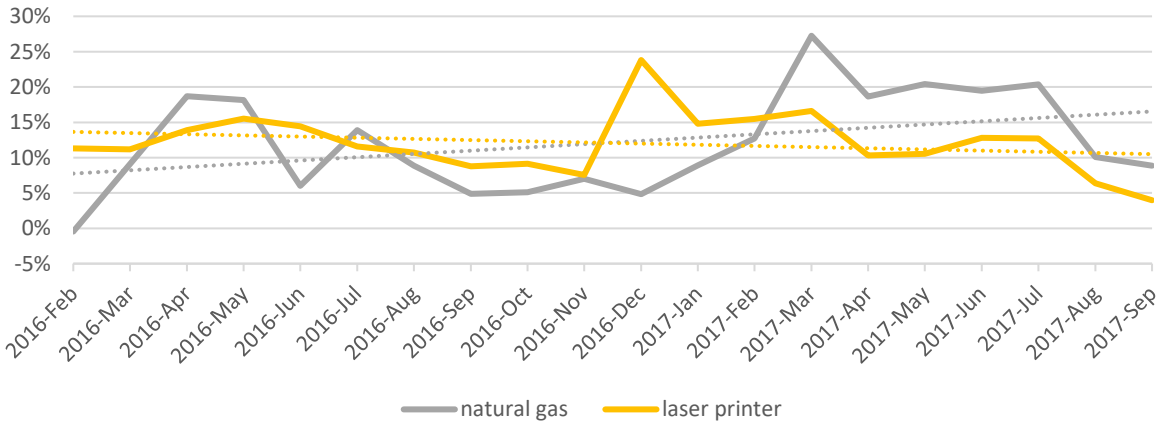

Figure 18. Price reduction for natural gas and laser printers (goods)

In Figure 18, the average price reduction for natural gas (grey) and laser printers (yellow) are displayed from February 2016 to September 2017 with the trend lines in the same colors, dotted. The data is only available from February 2016 because there was no data on the procurement of those goods via ProZorro before. Contrary to the impact on price on goods

overall, when price reduction has been decreasing over time, it is not the same for natural gas. Thus, we see an overall increasing trend for price reduction for natural gas but decrease in a price reduction for laser printers.

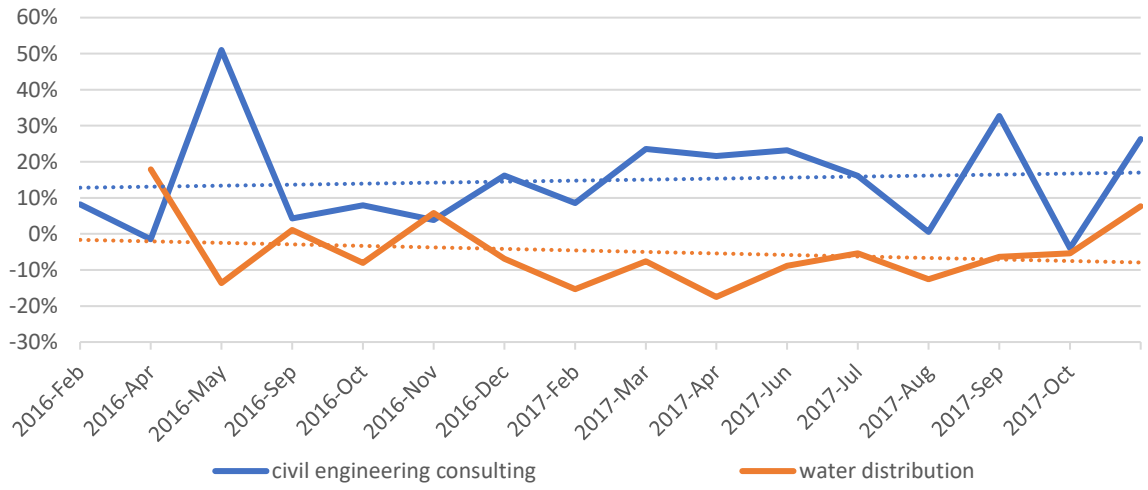

Figure 19. Price reduction for water distribution and civil engineering consulting (services)

Further, we are comparing civil engineering and water distribution in Figure 19. For the first time, we see a negative average price reduction, which illustrates a price increase for water distribution services since November 2016. Reasons for this will be discussed in Chapter 8. Price reduction for civil engineering consulting services is increasing over time.

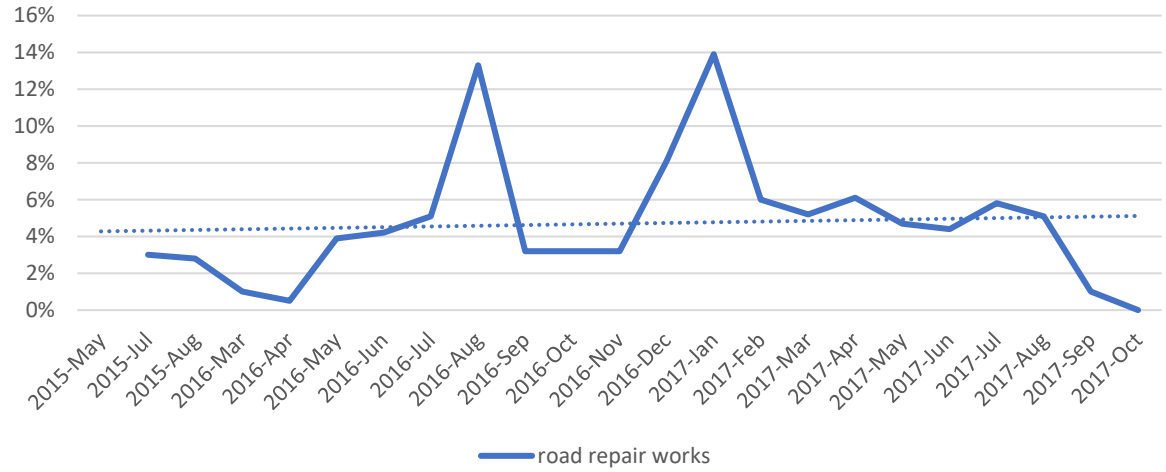

Figure 20. Price reduction for road repairs (works)

The average price reduction for road repair works from May 2015 to October 2017 is 5.43%. In Figure 20, the trend line is increasing and suggests the average price reduction for road repair works has been increasing over the time.

