

# Strategic Sourcing 2.0: Improving Fiscal Efficiency Using Big Data

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## Abstract

Increasing fiscal efficiency in public procurement remains a key challenge for governments across the world given that they spend up to one third of their budgets on it and systematic efficiency measurements have been largely lacking. We introduce a comprehensive framework for identifying potential savings and corresponding policy interventions. The framework combines traditional methods of strategic sourcing with economic theories of auctions and data science. The analysis rests on high resolution comprehensive administrative data on purchased items of standardized goods and services over several years typically encompassing millions of records per country. Such rich data allows for developing an innovative framework of 3 key elements: i) procurement market overview using interactive visualisations; ii) regression modelling of unit prices across government; and iii) in-depth micro analysis of selected large markets such as vehicles. The framework was refined through application in 7 Latin American countries, while its implementation is demonstrated here using Brazil's federal government as an example given that it is the largest country in our sample. Data-driven price modelling points at 16% savings due to improving public procurement processes and decisions, rather than fundamentally reconfiguring what is bought or the regulatory framework. Realistic policy changes such as increasing the length of advertising tenders or wider use of electronic auctions are required to achieve projected savings. Independently pricing each intervention also aids prioritisation. We conclude by discussing the strengths and weaknesses of the approach and suggesting future improvements.

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## 1. Introduction

Public procurement amounts to up to one third of general government expenditure across OECD countries and little over one fifth across Latin American countries (OECD, 2016, 2017). In the face of such an immense spending effort, maintaining and increasing fiscal efficiency remains a key challenge for governments across the world. However, so far systematic, real-time, and readily available efficiency measurements as well as explanatory frameworks have been largely lacking, making informed policy making challenging.

With the spread of e-procurement systems around the world (OECD, 2016, 2017), the ready and real-time availability of government-wide, high granularity spending data, typically on the contract or purchased item level, is increasingly available. Such datasets, if of acceptable quality and scope, can potentially provide the much needed efficiency metrics as well as identify cues as to which policy-relevant factors can influence them.

Against this background, this paper introduces a

*novel and comprehensive framework for identifying potential savings and implementing the necessary policy changes in the procurement of standardized goods and services.*

The approach proposed is both narrow and comprehensive. It narrowly focuses on unit prices paid for standardized goods and services for most of the analysis, but also offers a government-wide methodology proposing policy improvements. Conceptually, it combines traditional methods of strategic sourcing with economic theories of auctions and data science. Empirically, it employs mixed methods combining descriptive and explanatory quantitative models with in-depth case studies of selected markets. It has been refined through implementation in 7 Latin American countries including Brazil, Ecuador, Peru, or Uruguay (Figure 1) and 4 further sub-national entities such as the state of Santa Catarina or the city of Rio in Brazil. The below empirical examples are drawn from the authors' analysis of Brazil's federal government given that it is the largest country in our sample.<sup>1</sup>

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<sup>1</sup> The empirical analysis extensively draws on, but also goes considerably beyond the authors' prior analysis of Brazil's federal government published in (World Bank, 2017, pp. 55–66).

Figure 1. Overview of countries where the methodology has been applied in collaboration with national and region governments, 2017-2019



Source: own calculation

This article contributes both to the academic literature and policy debates. From an academic perspective, it develops a carefully tested mixed methods methodology for price modelling rooted in established theories and methods but applying them to a new context characterised by data of exceptional scope and depth. While there have been a few specific studies looking at isolated factors using similar data, to the best of our knowledge, our study is the first one to bring this literature together and propose a comprehensive methodology. From a policy perspective, our methodology offers a reliable and specific tool for policy makers to understand public procurement markets and to identify factors driving cost savings, either directly under policy influence (e.g. length of advertising tenders) or indirectly influencible (e.g. number of bids submitted). The methodology feeds into day to day policy making, leading to recommendations typically feasible within existing legal frameworks by tweaking the parameters of policy implementation. As the methodology is fully transparent and largely automated, real-time policy advice can be offered based on simulating the impacts of distinct policy scenarios.

## 2. Conceptual framework

The conceptual framework underpinning the analysis can be encompassing because the underlying data is both of a very broad scope virtually including all regulated public tenders and of great depth capturing detailed information on tendering procedures, the actors and results. Such data breadth is met with a broad evidence base, primarily rooted in economics on the impacts of auction design, market structure, and company characteristics; and in public administration research on the effects of administrative capacities. Wide data scope and strong theory, however, still make the identification of causal effects challenging; hence, our reliance on mixed methods, employing descriptive and explanatory quantitative models as well as in-depth analysis of selected case study markets. The methodological choices we made when developing this framework have tried to balance the precision of causal identification and broad scope, leaning towards a holistic approach most suitable for deriving policy-relevant insights.

The analytical framework consists of 3 key components which work best together but can also be deployed independently:

- i) public procurement market overview, using interactive visualisations;
- ii) regression modelling of unit prices across government; and
- iii) in-depth case study analysis of selected large markets such as vehicles.

While the set of variables in these analyses somewhat vary from method to method and country to country, the key dependent variable and the main groups of explanatory factors remain the same. These variables and the expected relationships between them represent the core elements of the conceptual framework. We review each of them in turn.

The main outcome variable we wish to explain is value for money which is defined as the quality of goods or works obtained for a given procurement price. Accordingly, value for money can improve because a given quality is achieved at a lower price or because a higher quality is achieved at a given price or both. Increasingly, value for money is not measured merely in terms of acquisition price and acquired quality, but more broadly applying life-cycle costing approaches (Saussier & Yukins, 2018). However, reliable and comparable data pertaining to value for money even for standardized goods and services is only available as **unit prices at the contract award**. Hence, we will take this variable as the key dependent variable for our analysis, defined as

$$\text{Unit price at contract award} = \text{total value of items contracted} / \text{standardized quantity of items contracted}$$

Such a definition of the dependent variable requires the units of measurement to be standard within markets we analyse, that is units of measurement can vary from market to market (e.g. kg for potato and litre for mineral water) but should stay the same within markets. This assures that the analysis can deliver valid conclusions within each market and with adequate quantitative transformations also across markets (i.e. explaining deviations from market average rather than absolute unit prices).

Using unit prices at contract award only approximates, and arguably imperfectly so, value for money. First, the focus on standardized goods and services and making comparisons with respect to market averages allows for keeping quality differences largely constant; even though some unobserved quality differences most certainly remain. Second, prices at contract award do not take into account cost changes due to contract modification during the implementation phase and they ignore a range of additional life-cycle costs such as maintenance costs borne by the government user. Third, payment and delivery schedules (e.g. delivering the same 10 chairs is likely to have different unit prices if it is to be done by tomorrow versus in 5 months) may differ impacting both the value of provision and production costs injecting an additional unobserved heterogeneity to unit price comparisons. In spite of such shortcomings, there is a wide ranging, policy relevant, and impactful literature using unit prices for academic research (Bandiera, Prat, & Valletti, 2009; Collier, Kirchberger, & Söderbrom, 2015; Fazekas & Tóth, 2018; Lewis-Faupel, Neggers, Olken, & Pande, 2016; Pricewaterhouse Coopers, 2013; Andrei Yakovlev, Vyglovsky, Demidova, & Bashlyk, 2015). While acknowledging shortcomings, we follow this literature and demonstrate unit prices' applicability and usefulness for public procurement research.

On the explanatory factors' side of the equation, the conceptual framework aims to be encompassing, capturing all major phases and actors of the process while also incorporating structural factors along with variables more or less directly influencible by policy (Table 1) (Fazekas & Blum, 2016). Crucially for the policy decisions this analysis can support, explanatory factors are gathered into 2 main groups at the end of the analysis: those which are directly amenable to policy intervention (e.g. length of advertising a tender) and those which can only indirectly be influenced by policy makers (e.g. number of bidders). While it is relatively straightforward to sort each predictor, in real life tenders they often appear in combinations giving rise to additional variables such as the locations of the buyer and the supplier determine their distance which is often an important factor determining prices.

Table 1. Summary of main groups of explanatory factors used in the analysis

Group	Definition	Examples	Type
<b>Market characteristics</b>	The technological and competitive structure of the market.	<ul style="list-style-type: none"> <li>• Number of potential suppliers</li> <li>• Technological complexity</li> </ul>	Structural
<b>Tender specifications</b>	The conditions for bidders to participate in a tender.	<ul style="list-style-type: none"> <li>• Length of advertising bids</li> <li>• Financial conditions of participation</li> </ul>	Directly policy influencible
<b>Buyer characteristics</b>	Level of administrative capacity of the buying office or agency.	<ul style="list-style-type: none"> <li>• Average time taken for evaluating bids</li> <li>• Buyer type-specific regulations</li> </ul>	Directly policy influencible
<b>Bidder/supplier characteristics</b>	Company productivity and capacity.	<ul style="list-style-type: none"> <li>• Company size</li> <li>• Company headquarters location</li> </ul>	Indirectly policy influencible
<b>Bidding outcomes</b>	Intermediate and final results of the tendering process	<ul style="list-style-type: none"> <li>• Number of bids submitted</li> <li>• Contract start date</li> </ul>	Indirectly policy influencible

Source: own compilation

Market or product group characteristics encompass those factors which describe the technological and competitive structure of the market where the items are purchased from. Most of these variables are in effect structural givens from the perspective of the analysis as they tend to be changing slowly or policy can only influence them at high cost. Procurement markets can be defined as a combination of product codes and geographical codes (Fazekas & Tóth, 2016) which capture fundamental differences, among others, by product complexity and technological characteristics, geographical characteristics (e.g. remoteness), and market concentration. Both for standardized goods and roads contracts, unit prices are strongly influenced by such factors; for example higher population density increases road costs (100 people by square km leads to a 10% price increase) on a global roads construction sample (Collier et al., 2015), or higher social capital leads to lower goods prices in Italy (Bandiera et al., 2009).

Tender specifications capture all the conditions defining who can bid, under which conditions and according to which assessment criteria. These variables are typically directly influencible by policy makers without changes to the legal framework. Tender specifications variables are defined in the tender preparation and bidding stages of the procurement process. Among many, advertising tenders in a widely used, free, online portal tends to lower prices, such as in Italian public works tenders where the effect size is 7% higher winning rebates (i.e. discounts compared to the reference price) (Coviello & Mariniello, 2014); or longer term, fixed price contracts are more expensive in Russian sugar purchases while larger volumes lead to lower unit prices (Andrey Yakovlev, Bashina, & Demidova, 2014).

