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Bunching Below Thresholds: Evidence from Portugal

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Dissertation presented as partial requirement for obtaining the Master's degree in Advanced Analytics

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BUNCHING BELOW THRESHOLDS: EVIDENCE OF PORTUGAL

by

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Dissertation presented as partial requirement for obtaining the Master's degree in Data Science and Advanced Analytics, with a specialisation in Business Analytics

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ABSTRACT

In a world where frequent fraud and manipulation cases are reported in the media, it is essential to understand how public procurement is developed. Thresholds on prices regulate public procurement to ensure equity, transparency, and fraud reduction. Although, thresholds can also contribute to manipulation in any phase of the procurement cycle. The main question to be answered through this work is if we could detect evidence of bunching on Portuguese public procurement, on local administrators and the national Government. The data used for the analysis were extracted from Portal BASE, concerning 2008 to 2019. Based on the McCrary Density test and bunching techniques, the main objective of the work was reached. Evidence of bunching was detected at the threshold level for most contracts (direct awards, prior consultation, and public tender) of local administrators and the national Government. More evidence of bunching was found in direct awards contracts related to goods and services. Public tenders were the type of contract with lower evidence of bunching. Moreover, these results contribute to a more accurate behaviour study of Portuguese public entities and methodologies to detect evidence of manipulation on public procurement.

KEYWORDS

Public Procurement; Bunching; Threshold

RESUMO

Num mundo onde casos de fraude e manipulação são frequentes na comunicação social, é essencial entender como se comporta a contratação pública. Os limites de valor regulam a contratação pública a fim de garantir equidade, transparência e diminuição de fraudes. No entanto, podem também contribuir para a manipulação dos contratos públicos em qualquer fase do ciclo de contratação pública. Este trabalho tem como foco conseguir detetar evidências de agrupamentos nos contratos públicos portugueses realizados pela administração local e pelo governo. Os dados utilizados para a análise foram extraídos do Portal BASE, relativos aos anos de 2008 a 2019. Com base no teste de densidade de McCrary e nas técnicas de agrupamento, o objetivo principal do trabalho foi alcançado. Foi detetada evidência de aglomeração ao nível do limiar para a maioria dos contratos (ajustes diretos, consulta prévia e concurso público) da administração local e do governo. Maiores evidências de agrupamento foram detetadas nos ajustes diretos, sendo que o concurso público é o tipo de contrato com menos evidência de agrupamento. Estes resultados contribuem para um estudo mais preciso do comportamento das entidades públicas portuguesas e das metodologias de deteção de evidência de manipulação na contratação pública.

PALAVRAS-CHAVE

Contratação Pública; Aglomeração; Limite de valor

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LIST OF ABBREVIATIONS AND ACRONYMS

ASF Autoridade de Supervisão de Seguros e Fundos de Pensões

CPV Common Procurement Vocabulary.

EU European Union.

GDP Gross Domestic Product.

OECD Organization for Economic Co-Operation and Development.

PCC Public Contracts Code.

RDD Regression Discontinuity Design.

1. INTRODUCTION

Public procurement – the public authority's goods and services purchase process from companies – is an important economic activity of governments. For the Organization for Economic Co-Operation and Development (OECD), public procurement provides innovation, resource and energy-efficient, and economic growth strategies. Every year European governments spend 14% of GDP on public procurement, more than 1.9 trillion euros (European Commission, 2017).

Public procurement has been increasing over the years in Portugal. In 2017, it represented 19,8% of total general government expenditures and 9,1% as a share of GDP. Health expenses represent the largest share of public procurement spending (33,8%), followed by economic affairs (22,1%) and public services (14,5%) (OECD, 2019). Portuguese procurement rules are established in the Public Contracts Code (PCC), published in decree No. 111-B/2017, 31 August. PCC aims to present the national legal system community directives related to public contracts for public works contracts, the lease or purchase of services. The Portuguese Procurement Portal, the BASE Portal, displays all contracts concluded under the PCC and access the information system that monitors public procurement in Portugal.

Public contracts can be divided into non-competitive and competitive procedures (Portal Base, 2020). In non-competitive practices, the contracting authority chooses or directly invite an entity (or several) to submit a tender. While in competitive procedures, the contracting authority announces its intentions on the Official Journal of the Portuguese Republic*, Diário da República,* and the Official Journal of the European Union. Then, any contractors apply by submitting their proposals. The main difference between the two groups of contracts is that a qualified jury decides the contracting entity in the competitive ones. Different types of contracts are made between the public and private sector, the direct award being the most frequent.

European Union (EU) defined some rules to ensure transparency, equity in public procurement, reduce fraud and corruption. These rules should serve as a guide for applying the national laws of each member state. According to EU laws, for higher tender's values that exceed a specific threshold, EU rules apply. For lower value tenders, national rules apply. Tenders with higher values require publication in the Official Journal of the European Union. Typically, it is a more expensive and slower process (European Commission, n.d.). Contrarily, lower value tenders tend to be faster and with more minor bureaucratic procedures.

Thresholds significantly influence the public procurement market (Bobilev et al., 2015). Thresholds create incentives for the contracting authorities to manipulate the project size to keep it below the threshold. Manipulating thresholds allows looser regulations and cheaper and faster procurement processes (Bobilev et al., 2015). Contracts with estimated costs below EU thresholds have higher probabilities of discretion over the procurement process and awarding of the contract. Public officials have more capabilities to manipulate procurement outcomes to below threshold tenders (Ján Palguta & Pertold, 2017); they can choose between non-competitive procedures and competitive procedures. Non-competitive procedures allow public officials to negotiate and select companies, making the contract requirements less clear (Tas, 2019).

The bunching phenomenon occurs when there is suspicion of manipulating contract values by the entities to avoid competitive procedures. Bunching refers only to entities that have altered their

behaviour to avoid crossing the threshold. Thus, there is a change in the behaviour of entities, which translates into an agglomeration of the value of contracts below the threshold, with an increase in the density of contracts. Evidence of manipulation of the estimated cost for below thresholds is called bunching below thresholds.

Public procurement is essential for the competitiveness of the Portuguese Government, as they have a significant role in public accounts and the quality of services made available to the population. Therefore, manipulating public procurement contracts to keep them below the threshold generates an economic and social impact. So, it is essential to analyse potential contracts manipulations, to create prevention and detection measures that will reduce the likelihood of manipulation and create a positive country impact. These considerations serve as a motivation for the main focus of this work, which aims to analyse Portuguese procurement data. Specifically, the main question to be answered through this work is if we could detect evidence of bunching on Portuguese public procurement, on local administrators and the national Government. The goal is to find evidence of bunching below threshold in Portuguese contracts within years 2008 and 2019 on local administrators and national Government. In addition, a deeper analysis of Portuguese public authorities was made to understand their behaviour better.

To accomplish these objectives, the work is divided into six sections. Section 3 includes a description of public procurement and introduces the related work developed by other authors. Section 3 presents the data, exploratory analysis and the methodology used. The results obtained and, a case study, is shown in section 5. Lastly, a summary of the results and future work are presented.

2. BACKGROUND

The current section starts with the principle concepts upon which this work was based. Then, an introduction to public procurement was made to understand the central area of this work better. This topic also mentions procurement rules since they are necessary to ensure public projects' fair, transparent, and equitable provision. Finally, a deeper analysis of related research areas was developed.

2.1. PUBLIC PROCUREMENT

The percentage of GDP spent by countries on public procurement represents its importance, since it will create a social, economic, and environmental impact (Khan, 2018). Public procurement is defined as the Government's process of purchasing goods, services and construction work from the private sector (Wachs et al., 2021) to fulfil government functions (Arrowsmith et al., 2000).

For Arrowsmith et al. (2000), the primary objective for procurement systems is to acquire the goods or services, considering the economic efficiency. Governments must ensure the best value for money for the citizens (Raymond, 2008) through low-cost purchases and defined benefits (Asare & Prempeh, 2016). For this reason, the supplier who wins a contract must meet all government requirements. To achieve the best value for money, governments must prevent waste and foster competition, transparency, and accountability during the different phases of the process (Asare & Prempeh, 2016). An effective public procurement prevents mismanagement and waste of public funds. The procurement process must not be affected by collusion, big-ridding, fraud, or corruption (OECD, 2008).

Public procurement has undergone changes over time, the most important being the shift from paper to electronic tools. E-procurement refers to the transformation that occurred in public procurement in 2004. That transformation aimed to create electronic tools for contractors and contracting authorities to simplify the procurement processes and make open access to public contracts information more accessible to everyone. Open access contributes to evaluating the actual impact in the public sector activities (Curado et al., 2020a). In addition, the public procurement development simplifies the pre-award and post-award stages of public procurement processes. As a result, it contributes to a more transparent and efficient procurement process (Bobowski & Gola, 2019).

There are three distinct phases of public procurement (Dorn et al., 2008):

- pre-bidding phase
- bidding phase
- post-bidding phase

The pre-bidding phase is the planning stage to decide the goods or services to buy, common to all Portuguese public procurement contracts. Next, the bidding phase refers to making a contract to acquire those goods or services. In this phase, the direct award contracts, the procedure is the most straightforward. The contracting authority directly invites one of its choices to submit a tender. Concerning the prior consultation contracts, the authorities directly invite at least three entities of their choice to submit a tender, being able to negotiate with them the aspects of the execution of the contract (Base, 2021). Although, for public tenders, a competitive procedure, made public on official Portuguese or EU channels (Base, 2021). Lastly, the post-bidding phase involves contract execution and guarantees its effectiveness (Arrowsmith et al., 2011; Fazekas, Mihály; Tóth, István János; King, 2013; Sabatier & Mazmanian, 1980).

Regarding the implementation of public policy, there are three theoretical approaches:

- top-down
- bottom-up
- hybrid

Top-down theory defends that policy implementation begins with a central government decision. In contrast, the policy implementation starts with the local bureaucrats for a bottom-up approach since they are closer to the real needs and problems than the central Government. The hybrid theory combines top-down and bottom-up approaches, central Government and local bureaucrats impact policy implementation (Fischer & Miller, 2017).

Procurement legislation and civil laws support public procurement (Beke et al., 2013). The primary goal is to limit or suggest actions to public authorities and certain public utility operators in the interest of reducing the likelihood of wrongdoing (Tóth & Fazekas, 2017). EU defined minimum public procurement rules to guide the purchase of goods, works, and services to create equal conditions for all members and an open and well-regulated market. The national rules of each member state must respect the general principles of EU law. EU rules are applied to tenders, published in the Official Journal of the European Union, whose value exceeds a specific threshold. For lower value tenders, national rules apply. Each member state-defined their own thresholds values according to the contract nature, contracting authority, and sector (Telles, 2013).

Thresholds aimed to guarantee an optimal contract allocation and align the behaviour of officials with societal interests of cost-efficient procurement (Jan Palguta & Pertold, 2014). Although thresholds can encourage corruption and rent-seeking behaviour, officials use too much discretion (Jan Palguta & Pertold, 2014). The contracting authority may want a faster and administratively cheaper procedure that improves the procurement process's efficiency. Also, the public officials can facilitate compliance with the competition on their behalf. Threshold’s manipulation can occur in different phases of the procurement cycle and in different ways (Lyra et al., 2021). For example, manipulating project sizes, inviting specific firms and friends, speeding procurement processes, and collecting bribes can be different ways to manipulate the project value to keep it below the threshold (Bobilev et al., 2015).

The entities' suspicion of manipulation of contract values to avoid competitive procedures is named bunching. Bunching occurs with changing the behaviour of an entity, which translates into an agglomeration of the value of contracts below the threshold, with an increase in the density of contracts.

Procurement law defined different thresholds and rules to follow in the procurement process. The thresholds differ for different contract types, public administration levels and procurement.