7.5 Summary findings

In this section, we summarize the results, compare our main findings on three types of purchases, including comparing the impact on specific purchases within each type. Testing the first hypothesis that e-procurement reduces the prices of government purchases over time, we do find that ProZorro indeed has reduced the level of prices for goods by 15.82%, services by 11.21% and 9.07% for works as shown in Table 9. The same is true for savings, although ProZorro resulted in a similar savings ratio of approximately 11-12% among goods and services and only 7% for works.

Type of purchase	Average price reduction (%)	Savings (%)
Goods	**15.82**	11.88
- Natural gas	13.00	
- Laser printers	12.93	
Services	**11.21**	11.00
- Water distribution	6.03	
- Civil engineering consulting	26.27	
Works	**7.07**	6.99
- Road repair	5.43	
Overall	13.83	8.74

Table 9. The impact of ProZorro on price and savings

According to Table 9, we see that indeed the price reduction was most prominent among goods, followed by services and works, which is consistent with both of our hypotheses predicting the weaker impact on price reduction on more complex purchases. However, for specific purchases within each type, this is not the case as the average price reduction for laser printers and natural gas is about the same. The same applies to services, where contrary to our expectation, more advanced service such as civil engineering consulting had 26.27% in price reduction compared to only 6.03% in less advanced water distribution. This means that our additional approach of adding robustness check rejected our hypotheses.

Table 11 shows the slope and R squared, or coefficient of determination, for all the trend lines. The trend lines representing average price reduction for all groups of purchases are declining, telling us the effect of ProZorro on prices of government purchases are decreasing over time. There is one exception, the trend line for all types of purchases adjusted for inflation, which is slightly upwards sloping, namely 0.02 percentage points per month. If we look at the selected items, we find that natural gas, civil engineering consulting, and road repair works

have upward-sloping trend lines, whereas laser printers and road repair works have downward-sloping trend lines. However, the trend lines have a coefficient of determination below 5% for all the selected items except natural gas and indicate that the slope is not representing the dataset to a high degree.

Type of purchase	b - slope	R squared (%)
Goods	**-0.06**	**6.62**
- Natural gas	0.49	16.77
- Laser printers	-0.14	3.94
Services	**-0.59**	**35.25**
- Civil engineering consulting services	0.56	2.46
- Water distribution services	-0.40	2.78
Works	**-0.02**	**0.09**
- Road repair works	0.60	1.39
Overall	**0.02**	**0.28**
- Overall (not adjusted for inflation)	-0.10	17.49

Table 10. Average price reduction trend lines data

7.5.1 Impact on prices

As Table 9 suggested, the overall impact of ProZorro is consistent with our hypotheses. Indeed, ProZorro had a positive impact by reducing the prices by significant amounts that varied from 5.43% for road repair works reaching incredibly high 26.27% for engineering consulting services. Furthermore, the price reduction was highest among goods, followed by services and works as the second hypothesis suggested. The average price reduction was decreasing over time for goods, services and works contrary to our beliefs that the price reductions should keep increasing as more suppliers get used to the new system. At the same time, the average price reduction did increase slightly over time for all the purchases combined.

This contrary decreasing price reduction trend made within each type of purchase made us look more closely into the ways how ProZorro analytics module calculates price reduction and savings. Both of those estimates are determined and calculated based on the estimated market value of a contract by procurers and the final price awarded to the bidders during an auction or negotiation, depending on the type of procedure. This is where our qualitative interviews helped us significantly when we heard one of ProZorro's Business Analytics' insights. During an interview, Sergiy Pavluik was not surprised that savings and price reduction had been decreasing over time. In fact, he was very skeptical about estimated market value as an

indicator. He mentioned that ProZorro staff always considered a tender with a significant amount of price reduction or savings suspicious and suggested that in initial stages of ProZorro, procurers have been overestimating the estimated market value which leads to such overestimated savings and price reductions. Fortunately, this practice is decreasing now because procurers have a database of previously awarded prices from which they estimate the market value of new tenders. Oleksa Stepanuik from a research think-tank dedicated to ProZorro also mentioned that the estimated market price was the best available proxy for ProZorro reformers to show the impact to legislators to push up the process and therefore is not the best practical tool given how it's calculated. Furthermore, both of our interviewees saw the decrease in price reduction over time as a positive development. They claimed that ProZorro is achieving its goals in terms of providing a mechanism for better estimation of procurement price that reflects the market price.

Secondly, there were severe inconsistencies regarding the direction of the trend lines when we analyzed the price effect for specific purchases such as natural gas and other items in our additional approach. Neither the direction of the trend line nor the actual average price reductions for natural gas, laser printers, water distribution, engineering consulting services and road repair works were aligned with the second hypothesis which predicted a more significant impact for relatively simpler purchases (natural gas and water distribution). We can see from Table 9 that the impact is nearly the same for natural gas and laser printers, and in the case of services, water distribution's prices have been affected to a lesser degree then engineering consulting. We cannot think of any reason other than industry-specific market factors within those industries that have caused those effects. For example, water distribution services have historically been provided by one or two state-owned enterprises in Ukraine, which might have caused a small price reduction, whereas engineering consulting has had more competitive market structure and therefore ProZorro had a 26.27% in price reduction.