Buyer characteristics-related variables describe the level of administrative capacity in the buying public entity such as a purchasing office or agency (Fazekas, 2017). While many of these characteristics are directly influencible by policy intervention such as capacity building trainings, many reforms may be challenging to implement such as giving more discretion to purchasing officials in the wake of public demands for accountability and impartiality. Among many others, procurement staff capacity lowers prices across many contexts (Best, Hjort, & Szakonyi, 2017), for example, in the US federal bureaucracy, one standard deviation increase in competence decreases cost overruns by 29% (Decarolis, Giuffrida, Iossa, Mollisi, & Spagnolo, 2018); or increasing procurement officers' autonomy compared to their auditors reduces prices of standard goods by 9% in Punjab, Pakistan (Bandiera, Best, Khan, & Prat, 2019).

Bidder and supplier characteristics capture the key determinants of companies participating in public procurement which determine their ability to offer low prices such as productivity and capacity. As suppliers are selected through tenders and results at least partially depend on the choices companies make, these characteristics tend to be only indirectly influencible for policy makers. Among many factors, company location and size is likely to influence prices while company risks such as tax haven registration or political connections also typically impact prices (Fazekas, Tóth, & King, 2016). For example, in India, roads built by politically connected contractors are on average 11% more expensive (Lehne, Shapiro, & Eynde, 2018).

Bidding outcomes corresponding to the intermediate or final results of the tendering process naturally influence unit prices contracted. These factors tend to be only indirectly influencible by the policy given the important role played by bidder decisions. A widely cited factors, the number of bidders, plays a highly influential role in determining prices under non-collusive conditions (Fazekas & Kocsis, 2017; Andrey Yakovlev et al., 2014).

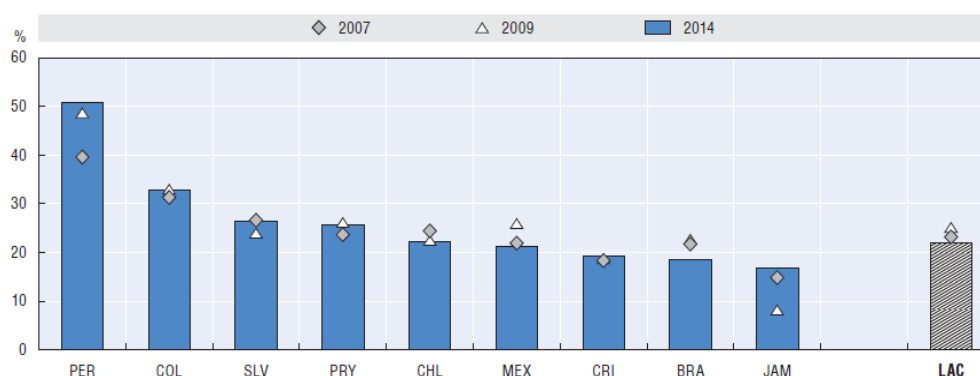
### 3. Data and measurement model

#### 3.1 Data

Public procurement data underlying the analysis must be high quality, wide scope and high resolution, including information on individual items purchased and their unit prices. The dataset, at a minimum must include structured information on tendering processes such as procedure type used or date of contract award and their outcomes such as the name of the winning bidder. In addition, additional information on actors, i.e. buyers and bidders, and data on contract implementation are of high value. Such data is available in most Latin American countries accounting for a large portion of public spending (Figure 2).

We take Brazil’s federal public procurement system as an example because it is one of the most advanced, comprehensive and large-scale datasets of the world and it is by far the largest among the countries analysed by the authors. Our analysis is conducted based on bidding data and procurement contracts from the Government Procurement system’s data warehouse (DW SIASG/Comprasnet) for the years 2014-2016 and only for the General Service System (SISG) agencies. The data was obtained directly from the data warehouse as a set of data tables. While increasingly procurement data analysis is done using publicly available data, and indeed much of the data underlying the analysis is publicly available in Brazil, using data directly exported by the government carries the advantages of very low to no data quality deterioration due to data acquisition and also the possibility of directly linking results back to government analytical systems.

Figure 2. Government procurement as a share of total government expenditures, 2007, 2009, 2014, selected Latin American and Caribbean countries.



Sources: IMF Government Finance Statistics (IMF GFS) database. Data for Mexico are based on the OECD National Accounts Statistics database. StatLink <http://dx.doi.org/10.1787/888933431536>

In spite of high quality data received directly from the government, data preparation has been challenging which is typical of the other countries the authors worked in. First, the regulatory framework is complex and changing over time so understanding the precise meaning of fields requires in-depth legislative and regulatory mapping as well as careful descriptive data analysis. Second, while many fields have been intended to be standardized, quality issues have remained such as standardized units of measurement differing randomly such as “kg” versus “10 kgs” as units; or company classification as micro, small, and medium only partially correlating with the companies’ contract value won. Third, the large dataset size - close to 1.5 million items purchased, 7 million bidder-item pairs, and over 112 million bids submitted - made it imperative

to use a high capacity server for initial data preparation, especially working with long string variables, while the regression analysis using only numerical values could be run on ordinary computers.

### 3.2 Methods and indicators

As outlined above, the analytical framework consists of 3 key components which work best together but can also be deployed independently:

- i) public procurement market overview, using interactive visualisations:
- ii) regression modelling of unit prices across government:
- iii) in-depth case study analysis of selected large markets such as vehicles

First, the public procurement market overview or exploration component makes use of interactive online visualisations using Tableau software to both setting the stage for subsequent analysis and providing initial insights into cost drivers. A high-level overview is essential in identifying the scope and boundaries of the analysis such as the amount of total spending, spending break-down by product group (e.g. goods, or more detailed product category such as vehicles) and geography (e.g. main regions of spending), trends over time, and public procurement share in the national budget (e.g. Figure 2). In addition, the overview component also begins to unpick major cost drivers by allowing users to explore bivariate relationships in great depth and using customized visualisations. Most of the main explanatory factors are incorporated already in this component such as the impact of market concentration on prices with interactive functions allowing users to filter subsamples (e.g. high value tenders or a selected region). The analytical tools are kept simple in this component predominantly restricted to simple visualisations and tables without explanatory models and predictions.

Second, the regression modelling of unit prices directly builds on the first component by bringing together all major explanatory factors into a single regression model. Such a comprehensive model allows for system-wide price predictions and simulating hypothetical scenarios, bearing in mind that every market is analysed in relation to its average price so only those markets are included which are sufficiently large to contain adequate levels of within-market price variability. In the Brazilian example, this meant markets with at least 50 items awarded worth at least 300,000 BRL (appx. 78,000 USD) in 2014-2016.

In particular, the following linear regression model for log unit prices of standardized products was estimated at the level of item purchased:

$$\text{Log}(Pr_i) = \alpha_i + \beta_1 * X_{1i} + \beta_2 * X_{2i} + \beta_3 * X_{3i} + \varepsilon_i$$

Where  $\text{Log}(Pr_i)$  represents the natural logarithm of unit price for the  $i$ th item purchased;  $X_{1i}$  stands for the set of directly policy influenceable predictors for the  $i$ th item purchased such as the choice of procurement method; while  $X_{2i}$  represents the set of indirectly policy influenceable predictors for the  $i$ th item purchased such as the number of bidders.  $X_{3i}$  denotes the set of control variables accounting for structural factors not amenable to policy intervention for the  $i$ th item purchased such as the year of purchase.  $\varepsilon_i$  stands for the error term of the regression model. The full list of variables used in the Brazilian analysis are reported in Table 2. Each of these policy-relevant variables derive from the literature using qualitative as well as quantitative methods while also being supported by robust economic theory. Interpretation and the relevant literature are discussed in the results section below.

Table 2. Overview of indicators used for price modelling, Federal Government of Brazil

Type	Group	Variable name
<b>Structural</b>	<b>Market characteristics</b>	Market ID: reflecting product code and location (1...316)
		Year of contract award (2014, 2015, 2016)
<b>Directly policy influenceable</b>	<b>Tender specifications</b>	Month of bidding (January, February, etc.)
		Publication of call for tenders (Y/N)
		Advertisement period length (days)
		Framework agreement (Y/N)
		Low season (June&December vs other months) #
		Framework agreement (Y/N)
	<b>Buyer characteristics</b>	Quantity of purchased goods (deciles)
		Buyer type (ministry, independent agency, etc)
<b>Indirectly policy influenceable</b>	<b>Bidder/supplier characteristics</b>	Ministry/highest level administrative unit (ministry of defence, Brazilian Forestry Service, etc)
		Buyer-supplier from the same state (Y/N)
		Supplier size (micro, small, large company)
		Supplier size (micro, etc) # buyer-supplier from the same state (Y/N)
		Supplier specialisation: number of markets the company supplies (deciles)
		Number of bidders (trimmed to 1-20)
	<b>Bidding outcomes</b>	Number of bidders (trimmed to 1-20) squared
		Annual winner market share (deciles)
		Annual winner share in buyer spending (deciles)

For the sake of simplicity, we opted for a straightforward ordinary least squares estimation of the regression parameters which is a computationally efficient estimator able to handle models run on millions of records while containing hundreds of explanatory variables. Including a battery of fixed effects for structural factors such as market and year allows for building models with exceptionally high explanatory power: across the countries and territories analysed, R2 ranges between 0.7 and 0.8. In spite of the linear functional form, the modelling framework is able to account for a range of nonlinear relationships by adopting a logged unit price dependent variable and also looking at alternative formulations of the independent variables, for example taking deciles of market concentration as a set of dummies rather than the continuous scale.

Such a simple modelling framework cannot fully account for a range of complex relationships between factors on multiple levels such as market and tender level factors or explanatory factors influencing not only the dependent variable but also each other (e.g. advertising tenders not only influences prices directly but also through the number of bidders). Alternative, more advanced modelling strategies such as Multilevel Modelling incorporating different measurement levels or Structural Equation Modelling incorporating complex and often indirect relationships among explanatory factors hence represent a natural extension to our approach.