The Portuguese public procurement threshold has changed over the years. Considering the period under analysis, the Portuguese threshold changed twice, so the details of this change are contained in two different laws decree: No. 18/2008, 29 January 2008, and No. 111-B/2017, 31 august.

The law decree No. 18/2008, 29 January 2008 approved the PCC and established the rules on public procurement in Portugal. The rules applied on this law decree are from July 2008 to December 2017. Table 1 presents the public procurement thresholds used on the law decree No. 18/2008, 29 January 2008.

In 2018, law decree No. 111-B/2017, 31 august, replaced the law decree No. 18/2008, 29 January 2008. The primary purpose of creating this law decree was to update the PCC with the new rules made on EU regarding public procurement. Table 2 presents the public procurement thresholds applied on the law decree No. 111-B/2017, 31 august.

Table 1 - Thresholds defined on law decree No. 18/2008, 29 January 2008

	Direct Awards
Public Works contracts	€150.000
Supply and service contracts	€75.000

Table 2 - Thresholds defined on law decree No. 111-B/2017, 31 august

	Direct Awards	**Prior Consultation**	**Public Tender**
Public Works contracts	€30.000	€150.000	€5.548.000
Supply and service contracts	€20.000	€75.000	€221.000 (a) €144.000 (b)

(a) Threshold applied for government (b) Threshold applied for municipalities

An abnormal concentration of procurement with values right below the defined threshold, also known as bunching, is one of the principal public procurement issues studied in this work.

2.2. RELATED WORKS

Several studies regarding public procurement thresholds were made to evaluate the impact of the manipulation and the bunching below the threshold. By now, some studies show evidence of manipulations schemes on public procurement in EU (Tas, 2019), Italy (Coviello et al., 2018; Coviello & Mariniello, 2014), Sweden (Bobilev et al., 2015), Poland (Tóth & Fazekas, 2017), Hungary (Szucs, 2017) and Czech Republic (Jan Palguta & Pertold, 2014).

Coviello and Mariniello (2014), Coviello et al. (2018) and Szucs (2017) studied the main essential features of public procurement. The effect of publicity on Italian public procurement was studied by Coviello and Mariniello (2014) that found that publicity contributes to improving the auction mechanism. The outcomes of increasing buyers' discretion on public procurement in Hungary and Italy were studied by Szucs (2017) and Coviello et al. (2018), respectively. In high-discretion procedures, results revealed that companies with political connections to the governing party are favoured (Szucs, 2017). Discretion improves public procurement results and the probability of repeatedly winning—consequently, the price of contracts increases and contractors' productivity decreases.

Jan Palguta and Pertold (2014) analysed the evidence of manipulation of tenders by official authorities. To detect evidence of manipulative and corrupt behaviours, the authors used Chetty et al. (2011) methodology. Additionally, the McCrary density and Placebo test approaches are developed to test the first method applied. Then, the expected and final contract value behaviour was analysed to understand the relation with the threshold. The results show evidence of manipulation of the contract value, evidencing bunching below the threshold. High-powered non-linear incentives allied to a non-transparent selection process and a high procurement price contributes to corruption and active waste. Moreover, avoiding open and transparent procurement processes leads to a waste of public resources since the contracts are winning by anonymous contractors and the final value of procurement's increases

Based on the McCrary density test, Bobilev et al. (2015) studied the behaviour of the different types of contracting authorities on Sweden public procurement data. Significant evidence of bunching below the EU threshold was detected for supplies and services made by governments, while in regional authorities, evidence of bunching below the threshold was not detected. The study demonstrates that procurement thresholds affect the strategic aspects of procurement behaviour and the results beyond the associated costs of a contract.

Tóth and Fazekas (2017) investigated Polish public procurement to detect evidence of manipulation schemes around thresholds defined by the EU and their reasons. Based on McCrary density test results, evidence of bunching below the EU thresholds were founded on local and central authorities. Beyond manipulating the contract value, the ignorance of the rules associated with public procurement is another malpractice that leads to bunching schemes. Furthermore, the manipulated tenders have fewer bidders, consistent with the other author's findings since public procurement tenders' manipulations are related to more flexible rules.

Tas (2019) focused his work investigating the EU public procurement data. Evidence of manipulation schemes of bunching below thresholds were detected using Regression Discontinuity manipulation tests. Findings suggest that authorities suspected of manipulation prefer to adopt

non-competitive procedures. Avoiding non-competitive practices reduce time-consuming processes and high costs.

The bunching methodology has also been applied to different taxes and categories of taxpayers.

Using the Republic of Cyprus data, Clifford and Mavrokonstantis (2021) studied the tax enforcement policy combining self and third-party reporting elements. Evidence of Bunching was detected on their analysis using standard bunching techniques developed by Saez (2010), Chetty et al. (2011) and Kleven, (2016). Their findings suggest that time is essential for authorities to understand the incentives created by taxes and take advantage of them over the years.

Some techniques related with Data Science were also applied in the field of economics (Damásio, Louçã, et al., 2018; Damásio, Mendonça, et al., 2018; Damásio & Nicolau, 2014, 2020; Vaz, Bação, et al., 2021; Vaz, Cusimano, et al., 2021; Vaz, Damásio, et al., 2021).

A summary of studied articles related to the main topic of this work is present in table 3.

Table 3 – Manipulation schemes literature summary

Paper	Year	Method used	Data set	Conclusions
(Coviello & Mariniello, 2014)	2014	Regression Discontinuity test	Italian procurement data	The likelihood of the winner being a large company and winning repeated auctions increases with publicity.
(Palguta & Pertold, 2014)	2014	Chetty et al. (2011) methodology, Placebo test and McCrary density test	Czech Republic procurement data	Bunching below the threshold is associated with anonymously owned firms and a higher final price of the contract.
(Bobilev et al., 2015)	2015	McCrary density test	Sweden procurement data	Thresholds of procurement contracts affect the cost of the contract and the outcomes associated.
(Tóth & Fazekas, 2017)	2017	McCrary density test	Poland procurement data	The ignorance of procurement rules and the manipulation is associated with contracts values below the threshold.
(Szucs, 2017)	2017	Regression Discontinuity test	Hungary procurement data	Discretion increases the contract price, decreases contractors' productivity, and increases the likelihood that the winning company has a political connection with the Government.
(Coviello et al., 2018)	2018	Regression Discontinuity test	Italian procurement data	The buyer's discretion increases the probability that the same firm wins procurement contracts regularly.
(Tas, 2019)	2019	Regression Discontinuity test	EU procurement data	Authorities suspected of manipulation prefer non-competitive procedures to avoid high costs and time-consuming processes.
(Clifford & Mavrokonstantis, 2021)	2021	Bunching techniques by Saez (2010), Chetty et al. (2011) and Kleven, (2016)	Republic of Cyprus data	Time is essential for individuals to understand the incentives created by taxes thresholds.

3. DATA

The BASE portal contains Portuguese public procurement data. In addition, the data includes information on the development of the entire contract formation procedure and its execution (Base, 2021).

Several steps were developed during this work and are displayed in Figure 1.

Figure 1 - Data preparation process

Firstly, the data was collected from the BASE portal through a web scraping work developed before by Curado et al. (2020).

The available data includes the characteristics of all the procurement's awarded in Portugal from December 2007 to November 2020, comprising 1.214.390 contracts. Each contract identifies the contracting and the contracted entity. Moreover, for each contract, several features are also provided:

- The ID of the contracted entity
- The ID of the contracting entity
- Initial value of the contract (in euros)
- The final value of the contract (in euros)
- Type of contract (Direct award, Prior Consultation and Public Tender)
- Common Procurement Vocabulary (CPV) of the contract and the close date of the contract

Considering that the data may contain inconsistencies, data preprocessing was applied to the principal analysis. The preprocessing steps include:

- Removing the contracts with values smaller or equal to zero euros, considering they only represent 0,17% of the total
- Removing contracts where there is no contracting or contracted NIF (Portuguese Fiscal Identification Number)
- Removing contracts that are still running
- Discard contracts before July of 2008 and after December of 2019, as the law decree used to support the analysis is from July of 2008 to December of 2019

The provided features allow computing new features relevant for the analysis:

- Execution Deadline - number of days to conclude the project
- Cost Overrun - the difference between the final price and the initial price of the project
- Frequency - the frequency that each contracting entity was contracted
- Administration Level - describes the contracting entity, Portuguese government or municipalities
- Execution Place - describes the Portuguese region where the contract was executed, Center, North, South and Islands. Moreover, the Administration Level.

The final data set contains 292.100 contracts between July 2008 and December 2019, worth 11.9 billion euros. Figure 2 displays the distribution of the contract's values. The number of contracts decreases as the amount increases, resulting in more contracts with lower values and fewer contracts with higher values.

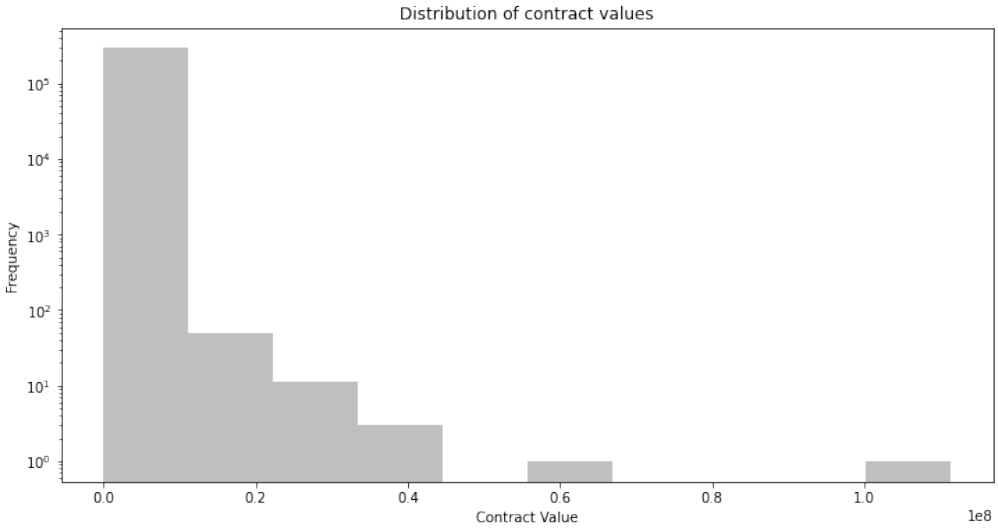

Figure 2 - Distribution of contract values from July of 2008 to December of 2019. In our data set, the contracts numbers are inversely proportional to the contract values.

First, the type of contract, considering the CPV of each contract and the public administration levels, were defined. The contract types can be public work contracts and supply and service contracts. Public work contracts consist of civil engineering works. In contrast, supply and service contracts cover the purchase or lease of products or services (Base, 2021).

The distribution of every kind of contract per year under analysis is shown in Figure 3. The number of public works contracts is constant from 2012 onwards. However, the number of goods and services contracts is higher than the number of public works contracts during all the years under analysis, reaching maximum levels in 2014 and 2017.