Third, we can observe a high volatility in the amount of savings, total estimated value and price reductions in various periods, specifically before of August 2016. This can be due to the pilot and experimental nature of ProZorro implementation in initial stages when there have been constant changes made to the system and regulations around it. The second noticeable trend is that following acceptance of the law "On Public Procurement," there is a considerable increase in the amount of procured contract after August 2016, but that starts decreasing by the mid of 2017. Perhaps, it could be due to tighter fiscal policies of the Ukrainian government,

which has decreased the public spending from 4.91 billion euros in the fourth quarter of 2016 to 4.03 billion in 2017 (State Statistics Service of Ukraine, 2017).

7.5.2 Impact on competition.

Although the level of competition was consistent according to our expectations and the average number of bids per lot was highest among goods, followed by services and works (see Table 6 in Chapter 6.4), the average number of bids overall was much lower than we expected (between 1.92 and 2.48). We did not find data of an average number of bids before ProZorro to claim whether the new average number of bids are significantly higher than it was before. Secondly, the impact of ProZorro on competition over the whole period raised many questions that need to be addressed. Initially, our first thought was to focus on the fact that our indicator averages the number of bids for all types of procurements, including non-competitive ones, and it could be that the volume of non-competitive procurement grew more than competitive ones. That explanation was proven to be wrong because as Figure 15 in Chapter 7.3 suggests, the ratio of competitive procurements was bigger than non-competitive ones for goods and works and equal for services. Nevertheless, we analyze reasons for decreasing competition trend in the section below.

7.5.3 Why counterintuitive competition results?

TI Ukraine (2007) found a similar trend of average bids per tender decreasing among other procurement types including competitive ones as well. They explained this adverse finding by the fact that the number of lots has been increasing much faster than the number of individual tenderers due to the rapid growth of e-procurement. Another reason for this trend has been noted by Larysa Luzinksa who mentioned, in an interview with us, that there is a low level of competition for procurements with low estimated value, specifically within sub-threshold procurement types, which make up a significant share of total procurements. To complement her thoughts, Director of the Innovative Projects Program at TI Ukraine, Viktor Netsulia also says that businesses do not want to pay money to participate in below-threshold auctions or waste their time, as they know they can be quickly and unfairly disqualified (TI Ukraine, 2017). As a result, TI Ukraine and ProZorro staff are currently advocating that there should be an amendment to the law “On Public Procurement,” which should cover below-threshold procurements, so the respective authorities will be allowed to implement changes to foster business competition for below-threshold procurements as well.

7.6 Weaknesses

Along with our research, we have noticed several limitations that did not make our data and findings as strong as we initially hoped. The first and the most important limitation is that we could not access the data for procurements that were happening before ProZorro implementation. Although we found websites with archives of old procurements by the Ukrainian government, there was no comprehensive data on the prices of government purchases available. Analysing price trends for goods, services, and works before ProZorro and after would have given us stronger evidence explaining a causal link between price change and e-procurement implementation.

ProZorro is relatively recent phenomena and only became mandatory in August 2016. Given the abnormally high level of price reductions and savings in 2015 (a period when pilot ProZorro was launched that was subject to constant changes), we could have just focused on the procurements that were conducted after August 2016 when the law obliged all the institutions to follow consistent rules for determining which tenders must go through ProZorro. Most likely it was a reason why TI Ukraine conducted their impact assessment of ProZorro only for the period of August until December 2016.

As was mentioned earlier, e-procurement and specifically ProZorro are only responsible for part of procurement life-cycle. In Figure 21 we can see that the program is present in tendering part of the life-cycle but absent in the planning and agreement execution part. Planning for where the government needs to spend public funds and which sectors need to be prioritized are done at higher political levels, where there are also higher risks of corruption. Although it is impossible to control and monitor violations that occur at the planning stage of procurement, there is a strong need to incorporate ProZorro in post-tender monitoring and agreement execution stage as well.

This additional post-award check would allow ProZorro procurers also to evaluate the bidders based on the quality of previously completed tenders. There have been complaints that the ProZorro system only assesses the bids on the price criteria, which pushes prices too low sacrificing the quality. This concern has been voiced by Peter Buck and Fredrick Arthur from the Norwegian Embassy who mentioned sole evaluation on price as the reason why the Nordic Environment Finance Corporation (NEFCO) does not participate in tenders through ProZorro. Furthermore, strong emphasis on price-based criteria only can lead to contract renegotiations

adjusting the price after the contract has been signed, which is not reflected in the ProZorro analytics module. Those amendments delay or make the real cost of the purchase higher than initially agreed price. In that sense, some of our price reduction data might be overestimated given that renegotiation of contracts has often taken place, especially for services and works.

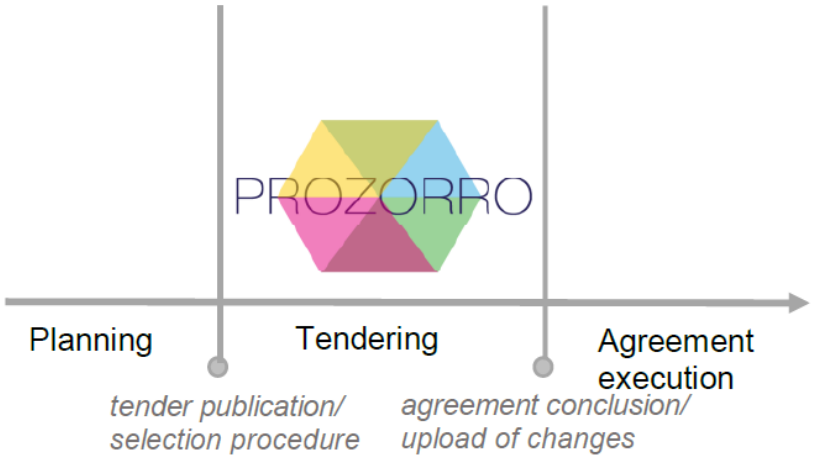

Figure 21. ProZorro in whole procurement cycle (ProZorro, 2017)