Our adopted methodology carries the advantage of exceptionally wide scope, while we cannot reliably claim that the identified correlations are necessarily causal. Nevertheless, we combine strong, well-tested theories underpinning the choice of explanatory factors as well as a mixed methods approach, including case studies in component 3, which together tentatively support

a causal interpretation. In addition, the exceptionally high explanatory power of the models, unusual for micro-level quantitative models, lends support to the claim that omitted variable bias doesn't plague our estimations.

Third, the in-depth case studies component is implemented on the back of the regression modelling component in order to get a more precise understanding of the causal mechanism underpinning the regression parameters and also to look at additional cost drivers such as product specifications. Such a detailed analysis drawing on quantitative data but also on diverse qualitative insights also considers the dependent variable more comprehensively. It looks at maintenance and running costs on top of purchase price, taking the dependent variable definition closer to the ideal, full life-cycle cost. Case studies can be conducted in a selected set of standardized and high value product markets such as vehicles, petrol, or IT infrastructure. By implication, a second set of savings scenarios can be identified in which deeper changes to the specification of products purchased delivers additional savings on top of changes to the purchasing processes only as identified by regression modelling.

### 3.3 Identifying relevant markets

For each of the above analyses, defining markets within which products are largely standardized is an essential first step. While there is no single best method of identifying markets for the 3 different analyses conducted, we set out some key considerations and outline the main market definition used in the regression analysis (Fazekas & Tóth, 2016).

Generally, relevant markets can be defined in a bottom-up or top-down approach. The top-down market definition follows from theoretical considerations evoking standard demand and supply side factors such as product substitutability or geographical range of suppliers. Using official classifications, markets can be defined by these factors: product code and geographical location which carries the advantage of taking key features from the e-procurement system directly which organises the data (e.g. different product lines evoke different regulations) as well as bidder behaviour (e.g. companies watch certain product codes for identifying bidding opportunities). Nevertheless, the so-identified market definitions depend on the accuracy of official classifications in defining products and geographical units both of which may change rapidly rendering at least some market definitions imprecise.

The alternative bottom-up market definition builds on the bidding patterns of companies on the whole public procurement market without recourse to widely used product or geographical classifications. It presumes that when two companies bid for the same tender they are likely to belong to the same market, hence, company co-bidding defines markets. Formally, this can be represented as clustering of companies in a co-bidding network over a period. Markets are defined by the companies who are very likely to co-bid, and the tenders they actually participate in jointly. Market boundaries are defined by the low probability, or complete lack of co-bidding among dense co-bidding clusters.<sup>2</sup> The strength of this approach is that it does not superimpose any statistical classification which may or may not be accurate in a given context, while also allowing for a formal identification of different degrees of product market similarity. However, a major shortcoming of this approach is that it is highly sensitive to the presence of collusive

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<sup>2</sup> This market definition approach is analogous to how internet companies devise music or video recommendations by simply observing co-occurrences of music or video files. On the general method see: <http://tdunning.blogspot.co.uk/2008/03/surprise-and-coincidence.html?m=1>

rings. If collusion is taking place on a market, it is likely to define markets incorrectly (e.g. companies divide up the market and withhold co-bidding on each others' submarkets).

In order to reflect the inherent uncertainty of official classifications and benefit from the flexibility of company bidding behaviour, we opted for a hybrid approach starting from the official product and region classifications but also combining some sub-markets under one market ID when a large amount of co-bidding was taking place among them. As a starting point, we defined public procurement markets using the following three dimensions:

- the type of the product or service, which can be defined based on the official classification codes, taking a detailed level: padrao;
- the location of the performance of the contract, approximated by the location of the buying office, at the detail of federal state such as Rio de Janeiro or Minas Gerais; and
- value of the tender in order to identify those high value purchases where location is largely irrelevant.

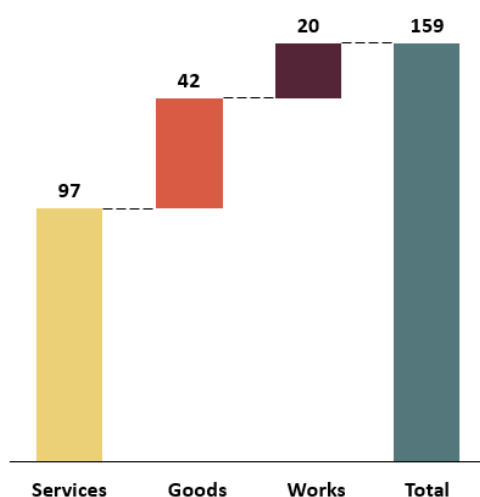
As mentioned already, in order to restrict the analysis to markets with standardized quality and units of measurement, we only included goods in the analysis while removing all services and works (removing 14.7% of observations). In addition, we also needed the unit of measurement to be fully standardized within each market so that we can compare prices. While this condition is not perfectly met, the overwhelming majority of items within each market analysed was the same. Finally, only large-enough markets were considered where the within-market variation was suitable for quantitative analysis, that is markets with at least 50 items awarded worth at least 300,000 BRL (appx. 78,000 USD) in 2014-2016. This condition resulted in a 58.8% decline in sample size. Overall, a little over 207,000 item purchases remain in the final dataset satisfying all conditions of relevant markets as well as having little to no missing data making them amenable to regression analysis.

## 4. Results: Understanding and explaining unit prices

### 4.1 Public procurement market overview

Procurement of goods and services carried out by the Federal Government of Brazil added up to more than R\$159 billion between 2012 and 2014, which accounts for 5 per cent of government spending during this period (Figure 3). Contracting of services accounted for the large majority of public purchases by the federal government in the years 2012 to 2014, and about 60 percent of the total value of purchases when taking together all three levels of government. Following services, materials were the second largest category of expenditure, accounting for about 26 percent, while construction works reached only 14 percent of the total contracted value.

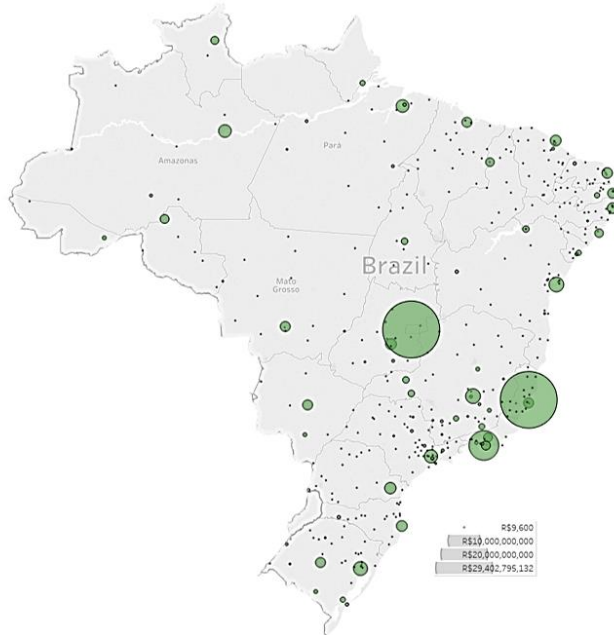
Figure 3: Distribution of government purchases (2012-2014, in billion reais)



Source: BOOST dataset

The location of the procuring entity and by implication the location of delivery varies greatly within Brazil, even if our data captures federal government purchases only (Figure 4). The capital district, Brasilia, and the largest urban centres such as Sao Paulo account for most of the spending while state capitals and some smaller cities also play an important role.

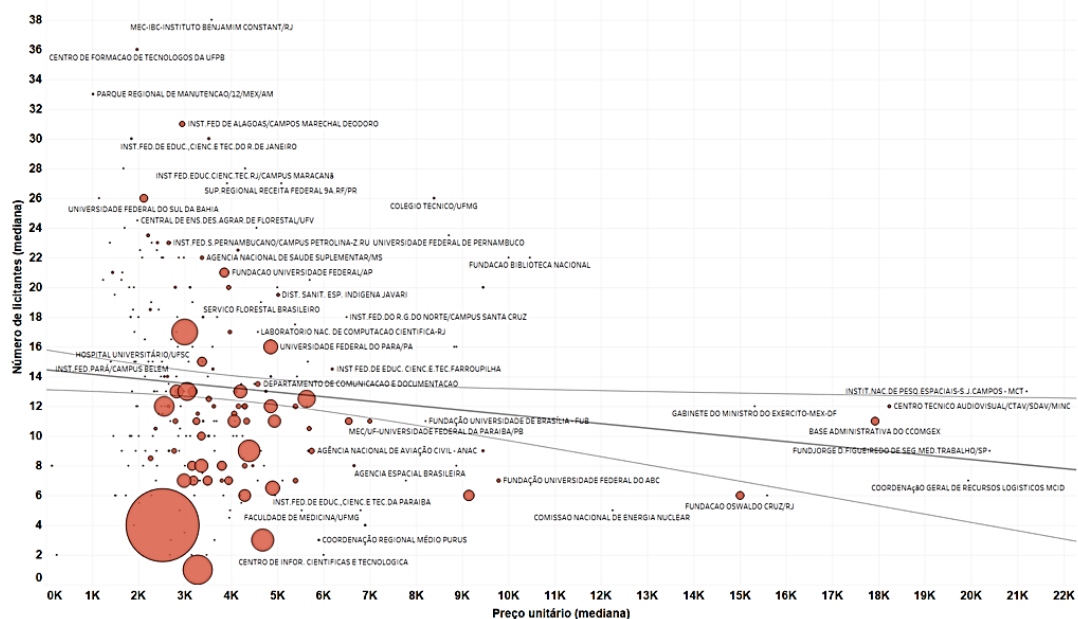
Figure 4: Distribution of government purchases by county of procuring entity (2014-2016, in reais)



Source: SIASG and Comprasnet DW

As a starting point for unpacking complex relationships on the organisational, tender process and outcome levels, Figure 5 shows the relationship between bidder number and unit prices by procuring entity within one market: desktops and laptops. In this bivariate, organisation level set-up, there appears to be only a relatively weak negative relationship between bidder number and unit prices.