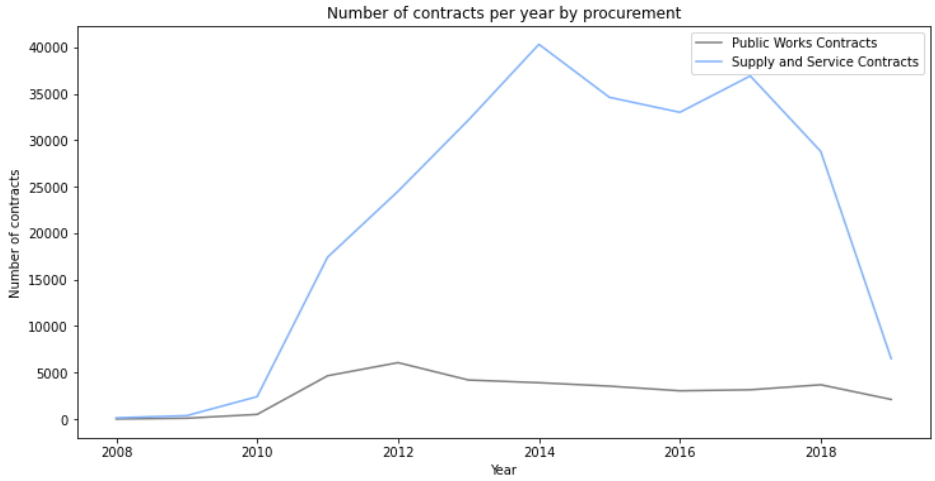

Figure 3 - Number of contracts per year by procurement from July 2008 and December 2019

Figure 4 displays the number of contracts realised for each public administration level, the Portuguese Government, and the municipalities. Portuguese Government are responsible for the projects which create an impact on the country. In contrast, municipalities are responsible for smaller and local projects. Based on Figure 4, the Government's number of contracts carried out is higher than those carried out by the municipalities during the analysis period, reaching a maximum from 2014 to 2017.

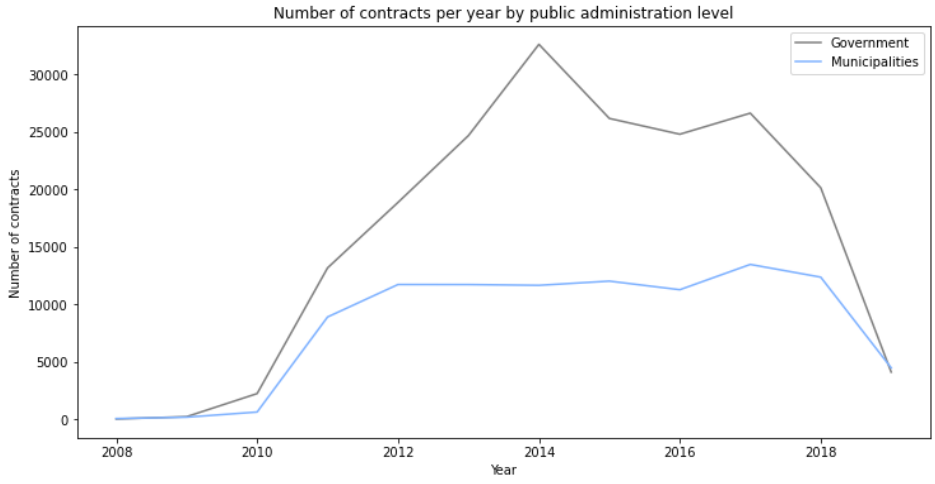

Figure 4 - Number of contracts per year by public administration level, the Portuguese government, and the municipalities, from July 2008 and December 2019

Table 4 show the descriptive statistics for the final data set. The data set contains 292.100 contracts, with an average initial contract price of €40.972,29 and an average final effective price of €61.262,42,

being the average cost overrun of €20.290,13. Most of the contracts are executed in *the Área Metropolitana de Lisboa*, followed by *Centro* and *Norte*.[1]

Table 4 - Final data set descriptive statistics

	count	mean	std	min	25%	50%	75%	max
Execution Deadline	292.100	801,50	160.729,92	0	20	90	361	60.498.000
Initial Contract Price	292.100	40.972,29	417.121,96	0	2576	9000	22.499	111.388.240
Total Effective Price	292.100	61.262,42	3.505.264,44	0	2366	8553,5	21.450	1.496.713.600
Government	292.100	0,68	0,47	0	0	1	1	1
Municipalities	292.100	0,32	0,47	0	0	0	1	1
Frequency Contracted	292.100	107,58	230,06	1	5	21	99	1784
Execution Place: Madeira	292.100	0,03	0,17	0	0	0	0	1
Execution Place: Açores	292.100	0,03	0,16	0	0	0	0	1
Execution Place: Norte	292.100	0,17	0,37	0	0	0	0	1
Execution Place: Centro[1]	292.100	0,23	0,42	0	0	0	1	1
Execution Place: Área Metropolitana de Lisboa[1]	292.100	0,38	0,48	0	0	0	1	1
Execution Place: Alentejo[1]	292.100	0,11	0,31	0	0	0	0	1
Execution Place: Algarve[1]	292.100	0,06	0,24	0	0	0	0	1
Cost Overrun	292.100	20.290,13	3.468.887,87	-23.355.357	0	0	0	1.496.698.633

A brief analysis of public procurement levels by contract types and procurement was made, presented in Table 5. Comparing the number of contracts and the public administration level, the national Government has 68% of the total contracts. Hence, being the Direct Award the most frequently, followed by Prior Consultation and Public Tender. Furthermore, most municipal contracts correspond to public works contracts, while most government contracts are from supply and services.

[1] The North of Portugal includes the districts *of Porto, Aveiro, Guarda, Viana do Castelo, Vila Real, Braga* and *Bragança*. The centre of Portugal includes *Coimbra, Viseu, Aveiro, Leiria, Castelo Branco, Covilhã, Caldas da Rainha, Figueira da Foz, Guarda, Torres Vedras, Alcobaça, Peniche, Pombal* and *Águeda*. *Área Metropolitana de Lisboa* includes *Lisboa* and *Setúbal*. Lasty, Alentejo includes the districts of *Évora, Elvas, Portalegre, Beja, Moura, Serpa, Sines and Santarém*.(Pordata, 2013)

Table 5 - Distribution of contract types by entities. The Portuguese government realised most of the contracts analysed in this work, being the most frequent direct awards.

	Municipalities	Municipalities (%)	Government	Government (%)	Total
Direct Awards	86.845	34%	166.967	66%	253.812
- Public works contracts	16.998	61%	10.912	39%	27.910
- Supply and service contracts	69.847	31%	156.055	69%	225.902
Prior Consultation	3530	18%	16.457	82%	19.987
- Public works contracts	1036	67%	521	33%	1557
- Supply and service contracts	2494	14%	15.936	86%	18.430
Public Tender	8098	45%	9800	55%	17.898
- Public works contracts	3759	71%	1515	29%	5274
- Supply and service contracts	4339	34%	8285	66%	12.624
Other types of contracts	71	18%	332	82%	403

Descriptive statistics for national Government and municipalities are displayed in Table 6 and Table 7, respectively. The average Cost Overrun is higher in contracts carried out by municipalities than by the Government. Thus, despite the Government signing more contracts, the municipalities present a higher average initial cost and a higher total effective price.

Table 6 - Government Contracts Descriptive Statistics. The Portuguese government realised more contracts than municipalities, being the *Área Metropolitana de Lisboa* the most frequent execution place.

	count	mean	std	min	25%	50%	75%	max
Execution Deadline	198.092	1051,06	194.451,22	0	20	90	365	60.498.000
Initial Contractual Price	198.092	37.880,73	419.644,39	0	1256	7250	19.500	59.398.828
Total Effective Price	198.092	49.150,30	2.230.623,99	0	1178	6872	18.603,25	844.740.200
Frequency Contracted	118.82	131,12	260,47	1	6	29	127	1784
Execution Place: Madeira	198.092	0,04	0,20	0	0	0	0	1
Execution Place: Açores	198.092	0,03	0,17	0	0	0	0	1
Execution Place: Norte	198.092	0,15	0,36	0	0	0	0	1
Execution Place: Centro[1]	198.092	0,23	0,42	0	0	0	0	1
Execution Place: Área Metropolitana de Lisboa[1]	198.092	0,42	0,49	0	0	0	1	1
Execution Place: Alentejo[1]	198.092	0,08	0,27	0	0	0	0	1
Execution Place: Algarve[1]	198.092	0,04	0,20	0	0	0	0	1
Cost Overrun	198.092	11.269,60	2.170.310,97	-23.355.357	0	0	0	834.697.945

Table 7 - Municipalities Contracts Descriptive Statistics. *Área Metropolitana de Lisboa* is the execution place with more contracts executed. The contracts realised by municipalities have higher average initial and total effective prices.

	count	**mean**	**std**	**min**	**25%**	**50%**	**75%**	**max**
Execution Deadline	94.008	275,62	24.408,15	0	20	75	334	7.482.685
Initial Contractual Price	94.008	47.486,80	411.682,37	0	6715	12.539	28.800	111.388.240
Total Effective Price	94.008	86.784,91	5.262.333,81	0	6417	12.000	27.500	1.496.713.600
Frequency Contracted	94.008	57,98	133,65	1	3	11	43	1784
Execution Place: Madeira	94.008	0,00	0,08	0	0	0	0	1
Execution Place: Açores	94.008	0,02	0,14	0	0	0	0	1
Execution Place: Norte[1]	94.008	0,19	0,39	0	0	0	0	1
Execution Place: Centro[1]	94.008	0,23	0,42	0	0	0	0	1
Execution Place: Área Metropolitana de Lisboa[1]	94.008	0,28	0,45	0	0	0	1	1
Execution Place: Alentejo[1]	94.008	0,17	0,38	0	0	0	0	1
Execution Place: Algarve[1]	94.008	0,10	0,30	0	0	1	0	1
Cost Overrun	94.008	39.298,12	5.240.574,44	-4379560	0	0	0	1.496.698.633

4. EXPLORATORY ANALYSIS

The distribution of the contracts price around thresholds was firstly analysed. Thereby is used in the contract value analysis, accordingly with procurement levels, contract types and procurement. The initial contract values were normalised according to their threshold for each procurement level, contract type and procurement, presented in sub-section 2.1 - Public Procurement. Thus, the normalised initial contract value is zero at the discontinuity point.

Based on thresholds defined on law decree No. 18/2008, January 2008, direct awards values distribution by Government and Municipalities are displayed in Figure 5.

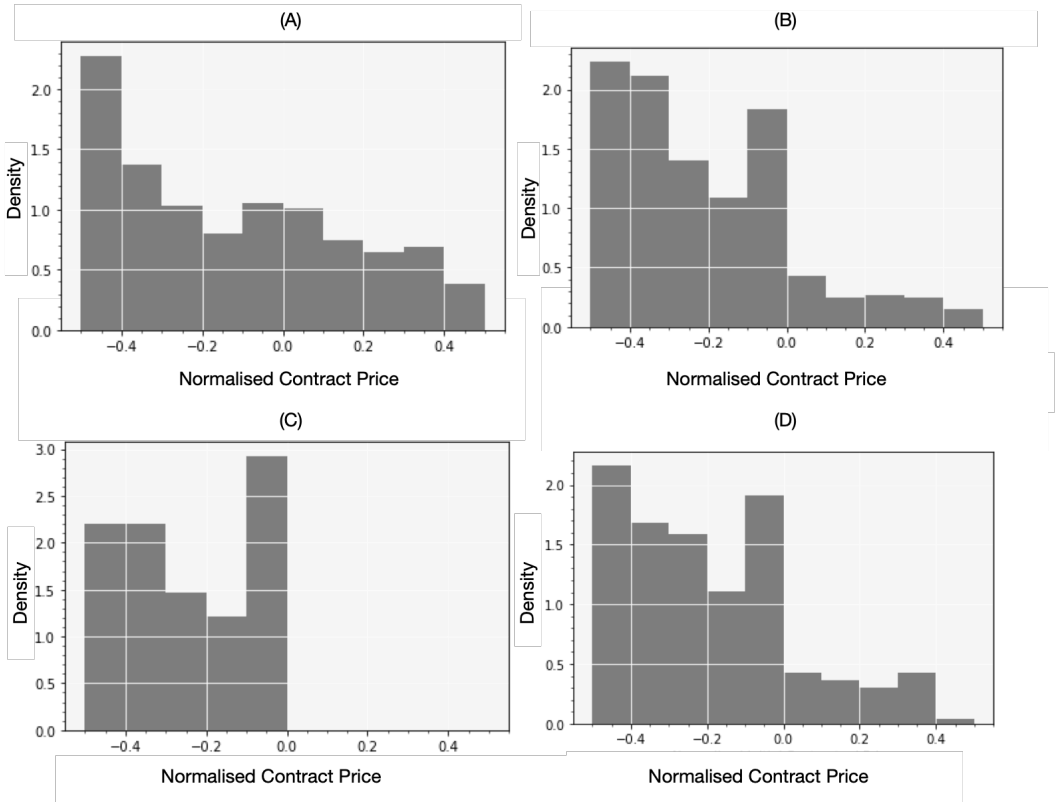

Figure 5 - Direct Awards values distribution, based on law decree No. 18/2008, January 2008. (A) Government public work contracts distribution. (B) Government supply and services contracts distribution. (C) Municipalities public work contracts distribution. (D) Municipalities supply and services contracts distribution.