Upon our visit to Ukraine and discussing with local experts, we found that procuring entities have full discretionary power in estimating the cost of tenders (estimated price variable), which in retrospect caused such a high amount of savings and price reductions in our study. After researching more about the weaknesses of the price reduction and savings indicators, we found those variables to be less reliable than we expected. There are no strict rules or control mechanisms to enforce or ensure that the procurement entities write the number that truly reflects the closest market value of the given purchase. Fortunately, because of new data continually being generated by the ProZorro, the practice of over-estimating initial tender costs is changing now. ProZorro is accumulating a lot of data which can be used by ProZorro auditors to compare new estimates with awarded prices of previous projects, which limits possibilities of procurers to overestimate the costs.

Finally, a factor that our study does not take into consideration is the price change after the contract has been awarded. Although this information is available in ProZorro database, we had to manually review thousands of tender documents to take into consideration contract amendments and renegotiation of terms, which are not reflected in the price data that we collected from ProZorro's data analytics tools.

8. Conclusion

8.1 Sum up

Main findings of our thesis show that ProZorro did indeed reduce the prices for government purchases. In fact, as we predicted in our second hypothesis, the impact on price was most influential among the goods, followed by services and works. When looking for more in-depth analysis, we found a lot of inconsistencies with regards to the trend impact on price and competition over time. In fact, our second hypothesis, which predicted a stronger impact on simpler purchases did not pass the robustness check, when we focused on the impact on the specific goods, services, and works. Additionally, despite the differences in competition levels among various purchases, there is still a relatively low level of competition. Based on the trend of competition data over the whole period, we conclude that ProZorro did not foster a high competition as was expected.

Based on the change of price, it is hard to argue and illustrate convincing evidence of a reduction in corruption because of how the estimated value of tenders are calculated. However, the fact that ProZorro had available real-time information that has been actively used by NGOs and media gives us a strong reason to believe that ProZorro is actively contributing to making the Ukrainian government more transparent and accountable. In fact, instances, when journalists refer to ProZorro's information to expose corrupt deals, are frequent. For example, the National Police overpaying 30% for its vehicles or an oncology center purchasing cleaning mops for 75 pounds each, using a vague description of “a device with a nozzle and holder” is prominent in the Ukrainian media (Hayman, 2016). Investigative journalists utilize ProZorro’s open data to find interesting connections between suppliers and procurers and another form of conflicts of interests that overall increase awareness about corruption among the general population. This kind of exposure with hard evidence pressures Ukrainian authorities to act to show the people that government does not tolerate corruption. However, there need to be other measures to support that pressure created by ProZorro because the government in Ukraine has been neglecting it. Thus, many of those incidents exposed by ProZorro did not end up being persecuted due to strengthen existing ties between businesses and high-level government officials. In that sense, ProZorro and public procurement reforms despite having an impact on prices through greater accountability and transparency, alone are not sufficient to affect other mechanisms in the country that should contribute to reducing corruption.

Significant reforms must be implemented in other government institutions, in addition, public procurement to make it work efficiently. Efficient judicial systems and independent courts are necessary to punish dishonest actors if the government wants to reduce corruption at the national level. It is well known that most challenging part for judges in corruption cases is finding the required evidence. However, in the case of Ukraine, despite the availability of information and violation in DoZorro (a monitoring portal for ProZorro), the violators go unpunished daily. For example, experts from TI Ukraine along with civil society activists with legal expertise found 3 thousand violations of tender procedures of varying degrees during one year of DoZorro. Here are the most common violations according to TI Ukraine.

Violations	**Number of violations**
Possible avoidance of the bidding procedure	711
Discriminatory requirements of the documentation	371
Ungrounded choice of the winner	248
Excessive requirements to the participants	178
A collision between the participants of the procurement	138
Groundless disqualification	125

Table 11. Most common violations in ProZorro (TI Ukraine, 2017)

Despite the availability of hard evidence provided through e-procurement, Ukrainian law enforcement only reacted to 671 cases by either canceling the procedure, introducing change to tender documentation or inspecting the case further. Among those cases, only 109 criminal proceedings have been found in the United Register of Court Decisions, and to make matters worse, only 3 received sentences (TI Ukraine, 2017). Mostly, there is a lot of discontent among civil society due to lack of punishments for wrongdoers, which is discrediting ProZorro reforms in the eyes of the public. This example clearly shows that e-procurement reforms must be accompanied with effective complementary reforms to ensure productive collaboration between monitoring and auditing authorities, ProZorro staff, law enforcement, and judicial agencies.

Furthermore, based on our visit to Ukraine and research we have seen first-hand, there are additional benefits of the new system that might not have been captured in this study. We saw how ProZorro reform brought business leaders, civil society community, academia, and government together within a unified electronic system that fostered their collaborative efforts to fight corruption. For example, Centre for Excellence in Procurement conducts studies to

measure ProZorro effectiveness and shares their independent findings to improve the system continuously. In addition to that ProZorro staff and Centre for Excellence in Procurement regularly hold seminars across the country providing training, workshops, and conferences for procurers and suppliers. In such a seminar, they teach all the relevant stakeholders how to utilize the new system, which results in significant long-term benefits that cannot be easily measured in a study like this.