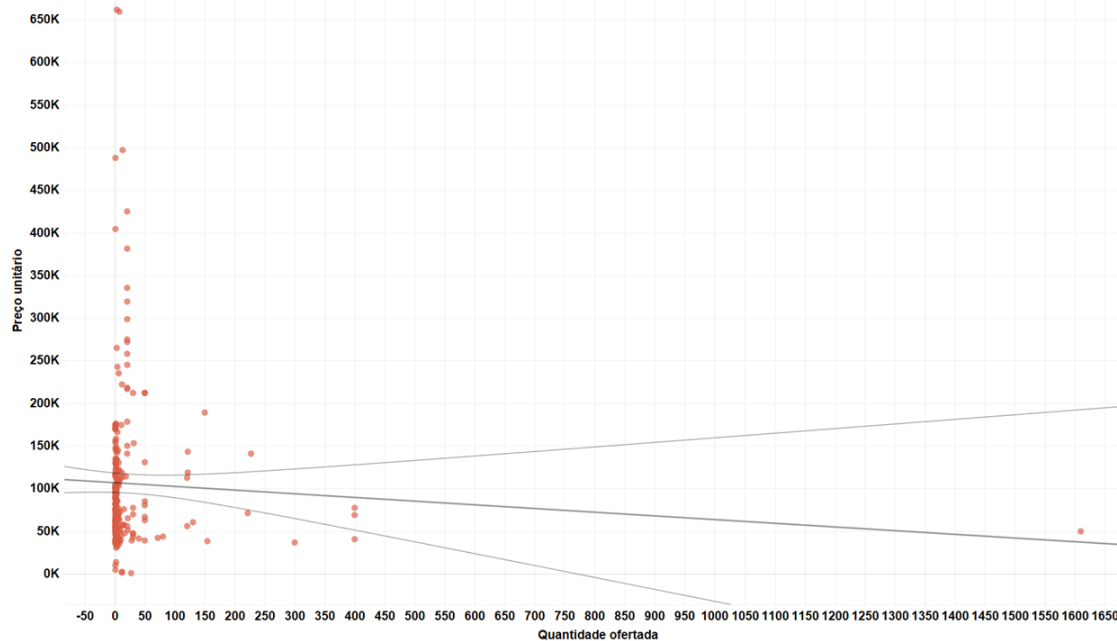
Figure 5: Level of competition and unit prices by procuring entity (2014-2016, median number of bidders per process and median unit price, only desktops & laptops)



Source: SIASG, Comprasnet and World Bank analysis

Looking at another factor, playing a crucial role in the regression and case study analyses, Figure 6 depicts the relationship between purchased quantity and unit prices in the market for cars, on the purchased item level. As suggested by theories of economies of scale, there is a marked negative relationship between quantity and price. However, indicative of the intricacies of unit price explanatory models, the simple bivariate linear fit is relatively weak pointing at a potential non-linear relationship and the presence of multiple confounders.

Figure 6: Unit price and purchased quantities of cars (2014-2016)



Source: SIASG, Comprasnet and World Bank analysis

## 4.2 Regression modelling of unit prices

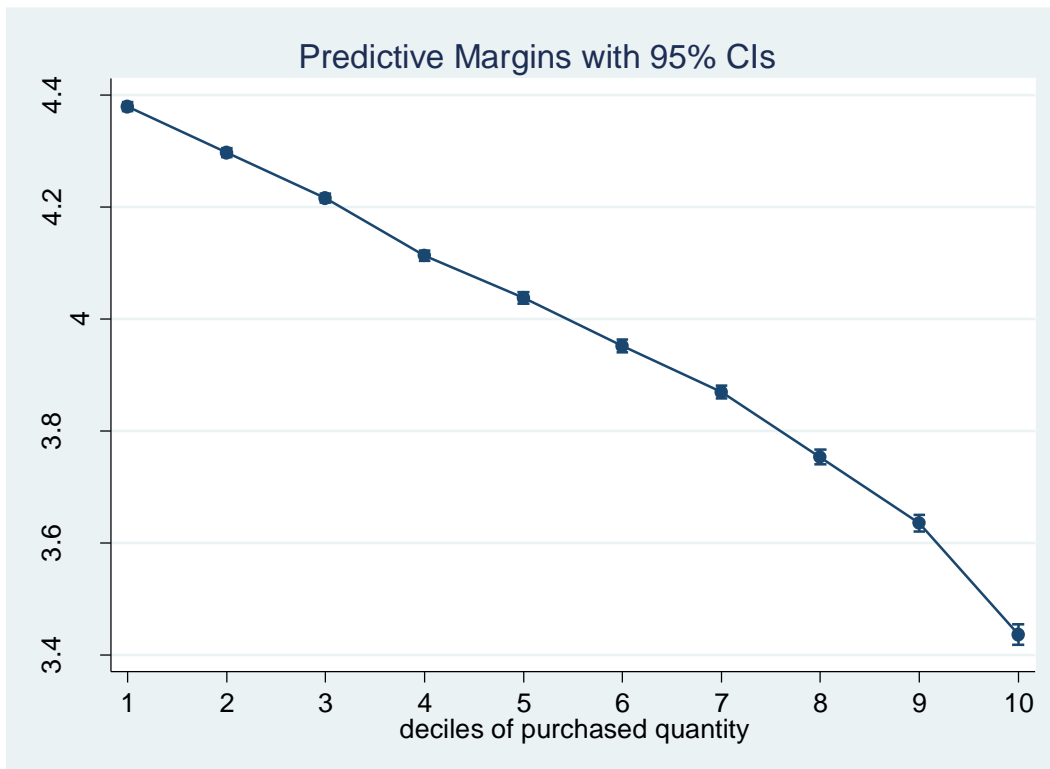
The linear regression models are fitted on the selected subsample of standardized goods in 2014-2016 to predict unit prices as outlined in section 3.2. These regression models explain 81-84% of the variance in unit prices, which is a remarkable result considering the diversity of the procurement dataset, as governments buy many different products and services, from water and paper to power transmission equipment. The remainder of this section discusses each main effect by predictor group.

First, structural factors, market ID and year, account for by far the largest portion of unit price variation, somewhat over 80% (Table 3). Please note that our market definition simultaneously considers product group as well as purchase location (approximated by buyer state), allowing for the same product market to be split by state when bidding across state borders was limited. This is hardly surprising given that prices greatly differ across markets. In addition, such rich set of fixed effects allows us to concentrate on the residual, within-market variance.

Second, including variables in the tender specifications group lift the model's explanatory power to 82%. By far the strongest predictor is the quantity of purchased goods with a near-linear effect which becomes steeper only at the upper end (deciles 8-10). For example, purchased quantities falling in the 2<sup>nd</sup> decile are associated with 6.7% lower unit prices than purchases in

the lowest decile. Such a strong effect of demand aggregation is in line with the logic of economies of scale in purchasing low complexity, standard goods.

Figure 7. Predicted marginal effect of purchased quantity deciles, Federal Government of Brazil, 2014-2016 (Table 3, model 2)

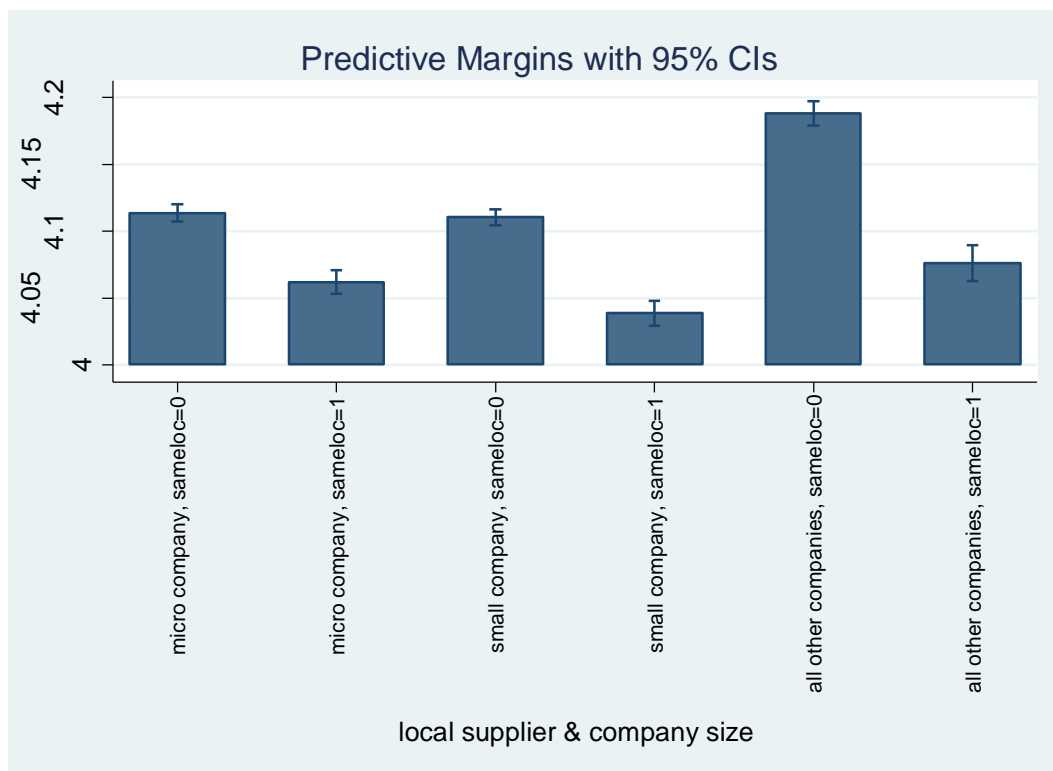


In spite of widespread policy advice and academic literature supporting framework agreements (Bandiera et al., 2009; Gur, Lu, & Weintraub, 2015), the regression models show that they are more rather than less expensive than stand-alone auctions. Moreover the effect size is large: 13% unit price increase due to framework agreements. Such an effect may reflect both the inefficiency of Brazilian framework agreements and the efficiency of one-off auctions. We find evidence for strong seasonality in federal purchases with June and December being the most expensive months. For example, March is 5.1% less expensive than December. Such seasonality in spending and resulting inefficiencies are widely documented in the literature, especially the last weeks of the financial year (Liebman & Mahoney, 2018). Moreover, our findings on advertising tenders confirm prior literature on the beneficial effects of publicity (Coviello & Mariniello, 2014). In our regression models, advertising on the central online platform lowers prices by 6-9%.

Third, the inclusion of buyer characteristics marginally lifts model explanatory power to 82.5% (Table 3, model 3). Among others, ministries seem to be purchasing considerably more expensive than independent agencies. Such differences among organisations are most likely down to regulatory as well as administrative capacity differences which is, for example, also found in a comparable Italian study (Bandiera et al., 2009).