Based on Figure 5, an apparent spike below the threshold, as depicted in Government and Municipalities supply and services contracts and Municipalities public work contracts. Contrarily, there is no apparent spike below the threshold in Government public work contracts.

Figure 6 and Figure 7 represent the value's distribution considering the thresholds defined on law decree No. 111-B/2017, 31 august for the Portuguese government and municipalities, respectively. Public Tenders regarding public work contracts were not analysed as the values of contracts in this category are far below the limit.

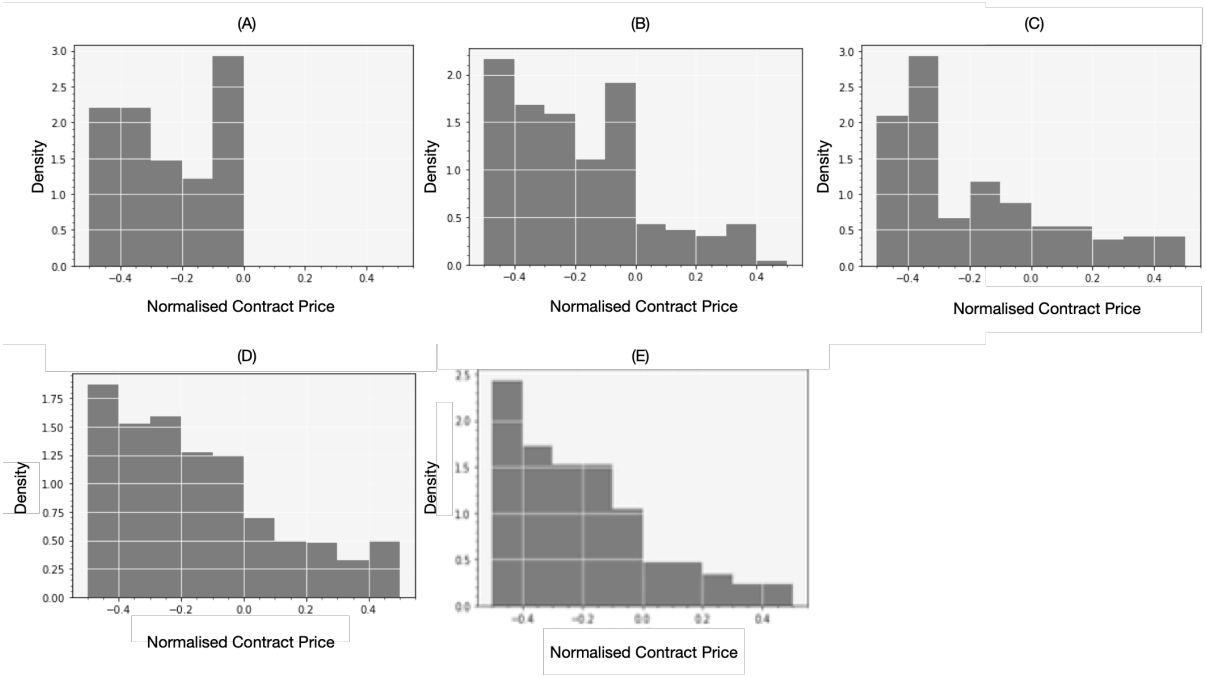

Figure 6 – Governments contracts values distribution, based on law decree No. 111-B/2017, 31 august. (A) Prior Consultation public work contracts distribution. (B) Prior Consultation supply and services contracts distribution. (C) Direct Awards public work contracts distribution. (D) Direct Awards supply and services contracts distribution. (E) Public Tender supply and services contracts distribution

In Figure 6, a slight spike below the threshold is described in the sub-figure regarding the direct awards of public work contracts. Although, the remaining government contracts show a clear spike below the defined threshold.

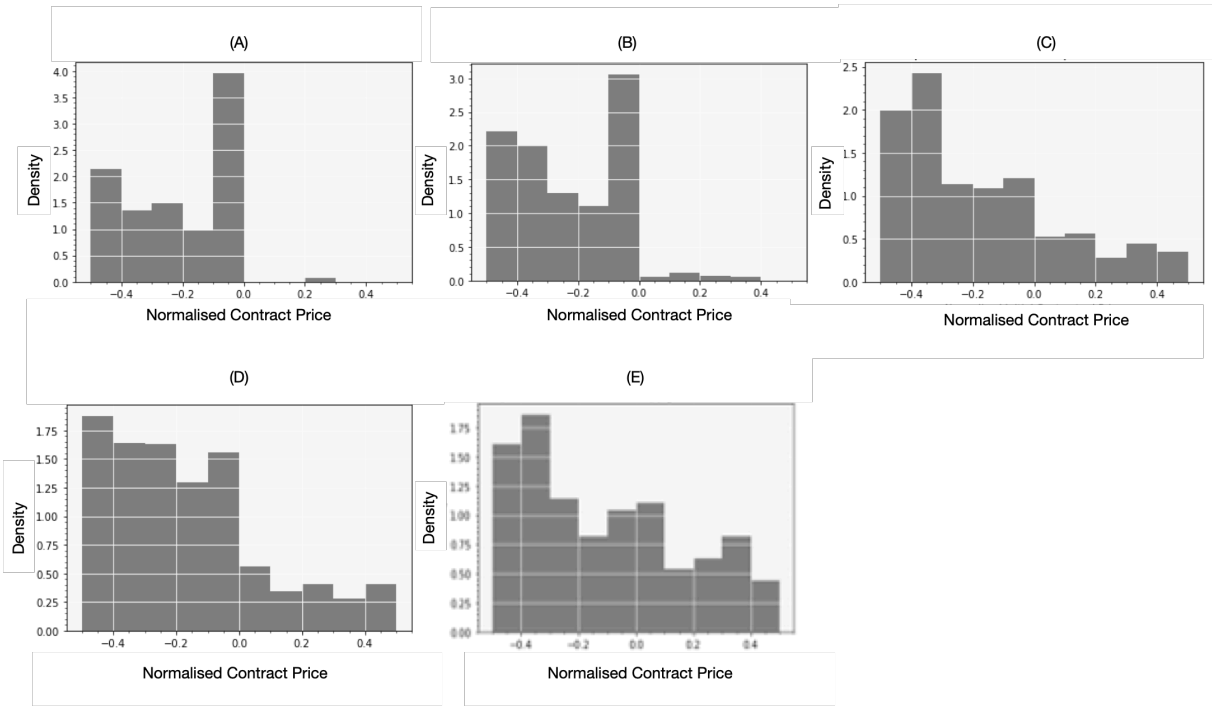

Figure 7 - Municipalities contracts values distribution, based on law decree No. 111-B/2017, 31 august. (A) Prior Consultation public work contracts distribution. (B) Prior Consultation supply and services contracts distribution. (C) Direct Awards public work contracts distribution. (D) Direct Awards supply and services contracts distribution. (E) Public Tender supply and services contracts distribution

In Figure 7, public tender contracts do not show an apparent spike around the threshold. However, the remaining sub-figures exhibit a clear spike below the defined threshold.

Overall, previous distributions show already some evidence of bunching around the threshold in different contract types and procurement levels. Therefore, in the following sections, some methodologies were applied to test evidence of bunching.

5. EMPIRICAL STRATEGY

In the previous section, the graphs suggest patterns that we can associate with evidence of bunching around the threshold. We begin our analysis by presenting evidence of discontinuity at the defined threshold, using a Regression Discontinuity Design technique, by implementing the McCrary test.

The McCrary density discontinuity test pretends to examine any significant discontinuity in the density function of the running variable (McCrary, 2008). Density discontinuity tests aim to find proof of manipulation at the discontinuity point. By comparing the project values below and above the defined threshold, potential evidence of manipulation of the project value can be detected. In a non-manipulative case, the density of contract values should be continuous. Otherwise, a discontinuity density function may represent evidence of manipulation at the discontinuity point.

The test is based on a non-parametric local polynomial density estimator of Cheng, Jianqing, and Marron (1997) for the discontinuity in the density function of the running variable. The test has two different parts. The test starts with the creation of a histogram. The histogram bins are developed to not include points from both sides of the discontinuity point. In the second step, the histogram is smoothed, using local linear regression on both parts at the discontinuity point. The midpoints of the histogram bins are used as a regressor. Additionally, the normalised counts of the number of observations falling into the bins are used as outcomes. Regarding the discontinuity point is estimated as the log difference in height on the intercept:

$$\hat{\theta} = ln\hat{f}^{+} - ln\hat{f}^{-} \quad (1)$$

In the equation, $\hat{\theta}$ represents the discontinuity point. Furthermore, $\hat{f}^{+}$ and $\hat{f}^{-}$, corresponds to the estimated values for the discontinuity above and below the discontinuity point, respectively.

Concluding the discontinuity point calculation, a standard t-test was constructed for H0: $\hat{\theta} = 0$, in other words, no statistical evidence of discontinuity at the discontinuity point. Therefore, in our analysis, the null hypothesis is that the contract values are continuous at the discontinuity point. No signs of contract values manipulation are detected to be below the defined threshold.

The methodology developed by McCrary was applied to popular elections and to roll call voting to the House of Representatives in the United States. To test for evidence of manipulation at the popular elections data regarding each candidate in contested elections to the United States House of Representatives, between 1900 and 1990 was used. Data within 1857 and 2004 was used to test for evidence of manipulation at the roll call voting in the House of Representatives. The null hypothesis was not rejected for popular elections, as presented in Figure 8, based on the McCrary test. The estimated curve does not show strong discontinuity at zero. Although, the null hypothesis is rejected to roll call voting. There are discontinuity signs at 50 per cent, as presented in Figure 9. Thus, evidence of manipulation was found at the roll call voting in the House of Representatives.