8.2 Policy implications

The results of our findings are consistent with another study conducted by TI Ukraine and Open Contracting Partnership to evaluate the impact of ProZorro. They also found how the savings initially were higher around 14.1% in mid-2016, falling to 9.6% in March 2017 and concluded that the decreasing savings rate is an indicator of better planning for procurers since they can predict the estimated market value of new tenders more accurately now (Open Government Partnership, 2017).

A study that assessed the impact of e-procurement on infrastructure provision in India and Indonesia by Lewis-Laupel et al. (2014) also emphasizes the fact that an e-procurement mechanism resulted in prioritization of low prices over quality, leading to a situation where suppliers still try to make their profit margins by cutting on quality. There are concerns about ProZorro overemphasizing the price aspect and not evaluating the suppliers on other criteria as well. Therefore, we recommend policymakers find better mechanisms for assessing the suppliers on non-price criteria as well. Evaluation based on a review from previous customers of suppliers and the quality of previously completed projects are just some examples of how it can be done. Integrating ProZorro with a tax database and other business-related registries to evaluate suppliers on additional metrics is an additional tool that needs to be implemented as well. Further integration of ProZorro with other public institutions has also been recommended by Vox Ukraine in their article dedicated to the ProZorro anniversary in 2016 and has also mentioned the lack of open and digitized data in other public institutions.

8.3 Recommendations

To reduce corruption in G2B services, the governments should provide the whole set of e-government services in addition to e-procurement. In the case of Ukraine, there is a mismatch

between ProZorro and other government agencies and institutions that do not provide an online service to the citizens. In our interview, Larysa Luzinska who works with suppliers told us that majority of suppliers complain about difficulties obtaining necessary documents online from other government institutions. She hopes that ProZorro will push for further development of other e-government services that will make it easy for citizens and businesses to obtain documents, permits, licenses among others.

To complement above mentioned point, it is worth noting again that despite being such a powerful tool ProZorro alone cannot solve the problem of corruption. First, it is just a technical tool that does not even cover the whole procurement cycle (especially the planning stage, which occurs at the political level), and to achieve further tangible outcomes, there need to be reforms in other branches of the government as well. Whether it is creating an independent law enforcement and judicial system, or easing regulatory environment for small businesses, the government of Ukraine needs to complement e-procurement reforms with other effective reforms on all fronts to eradicate this complex problem.

Although ProZorro gives an option for suppliers and procurers to enter per unit information about purchases, most stakeholders do not provide per unit price for the purchases. Thus, we had a hard time assessing the prices of individual goods as most prices were listed for the bundle of goods. ProZorro creators should make it mandatory for stakeholders to have per unit price to be able to have more comprehensive data on prices of individual goods and services that were purchased.

8.4 Further research

Additional research about mechanisms of estimating market price for contracts can be conducted, given the importance of those metrics in showing the positive impacts of ProZorro. Specifically, one can elaborate on the factors that could affect procurer’s willingness to manipulate the estimated market price. The extensive amount of discretionary power given to procurers makes it possible for them to manipulate the estimated market value for their tenders according to their benefits. Therefore, there should be clear rules that control estimated value for tenders to have a price that truly reflects the market price of purchase. Given that ProZorro accumulates data, it should be easier to do it based on the data of previous contracts, which ProZorro is doing right now.

Another crucial data analytics feature of ProZorro is its potential in developing risk indicators that automatically take into consideration all the characteristics of the auction. In addition to that, the indicators could work based on mathematical formulas without human intervention, which will further minimize corruption risks (TI Ukraine, 2017). Given rapid developments in machine learning and better data analytics capabilities that are available today, it would be worth researching the effectiveness of the use of those risk indicators. In fact, there are already pilot initiatives offered by ProZorro team that has an interesting data, including a heat map of corruption risks. Those risks are calculated based on sophisticated mathematical algorithms in real-time, which TI Ukraine and ProZorro hope will be used by businesses as well as law-enforcement agencies. Given those developments, it is worth researching how efficient the DoZorro platform is in predicting the wrongdoings in public procurement in Ukraine.

Finally, in our research, we did not mention that ProZorro has in fact made it possible for Ukraine to fulfill requirements to be able to sign the WTO Agreement on Government Procurement (GPA), which made Ukrainian public procurement available for foreign bidders as well. Given the increasing importance of the impact of globalization on corruption, it would have been interesting to research and compare the tenders where there was a foreign bidder with tenders where only Ukrainian firms have participated.

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10. Appendix

The appendix contains relevant information that has been cited in the thesis with large tables and figures that cannot be included in the body of this thesis.

Table 12 contains the classification of goods, services, and works according to CPV. The table is mentioned in Chapter 6.2 *Collecting data*. Reading through the different classifications in the Table one can get a better overview of what the public sector is procuring.

Goods	**Services**	**Works**
03000000-1 Agricultural, farming, fishing, forestry and related products	48000000-8 Software package and information systems	45000000-7 Construction work
09000000-3 Petroleum products, fuel, electricity and other sources of energy	50000000-5 Repair and maintenance services	
14000000-1 Mining, basic metals, and related products	51000000-9 Installation services (except software)	
15000000-8 Food, beverages, tobacco and related products	55000000-0 Hotel, restaurant, and retail trade services	
16000000-5 Agricultural machinery	60000000-8 Transport services (excl. Waste transport)	
18000000-9 Clothing, footwear, luggage articles and accessories	63000000-9 Supporting and auxiliary transport services; travel agencies services	
19000000-6 Leather and textile fabrics, plastic and rubber materials	64000000-6 Postal and telecommunications services	

Table 12. All categories of purchases according to CPV

Table 13 displays a list of people that we interviewed in Kyiv, their professional title and where they work. Their feedback and insights have been used throughout the whole thesis, but especially in section 6 *Data and empirical method* where we got a better understanding of e-procurement in Ukraine and the data received from ProZorro and section 7.5.1 *Impact on prices* where we talked about business analytics insights.