Fourth, including supplier characteristics in the regression models further increase explanatory power to 83% (Table 3, model 4). Intriguingly, supplier size and location are best combined for predicting prices: small local companies tend to be the cheapest while a supplier registered in the same state as the buyer tends to lower prices compared to a non-local supplier (Figure 8). This effect is quite interesting in light of the literature which generally considers the presence of non-local bidders as beneficial for competition and as a signal of market openness (Coviello & Gagliarducci, 2017; Lewis-Faupel et al., 2016).

Figure 8. Predicted marginal effect of supplier location and size, Federal Government of Brazil, 2014-2016 (Table 3, model 4)



Moreover, and quite interestingly, highly specialised suppliers, that is suppliers which supply only a handful of markets, tend to be the most expensive. Suppliers in the 3<sup>rd</sup> decile of specialisation are on average 6% cheaper than suppliers in the lowest (most) specialised decile. Academic literature, while quite limited in this regard, suggests that less specialised suppliers have more diverse income streams making them less vulnerable to government spending shocks, potentially allowing them to lower prices (Coviello, Marino, Nannicini, & Persico, 2017).

Fifth, including indicators of bidding outcomes further lifts model explanatory power to 83.6% (Table 3, model 5). Most importantly, an increasing supplier's annual market share is associated with increasing unit prices, a relationship which is particularly steep at the lower end of the distribution (Figure 9). For example, moving from the lowest decile of supplier market share to the 2<sup>nd</sup> decile increases unit prices by 15%. Increasing market share and the corresponding growing market power is widely documented to push prices up. A similar, albeit somewhat less

steep impact is associated with winner's share in buyer's total spending with less concentrated spending leading to lower prices in the models.

Figure 9. Predicted marginal effect of annual winner market share deciles, Federal Government of Brazil, 2014-2016 (Table 3, model 5)

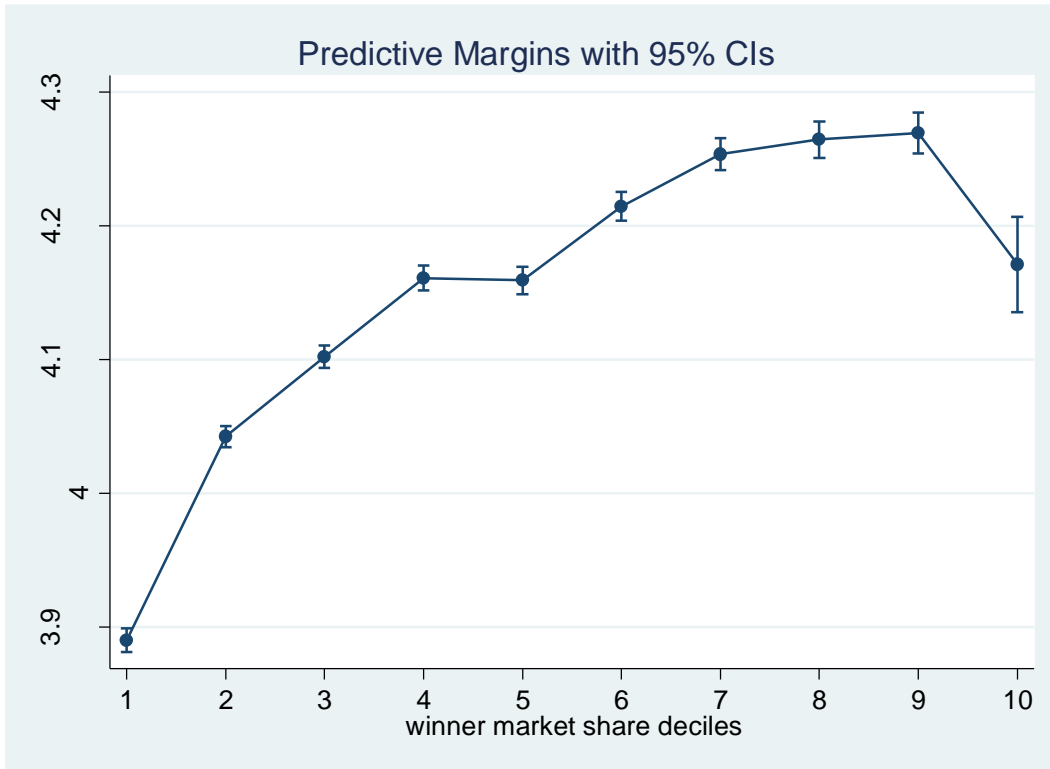


Table 3. Unit price regression models, OLS, Federal Government of Brazil, 2014-2016

model	1	2	3	4	5
dependent variable	log unit price				
<b>Month of bidding</b>					
BASELINE: month=12					
month=1		0.0191 (0.147)	0.0221 (0.096)	-0.0170 (0.195)	-0.0279* (0.031)
month=2		0.00965 (0.352)	0.0430*** (0.000)	0.0137 (0.189)	0.00342 (0.739)
month=3		-0.0510*** (0.000)	-0.00110 (0.915)	-0.00608 (0.551)	-0.00537 (0.594)
month=4		-0.0378*** (0.000)	-0.00282 (0.792)	-0.00620 (0.557)	-0.000557 (0.957)
month=5		-0.00167 (0.867)	0.0362*** (0.000)	0.0366*** (0.000)	0.0354*** (0.000)
month=6		0.00582 (0.515)	0.0335*** (0.000)	0.0357*** (0.000)	0.0256** (0.004)
month=7		-0.0276** (0.005)	0.00978 (0.331)	0.0138 (0.164)	0.0175 (0.074)
month=8		-0.00972 (0.296)	0.0373*** (0.000)	0.0421*** (0.000)	0.0189* (0.040)
month=9		-0.0407*** (0.000)	-0.000646 (0.945)	0.00168 (0.856)	-0.0166 (0.068)
month=10		-0.0519*** (0.000)	0.0122 (0.185)	0.0215* (0.018)	0.0256** (0.004)
month=11		0.0121 (0.179)	0.0501*** (0.000)	0.0566*** (0.000)	0.0521*** (0.000)
<b>Publication of call for tenders</b>					
BASELINE: publication=No					
publication=Yes		-0.0945*** (0.000)	-0.0667*** (0.000)	-0.0561*** (0.000)	-0.0588*** (0.000)
<b>Advertisement period length</b>					
BASELINE: 8 days <= Advertisement period <= 16 days					
Advertisement period < 8 days		0.00337 (0.661)	0.00886 (0.246)	-0.00892 (0.238)	-0.000341 (0.963)
Advertisement period > 16 days		0.0950*** (0.000)	0.0901*** (0.000)	0.0677*** (0.000)	0.0672*** (0.000)
<b>Framework agreement</b>					
BASELINE: Framework agreement=No					
Framework agreement=Yes		0.131*** (0.000)	0.0823*** (0.000)	0.0632*** (0.000)	0.0684*** (0.000)
<b>Low season # Framework agreement</b>					
BASELINE: Low season=Yes # Framework agreement=No					
Low season=Yes # Framework agreement=Yes		0.0131 (0.308)	0.0264* (0.041)	0.0323* (0.011)	0.0273* (0.029)
BASELINE: Low season=Yes # Framework agreement=Yes					
Low season=Yes # Framework agreement=Yes		-0.00382 (0.740)	-0.0122 (0.289)	-0.0140 (0.219)	-0.0206 (0.066)
<b>Quantity of purchased goods</b>					
BASELINE: ca_bid_quantity10=1					
ca_bid_quantity10=2		-0.0665*** (0.000)	-0.0776*** (0.000)	-0.0790*** (0.000)	-0.0829*** (0.000)
ca_bid_quantity10=3		-0.137*** (0.000)	-0.155*** (0.000)	-0.163*** (0.000)	-0.163*** (0.000)
ca_bid_quantity10=4		-0.226*** (0.000)	-0.249*** (0.000)	-0.264*** (0.000)	-0.267*** (0.000)
ca_bid_quantity10=5		-0.303*** (0.000)	-0.338*** (0.000)	-0.351*** (0.000)	-0.342*** (0.000)
ca_bid_quantity10=6		-0.379*** (0.000)	-0.425*** (0.000)	-0.442*** (0.000)	-0.428*** (0.000)
ca_bid_quantity10=7		-0.459*** (0.000)	-0.510*** (0.000)	-0.533*** (0.000)	-0.510*** (0.000)
ca_bid_quantity10=8		-0.545*** (0.000)	-0.607*** (0.000)	-0.649*** (0.000)	-0.626*** (0.000)
ca_bid_quantity10=9		-0.637*** (0.000)	-0.711*** (0.000)	-0.775*** (0.000)	-0.744*** (0.000)