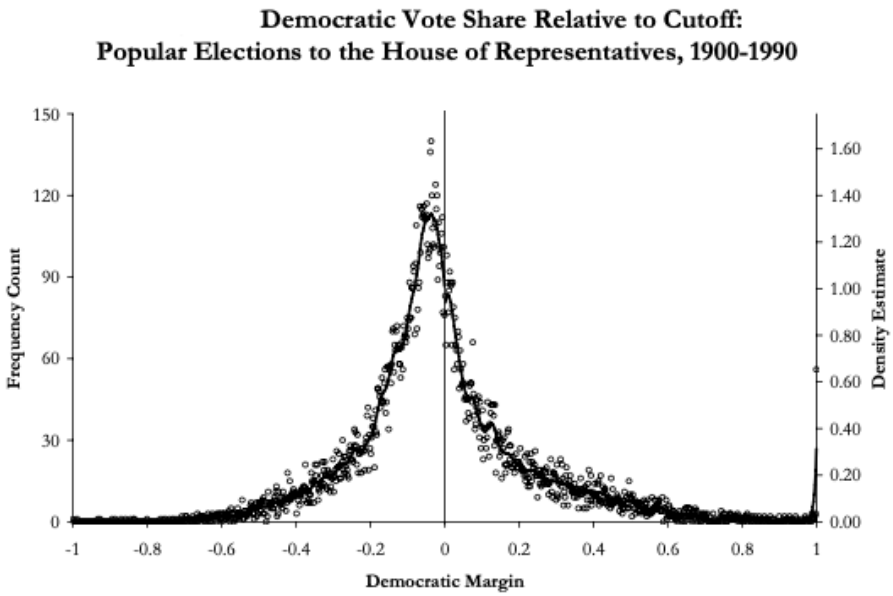

Figure 8 – Popular elections to the House of Representatives McCrary test results by McCrary, 2008.[2] Notes: The democratic margin is defined as the fraction between all votes received and the largest vote share of the other candidates. The circles represent the average observed values, and the bold lines represent the point estimates. Based on Figure 8, there is no strong evidence of discontinuity at 0.

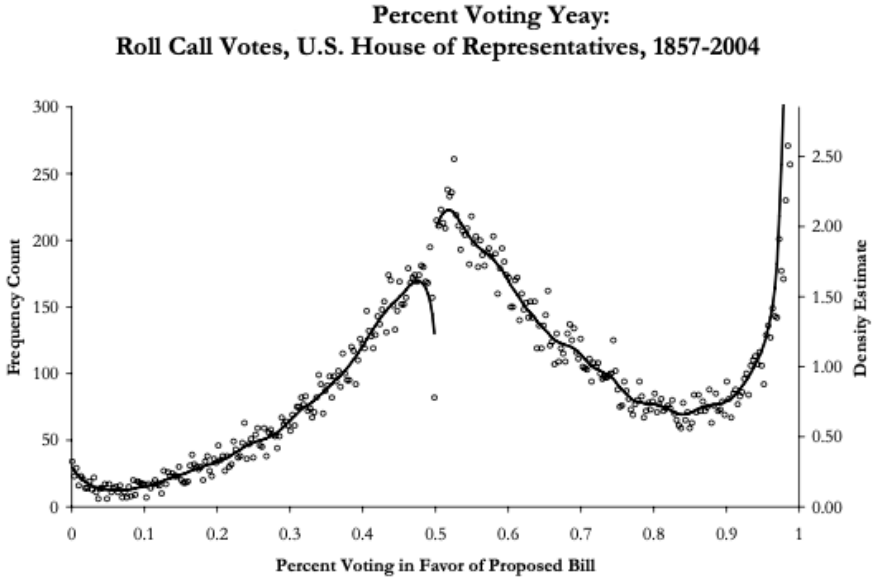

Figure 9 - Roll Call Votes of the House of Representatives McCrary test results by McCrary, 2008. [3] Notes: The circles represent the average observed values, and the bold lines represent the point estimates. Based on Figure 9, a significant discontinuity at 50 percent was detected.

Considering the McCrary test application, we expected to achieve results like McCrary (2008).

[2] Image sourced from: https://eml.berkeley.edu/~jmccrary/mccrary2006_DCdensity.pdf
[3] Image sourced from: https://eml.berkeley.edu/~jmccrary/mccrary2006_DCdensity.pdf

Once the McCrary density discontinuity test was concluded, we studied evidence of bunching patterns around the defined thresholds by implementing standard bunching techniques developed by Saez (2010) and Chetty et al. (2011).

Based on US federal income tax, Saez (2010) developed a methodology to measure the difference between individuals before and after the defined threshold. These individuals excess is those who changed their behaviour to be below the defined threshold. The method aims to detect only the presence of bunching.

Using danish tax records between 1994 and 2001, Chetty et al. (2011) implemented a methodology to study the effects of taxes policies on labour supply. The methodology based on non-parametric models seeks to obtain individual distribution that is not affected by the influence of the tax point. Firstly, the authors average the density of individuals over the years. Afterwards, an income compartment close to the tax point is chosen to calculate the counterfactual distribution. Contrarily to the Saez (2010) methodology, this method requires counterfactual density to measure the excess of individuals. In their results, evidence of bunching was detected for individuals with deductions greater than DKr 20,000, as presented in Figure 10.

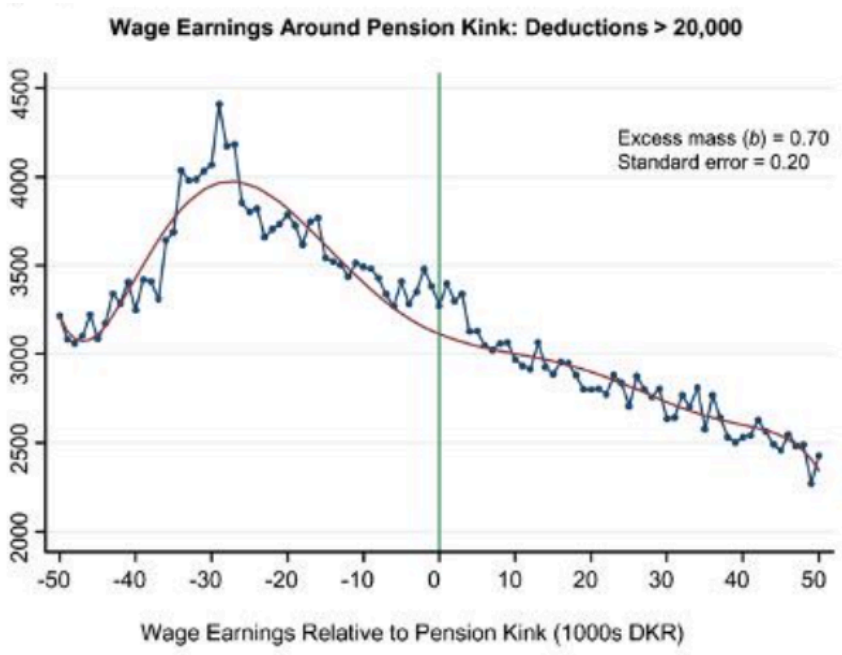

Figure 10 - Aggregate Bunching at the Pension Kink tested by Chetty et al. (2011).[4] The Figure plots the distribution of the wage earnings of pension kink (vertical green line, at 0) for individuals who have deductions greater than DKr 20,000. The figure reports a blue line that describes the proper density and a red line describing the counterfactual estimate. The bunching excess mass (b) and the standard error are also reported in this analysis. Based on Figure 10, bunching is evident, being the excess mass of 0.70.

[4] Image sourced from https://dash.harvard.edu/bitstream/handle/1/9639984/Friedman-AdjustmentCosts.pdf;sequence=1

The primary purpose of the bunching technique is to measure the excess mass (bunching) related to a discontinuity in an observed density of the decision variable. Therefore, the excess mass was estimated above and below the decision variable at the discontinuity level.

The bunching methodology measures the number of entities shifting from the right side of the threshold to the left by grouping entities into turnover bins, estimating the counterfactual density, and comparing the counterfactual to the actual density function. The counterfactual density corresponds to the size distribution without entity shiftings from the right threshold side to the left side. Moreover, the counterfactual density is calculated by fitting a flexible polynomial function to the observed distribution expect for the area below the discontinuity point. Finally, the bunching area is calculated through visual inspection.

The bunching excess mass, $\hat{b}$, results from the difference between the observed number of entities, c_i, and the counterfactual number, $\hat{c}_i$, in the bunching interval $[t_L, t_u]$, below the discontinuity point:

$$\hat{b} = \frac{\sum_{i-t_L}^{t_u}(c_i - \hat{c}_i)}{\sum_{i-t_L}^{t_u}(c_i/N)} \quad (2)$$

In the equation, N is the number of bins within the bunching interval, t_L and t_u corresponds to the lower and upper region that define the bunching region, respectively. Also, b corresponds to the number of entities that shifted to the bunching interval relative to the expected number of entities per bin in the bunching area.

Based on bunching techniques application, we expected to achieve results like Chetty et al. (2011), as presented in Figure 10.

6. RESULTS AND DISCUSSION

The presence of discontinuity at the threshold will be validated through McCrary (2008) test. The initial contract values were normalised at the threshold itself as defined in subsection 2.1 - Public Procurement. Thus, in the presence of discontinuity, it should be expected at zero. Therefore, the McCrary test was developed concerning a normalised threshold value of zero, corresponding to the running variable.

Figures 11 and 12 present the results for each type of contract, procurement and procurement level, considering the law decree No. 18/2008, January 2008 and law decree No. 111-B/2017, 31 august, respectively.

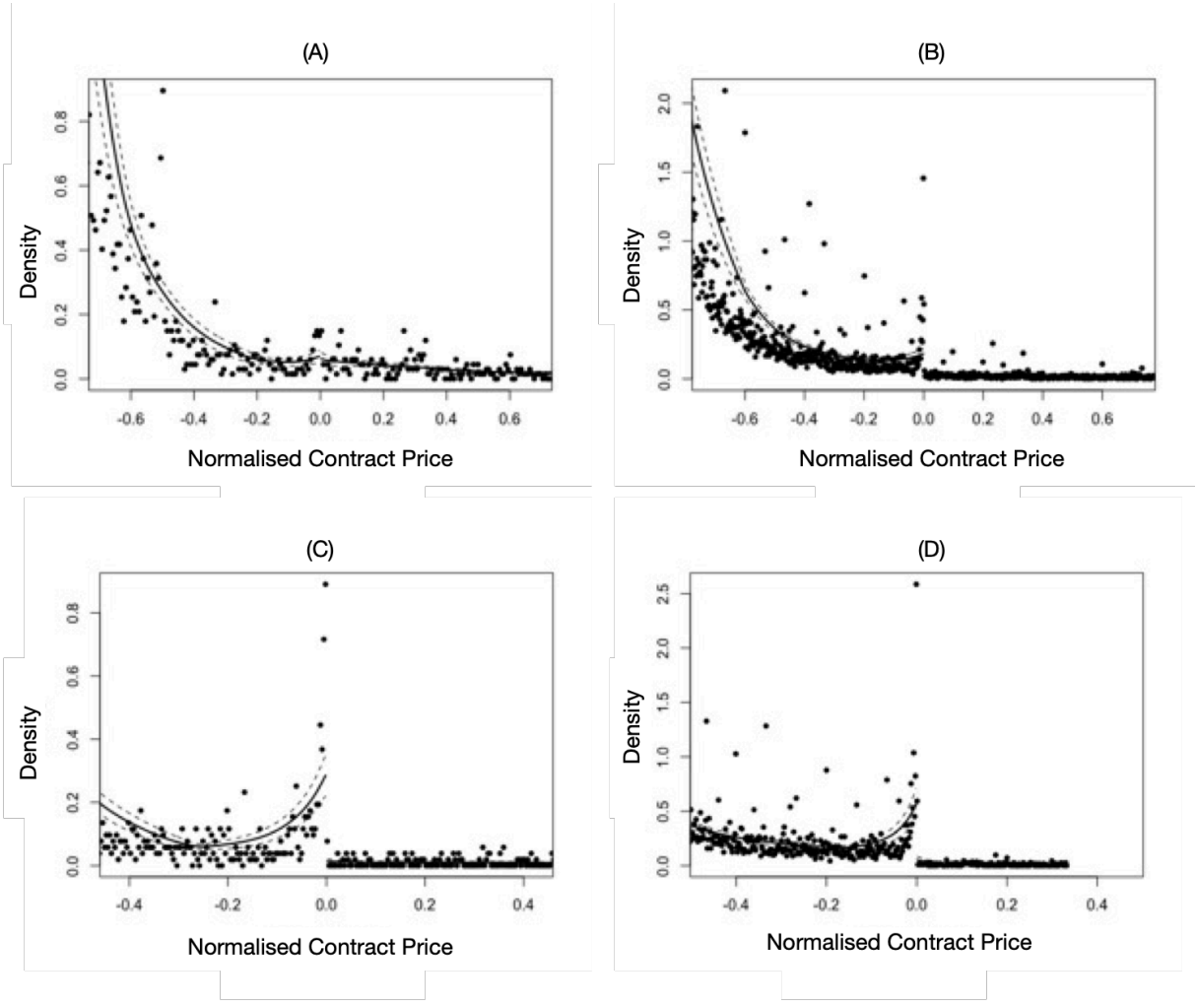

Figure 11 - McCrary test results, based on law decree No. 18/2008, January 2008. Notes: The sub-figures represent: (A) Government public work contracts distribution. (B) Government supply and services contracts distribution. (C) Municipalities public work contracts distribution. (D) Municipalities supply and services contracts distribution. Each sub-figure reports the contract price normalised at the threshold itself defined on law decree No. 18/2008, January 2008. Considering each sub-figure, circles represent the average observed values. Around the threshold, the thin lines represent 95% confidence intervals for the point estimates, the bold lines.