Name	**Title**
Yuri Bugay	Former ProZorro staff currently leads eHealth initiative in Ukraine
Larysa Luzinska	PR Manager ProZorro
Pavliuk Serhiy	ProZorro Analytics/TI Project Manager
Oleksa Stepaniuk	Data Analyst at Kyiv School of Economics
Petter Bauck	Counsellor Development at Norwegian Embassy in Ukraine
Fredrik Arthur	Advisor at Norwegian Embassy in Ukraine
Sviatoslav Abramov	Assistant to Director at CoST Ukraine National
Yuri Bugay	Former ProZorro staff currently leads eHealth initiative in Ukraine
Larysa Luzinska	PR Manager ProZorro
Pavliuk Serhiy	ProZorro Analytics/TI Project Manager

Table 13. Interviewees of the study

Table 14 shows the data used in our analysis Chapter 7.1 *Impact on overall price and savings*, for all goods, services and works with our manual calculations of savings (in %) as well as price reductions adjusted for inflation every month.

Year-month	Average price reduction	Savings	Inflation	Average price reduction (adjusted for inflation)
2015-Feb	13,70 %	8,21 %	5,30 %	8,40 %
2015-Mar	13,35 %	11,25 %	10,80 %	2,55 %
2015-Apr	20,48 %	12,47 %	14,00 %	6,48 %
2015-May	13,26 %	12,44 %	2,20 %	11,06 %
2015-Jun	13,62 %	11,27 %	0,40 %	13,22 %
2015-Jul	16,07 %	13,97 %	-1,00 %	17,07 %
2015-Aug	17,92 %	17,56 %	-0,80 %	18,72 %
2015-Sep	14,67 %	8,62 %	2,30 %	12,37 %
2015-Oct	16,28 %	10,42 %	-1,30 %	17,58 %
2015-Nov	16,62 %	12,15 %	2,00 %	14,62 %
2015-Dec	16,70 %	14,85 %	0,70 %	16,00 %
2016-Jan	20,43 %	16,30 %	0,90 %	19,53 %
2016-Feb	19,55 %	11,53 %	-0,40 %	19,95 %
2016-Mar	18,73 %	13,04 %	1,00 %	17,73 %
2016-Apr	18,11 %	17,13 %	3,50 %	14,61 %
2016-May	18,61 %	1,89 %	0,10 %	18,51 %
2016-Jun	17,22 %	9,39 %	-0,20 %	17,42 %
2016-Jul	16,48 %	8,54 %	-0,10 %	16,58 %
2016-Aug	16,91 %	11,42 %	-0,30 %	17,21 %
2016-Sep	15,34 %	5,83 %	1,80 %	13,54 %
2016-Oct	14,76 %	5,51 %	2,80 %	11,96 %
2016-Nov	13,70 %	6,66 %	1,80 %	11,90 %
2016-Dec	13,25 %	4,37 %	0,90 %	12,35 %
2017-Jan	15,73 %	2,56 %	1,10 %	14,63 %
2017-Feb	15,16 %	8,03 %	1,00 %	14,16 %
2017-Mar	15,31 %	4,69 %	1,80 %	13,51 %
2017-Apr	14,39 %	5,57 %	0,90 %	13,49 %
2017-May	14,10 %	5,92 %	1,30 %	12,80 %
2017-Jun	13,43 %	4,63 %	1,60 %	11,83 %
2017-Jul	12,93 %	3,93 %	0,20 %	12,73 %
2017-Aug	12,41 %	4,21 %	-0,10 %	12,51 %
2017-Sep	12,60 %	2,95 %	2,00 %	10,60 %
2017-Oct	12,70 %	0,98 %	2,00 %	10,70 %
Average	**15,59 %**	**8,74 %**	**1,76 %**	**13,83 %**

Table 14. Price reduction, savings and inflation for goods, services and works

In Table 15, 16 and 17 the price reduction, estimated value, and savings are displayed, in the Ukrainian currency UAH, for respectively goods, services and works. This data is used in Chapter 7.2 *Impact on price and savings for various purchases*.