	(0.000)	(0.000)	(0.000)	(0.000)
ca_bid_quantity10=10	-0.802***	-0.897***	-0.991***	-0.943***
	(0.000)	(0.000)	(0.000)	(0.000)
<b>Buyer type</b>				
BASELINE: ministry				
independent agency		-0.472***	-0.351***	-0.277***
		(0.000)	(0.000)	(0.000)
foundation		-0.340***	-0.274***	-0.118
		(0.000)	(0.000)	(0.096)
other		-0.430	-0.351	-0.379
		(0.302)	(0.393)	(0.347)
<b>Ministry/highest level administrative unit</b>				
BASELINE: Ministerio Da Saude				
Ministerio Da Cultura		0.348***	0.332***	0.298***
		(0.000)	(0.000)	(0.000)
Ministerio Da Educacao		-0.297***	-0.232***	-0.222***
		(0.000)	(0.000)	(0.000)
Ministerio Da Fazenda		-0.237***	-0.172***	-0.123***
		(0.000)	(0.000)	(0.000)
Ministerio Da Integracao Nacional		-0.0137	-0.0207	0.0168
		(0.901)	(0.848)	(0.875)
Ministerio Da Justica		-0.295***	-0.201*	-0.0369
		(0.000)	(0.014)	(0.645)
Ministerio Da Previdencia Social		-0.0936	0.00607	0.172**
		(0.172)	(0.929)	(0.010)
Ministerio Das Cidades		-0.180	-0.149	-0.0744
		(0.481)	(0.555)	(0.764)
Ministerio Das Comunicacoes		0.445***	0.389***	0.386***
		(0.000)	(0.000)	(0.000)
Ministerio Das Relacoes Exteriores		-0.292**	-0.188	-0.136
		(0.004)	(0.057)	(0.162)
Ministerio De Minas E Energia		-0.815***	-0.690***	-0.569***
		(0.000)	(0.000)	(0.000)
Ministerio Defesa		-0.189***	-0.196***	-0.145***
		(0.000)	(0.000)	(0.000)
<i>further 176 categories suppressed</i>				
<b>Buyer-supplier from the same state</b>				
BASELINE: Same location=No				
Same location=Yes			-0.0468***	-0.0518***
			(0.000)	(0.000)
<b>Supplier size</b>				
BASELINE: micro company				
small company			0.0212***	-0.00319
			(0.000)	(0.474)
all other companies (medium, large, etc)			0.140***	0.0744***
			(0.000)	(0.000)
Missing			0.958	0.908
			(0.058)	(0.067)
<b>Same location # supplier size</b>				
Same location=Yes # small company			-0.0238**	-0.0200**
			(0.002)	(0.010)
Same location=Yes # all other companies (medium, etc)			-0.0640***	-0.0601***
			(0.000)	(0.000)
Same location=Yes # missing			0.276	0.563
			(0.751)	(0.510)
<b>Supplier specialisation(deciles)</b>				
BASELINE: Supplier specialisation decile=1				
Supplier specialisation decile=2			0.00315	-0.00617
			(0.646)	(0.360)
Supplier specialisation decile=3			-0.0595***	-0.0856***
			(0.000)	(0.000)
Supplier specialisation decile=4			-0.104***	-0.173***
			(0.000)	(0.000)

Supplier specialisation decile=5					-0.0885*** (0.000)	-0.120*** (0.000)
Supplier specialisation decile=6					-0.127*** (0.000)	-0.161*** (0.000)
Supplier specialisation decile=7					-0.219*** (0.000)	-0.248*** (0.000)
Supplier specialisation decile=8					-0.230*** (0.000)	-0.283*** (0.000)
Supplier specialisation decile=9					-0.293*** (0.000)	-0.362*** (0.000)
Supplier specialisation decile=10					-0.478*** (0.000)	-0.593*** (0.000)
<b>Number of bidders (trimmed to 1-20)</b>						0.0242*** (0.000)
<b>Number of bidders (trimmed to 1-20) squared</b>						-0.000416*** (0.000)
<b>Annual winner market share (deciles)</b>						
BASELINE: Annual winner market share decile=1						
Annual winner market share decile=2						0.152*** (0.000)
Annual winner market share decile=3						0.212*** (0.000)
Annual winner market share decile=4						0.271*** (0.000)
Annual winner market share decile=5						0.269*** (0.000)
Annual winner market share decile=6						0.324*** (0.000)
Annual winner market share decile=7						0.363*** (0.000)
Annual winner market share decile=8						0.374*** (0.000)
Annual winner market share decile=9						0.379*** (0.000)
Annual winner market share decile=10						0.281*** (0.000)
<b>Annual winner share in buyer spending (deciles)</b>						
BASELINE: Annual winner share in buyer spending decile=1						
Annual winner share in buyer spending decile=2						0.0886*** (0.000)
Annual winner share in buyer spending decile=3						0.139*** (0.000)
Annual winner share in buyer spending decile=4						0.134*** (0.000)
Annual winner share in buyer spending decile=5						0.183*** (0.000)
Annual winner share in buyer spending decile=6						0.194*** (0.000)
Annual winner share in buyer spending decile=7						0.250*** (0.000)
Annual winner share in buyer spending decile=8						0.246*** (0.000)
Annual winner share in buyer spending decile=9						0.268*** (0.000)
Annual winner share in buyer spending decile=10						0.324*** (0.000)
Market ID (product code+location)	Y	Y	Y	Y	Y	
Year of contract award	Y	Y	Y	Y	Y	
Constant	Y	Y	Y	Y	Y	
Observations	207067	207067	207067	207061	207054	
Adjusted R-squared	0.810	0.820	0.825	0.830	0.836	

p-values in parentheses; \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

### 4.3 In-depth case study analysis

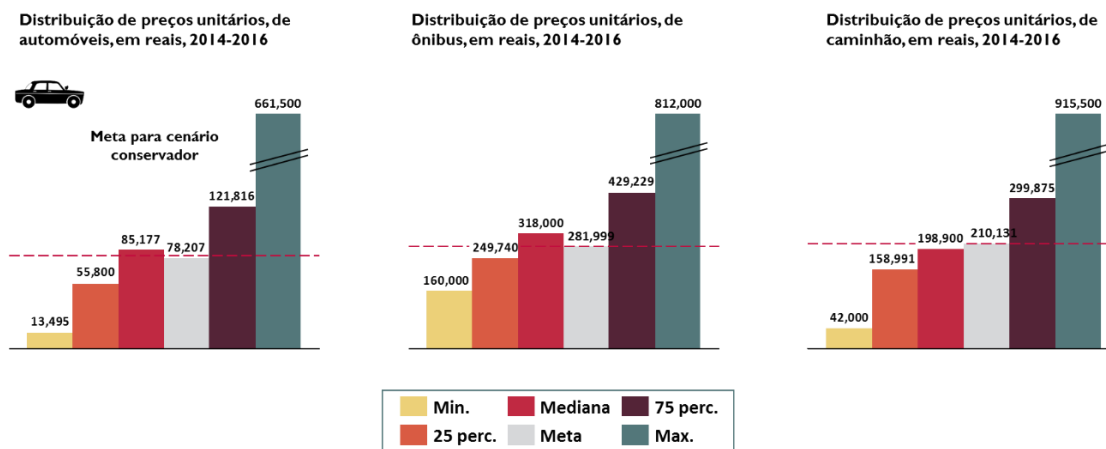
Among the countries analysed through our mixed methods research, a number of markets was analysed in greater depth as a case study. These markets include, IT, paper, petrol, or vehicles. As it is one of the most extensively analysed markets, we show the in-depth analysis on vehicles for the federal government of Brazil.

Vehicle purchases present a very attractive opportunity for an in-depth price analysis as well as identifying savings opportunities because they typically represent standardized products with well-defined market segments, the purchasing value is large, and many different Federal Government agencies buy vehicles. Between 2014 and 2016, the Federal Government purchased 33 distinct products in the vehicles category, four of which - buses, trucks, cars and ambulances - accounted for 80 percent of the total value purchased during the period. Additionally, 90 percent of the demand for cars in 2014 originated from institutions located in the Federal District.

The subsequent analysis revisits many of the predictors identified in the regression models, discusses them in greater detail while also looking at further dimensions of purchasing decisions. While demand is concentrated in a few market segments, half of all vehicle purchases covered only one or two units, thus dispersing demand among many government agencies. The largest car purchase in 2014 did not reach 16 percent of total demand for cars that year. Moreover, even though 103 different agencies have purchased vehicles, just seven of them accounted for 90 percent of the total value purchased. Equally relevant is the fact that 75 percent of the agencies that bought vehicles between 2014 and 2016, bought no more than 11 units over three years. This reveals the fragmentation of demand and the difficulties of most agencies to obtain lower prices through economies of scale.

Data on car purchases from the years 2014 to 2016 show that suppliers offered different prices for the same product, depending on the buyer, the quantity demanded, the time of the year, among other factors. In particular, the fragmentation of demand for vehicles resulted in large differences in the prices paid by the Federal Government (Figure 10). For example, for a sedan-type car that has capacity for five passengers, prices ranged from R\$ 55,000 to R\$ 120,000, even considering only prices between the 25th and 75th percentiles. The discretion of the car specification is one of the reasons for this difference, which in some cases may result in the purchase of a product that exceeds its utility to the government. The data also show that price outliers occurred almost exclusively on very small purchases, of a few units.

Figure 10. Fragmentation of demand resulted in great dispersion of prices



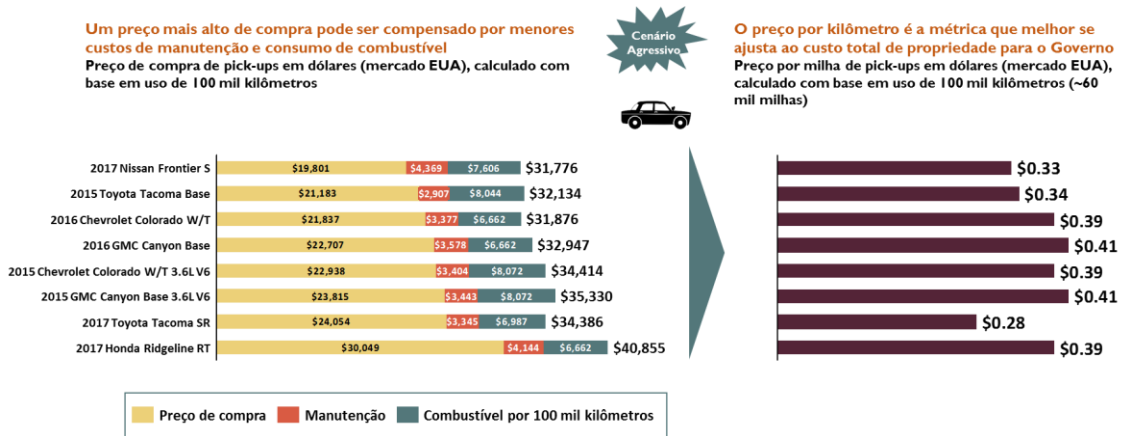
Source: DW SIASG/Comprasnet and World Bank Analysis.

Seasonality also features as a strong driver of prices. Almost 80 percent of the value of vehicles purchased occurred in the last quarter of the year, precisely the period when vehicle prices are the highest. Possibly, the launch of new models may have contributed to the seasonality of prices. But execution so concentrated at the end of the year for a high value item raises the question of whether demand has been suppressed throughout the year or whether it is a result of budget unfreeze at the end of the year. Either option represents a significant opportunity for improving efficiency.