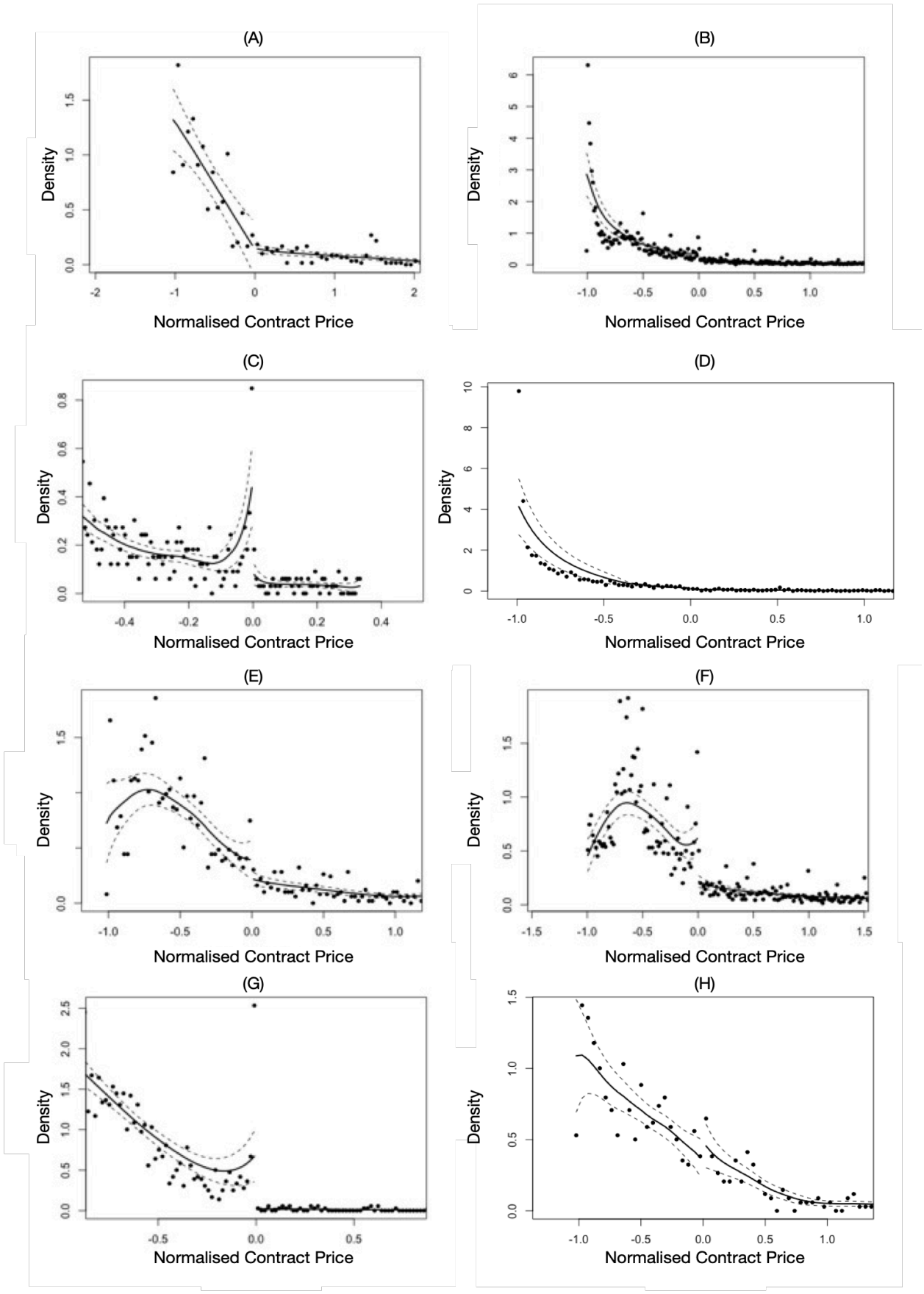

Figure 12 – McCrary test results, based on law decree No. 111-B/2017, 31 august. Notes: The sub-figures represent: (A) Government: Direct Awards public work contracts. (B)

Government: Direct Awards supply and services contracts. (C) Government: Prior Consultation supply and services contracts. (D) Government: Public Tender supply and services contracts. (E) Municipalities: Direct Awards public work contracts. (F) Municipalities: Direct Awards supply and services contracts. (G) Municipalities: Prior Consultation supply and services contracts. (H) Municipalities: Public Tender supply and services contracts. Each sub-figure reports the contract price normalised at the threshold itself defined on law decree No. 111-B/2017, 31 august. Considering each sub-figure, circles represent the average observed values. Around the threshold, the thin lines represent 95% confidence intervals for the point estimates, the bold lines.

Our analysis shows evidence to support the existence of discontinuity in most analysed cases. The null test hypothesis is that the values are continuous around the threshold, so there is no evidence that the values were manipulated below the threshold. In Figure 11, the Government public work contracts present a p-value higher than 5% (0,58). Furthermore, the Municipalities supply and services contracts regarding public tenders, in Figure 12, also presents a p-value higher than 5% (0,15), so the null hypothesis is not rejected in both cases. Consequently, there is no statistical evidence of manipulation of the running variable at the discontinuity point. However, in all the other sub-figures, the null hypothesis is rejected with a robust p-value of near 0. Hence, there is a discontinuity at the discontinuity point, which indicates evidence of manipulation below the threshold. As a result, there is an increase in contracts below the defined threshold, followed by a drop in contracts. Concerning the Prior Consultation for public works, the available data is insufficient to realise the density test since the test requires a large amount of data around the threshold.

Following the analysis of the McCrary test, a bunching technique was applied. The main goal was to find evidence of bunching at discontinuity points detected with the previous method. In addition, the bunching technique was developed concerning the non-normalised threshold.

The results of the bunching technique application for each type of contract, procurement and procurement level are presented in Figures 13 to 15.

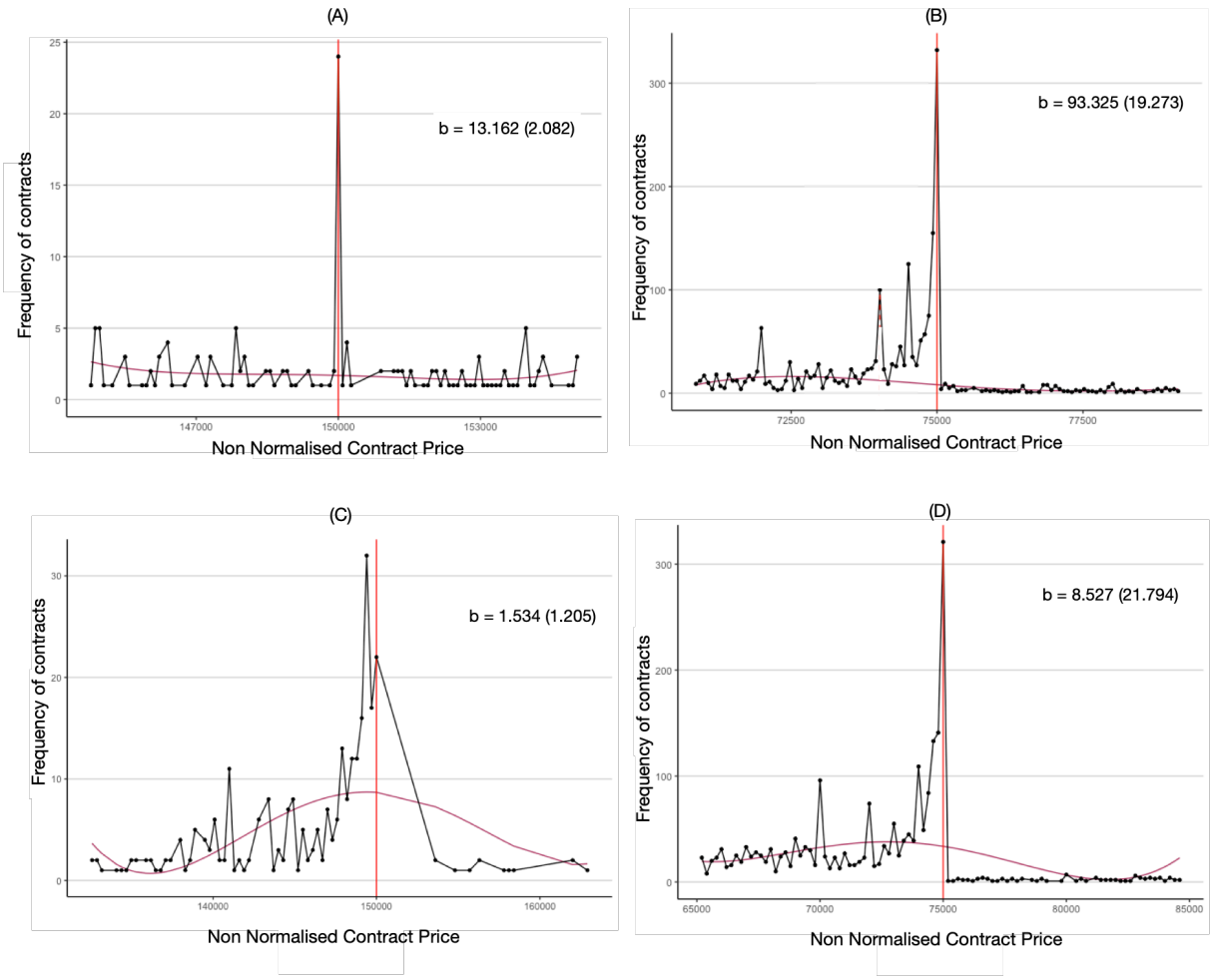

Figure 13 - Bunching technique results, based on law decree No. 18/2008, January 2008. Notes: The sub-figures represent: (A) Government public work contracts distribution. (B) Government supply and services contracts distribution. (C) Municipalities public work contracts distribution. (D) Municipalities supply and services contracts distribution. Each sub-figure reports a black line that describes the proper density, a marron line describing the counterfactual estimate and a solid vertical line that marks the threshold defined in subsection 2.1 - Public Procurement. In addition, it represents the non-normalised initial contract value. Also, the sub-figures show the normalised excess bunching mass (b) around the threshold, with bootstrapped standard errors in parentheses.

Concerning Figure 13, Government public work contracts do not show evidence of bunching as excepted in the discontinuity point. Contrarily, all the other sub-figures show a significant discrepancy below and above the defined threshold. Thus, the results follow the earlier analysis.

Figure 14 and Figure 15 present the bunching technique results for the Portuguese government and municipalities contracts, respectively.