Year-month	Savings (UAH)	Expected value (UAH)	Savings (%)	Average price reduction	Inflation	Average price reduction
2015-Feb	971,57	11 839,31	8,21 %	13,70 %	5,30 %	8,40 %
2015-Mar	303 442,65	2 692 530,76	11,27 %	12,34 %	10,80 %	1,54 %
2015-Apr	51 510,14	399 775,88	12,88 %	19,12 %	14,00 %	5,12 %
2015-May	78 043,86	576 157,78	13,55 %	13,60 %	2,20 %	11,40 %
2015-Jun	184 278,76	1 475 348,87	12,49 %	13,03 %	0,40 %	12,63 %
2015-Jul	1 919 618,02	13 462 136,69	14,26 %	15,27 %	-1,00 %	16,27 %
2015-Aug	3 053 635,27	17 053 534,80	17,91 %	17,84 %	-0,80 %	18,64 %
2015-Sep	3 971 852,90	44 401 237,43	8,95 %	16,13 %	2,30 %	13,83 %
2015-Oct	2 862 117,18	24 390 065,50	11,73 %	16,43 %	-1,30 %	17,73 %
2015-Nov	2 387 132,49	16 633 571,14	14,35 %	16,38 %	2,00 %	14,38 %
2015-Dec	2 339 995,09	14 104 295,65	16,59 %	16,21 %	0,70 %	15,51 %
2016-Jan	1 997 538,34	11 247 974,26	17,76 %	19,85 %	0,90 %	18,95 %
2016-Feb	13 608 699,47	115 454 509,20	11,79 %	19,37 %	-0,40 %	19,77 %
2016-Mar	4 789 229,86	29 498 507,36	16,24 %	18,65 %	1,00 %	17,65 %
2016-Apr	9 164 621,78	40 478 012,90	22,64 %	18,74 %	3,50 %	15,24 %
2016-May	9 290 308,95	463 602 094,70	2,00 %	19,06 %	0,10 %	18,96 %
2016-Jun	17 772 820,83	129 082 711,80	13,77 %	17,68 %	-0,20 %	17,88 %
2016-Jul	38 822 931,94	200 158 928,10	19,40 %	17,35 %	-0,10 %	17,45 %
2016-Aug	41 131 130,43	182 184 522,30	22,58 %	17,24 %	-0,30 %	17,54 %
2016-Sep	28 693 105,91	221 317 988,80	12,96 %	15,79 %	1,80 %	13,99 %
2016-Oct	43 271 173,14	400 794 927,90	10,80 %	15,30 %	2,80 %	12,50 %
2016-Nov	95 966 371,52	708 553 723,90	13,54 %	13,92 %	1,80 %	12,12 %
2016-Dec	59 576 051,75	769 588 083,60	7,74 %	13,51 %	0,90 %	12,61 %
2017-Jan	42 973 462,88	1 318 759 342,00	3,26 %	16,24 %	1,10 %	15,14 %
2017-Feb	171 340 286,44	1 420 235 639,00	12,06 %	15,45 %	1,00 %	14,45 %
2017-Mar	75 710 109,15	728 525 381,60	10,39 %	15,53 %	1,80 %	13,73 %
2017-Apr	73 083 585,57	578 229 163,90	12,64 %	14,62 %	0,90 %	13,72 %
2017-May	63 276 379,98	485 428 413,60	13,04 %	14,71 %	1,30 %	13,41 %
2017-Jun	56 765 534,38	367 711 735,90	15,44 %	14,38 %	1,60 %	12,78 %
2017-Jul	51 679 055,41	631 568 652,30	8,18 %	14,03 %	0,20 %	13,83 %
2017-Aug	35 727 540,85	344 532 078,90	10,37 %	13,64 %	-0,10 %	13,74 %
2017-Sep	15 937 580,76	389 148 540,30	4,10 %	13,71 %	2,00 %	11,71 %
2017-Oct	1 616 110,62	144 383 772,80	1,12 %	13,38 %		
2017-Oct		7 735 339,54	0,00 %			
Average			**0,1188**	**0,1582**	**1,76 %**	**0,1414**

Table 15. Price reduction, estimated value and savings for goods

Year-Month	Expected value (UAH)	Savings (UAH)	Average price reduction	Savings (%)	Inflation	Average price reduction
2015-Mar	5 896,23	3 341,20	57,00 %	56,67 %	5,30 %	51,37 %
2015-Apr	13 303,10	4 470,36	46,00 %	33,60 %	10,80 %	22,80 %
2015-May	29 389,22	1 326,32	10,00 %	4,51 %	14,00 %	-9,49 %
2015-Jun	153 496,96	14 046,02	22,00 %	9,15 %	2,20 %	6,95 %
2015-Jul	256 019,12	45 281,13	25,00 %	17,69 %	0,40 %	17,29 %
2015-Aug	161 060,62	25 786,29	22,00 %	16,01 %	-1,00 %	17,01 %
2015-Sep	609 337,48	55 632,17	12,00 %	9,13 %	-0,80 %	9,93 %
2015-Oct	1 875 579,22	247 538,08	19,00 %	13,20 %	2,30 %	10,90 %
2015-Nov	1 975 315,58	247 616,70	21,00 %	12,54 %	-1,30 %	13,84 %
2015-Dec	1 318 129,84	187 457,37	21,00 %	14,22 %	2,00 %	12,22 %
2016-Jan	934 082,59	240 722,59	23,00 %	25,77 %	0,70 %	25,07 %
2016-Feb	1 382 098,10	314 446,49	22,00 %	22,75 %	0,90 %	21,85 %
2016-Mar	2 666 605,78	569 535,82	23,00 %	21,36 %	-0,40 %	21,76 %
2016-Apr	5 185 407,87	617 693,05	19,00 %	11,91 %	1,00 %	10,91 %
2016-May	13 130 753,13	1 011 949,36	21,00 %	7,71 %	3,50 %	4,21 %
2016-Jun	39 277 742,09	3 445 169,91	18,00 %	8,77 %	0,10 %	8,67 %
2016-Jul	53 888 518,18	9 254 645,52	19,00 %	17,17 %	-0,20 %	17,37 %
2016-Aug	72 596 916,32	5 345 621,90	20,00 %	7,36 %	-0,10 %	7,46 %
2016-Sep	69 115 469,99	4 120 373,17	19,00 %	5,96 %	-0,30 %	6,26 %
2016-Oct	158 071 538,20	5 080 812,73	16,00 %	3,21 %	1,80 %	1,41 %
2016-Nov	282 057 458,20	16 180 195,82	14,00 %	5,74 %	2,80 %	2,94 %
2016-Dec	332 469 291,80	9 207 684,53	13,00 %	2,77 %	1,80 %	0,97 %
2017-Jan	239 439 645,60	7 893 213,40	14,00 %	3,30 %	0,90 %	2,40 %
2017-Feb	250 155 902,00	12 406 518,90	15,00 %	4,96 %	1,10 %	3,86 %
2017-Mar	242 194 932,60	10 824 881,25	16,00 %	4,47 %	1,00 %	3,47 %
2017-Apr	169 909 591,90	16 250 106,44	16,00 %	9,56 %	1,80 %	7,76 %
2017-May	148 402 714,40	7 641 535,40	15,00 %	5,15 %	0,90 %	4,25 %
2017-Jun	136 130 525,00	6 079 138,38	14,00 %	4,47 %	1,30 %	3,17 %
2017-Jul	119 212 449,90	3 936 880,68	14,00 %	3,30 %	1,60 %	1,70 %
2017-Aug	99 409 571,07	3 868 236,13	13,00 %	3,89 %	0,20 %	3,69 %
2017-Sep	63 448 950,56	2 095 190,93	14,00 %	3,30 %	-0,10 %	3,40 %
2017-Oct	57 456 529,08	159 430,32	12,00 %	0,28 %	2,00 %	-1,72 %
2017-Nov	3 107 272,41	-		0,00 %		0,00 %
Average			**19,00 %**	**11,00 %**	**2,00 %**	**0,0951**