On the one hand, almost 90 percent of vehicle purchases through framework agreements occurred in the last quarter, which seems to indicate that there is some dissatisfaction with the offers in the agreements, since the agencies seem to use this instrument only when there is not enough time to conduct an individual bidding. On the other hand, purchases through other procedures that did not use framework agreements, accounted for only 35 percent of the total over the same period. These numbers seem to suggest that it would be important to evaluate the offers provided through framework agreements to ensure that they meet the demands of the various purchasing agencies.

Considering elements of full life-cycle costing as opposed to purchase prices, the data shows that almost 54,000 new vehicles were purchased in 2014-2016 bringing very different maintenance costs compared to older vehicles they replace at least in part. On average, the costs of operating a vehicle can represent between 15 and 33 % of the total lifetime cost of the vehicle (Figure 11) (Automotive Fleet 2016). Federal government procurement data show that at least R\$ 969 million was spent in the years 2014 to 2016 on the operation of vehicles - excluding acquisition costs.

Figure 11. Price per kilometre of a vehicle



Source: Automotive Fleet Magazine

## 5. Savings potential and policy implications

Both the system-wide regression models and the in-depth case studies lend themselves for savings estimations and policy recommendations. In both cases, savings estimations derive from the identified relationships between the predictor in question and unit prices as well as realistic policy change scenarios (Table 4). While the responsiveness of unit prices to changes in each predictor can be estimated and formally tested, savings scenarios are less 'hard', doesn't derive directly from the data. They reflect what is deemed politically and technically feasible and worthwhile based on the policy dialogue with the governments in question.

In order to reflect the different degrees of policy change implied by the regression models and the case studies, we differentiate conservative and aggressive scenarios. In the conservative scenario, what is purchased is not changed, only the how; such as the number of items purchased in one tender, or whether a tender is advertised. In the aggressive scenario, some aspects of what is bought are also changed, for example moving government data storage from own servers to the cloud or buying laptops with a small number of standard specifications as a default. While these changes have substantial quality implications, they always remain to serve the same underlying need and are deemed realistic based on the authors' policy dialogue with governments of each country and territory analysed.

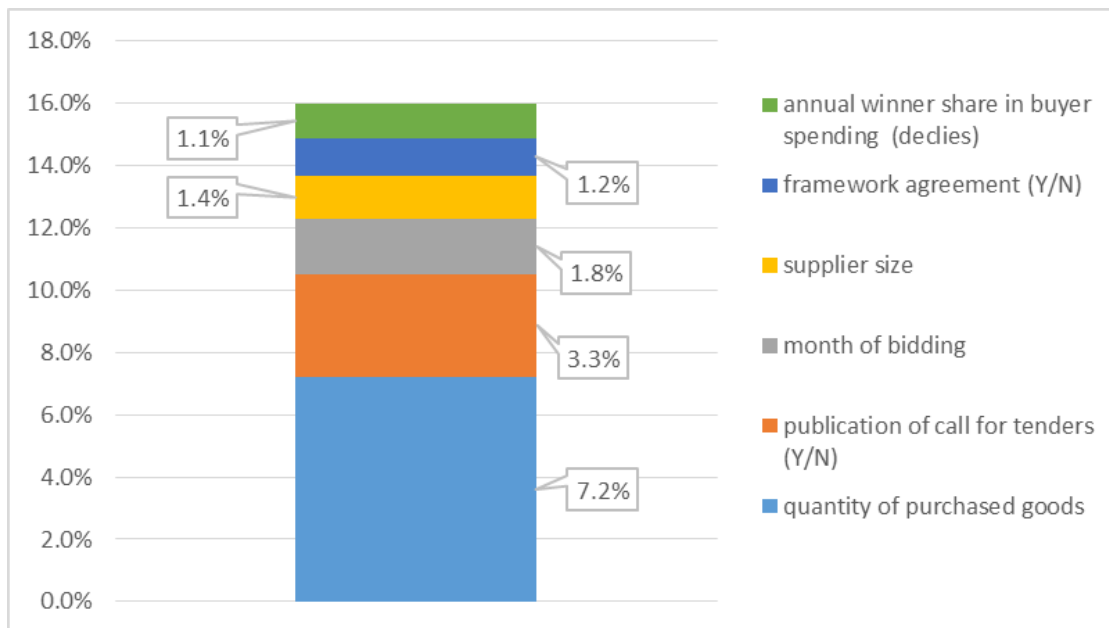
Regarding savings in the conservative scenario, the regression-based savings modelling typically identifies a 15-20% of savings potential across the analysed countries, with a 16% savings prediction for the Federal Government of Brazil (Figure 12). Such a substantial total predicted savings is achieved by drawing on only the most readily influencible factors and assuming only relatively small policy changes. None of these changes requires altering the regulatory framework, rather imply small tweaks to procurement process design and implementation decisions.

By far the largest price impact can be achieved by demand aggregation: 7.2% decrease in average unit prices across government is predicted if 50% of small purchases of 1-10 units are combined to reach at least 11 units (Table 4). Improving tender advertisement, from 40% to 100% publication rate, could contribute to a further 3.3% unit price reduction. Next, moving purchases from the expensive months, November and December, to a nearby month, January, could lead to a 1.8% unit price drop across the federal government. Reallocating contracts from medium and large companies to small companies could lead to a further 1.4% savings in unit prices paid. Furthermore, scraping inefficient framework agreements and using competitive, one-off electronic auctions instead could further lower unit prices by 1.2%. And finally, lowering spending concentration for buyer of very high concentrations could lead to sizeable savings: a 1.1% savings is predicted due to moving half of items from highest spending concentration buyers (10th decile) to lower spending concentration buyers (9th decile).

Table 4. Summary of savings scenarios by predictor, Federal Government of Brazil

Type	Group	Variable name	Conservative savings scenario values
Directly policy influenceable	Tender specifications	Month of bidding (January, February, etc.)	November & December purchases postponed to January
		Publication of call for tenders (Y/N)	100% set to yes
		Advertisement period length (days)	NO change
		Framework agreement (Y/N)	100% set to one-off auction
		Low season (June&December vs other months) # Framework agreement (Y/N)	100% set to one-off auction
		Quantity of purchased goods (deciles)	all small purchases (1-10 units) set to 11 or more units
		Buyer char.	Buyer type (ministry, independent agency, etc)
	Ministry/highest level administrative unit (ministry of defence, Brazilian Forestry Service, etc)		NO change
	Buyer-supplier from the same state (Y/N)		NO change
	Indirectly policy influenceable	Bidder/supplier char.	Supplier size (micro, small, large company)
Supplier size (micro, etc) # buyer-supplier from the same state (Y/N)			Half of the contracts going to large companies awarded to small companies # NO change
Supplier specialisation: number of markets the company supplies (deciles)			NO change
Bidding outcomes			Number of bidders (trimmed to 1-20)
		Annual winner market share (deciles)	NO change
		Annual winner share in buyer spending (deciles)	Move half of items from highest spending concentration buyers (10th decile) to lower spending concentration buyers (9th decile)

Figure 12. Predicted total savings in total and by predicot, % compared to observed unit price, Federal Government of Brazil, 2014-2016



A crucial aspect of both implementing realistic policy scenarios and realizing unit price decrease is the wide heterogeneity of markets and procuring entities across the country in terms of price responses to the very same interventions (Figure 13 and Figure 14). The differences in responsiveness is largely due to the differences in starting points, some markets and entities have already been rather efficient, performing close to the proposed performance improvement standards. For example, if a procuring entity has all its tenders already advertised, the policy intervention of eliminating non-advertisement, naturally will have no price impact. Conversely, in a market where most items are not advertised, the savings impact of more online advertisement will be major. Such heterogeneous impacts and the precise identification of weak baseline performance allows policy makers to implement targeted interventions at low cost such as training in selected procuring entities.

Figure 13. Distribution of predicted total savings by main market, Federal Government of Brazil, 2014-2016

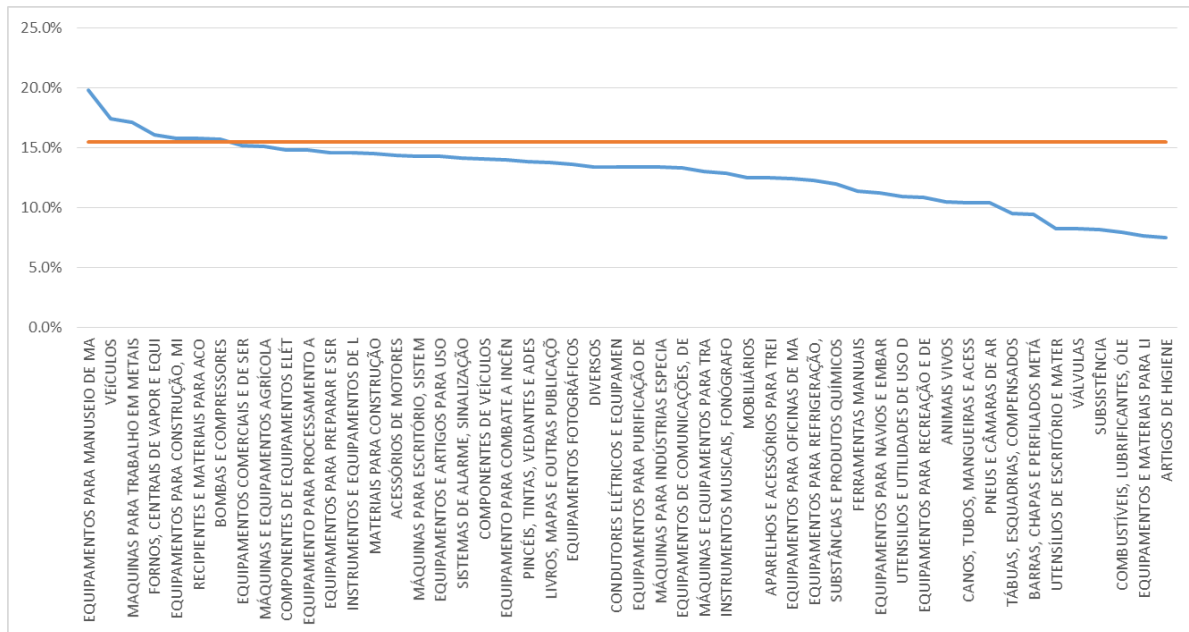
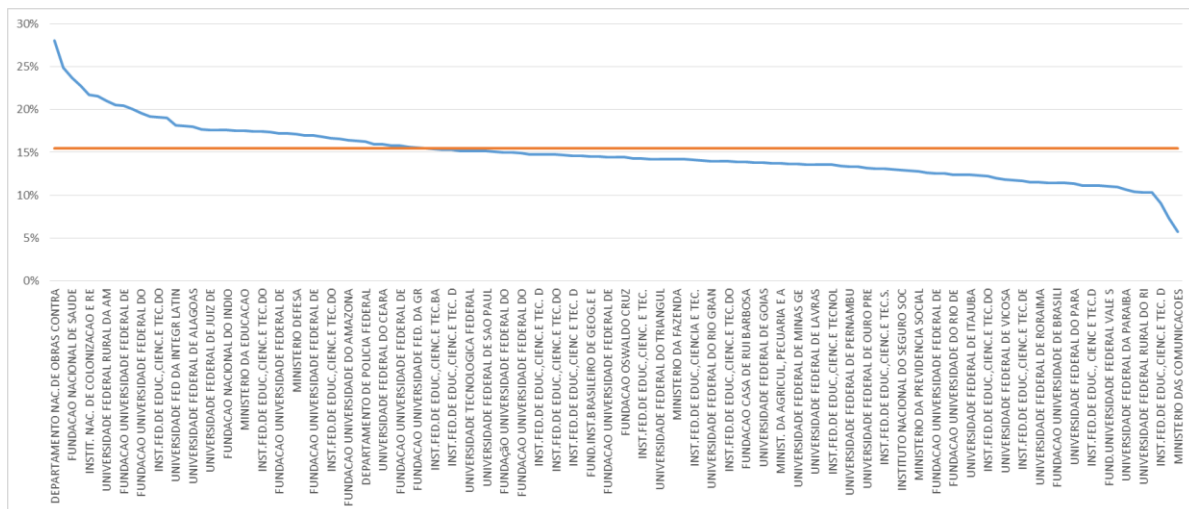