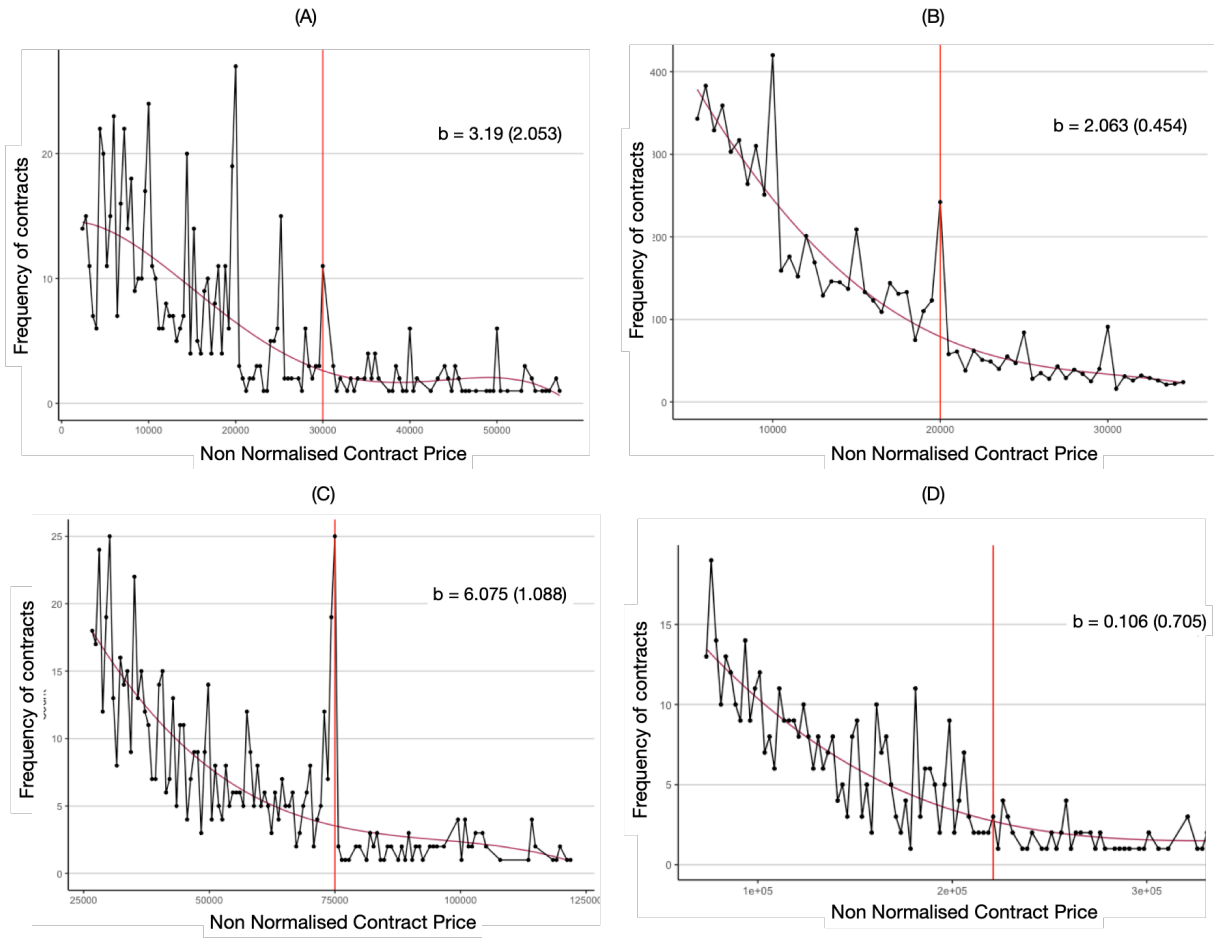

Figure 14 - Bunching technique results for Government contracts, based on law decree No. 111-B/2017, 31 august. Notes: The sub-figures represent: (A) Direct Awards public work contracts. (B) Direct Awards supply and services contracts. (C) Prior Consultation supply and services contracts. (D) Public Tender supply and services contracts. Each sub-figure reports a black line that describes the proper density, a marron line describing the counterfactual estimate and a solid vertical line that marks the threshold defined in subsection 2.1 - Public Procurement. In addition, it represents the non-normalised initial contract value. Also, the sub-figures show the normalised excess bunching mass (b) around the threshold, with bootstrapped standard errors in parentheses.

The results show a clear agglomeration below the defined threshold in each sub-figure, in Figure 14.

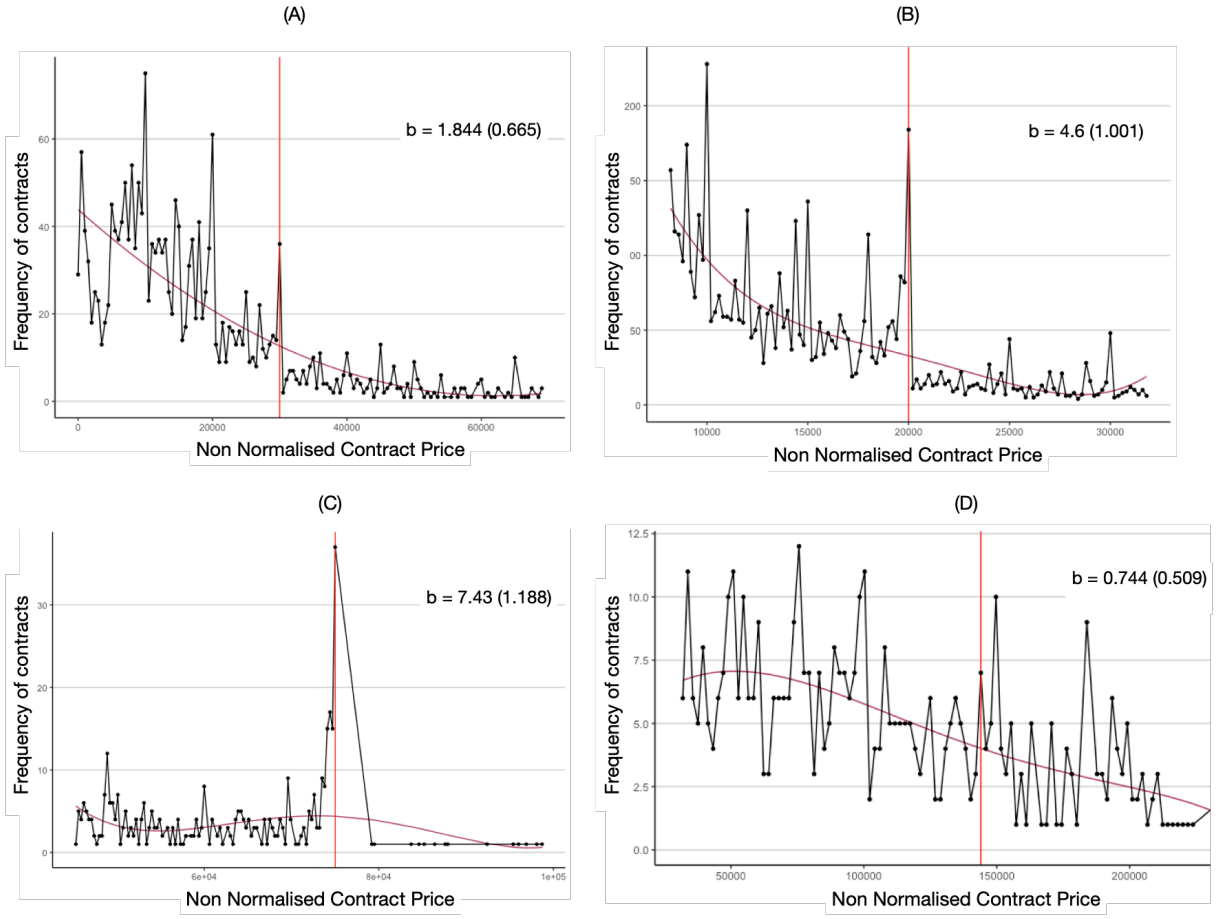

Figure 15 - Bunching technique results for Municipalities contracts, based on law decree No. 111-B/2017, 31 august. Notes: The sub-figures represent: (A) Direct Awards public work contracts. (B) Direct Awards supply and services contracts. (C) Prior Consultation supply and services contracts. (D) Public Tender supply and services contracts. Each sub-figure reports a black line that describes the proper density, a marron line describing the counterfactual estimate and a solid vertical line that marks the threshold defined in subsection 2.1 - Public Procurement. In addition, it represents the non-normalised initial contract value. Also, the sub-figures show the normalised excess bunching mass (b) around the threshold, with bootstrapped standard errors in parentheses.

Evidence of bunching is apparent in most of the sub-figures presented in Figure 15, considering the results show a sharp mass bunching at the initial contract value. However, Municipalities supply and services contracts regarding public tenders present unclear evidence of bunching. There is no strong agglomeration of mass bunching at the threshold, in this case.

Table 8 summarises the bunching techniques results for each type of contract, procurement and procurement level.

Table 8 - Summary of bunching technique results

	Estimated bunching mass	The standard deviation of the bunching mass	Normalised estimated bunching mass	The standard deviation of the normalised bunching mass	Estimated elasticity
Contracts based on law decree No. 18/2008, January 2008					
Direct Awards					
Government:					
- Public Work contracts	3,64	0,683	2,676	0,715	0,008
- Supply and Services contracts	960,604	36,981	93,325	19,273	0,436
Municipalities:					
- Public Work contracts	13,316	5,796	1,534	1,205	0,015
- Supply and Services contracts	282,889	11.556,4	7,423	60,603	0,066
Contracts based on law decree No. 111-B/2017, 31 august					
Direct Awards					
Government:					
- Public Work contracts	8,375	4,042	3,19	2,053	0,213
- Supply and Services contracts	162,992	30,65	2,063	0,454	0,258
Municipalities:					
- Public Work contracts	23,342	7,828	1,844	0,665	0,154
- Supply and Services contracts	31,782	5,787	3,867	1,022	0,193
Prior Consultation					
Government:					
- Supply and Services contracts	21,466	2,198	6,075	1,088	0,284
Municipalities:					
- Supply and Services contracts	32,611	2,94	7,43	1,188	0,149
Public Tender					
Government:					
- Public Work contracts	0,287	1,799	0,106	0,705	0,006
Municipalities:					
- Public Work contracts	2,986	1,967	0,744	0,509	0,049

Concluding, the present results are in line with the McCrary Density test conclusions. In addition, evidence of bunching was detected at the discontinuity points. Moreover, evidence of bunching was detected in direct awards, public tenders and prior consultation. Being more frequent in direct awards related to supply and services than in direct awards about public works contracts. Also, in public tenders, the evidence of bunching is lower compared with the other contracts.

6.1. CASE STUDY

The present sub-section presents a case study of evidence of bunching and non-bunching authorities, based on thresholds defined on law decree No. 18/2008, 29 January 2008. Direct Awards for supply and services will be the object of the study.

Firstly, the presence of discontinuity at the threshold was evaluated by applying the McCrary Density test. The null test hypothesis is that the values are continuous around the threshold, no evidence of manipulation below the threshold are detected. Consequently, the evidence of bunching at the discontinuity point was studied through the bunching technique.

Figures 16 (a) display McCrary Density Test results for the *Autoridade de Supervisão de Seguros e Fundos de Pensões* (ASF), a government entity responsible for the insurer reinsurer, pension funds and insurance mediation regulation and supervision. Figure 16 (b) presents the test results for *Município de Loures*, a Portuguese municipality.

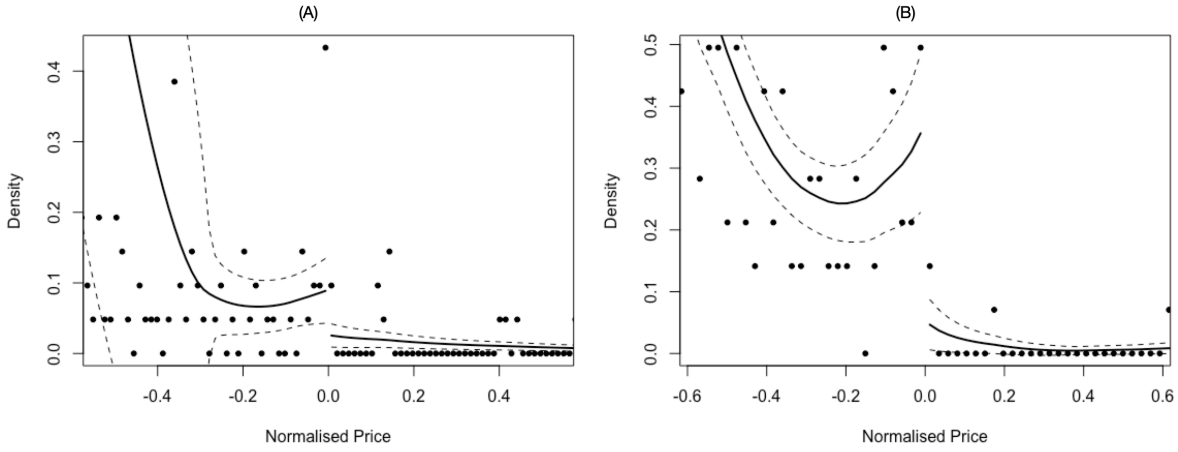

Figure 16 - McCrary test for *ASF* (A) and *Município de Loures* (B). Considering each sub-figure, circles represent the average observed values. Around the threshold, the thin lines represent 95% confidence intervals for the point estimates, the bold lines.

Figure 17 (a) presents the McCrary test for *Unidade Local De Saúde Do Norte Alentejano, E.P.E.,* a government hospital unit. Lastly, Figure 17 (b) show the test results for *Município de Alcobaça*, a Portuguese municipality.

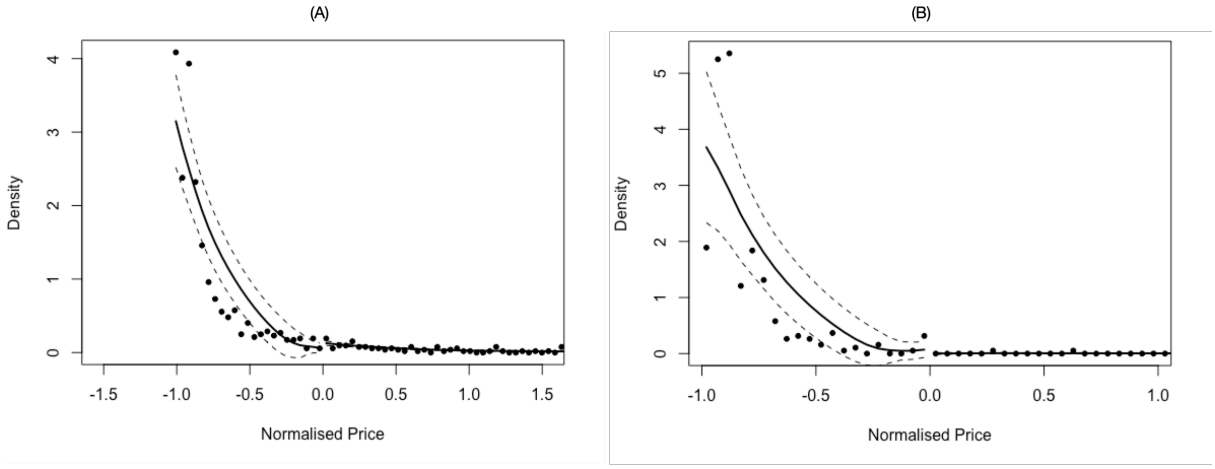

Figure 17 - McCrary test for *Unidade Local de Saúde do Norte Alentejano* (A) and *Município de Alcobaça* (B). Considering each sub-figure, circles represent the average observed values. Around the threshold, the thin lines represent 95% confidence intervals for the point estimates, the bold lines.

Based on Figure 16 results, the null hypothesis is rejected with a robust p-value of near 0. Furthermore, the results show discontinuity at the normalised price, which may indicate evidence of bunching below threshold. However, in Figure 17, the null hypothesis is not rejected, as the p-value is higher than 5%. Thus, evidence of bunching below threshold is denied.

Finally, the bunching technique was applied to the previously analysed authorities to find evidence of bunching at the defined threshold. The results are shown in Figure 18 and Figure 19.

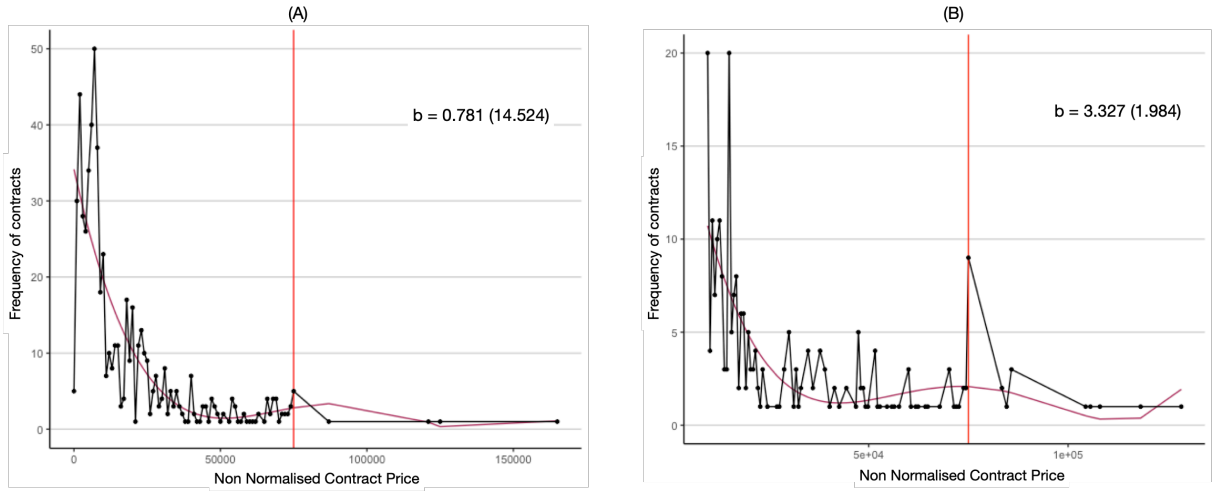

Figure 18 - Bunching technique results for *ASF* (A) and *Município de Loures* (B). Each sub-figure reports a black line that describes the proper density, a marron line describing the counterfactual estimate and a solid vertical line that marks the threshold defined in subsection 2.1 - Public Procurement. In addition, it represents the non-normalised initial contract value. Also, the sub-figures show the normalised excess bunching mass (b) around the threshold, with bootstrapped standard errors in parentheses.

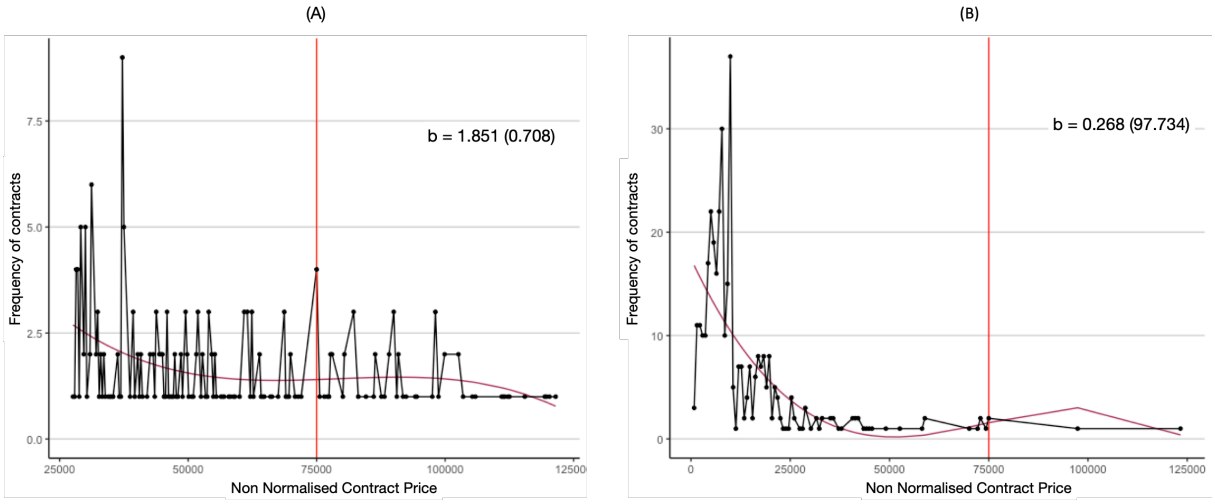

Figure 19 - Bunching technique results for *Unidade Local de Saúde do Norte Alentejano* (A) and *Município de Alcobaça* (B). Each sub-figure reports a black line that describes the proper density, a marron line describing the counterfactual estimate and a solid vertical line that marks the threshold defined in subsection 2.1 - Public Procurement. In addition, it represents the non-normalised initial contract value. Also, the sub-figures show the normalised excess bunching mass (b) around the threshold, with bootstrapped standard errors in parentheses.

Evidence of bunching was detected in Figure 18 as there is a sharp mass bunching below the threshold. Although in Figure 19, there is no evidence of bunching mass below the discontinuity point, there is no contracts concentration below the defined threshold in both cases.

7. CONCLUSION

Thresholds prices on public procurement contribute to an optimal contract allocation, transparency, and fraud reduction. However, thresholds also incentives authorities to have manipulated behaviour. For Giriūnas and Mackevičius (2014), the most significant percentage of fraud remains in the public sector rather than the private sector. The public sector has become an attractive sector for fraudsters (Kemp, 2010) since the work scope in public procurement is greater and more tangible than in the private sector. In addition, the procurement complexity and the public procurement purpose are more complex and vulnerable to political issues (Rustiarini et al., 2019) and derived from the few audits carried out compared to the private sector (Mitchie et al., 2011). For this, it is essential to have a continuous study in the detection and prevention of fraud.

Considering this problem, the main question to be answered through this work was if we could detect evidence of bunching Portuguese public procurement on local administrators and the national Government. To accomplish the main objective, two different methodologies were applied. First, the McCrary Density test was applied to test the presence of discontinuity at the threshold level. Moreover, the bunching technique was used to find evidence of bunching at the discontinuity points.

Evidence of bunching was found at the discontinuity points. Furthermore, evidence of bunching was found for most analysed cases. Except for the government public work contracts, based on law decree No. 18/2008, January 2008, and Public Tender, based on law decree No. 111-B/2017, 31 august, regarding public work contracts performed by local administrators.

The results suggest evidence of bunching that was found in all the procurement levels and for the contracts developed by the government and municipalities. However, there is more evidence of bunching in direct awards contracts related to goods and services than in direct awards about public works contracts. Moreover, there is no significant discrepancy between the different contract types since evidence of bunching was detected in all of them. Nevertheless, in public tenders, the evidence of bunching is lower than the remaining contracts.

Future work would pass for a detailed study on which contracts are more likely to be manipulated. In addition, a thorough analysis of the features that distinguish a manipulative authority would contribute to better fraud prevention and detection work.

Considering public procurement has a crucial role in public accounts, the findings of this work were essential for future work. Public officials can implement the McCrary test and bunching methodologies to help prevent manipulation schemes.

8. BIBLIOGRAPHY

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