Table 16. Price reduction, estimated value and savings for services

Year-Month	Expected Value (UAH)	Savings (UAH)	Savings (%)	Average price reduction	Inflation
2015-May	21 677,30	505,31	2,33 %	9,00 %	5,30 %
2015-Jun	5 851,79	154,58	2,64 %	4,00 %	10,80 %
2015-Jul	19 067,36	179,86	0,94 %	1,00 %	14,00 %
2015-Aug	177 281,19	25 934,98	14,63 %	9,00 %	2,20 %
2015-Sep	1 054 194,96	19 377,29	1,84 %	3,00 %	0,40 %
2015-Oct	1 210 464,52	103 539,22	8,55 %	6,00 %	-1,00 %
2015-Nov	1 044 658,38	103 420,10	9,90 %	7,00 %	-0,80 %
2015-Dec	336 496,27	45 913,47	13,64 %	15,00 %	2,30 %
2016-Jan	69 110,63	16 285,22	23,56 %	24,00 %	-1,30 %
2016-Feb	1 154 218,59	175 210,40	15,18 %	13,00 %	2,00 %
2016-Mar	4 551 718,64	739 531,28	16,25 %	10,00 %	0,70 %
2016-Apr	7 860 579,57	807 847,21	10,28 %	10,00 %	0,90 %
2016-May	15 440 142,64	1 343 666,22	8,70 %	10,00 %	-0,40 %
2016-Jun	20 987 797,38	1 849 502,53	8,81 %	9,00 %	1,00 %
2016-Jul	200 768 492,70	5 799 984,48	2,89 %	8,00 %	3,50 %
2016-Aug	105 479 464,50	11 279 449,35	10,69 %	10,00 %	0,10 %
2016-Sep	201 801 067,30	10 703 503,76	5,30 %	8,00 %	-0,20 %
2016-Oct	225 946 254,30	13 705 286,71	6,07 %	8,00 %	-0,10 %
2016-Nov	451 047 426,50	37 752 369,67	8,37 %	10,00 %	-0,30 %
2016-Dec	262 190 156,70	12 055 248,71	4,60 %	10,00 %	1,80 %
2017-Jan	119 711 445,40	8 078 189,06	6,75 %	15,00 %	2,80 %
2017-Feb	464 149 616,60	38 182 453,70	8,23 %	11,00 %	1,80 %
2017-Mar	643 938 253,40	25 080 369,91	3,89 %	11,00 %	0,90 %
2017-Apr	564 547 724,80	21 376 595,24	3,79 %	9,00 %	1,10 %
2017-May	435 821 758,70	22 148 539,09	5,08 %	8,00 %	1,00 %
2017-Jun	723 791 417,30	24 815 073,45	3,43 %	7,00 %	1,80 %
2017-Jul	566 739 026,70	22 205 750,14	3,92 %	7,00 %	0,90 %
2017-Aug	488 243 138,80	17 180 312,48	3,52 %	6,00 %	1,30 %
2017-Sep	243 307 277,80	6 366 608,85	2,62 %	6,00 %	1,60 %
2017-Oct	120 574 080,80	416 713,65	0,35 %	6,00 %	0,20 %
2017-Nov	16 511 305,32	-	0,00 %		-0,10 %
Average			**6,99 %**	**9,07 %**	**2,00 %**

Table 17. Price reduction, estimated value and savings for works

Table 18. *Average number of bids for goods, services, and works* shows the data used for the analysis of competition in the different purchasing categories in Chapter 7.3 *Impact on competition*.

Year-Month	Goods	Services	Works
2015-Feb	6,2		
2015-Mar	4,8	7,0	
2015-Apr	3,9	3,2	
2015-May	2,4	2,0	2,0
2015-Jun	2,5	2,1	1,2
2015-Jul	2,8	2,9	1,0
2015-Aug	3,1	2,4	1,4
2015-Sep	2,9	2,0	1,9
2015-Oct	2,8	2,2	1,6
2015-Nov	2,9	2,5	1,6
2015-Dec	2,8	2,5	2,0
2016-Jan	3,6	2,9	2,7
2016-Feb	3,3	2,6	2,6
2016-Mar	3,0	2,7	2,0
2016-Apr	2,6	2,1	2,1
2016-May	2,6	2,2	1,7
2016-Jun	2,5	2,1	1,7
2016-Jul	2,5	2,2	1,6
2016-Aug	2,6	2,2	1,9
2016-Sep	2,4	2,3	1,9
2016-Oct	2,5	2,0	1,8
2016-Nov	2,2	2,1	1,8
2016-Dec	2,2	2,1	2,1
2017-Jan	2,5	2,2	2,6
2017-Feb	2,5	2,2	2,5
2017-Mar	2,5	2,2	2,3
2017-Apr	2,4	2,2	2,1
2017-May	2,4	2,0	2,0
2017-Jun	2,3	2,0	1,9
2017-Jul	2,4	2,0	1,9
2017-Aug	2,3	2,0	1,8
2017-Sep	2,3	1,9	1,8
2017-Oct	2,0	1,6	1,3
Average	**2,8**	**2,4**	**1,9**

Table 18. Average number of bids for goods, services, and works