Figure 14. Distribution of predicted total savings by federal entity, Federal Government of Brazil, 2014-2016



Regarding savings in the aggressive scenario, the detailed case study analysis of selected markets has identified a savings potential for the Brazilian Federal Government amounting to 22%. For the vehicles market in particular, the savings potential amounts to 852 million BRL of the total current spending of 3,872 million BRL. These savings are predicted to accrue due to a range of factors, some of which also considered in the conservative scenario:

- Consolidation of demand in one main contract, with justified exceptions;
- Limit to specifications and requirements of products according to functionality;
- Standardization of specifications according to functionality;

- Adoption of a criterion for evaluating proposals for the acquisition of new vehicles based on the price per kilometre or other metric that takes into account operating costs and, ideally, other key elements of total life-cycle cost;
- Development and implementation of a fleet management policy for government vehicles;
- Demand control in the last quarter of the year, in order to avoid purchases in the last month and better distribute demand throughout the year.

In the Brazilian analysis, 4 markets were analysed in addition to vehicles. The extrapolation to arrive at a government-wide savings figure for the aggressive scenario is based on the average of all these markets. While the scope of case study analysis is arguably much smaller than the previously discussed regression analysis, its much greater depth lends it a high degree of reliability, hence good arguments for extrapolation. In addition, the roughly comparable savings rates delivered by the 2 different methods underpins the feasibility of the proposed government-wide savings.

## 6. Conclusions and critical assessment

We conclude by discussing the strengths and weaknesses of the outlined analytical approach and what future improvements could be made. Moreover, we also outline the potential scope and limitations of implementing such an analysis throughout the world.

The strength of the analytical framework rests in its rich empirical basis, government-wide administrative data of great detail; the strong links between well-established economic theories and the relationships sought; and the diversity of analytical methods, both quantitative and qualitative, leading to similar conclusions across the board. Moreover, our experiences with applying the framework in 7 Latin American countries and 4 sub-national entities in the region suggest that the methods are replicable and largely standard across diverse contexts. Even though, regulatory, data source, and market differences require a great deal of care and adaptation of the generic tools described above.

However, the analytical framework is not without its weaknesses, some of which can be addressed in future iterations or with better data. Most fundamentally, missing and incorrect data can invalidate findings which is, luckily, a relatively limited problem in transactional e-procurement systems. Nevertheless, highly technical and seemingly minor problems can pose substantial challenges. For example, lack of sufficiently standardized units of measurement can render unit price comparisons flawed. Furthermore, missing information on payments and contract implementation raises questions about the validity of findings given that payments may well deviate substantially from contracted values.

On a methodological level, a simple linear regression model is efficient and easy to interpret, but fails to take into account complex causal links between the factors included (e.g. advertisement influencing the number of bidders as well as prices) and the different levels of observations playing a crucial role in prices (e.g. tender level vs supplier level factors). Without more careful identification of causal effects, the methodology can only capture correlations and has to rely on theory and case study methodology for further support.

From a policy perspective, while savings scenarios and predictors are actionable and directly relate to policy decisions made by procurement agencies, ministries of finance or individual buyers; achieving and successfully implementing savings strategies remain challenging on their own. Overcoming resistance of front-line staff or upskilling key procurement officials may be more challenging than it seems at first.

## References

- Bandiera, O., Best, M. C., Khan, A., & Prat, A. (2019). Incentives and the Allocation of Authority in Organizations: A Field Experiment with Bureaucrats. In *American Economic Association Annual Meeting*. Atlanta, Georgia, USA: AEA.
- Bandiera, O., Prat, A., & Valletti, T. (2009). Active and Passive Waste in Government Spending: Evidence from a Policy Experiment. *American Economic Review*, *99*(4), 1278–1308. <https://doi.org/10.1257/aer.99.4.1278>
- Best, M. C., Hjort, J., & Szakonyi, D. (2017). *Individuals and Organizations as Sources of State Effectiveness* (NBER Working Paper Series No. No. 23350). *National Bureau of Economic Research Working Paper Series*. <https://doi.org/10.3386/w23350>
- Collier, P., Kirchberger, M., & Söderbrom, M. (2015). The cost of road infrastructure in low and middle income countries.
- Coviello, D., & Gagliarducci, S. (2017). Tenure in Office and Public Procurement. *American Economic Journal: Economic Policy*, *9*(3), 59–105.
- Coviello, D., & Mariniello, M. (2014). Publicity requirements in public procurement: Evidence from a regression discontinuity design. *Journal of Public Economics*, *109*, 76–100.
- Coviello, D., Marino, I., Nannicini, T., & Persico, N. (2017). *Direct Propagation of a Fiscal Shock: Evidence from Italy's Stability Pact* (Working Paper No. 484). Naples, Italy.
- Decarolis, F., Giuffrida, L. M., Iossa, E., Mollisi, V., & Spagnolo, G. (2018). *Bureaucratic Competence and Procurement Outcomes* (NBER Working Paper Series No. No. 24201). *National Bureau of Economic Research Working Paper Series*. <https://doi.org/10.3386/w24201>
- Fazekas, M. (2017). *Assessing the quality of government at the regional level using public procurement data* (Working Papers No. WP 12/2017). Brussels.
- Fazekas, M., & Blum, J. R. (2016). *Improving public procurement outcomes: review of tools and the state of evidence base*. Washington, DC.
- Fazekas, M., & Kocsis, G. (2017). Uncovering High-Level Corruption: Cross-National Corruption Proxies Using Government Contracting Data. *British Journal of Political Science*.
- Fazekas, M., & Tóth, B. (2016). *Assessing the potential for detecting collusion in Swedish public procurement*. Stockholm.
- Fazekas, M., & Tóth, B. (2018). The extent and cost of corruption in transport infrastructure. New evidence from Europe. *Transportation Research Part A: Policy and Practice*, *113*. <https://doi.org/10.1016/j.tra.2018.03.021>
- Fazekas, M., Tóth, I. J., & King, L. P. (2016). An Objective Corruption Risk Index Using Public Procurement Data. *European Journal of Criminal Policy and Research*, *22*(3), 369–397. <https://doi.org/10.1007/s10610-016-9308-z>
- Gur, Y., Lu, L., & Weintraub, G. Y. (2015). *Framework Agreements in Procurement: An Auction Model and Design Recommendations* (Columbia Business School Research Paper No. No. 13-24). New York.
- Lehne, J., Shapiro, J. N., & Eynde, O. Vanden. (2018). Building connections: Political corruption

- and road construction in India. *Journal of Development Economics*, 131, 62–78.
- Lewis-Faupel, S., Neggens, Y., Olken, B. A., & Pande, R. (2016). Can Electronic Procurement Improve Infrastructure Provision? Evidence from Public Works in India and Indonesia. *American Economic Journal: Economic Policy*, 8(3), 258–283.
- Liebman, J. B., & Mahoney, N. (2018). *Do Expiring Budgets Lead to Wasteful Year-End Spending? Evidence from Federal Procurement* (NBER Working Paper No. No. 19481). Cambridge, MA.
- OECD. (2016). *Government at a Glance: Latin America and the Caribbean. 2017*. Paris: OECD.
- OECD. (2017). *Government at a Glance. 2017*. Paris: OECD.
- Pricewaterhouse Coopers. (2013). *Identifying and reducing corruption in public procurement in the EU*. Brussels: PricewaterhouseCoopers and Ecorys.
- Saussier, S., & Yukins, C. (2018). Life-cycle costing in public procurement. In G. Piga & T. Tátrai (Eds.), *4th Interdisciplinary Symposium on Public Procurement*. Paris.
- World Bank. (2017). *A Fair Adjustment: Efficiency and Equity of Public Spending in Brazil-Public Expenditure Review*. Washington, DC: World Bank.
- Yakovlev, Andrei, Vyglovsky, O., Demidova, O., & Bashlyk, A. (2015). *Incentives For Repeated Contracts In Public Sector: Empirical Study Of Gasoline Procurement In Russia* (HSE Working papers No. WP BRP 24/PA/2015). Moscow: National Research University - Higher School of Economics. <https://doi.org/DOI>:
- Yakovlev, Andrey, Bashina, A., & Demidova, O. (2014). *The effectiveness of simple homogeneous commodity procurement under rigid governmental regulation: the case of granulated sugar procurement in Russia* (HSE Working papers No. WP BRP 13/PA/2014). Moscow: National Research University - Higher School of Economics. <https://doi.org/DOI>: