

Gender in public procurement:

Extent, distribution, and impacts

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ABSTRACT

A crucially under-documented gender gap is the difference in public procurement spending that flows to companies led or owned by men vs women. The role of gender in public procurement is of wide interest given that public procurement represents about third of government spending in OECD countries. As country-level gender data on labour force participation and wages do not account for gender differences in public procurement, there is a need for large-scale administrative data-driven assessment. Hence, this study sets out to precisely estimate the prevalence and distribution of women-managed companies in European public procurement markets and to provide insights on the potential policy determinants and impacts of women-run businesses. We merge a large-scale EU-wide public procurement database (TED) with gendered firm management data (BvD) for 2006-2016. Overall, we find that 26.3% of government suppliers' managers are women and that for 16.5% of suppliers of large value contracts across the EU the management is majority women. We could establish that public procurement, on average, reflects gender gaps in the wider economy with a small deviation of 2-5% between economy-wide and public procurement-specific women management shares. We also find that a majority of women on company boards tend to lower the risk of corruption, though the average effect size is small: 2% point change in single bidding.

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1. Introduction

Around the world, governments spend a large portion of their budgets¹ buying goods and services from the private sector. Unequal access to these public resources by private entities is a relevant issue across the development spectrum. Existing literature on favouritism in public resource allocation finds that bias in access to public contracts has a significant impact both on the quality of procurement outcomes achieved and on the economic wellbeing on favoured vs. unfavoured groups. However, it mostly discusses the impact of political connections on ease of access to public contracts without accounting for the gender perspective (Dahlström, Fazekas, and Lewis 2019; Dávid-Barrett and Fazekas 2019).

The question at hand is whether women have relatively better chances of closing the existing gender gap in this public-private marketplace, or whether governments themselves amplify economic imbalances? If we assume, as existing literature suggests, that economic transactions in public procurement are deeply embedded in local political cultures (Popa 2019), and that an unequal distribution of political power between men and women prevails in most economies (Milazzo and Goldstein 2019), we can expect to see public procurement markets to amplify inequalities in regions with already large gender gaps and where established men-dominated networks at the intersection of business and politics control key decision making positions.

In that regard, it is noted that tackling gender imbalances in decision-making positions in politics and business is part of the European Commission's agenda, and policies are being adopted to improve the current situation (European Commission 2019).² These policies are backed by statistics on gender imbalance in managing positions of both public and private organizations. However, data on gender imbalances in the amount of public spending that flows to companies led or owned by men vs by women is missing, despite clear policy goals that have been set on women economic empowerment and the significant potential of public procurement to impact their achievement.

This report aims to fill the empirical gap on gender imbalances in public procurement and explore the hypothesis that inequalities in the benefits reaped from public spending can

¹. In OECD countries public procurement accounted for 29.1% of government expenditures on average in 2017 (OECD 2019).

². For example, they aim for greater gender balance in publicly listed companies by increasing women's share in non-executive board-member positions to 40% (European Commission 2012) from the level of 23% as of 2016 (Regner and Kratsa-Tsagaropoulou 2016).

also be traced back to unequal distribution of political and economic power between men and women and other factors, deepening political and economic gender inequality. The study looks at economic gender gaps from a new perspective, exploring the following research questions:

- ✔ What percentage of public procurement spending goes to women-run businesses? How does it compare to the general economy?
- ✔ How do gendered macro indicators correlate with gender composition of private sector management?
- ✔ How is gender composition of company management board associated with corruption risks in public procurement?

We focus on women in company management rather than ownership for a variety of reasons. While gendered ownership has been of central interest for a wide range of actors, most of these analyses looked at ownership by women in SMEs rather than across all company sizes. However, public procurement is dominated by large companies whose ownership structure is complicated, often diffuse and in many cases impossible to fully track back to individuals (e.g. owners in tax havens). Hence, ownership is not an ideal candidate for measuring control and financial returns for women in public procurement both substantially and methodologically. Instead, we look at gender of management because we can infer their gender accurately and because management positions are directly linked to control and financial benefits so they reflect on gender gaps in a straightforward manner.

To address the above research questions the report is structured as follows: first, we review the institutional context of public procurement as well as policies focused on improving economic gender equality in the field. We also review past work on economic gender gaps in business ownership and management. Second, we present and prepare the data that will be used to quantify gender gaps in public procurement. For this purpose, we merge two large micro-level datasets. The first is a unique database of nearly all high value public contracts in 35 European countries awarded since 2009. The second is company data including ownership and board membership. We then estimate the share of public contracts awarded to firms led by women at the regional, national, and European levels. These data allow first conclusions as to whether government contracting entities mitigate or compound economic gender gaps. Third, if the latter is the case, we further investigate countries and industries with largest gender disparities as compared to general economy vs specific countries and sectors which give preference to women-owned businesses. We also seek to establish correlations between gender inequality in accessing public capital and unequal distribution of political and economic power between men and women. Furthermore, we evaluate impacts of gender composition of company management board on corruption risks in public procurement. Finally, we conclude the report by tying the findings together and suggesting further area of research as well as providing policy recommendations.

2. Institutional context and related work

Public procurement tenders make up a significant part of overall public expenditure. Among OECD countries an average of 11.8% of GDP is spent annually on public contracting (OECD 2019). However, these markets can be subject to capture by corrupt practices, favouritism, and other factors distorting procurement outcomes (OECD 2007, 2017). Recent research suggests that political connections, incumbency, and other non-performance related firm attributes may have an important impact on firms' success in public contracting (Broms, Dahlström, and Fazekas 2019; Dahlström, Fazekas, and Lewis 2019; Dávid-Barrett and Fazekas 2019; Fazekas 2017; Fazekas and King 2019; Lapuente and Fazekas 2016). However, there is no data-driven evidence on whether woman-led or -owned companies are disadvantaged in procurement and how gender aspects of business ownership and management composition are related to corruption risks in public procurement, the largest direct channel of public spending to the private sector.

The existing body of literature on economic gender gaps mostly covers topics of gender pay gap, gender imbalance in managing positions of both public and private organizations as well as in ownership rights of land, businesses, and other assets. Research on proving and quantifying gender pay gap started in 1957 with seminal study of Becker and Leonard (Leonard and Becker 1957) and became a trending topic over the last three decades with numerous empirical studies all over the world using different data, methods, and time periods. A study by Weichselbaumer and Winter-Ebmer (2005) provides a meta-analysis of the international wage gap and summarizes more than 260 studies on the topic. It has been concluded that based on analysed studies raw pay differentials have decreased significantly over the observed period. However, authors also highlight that the data used by those studies are not satisfactory and have serious limitations including concerns about representativity (Weichselbaumer and Winter-Ebmer 2005). Improved data collection tools and techniques, in particular larger amount of administrative data collected by states as well as organic, unstructured big data emerging from the “internet of things”, social media, mobile and citizen-generated data etc. (UN Women 2018), in combination with development of data science methods have opened a new world for researchers. The UN report on gender equality and big data (UN Women 2018) presents a variety of recent development projects led by different international organizations such as UN Global Pulse, the UN Global Working Group on Big Data for Official Statistics, and the World Bank Group that use innovative methods employing big data to tackle gender inequalities. One of the projects “Mapping indicators of women's welfare at high spatial resolution” utilizes high-resolution geospatial data from Bangladesh, Nigeria, Haiti, Kenya, and Tanzania to map landscapes of gender inequality related to literacy, stunting, and other social and health matters.

Many previous studies in the broader literature have also examined the gender imbalance in company boards and the issue of the boardroom glass ceiling in different sectors of the economy. As has been previously reported in the literature, European experience in advancing women to be on company boards has been heterogeneous: North European countries have relatively high share of women managers as of 2012 (Norway – 41% following the introduction of a 40% rule in 2003, Sweden – 27%, Finland – 20%, Denmark – 17%) while there are only 13% in Germany, 9% in France, 8% in Spain and 3% in Portugal (Hurn 2012). When narrowed down to a sectoral level research, authors reveal even larger gender gaps and imbalances. For instance, the study on the Financial Times Stock Exchange 100 Index companies (FTSE)³ - 100 companies listed on the London Stock Exchange with the highest market capitalisation - suggests that in 2010 there were only 12.5% women directors and 5.5% women executive directors on boards of 100 largest public companies traded at London Stock Exchange. This topic has been also explored extensively in the field of legal services and accounting (Atena and Tiron-Tudor 2019) where women make up 70% of the workforce in such countries as Finland, France and Germany, however, are not represented accordingly in top management positions. Some authors have driven the further development of the topic and tried to draw conclusions on relationship between board gender diversity and firm performance indicators such as implementation of innovations (Hernández-Lara and Gonzales-Bustos 2020), growth in sales and productivity (Kotiranta, Kovalainen, and Rouvinen 2010), and the capital structure of microfinance institutions (Adusei and Obeng 2019).

A growing body of literature has also examined economic gender gaps in ownership rights of businesses, land, other property and assets. A recent report on women's entrepreneurship (Global Entrepreneurship Research Association 2016) has evaluated women's business ownership across the 63 economies in the total entrepreneurial activity as well as a share of established businesses. According to this study, women's business ownership in total entrepreneurial activity ranges from lows of 3% in Germany, Jordan, Italy and France to 37% in Senegal. High-parity economies where women own businesses at the same level as men or higher include Indonesia, the Philippines and Vietnam in Asia and Mexico and Brazil in Latin America (Global Entrepreneurship Research Association 2016). Interestingly, the study draws a conclusion that with the improvement of economic development, women's ownership among established businesses decreases and the economic gender gap in business ownership widens (Global Entrepreneurship Research Association 2016). At the startup level, however, some researchers also find a well-established gender gap which is, for instance, measured in the US for businesses registered between 1995 and 2011 at the level of 63% (Guzman and Kacperczyk 2019). As authors argue, women-led or owned ventures have lower chances of getting external funds from venture capitalists and other financing institutions

³. The Financial Times Stock Exchange 100 Index is a share index of the 100 companies listed on the London Stock Exchange with the highest market capitalisation (Londond Stock Exchange n.d.).

which is by 65% explained by initial difference in startup orientation with weak external signals of potential growth and by 35% stems from investors' gendered preferences.

This literature also suggests that women-led or -owned businesses are less likely than others to engage in corrupt practices or have such attributes as political connections, incumbency, and other non-performance related firm attributes that may have an important impact on firms' success in public contracting, hence one could expect that women-led or -owned businesses will perform worse than others in this sector (Cvetanoska and Kubbe 2019; Esarey and Chirillo 2013; Swamy et al. 2001; Transparency International 2016; van der Vleuten and Verloo 2012). According to Swamy et al. (2001), women are less involved in bribery cases and less tolerant to bribe taking. Even when engaging in corruption, women tend to be less aggressive and receive lower benefits than men would in the similar situations (Dabalén and Wane 2008). From a private businesses' business point of view, companies with women in top management pay less bribes and consider corruption as less of an obstacle to doing business (Breen et al. 2017). Abovementioned gender differences in corruption patterns are mostly attributed to more risk-averse behaviour of women if general due to their social roles (Dabalén and Wane 2008) and women being more vulnerable to punishment and risks related to corruption activities due to explicit or tacit gender discrimination (Esarey and Chirillo 2013). Esarey and Chirillo also suggest that women may be excluded from the closed social networks of elites with the power to engage in corruption.

Even assuming that women may occupy formal decision-making positions, other factors may hinder their success. For example, in countries with public spheres dominated by men, established networks may implicitly or explicitly control resource allocation (Cvetanoska and Kubbe 2019). As public contracting sits at the intersection between public and private spheres, it may be victim to both corruption and private-sector gender biases. In that regard, it is noted that preferential treatment for women owned businesses in public procurement is one of the options at the disposal of policy makers is a relatively new concept in Europe; however other countries have established minimum quotas for the participation of women in this sector. For example, in Chile public procurement regulations incorporate gender-specific evaluation criteria. The public procurement agency launched the Women Supplier Certification which helps to identify women-led businesses as well as those with more than 50% of women workforce (Rimmer 2017). There is another type of support in Canada that NGOs help businesses owned by women to bid on public contracts (International Trade Centre 2020). By now, there is a wide array of policy options available for governments and international organisations for facilitating women run and owned enterprises' participation in public procurement. Such policies, among others, include targeted capacity development, set-asides, preferences, and sub-contracting plans (International Trade Centre 2014).

3. Data and Preparation

This section provides a short overview of how the database has been prepared, outlining data sources and the main steps of data cleaning and matching. The full description of data preparation see the Appendix. The key data challenge which we had to overcome to make the below analysis possible was to collect and combine large-scale administrative datasets on public procurement and registered companies across the EU. We used the following source datasets:

- Company registry, management, ownership⁴ and financial information database as compiled by Bureau van Dijk (BvD) (Bureau Van Dijk 2019) which is the largest cross-country company dataset of companies in Europe. While the data offers time series, for ease of use we took the latest available entry for each company in the dataset, typically 2016.
- Official public procurement data published on the EU's Tenders Electronic Daily (TED) website for the period 2006-2016. Data was collected by the DIGIWHIST project and the Government Transparency Institute using automated web scrapers and parsing algorithms extracting key fields from a complex xml source dataset (for a general introduction to database building approaches see Czibik, Fazekas, and Toth (2015)).⁵

These datasets have been linked by matching on company names and addresses. While company names and addresses are highly standardized in the company registry dataset, the same is not true for public procurement data. Hence, the great diversity of how companies are represented in the public procurement data has been reduced by standardizing company names and addresses (e.g. transforming abbreviations such as ltd.). We then applied machine learning methods using the Dedupe software library (Forest and Derek, 2019) to identify most likely matches in company names and addresses in the datasets.

As a next step after the data collection and matching, we perform a thorough check of variables that are critically important for the analysis. One of those variables is gender of managers that we take from BvD dataset. We checked and improved the existing gender variable in the source BvD dataset in two alternative ways:

⁴. Please note that while ownership data is available in the BvD dataset, due to the technical complexity of analysing such data and the additional difficulties of identifying the gender of ultimate owners, ownership data remained outside of the scope of this article.

⁵. For a full description of the data source and methods see: opentender.eu/uk/about/how-opentender-works.

- Manual check (googling names) as a benchmark;
- Automated gender identification using the Python software library “gender-guesser” (Pérez 2015) that identifies the gender of a person based on his/her name and country of origin using regional and national registries of names and gender recorded at birth. Such approaches have been used extensively in computer science studies on gender discrimination (Jadidi et al. 2018; May et al. 2019). Advantages and limitations of this approach as well as results of a manual check of our gender inference procedure are presented in the Appendix.

Another fundamental issue to consider is to make sure that the sample of companies we have in BvD is representative of the whole population of firms in the EU with respect to key company characteristics. This is a challenge for BvD data because despite its scale significant gaps in coverage remain in some countries, sectors, and company types.

Weighting the BvD dataset, as a benchmark of the economy-wide distribution of firms, allows us to draw reliable comparisons between all companies in the economy and those companies which hold government contracts. The weighting procedure is applied so that the BvD dataset has approximately the same proportions of country-industry categories as the whole economy based on representative surveys and statistical office data. As we have the full population of advertised public procurement tenders from TED, there was no need to apply weights to company data matched to contracts. Given the incomplete data in some countries and industries some countries had to be removed from the analysis. In the end, the BvD sample used for the analysis contained information on 20 EU countries with 22.7 million companies.

In addition to the large-scale micro-level datasets on companies and government contracts, we relied on macro-variables for some analyses. These additional macro-datasets used are:

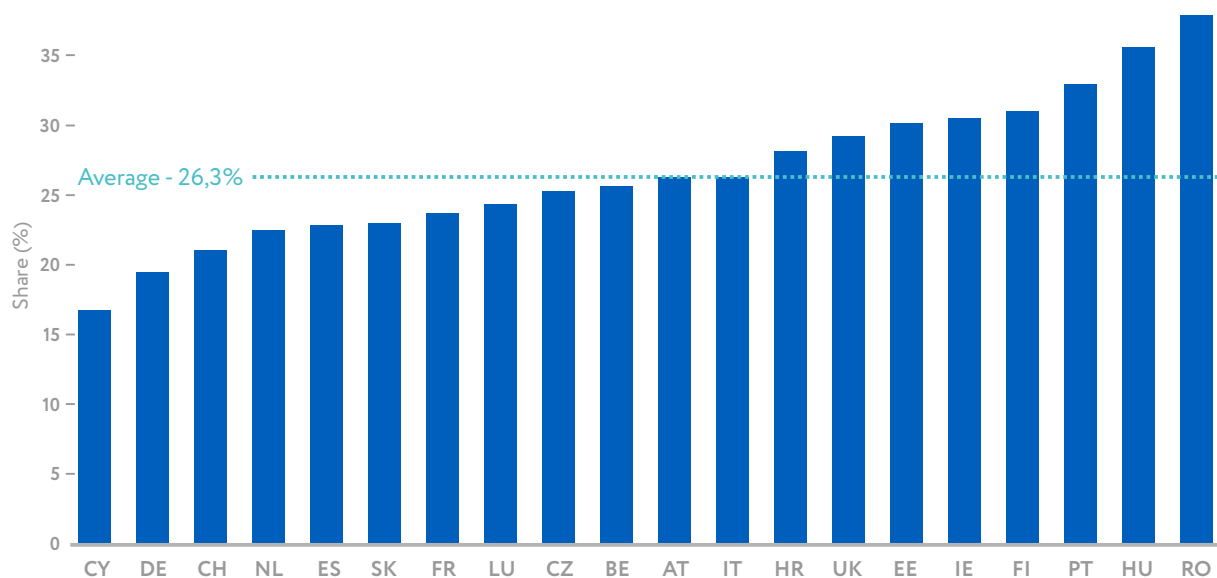
- V-Dem v.8 (Varieties of Democracy) dataset provides access to a multidimensional and disaggregated dataset that reflects five high-level principles of democracy: electoral, liberal, participatory, deliberative, and egalitarian. Variables of interest for our research are gender-related indicators such as lower chamber gender quota, power distribution by gender, year when women got the right to vote, women share in parliament, etc. (Coppedge et al. 2018).
- Eurostat annual enterprise statistics by size class for special aggregates of activities (NACE Rev. 2) (Eurostat n.d.) which provides information on how many companies are present in a particular country and sector as of 2016. We refer to this dataset as a benchmark of general economy and the distribution of businesses within country - sector dimension.
- World Development Indicators - Female share of employment in senior and middle management (%) (The World Bank 2020).

4. Results: scale, distribution, and macro correlates of women management in public procurement

Gender in the economy and public procurement by country, sector and company size

Macro- and micro-level objective indicators of women participation in public procurement activities and their success in this market as well as in the general economy remain an open question in literature and provide room for different interpretations. The simplest measure of women's participation in management of businesses is the share of women managers on company boards in general. Observing this indicator across EU member states is a starting point of an empirical analysis. Later on, we introduce more specific measures considering the share of women on company boards per company allowing us to trace women majority for example. As one can see in Figure 1, within the sample of selected European countries on the macro level we observe significant differences in the weighted average share of women on company's board with an average of 26.3%. Interestingly, 2 Eastern European EU Member States have the highest share of women in company management: Romania and Hungary. The differences across European countries are also striking, the countries with the highest women participation in company management have about 2-times women-shares than the lowest (Cyprus, Germany and Switzerland).

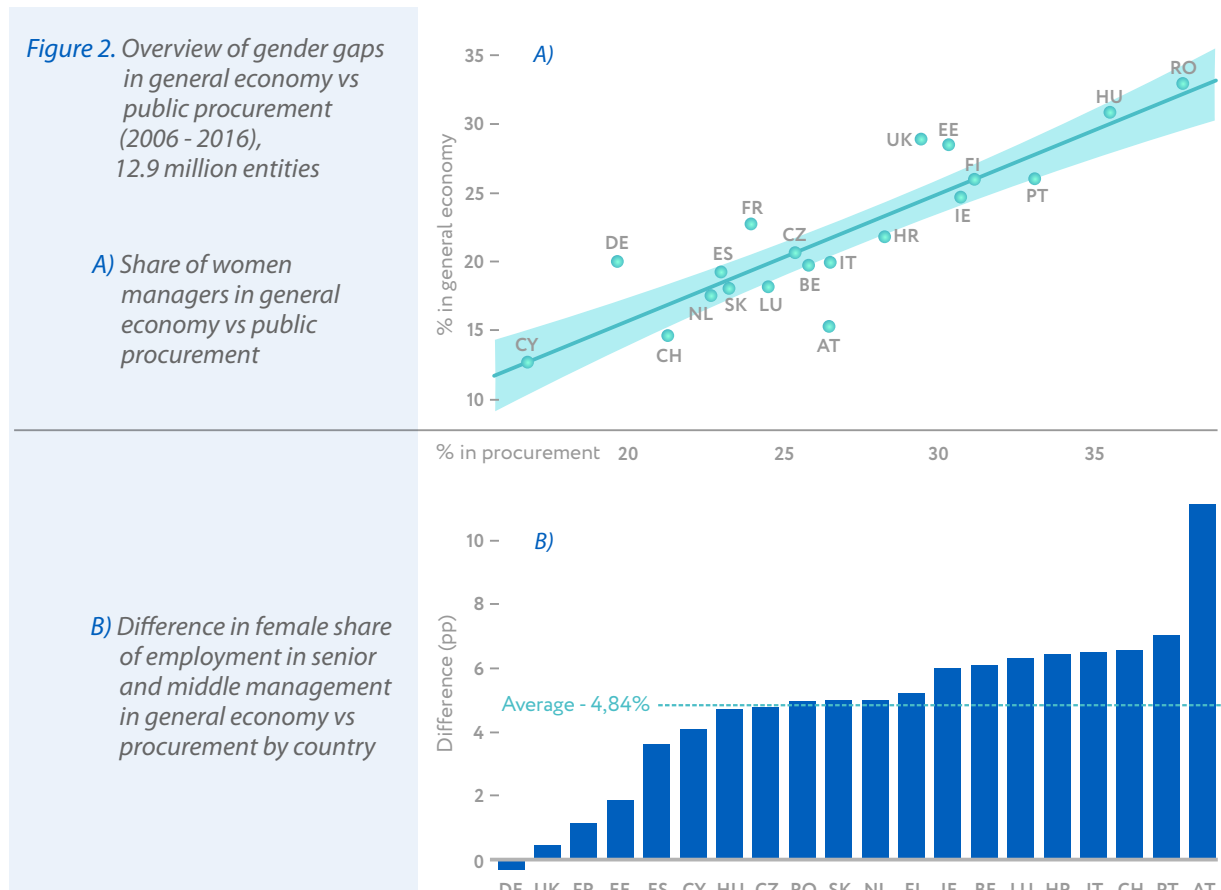
Figure 1. Percentage of women in company management in the general economy by country (2016), 12.9 million entities



More interesting, however, is the comparison between the general economy represented by the weighted BvD data and public procurement suppliers as depicted in Figure 2. The share of women-led companies in the economy and public procurement are very strongly positively associated (Figure 2.A). Nevertheless, a more detailed look reveals a range of

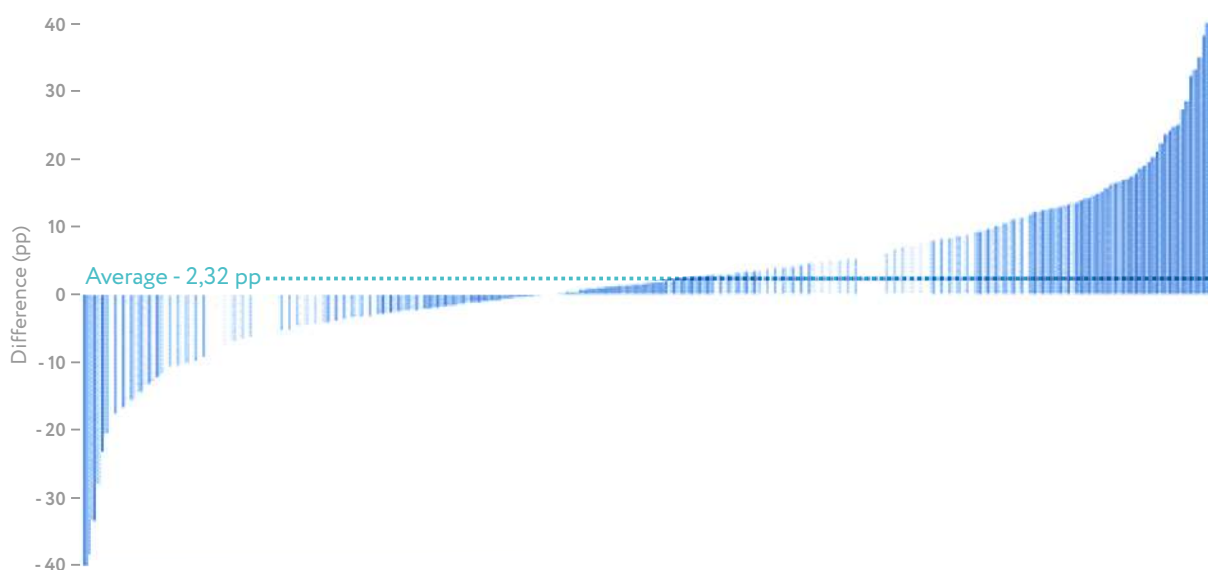
gender composition disparities between procurement and the wider economy (Figure 2.B). In all analysed EU countries, except Germany, companies that participate in public procurement tend to have a lower share of women than companies in the general economy. On average across all countries, the share of women-led businesses in the economy is higher than in public procurement by 4.8 percent point. The biggest gap, by far, can be observed in Austria which purports a roughly 11 percent point gap while Portugal, Switzerland, and Italy also have a high gap of around 6 percentage points. On the other end of the distribution, Germany, the UK, France, and Estonia display very low discrepancies in women participation in management between the wider economy and public procurement.

Such a close alignment between women management participation in companies in the wider economy and public procurement points at no strong entry barrier for women-managed companies in public procurement. Instead, what we see is that the general economic participation of women in the wider economy being largely reflected in public procurement. From a policy perspective, public procurement, however, is largely regulated and controlled at the EU level, unlike the general economy. Therefore, EU public procurement regulatory framework has a wide potential of incorporation of gender-specific criteria or other types of support of women-led/owned businesses. Such an approach would lead not only to improvement of gender balance in public procurement, but also to positive effects in the wider economy given high importance of public procurement accounting for 15% of EU GDP.



When narrowed down to a country-sector level (Figure 3), we find that, despite most countries having a higher share of women-led businesses in the general economy than public procurement, only ~55% of the country-sector groups have relative underrepresentation of women-run businesses in public procurement. The rest of the sample has the opposite situation when there are relatively more women-managed entities in public procurement than in the general economy.

Figure 3. Difference in the share of women managers in general economy (weighted BvD) vs public procurement. (TED) by country & sector, all European countries (2006 – 2016), 12.9 million entities



Given the large discrepancies at the 2 tails of the distribution, that is the country-sector groups with the highest and lowest gaps between the general economy and public procurement, we also take a closer look at them (Table 1). In the list of top 10 industries favouring women-led companies (left tail of the distribution, companies having lowest gaps between general economy and public procurement) we find some of the “traditional women occupations” such as travel agency tour operators, manufacture of food products, veterinary activities (Lippa, Preston, and Penner 2014), while “traditional men occupations” are also present - manufacture of motor vehicles trailers and semi-trailers, warehousing and support activities for transportation, etc. (Mcdowell 2015). However, some of the sectors classified as favouring women-led companies in public procurement in some countries were classified as favouring men in others: for instance, veterinary activities in Spain were classified as favouring women-run businesses, while in the Netherlands they were classified as favouring men-led entities. In addition, legal and accounting activities were found as the most frequent category in the list of top 10 industries favouring men-led which confirms previous studies that highlighted the fact that in this field women make up 70% of the workforce, however, are not represented accordingly in top management positions (Atena and Tiron-Tudor 2019).

Table 1.A) TOP 10 industries favouring women-led companies in public procurement (2006 - 2016)

Country	Industry according to NACE	Difference in %
ES	Veterinary activities	-63.1
CZ	Travel agency tour operator reservation service and related activities	-58.2
AT	Manufacture of food products	-46.8
PT	Manufacture of motor vehicles trailers and semi-trailers	-39.2
AT	Warehousing and support activities for transportation	-38.5
CZ	Information service activities	-38.3
CZ	Manufacture of wearing apparel	-34.3
SK	Manufacture of rubber and plastic products	-33.3
PT	Manufacture of rubber and plastic products	-30.0
BE	Waste collection treatment and disposal activities; materials recovery	-28.3

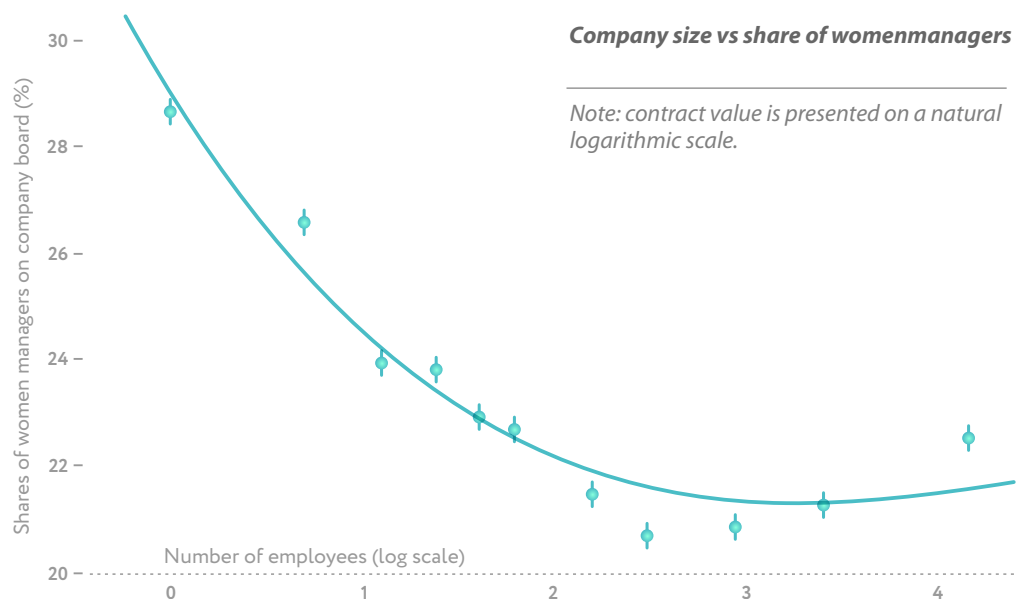
Table 1.B) TOP 10 industries favouring men-led companies in public procurement (2006 - 2016)

Country	Industry according to NACE	Difference in %
NL	Veterinary activities	49.0
AT	Employment activities	41.7
FI	Manufacture of wearing apparel	41.7
PT	Legal and accounting activities	40.2
SK	Legal and accounting activities	39.0
HR	Travel agency tour operator reservation service and related activities	38.2
PT	Publishing activities	38.2
EE	Legal and accounting activities	37.1
BE	Other manufacturing	35.0
HR	Legal and accounting activities	35.0

The great advantage of the micro data is that it is possible to examine correlates of female managers beyond the familiar country-sector breakdown. A crucial relationship which will influence a range of analysis below, is between firm size and the gender balance in management. Figure 4 presents the non-linear relationship between the number of

employees as a proxy for firm size and the share of women in corporate management. For the purpose of this visualization, the continuous measurement of a number of employees was transformed into the logarithmic scale and observations were grouped into even-sized bins. The quadratic regression line demonstrates the negative relationship between the size of the company and the share of women in management, while the relationship flattens towards the right side of the distribution represented by extremely large firms. In other words, the bigger the company, the lower the share of women managers except for the minority of extremely large entities where the relationship flattens.

Figure 4. Company size (number of employees, grouped into even-sized bins) and the share of women managers on company board in the general economy, all European countries (2016), 2 million entities



While there has been lots of policy discussion around woman-led companies, our detailed data enumerating the gender of each top manager of a company reveals the potential ambiguity of such a term. Such an ambiguity leads to vastly different scales of women participation in company management hence could result in different policy responses. In this respect, we outline 3 straightforward definitions for “companies run by women” or “women-led businesses”:

- i) at least 1 woman in management,
- ii) majority of women in management, and
- iii) only women in management.

Distributions of the above-mentioned categories in the sample are presented in Figure 5. Please note that in this analysis we only considered companies with 3 or more board members in order to exclude private entrepreneurs and small businesses that do not have a large enough pool of managers which would warrant a meaning full statistics based on women share in management. By implication, SMEs, micro enterprises and self-employed individuals are excluded from the below analysis.

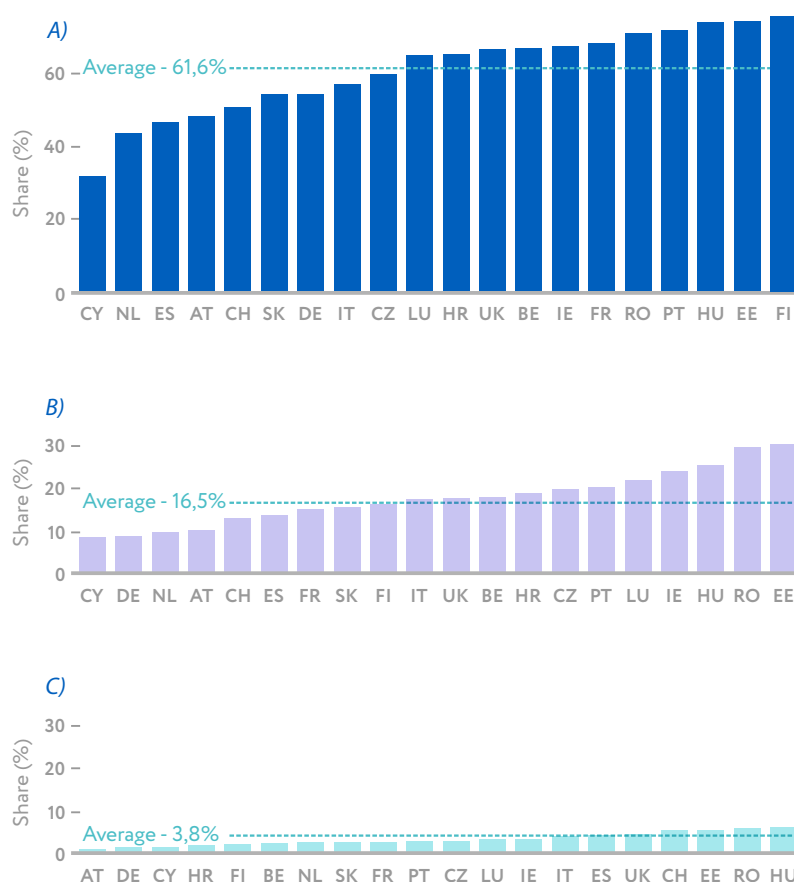
Figure 5. Distribution of firms according to different definitions of women-led businesses in the general economy (2006 - 2016), 2 million entities

A) Share of companies with – at least 1 woman on management board by country

B) – majority of women in management

C) – only women in management

Note: companies with 3 or more managers.



As presented in Figure 5, all three distributions are significantly different with countries being in a different order as well as averages at different levels. If we consider companies with at least 1-woman manager on board, the average percentage in the observed sample is 61.6% with most countries trending around average value. Considering the share of firms with a majority of women managers, there are, on average, 16.5% of such companies in the sample with most countries clustered around average, in the 10 – 20% range. At the same time, companies with only women managers on the company board constitute a small proportion of the sample in each country – 3.8%, on average. What is particularly interesting about this arguably most restrictive definition of women-led management is that in the list of country-sector groups with highest share of women managers we could find women's traditional occupations such as manufacture of textile (Lippa, Preston, and Penner 2014), however we could also find a number of sectors which are considered traditionally "male" occupations (Mcdowell 2015), for instance, construction of buildings in Luxembourg, repair and installation of machinery and equipment in Austria (Table 2). When comparing the country distributions according to the 3 different definitions, the country rankings are also strikingly different. One notable example is Finland. It ranks on the top when it comes to the share of companies with at least one woman manager, but drops to the middle of the

ranking in terms of majority women-run businesses, and falling even further to the bottom of the ranking in terms of companies managed only by women. Interestingly, Hungary and Romania are ranked among top five countries with highest share of women managers according to all three definitions. In terms of companies with majority of women in management and only women on company board, Hungary and Romania are ranked 3rd/2nd and 1st/2nd, respectively.

Table 2. Top-15 country-sectors with highest share of women managers in the general economy (2016)

Country	NACE industry	% of women managers
SK	Manufacture of textiles	100.0
PT	Manufacture of electrical equipment	100.0
FR	Water collection treatment and supply	80.0
EE	Manufacture of textiles	75.0
DE	Other mining and quarrying	70.0
FR	Postal and courier activities	66.7
AT	Repair and installation of machinery and equipment	66.7
BE	Manufacture of furniture	66.7
IE	Manufacture of wood and of products of wood and cork except furniture; manufacture of articles of straw and plaiting materials	66.7
IE	Manufacture of wearing apparel	66.7
EE	Legal and accounting activities	66.7
IE	Telecommunications	66.7
IT	Sewerage	66.7
LU	Construction of buildings	66.7
FI	Veterinary activities	62.5

While the different definitions of women-led management are interesting on their own and point at different policy consequences, it is necessary for the subsequent analysis to settle on one definition in order to keep it tractable. We argue that from a perspective of controlling the entire business strategy and manage the day-to-day operations of an organization, the definition of women-led business can be based on two out of three previously discussed indicators – i) majority women in management or ii) all women managers. Given the very low share of companies exclusively run by women, such a choice would be limiting for further analysis. Therefore, we define a women-led business enterprise as one that is more than 50%

operated and controlled by women. Our choice is shared by a range of studies on businesses and organizations owned or led by women (BDRG Continental 2016; Government of Canada 2015; Parker 2010; UK Government. Department for Business Innovation and Skills 2015).

Gender in public procurement in the light of macroeconomic trends

To explore the macroeconomic context of women-led businesses in public procurement we look at gender-related V-Dem variables which reflect gender policies and egalitarian freedoms in a country while we also explore the national context as defined by public procurement-related corruption risks.

First, we look at the relationships between democracy-related variables and public procurement variables such as the share of contract value or number of contracts going to women-led firms. In Figure 6 A) we present a relationship between threshold of parliamentary gender quota and share of contract value that goes to businesses with majority of women managers; subfigure B) demonstrates correlation between share of women ministers and share of contract value that goes to businesses with majority of women managers; and subfigure C) shows the relationship between CSO women's participation and share of contracts that go to companies run by women. All the presented relationships are positive significant, meaning that the improvements in democracy indicators go hand in hand with a higher share of contracts or contract value going to women-led contractors.

Additionally, we also explored the correlations between gender-related policies (such as gender threshold in parliament, share of women ministers, CSO's women participation, balance of power, equality before law, access to justice, etc.) with gender composition of firms participating in public procurement, however those correlations did not prove to be significant.

Figure 6. Correlations of gender policies and success of women-led firms in public procurement (2006 - 2016), 140 thousand entities

A) Lower chamber gender quota threshold vs share of contract value that goes to women-led firms (corr =0.51)

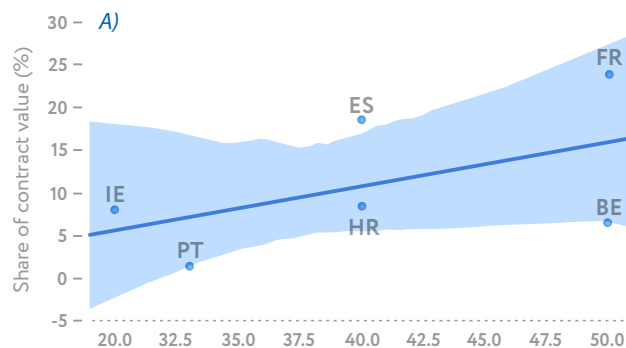
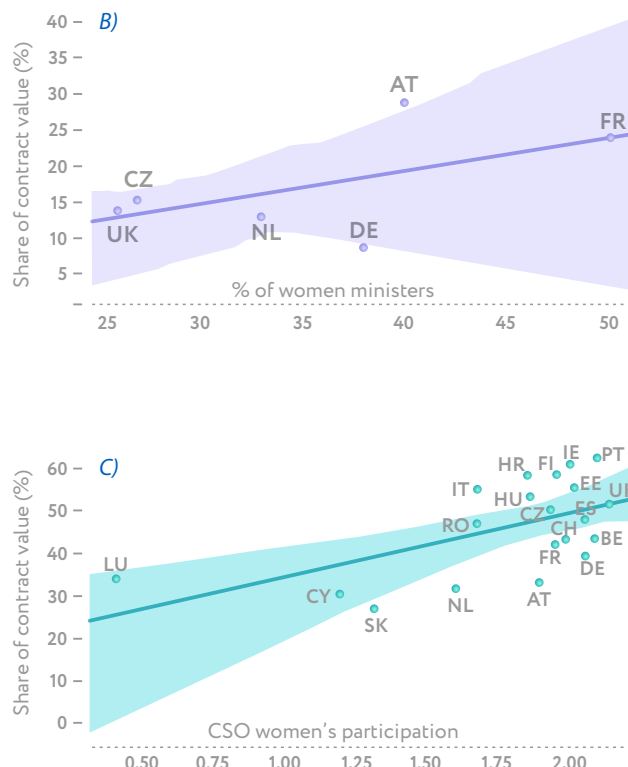


Figure 6. Correlations of gender policies and success of women-led firms in public procurement (2006 - 2016), 140 thousand entities

B) Share of women ministers vs share of contract value that goes to women-led firms (corr =0.55)

C) CSO women's participation vs share of contracts that go to women-led businesses

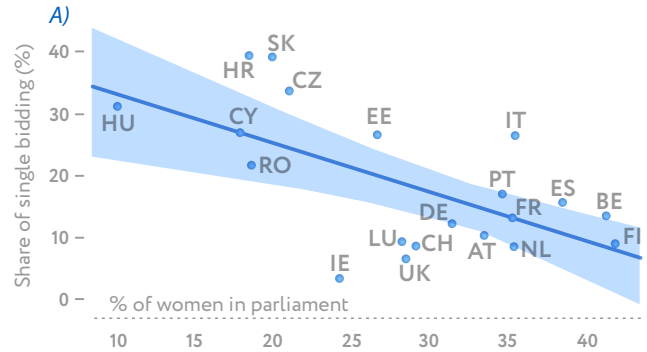


Second, we extend the analysis to corruption risks in public procurement because corruption has been shown to be a major barrier to entry for women-led businesses (Bauhr, Charron and Wängnerud, 2019). To do so, we focus on single bidding as one of the most prominent corruption risk indicators in public procurement across Europe (Fazekas and Kocsis, 2020). The logic behind focusing on single bidding is due to the fact that i) on the country level it significantly correlates with widely-used survey-based measures of corruption such as Perception of Corruption Index by Transparency International and Control of Corruption Index by the World Bank, ii) it predicts overpricing on the auction level (Wachs, Fazekas, and Kertész 2020), and iii) it is available at the contract-firm-sector-country level, thus gives sufficient variation for the subsequent analysis. Furthermore, single bidding has been described as a key indicator of deliberately restricted access and partisan favouritism on otherwise competitive markets (David-Barrett and Fazekas 2016; Laffont and Tirole 1991).

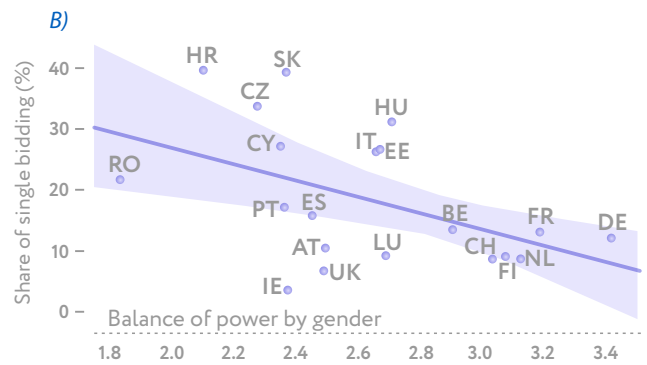
Based on this approach, we present relationships between democracy related variables and share of single bidding in the public procurement market. Figure 7 shows how A) share of women in parliament, B) balance of power distribution by gender, C) equality before the law and individual liberty index, and D) access to justice for women are correlated with the overall share of single bidding. All the correlations are negative which states that improvements in the above-mentioned democracy variables are related to lower levels of single bidding in public procurement.

Figure 7. Correlations of gender policies and corruption risks in public procurement (2006 - 2016), 140 thousand entities

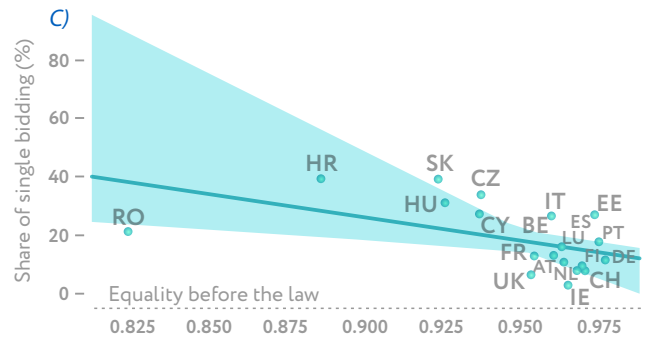
A) Share of women in parliament vs share of single bidding (corr = -0.62)



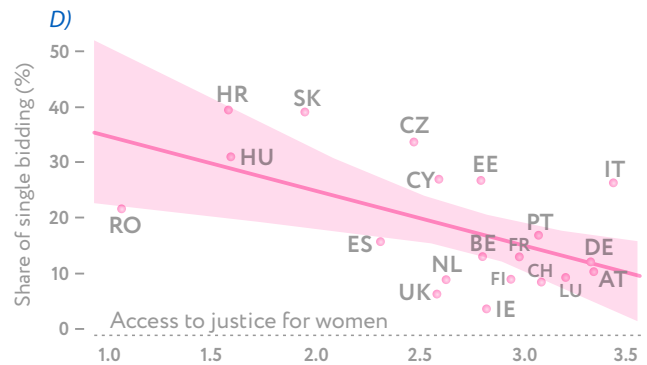
B) Balance of power distributed by gender vs share of single bidding (corr = -0.48)



C) Equality before the law and individual liberty index vs share of single bidding (corr = -0.62)



D) Access to justice for women vs share of single bidding (corr = -0.56)



5. Results: The impact of gender composition of company management on corruption risks in public procurement

Empirical models and causal identification

To formally test how gender balance of company management is related to the risk of single bidding in public procurement on the contract level, we employ binary logistic regression on cross-sectional procurement data (previously merged with gender-related company characteristics). Given the poor quality of time-related variables in the BvD management dataset, gender-related company characteristics were aggregated over the whole time period. The sample of firms for logistic regression is not restricted to firms with three or more managers on a company board as it was done in the previous section. Rather, the below models are built using contracts awarded to firms of all size categories, including SMEs. This is because we wanted to retain as broad sample as possible for maximizing generalizability of findings.

The binary variable whether a contract received a single bid plays the role of the dependent variable; the independent variable of interest is a binary variable whether a firm is run by a majority of women or not. As control variables we include a host of available company characteristics which are known to influence company performance and single bidding.

The cross-section regression equation we estimate is

$$y_i = \beta_0 + \beta_1 * majority\ women_i + \beta_2 * X_i + e_i,$$

where y_i is whether a contract i had single bidding, $majority\ women_i$ is a binary variable whether most of the managers of a company that won a contract i are women, and X_i is the matrix of control variables.

The matrix of control variables contained the following indicators:

- ✓ Country
- ✓ Year of contract award
- ✓ Sector
- ✓ Board size
- ✓ Number of employees
- ✓ Contract value
- ✓ EBITDA (Earnings before interest, taxes, depreciation, and amortization)
- ✓ Total assets

In the absence of an experimental setting, the contract-level cross-section data models provide an approximation for the hypothesized causal effects for several reasons. First, country, sector and year dummies control for common shocks occurring over time separately in each of the sectors and countries. Secondly, our analysis is based on the full sample of public procurement activities in selected countries with an exception of highly specific procurement lines such as defense contracts which means that sampling bias poses little threat to identification.

Regression results

Estimated⁶ logistic regressions are presented in Table 3 with different specifications:

- 1) estimates the relationship between majority of women on board with country control and single bidding,
- 2) adds sector and year dummies as controls,
- 3) further includes board size, number of employees and contract value,
- 4) further takes into account EBITDA and total assets to capture size of the company in terms of financial metrics.

Please note that we apply a logarithmic transformation to the numerical control variables (contract value, board size, number of employees, EBITDA, and total assets) to reduce skewness of distribution and variability of data since these indicators naturally have a highly skewed distribution with a long right tale: most of the firms follow in the category of low to medium range of company size and financial-based performance indicators, while there is a relatively small share of extremely large firms or companies with extraordinary high assets base and operating performance. The same logic applies to public procurement contract values.

In line with the previous sections of the report, we put forward a hypothesis: when women are involved in procurement, public procurement is less likely to be corrupt.

⁶. Our regressions are run using the `glm` function from `stats` package to estimate logistic models (Tuszynski and Khachatryan 2015) and `logitmfx` (Fernihough 2015) function to get marginal effects in the R programming environment (R Development Core Team 2011).

Table 3. Logistic regression models predicting single bidding

	Dependent variable: single bid contract			
	(1)	(2)	(3)	(4)
Majority of women managers on the board	-0.005[•]	0.0008	-0.023^{***}	-0.018[*]
Log Board size	-	-	-0.032 ^{***}	-0.004
Log Number of employees	-	-	0.015 ^{***}	0.005 [•]
Log Contract value	-	-	0.014 ^{***}	-0.009 ^{***}
Log EBITDA	-	-	-	0.027 ^{***}
Log Total assets	-	-	-	-0.018 ^{***}
Country FE	Yes	Yes	Yes	Yes
Sector FE	-	Yes	Yes	Yes
Year FEP	-	Yes	Yes	Yes
pseudo R ² (McFadden)	0.105	0.12	0.585	0.80
# of observations	1.76M	1.76M	1.76M	1.76M

Note: Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '•'

Based on the regression results, we find evidence that contracts won by companies with a majority of women managers are associated with a lower probability of single bidding. Specifications that have a significant coefficient on the gender variable show a negative relationship: models 1, 3 & 4 show statistically significant (at 95% confidence level) negative association of company being run by women and probability of single bidding. From the 3rd and 4th specifications that have both a significant coefficient on the gender variable and high explanatory power, one can draw a conclusion that if a company is run by women, the probability of winning a contract with a single bid is lower by 2.3-1.8 percentage points. With regards to control variables, one could see that higher-value contracts won by larger companies in terms of number of employees are associated with marginally higher, however statistically significant, probability of single bidding (model 3). Once we also include controls for the operating performance of the company and assets base as proxies for company size (model 4), we observe a positive association between EBITDA that a company generates and the probability of single bidding, while total assets are associated negatively with the dependent variable.

Nevertheless, it is necessary to highlight that the relationship between share of women-led companies and corruption in public procurement as well as the general economy could also be looked at from the opposite perspective. The negative association of higher share of women-run businesses and corruption could be explained by unequal distribution of political power between men and women and established male-dominated networks at the intersection of business and politics that control resource allocation and potentially restrict women-run and -owned businesses' participation (Bauhr, Charron and Wängnerud, 2019).

6. Conclusion and call for further work

Mapping the access of women-led companies to public procurement overall as well as by sector and country could provide a roadmap for focused policy interventions. Closing a crucial evidence gap helps policy makers to make informed choices and pursue effective measures to increase inclusiveness in public procurement markets. We hypothesize that increased participation by women owned or led businesses in these markets would not only help in achieving gender equality as a goal in itself, but also improve procurement outcomes by increasing the pool of potential suppliers and therefore enhancing fair and effective competition.

In this study we presented a unique combination of data from general economy and public procurement market in 20 European countries that helped us answer the question whether there is a discrepancy between the share of women-run businesses in the whole economy and public procurement in Europe. According to our results, in all countries except for Germany, the share of women-led businesses winning public procurement contracts tend to be lower than the share of women-led companies in the whole economy. The average difference across Europe, nevertheless, is small, amounting only to about five percentage points. Crucially, from a policy perspective, the share of women in company management and the share of women-run businesses in the whole economy and in public procurement are closely correlated. This suggests that gender balance in public procurement is largely determined by the broader economic context. Of course, this still leaves the door open for the strategic use of public procurement for furthering gender goals in the wider economy given the large purchasing power of governments in markets amounting to roughly 15% of European GDP.

Further underpinning the importance of policy levers in this area, we also found that improvements in democracy indicators are positively associated with higher share of contracts and contract value going to women managers. With single bidding as a proxy for corruption risks in public procurement, we found out that improvements in gender-related democracy variables are associated with lower levels of single bidding in public procurement. From regression model estimations, we can draw the conclusion that if a company is run by women, the probability of winning a contract with a single bid is lower by 2.3 percentage points.

The collected data as well as quantified gender gaps in public procurement could support the first steps towards identifying adequate measures to be taken. The effectiveness of such measures, as compared to other measures such as increasing gender-neutral access to procurement markets through e-procurement systems and other measures rendering the procurement process more objective and less likely to be captured must be addressed. Further work needs to be done on the relationship of business ownership structures vs. management aspect and public procurement outcomes with the focus on corruption risks. Based on the identified a statistically significant negative association between a company being run by women and lower probability of single bidding, future work should concentrate on the causes of such outcomes. Network aspects of the gender-corruption relationship could be explored, for example the claim that procurement contracts won by women-led businesses are less likely to be corrupt not because women are more virtuous, but because they are less likely to be embedded in the networks that spawn corruption. Furthermore, the present study could only look at women's role in managing government suppliers, but data is available on company ownership across Europe hence the role of gendered ownership in procurement outcomes could further be investigated along similar lines to this study. The overall aim would be to foster informed policy choices by providing a map of women's access to public contracts throughout Europe and comparing the effectiveness of measures taken in that regard.

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Appendix

Data description

Bureau van Dijk (BvD) data is the largest administrative cross-country company-level dataset of companies in Europe.⁷ BvD databases contain information on company's business profile including country of operations, NACE code, number of employees etc. In addition to that, we used data on company's management such as number of directors, information of each director including name, unique contact identifier, appointment date, resignation date, gender, date of birth, countries of nationality, whether a director is a shareholder as well. BvD also contains financial data on a company: for each company there is information on submission of annual reports with corresponding dates of reporting and financial statements data such as total assets, liabilities, equity, revenue, EBITDA, profit etc. Despite covering firms in all European countries, we note that BvD dataset is still incomplete, systematically missing some company classes and company sources, particularly the under-representation of small firms (Andrews, Chiara, and Gal 2016). Company registry and management data we used in the analysis provide a snapshot of an entity as of 2016 year-end. Financial data include multiple records for each entity for different years up to 2016 financial year-end, we used the latest available values.

Public procurement data (TED) were taken from official government public procurement portals using automated web scrapers and parsing algorithms extracting key fields from semi-structured html code (for technical database building details see (Czibik, Fazekas, and Toth 2015)). As a result, we get contract-level data that provides information on winners as well as values for each contract, corruption risk index, year of the contract etc. All contracts regulated by national public procurement laws must be reported on these portals, if their value is above official thresholds. Besides contracts below thresholds, certain contracts may be missing such as top secret defense contracts. By implication, our contracting data provide a close picture of how firms participate in public procurement market, what contracts they win and what are single bidding and potential corruption risks associated with each business presented in the data. The contracts are also very diverse, encompassing contracts in markets such as office supplies, specialized legal services, road construction, or electricity. We collected all contracts in European countries from 2006 to 2016 which sums up to 1.8 million contracts in 29 countries.

As the TED contract level dataset and the BvD firm level dataset do not share a common unique identifier for firms, for instance tax registry IDs, we need to match firms in one database with the other. As the number of firms in the contract dataset is significantly smaller, we look up firms from the TED dataset in the BvD data. We proceed as follows: first we apply

⁷ This data was obtained by the DIGIWHIST project for the purposes of research and analysis of public procurement performance across Europe.

string processing, including the removal of extra white space, punctuation, and accented characters. We then look for exact matches in the BvD data. If we find such a match, we link the records in the two datasets and set them aside. For the remaining cases, we begin an iterative process of more intensive string processing methods and continued lookups. For instance, we look up firms with the "ö" character with both "o" and "oe" substituted in. We then try to remove commonly used business entity suffixes (i.e. Ltd., Inc., etc.) by country. Finally, the firms in the TED dataset have previously been deduplicated (cite Wachs, Fazekas, Kertesz, IJDSA 2020). We draw on the collection of firm aliases identified during this process to improve the look up in the BvD database. For instance, if "Coca-Cola Corporation" less frequently but still commonly occurred in the contracting dataset as "The Coca Cola Corp." - we also look up this alternative representation. By applying the more extensive string processing methods only later in the process, after checking if soft-touch approaches could find a match, we reduce the chances of finding false matches.

V-Dem (Varieties of Democracy) dataset is an open project headquartered in Gothenburg, Sweden that provides free access to a multidimensional and disaggregated dataset that reflects five high-level principles of democracy: electoral, liberal, participatory, deliberative, and egalitarian. Variables of interest for our research are freedom of domestic movement for women, property rights for women, access to justice for women, CSO women's participation, women civil liberties index, women civil society participation index, women political empowerment index, women political participation index, equality before the law and individual liberty index, election women in the cabinet, lower chamber gender quota, power distributed by gender, year when women got the right to vote, women share in parliament.

As a benchmark of general economy and the distribution of businesses within country-sector dimension, we refer to Eurostat annual enterprise statistics by size class for special aggregates of activities which provides information on how many companies are present in a particular country and sector as of 2016.

Gender identification

We perform a thorough check of variables that are critically important for our analysis. One of those variables is gender of managers that we take from BvD dataset that contains 52 521 410 observations. The task in this case is to check whether the gender variable is accurate or, alternatively, develop an approach to define gender of a person in a dataset with the highest accuracy.

For this purpose, we take a subset of columns we need for further analysis – 'Full name', 'Gender', 'Country'. Overall there are 52 521 410 rows. As information in all the three columns is crucial for gender identification, we drop an observation if there is any data missing – 36 775 595 observations. We take observations only for 28 EU countries and randomly sample 100 women and 100 men (as defined by BvD) for each country – we get 5 600 people.

As a next step, we implement double-checking of an existing gender variable in two alternative ways:

- Manual check (googling names) as a benchmark;
- Gender guesser identification which involves the use of an already developed Python package called “gender-guesser” (Pérez 2015) that allows to identify a gender of a person based on his/her name and country of origin.

Such method of using country name-dictionaries for gender and/or nationality identification has been widely used in computational social sciences. The method proved its benefits for a variety of research topics ranging from the role of gender and gender gap in scholarly authorship in general (Mozaffarian and Jamali 2008; West et al. 2013) as well as in some particular fields and sciences such as computational biology (Bonham and Stefan 2017), software development (Vasilescu, Serebrenik, and Filkov 2015), programming (May, Wachs, and Hannák 2019), online design community (Wachs et al. 2017), social media (Liu and Ruths 2013; Tang et al. 2011) etc.

Despite a wide use and simplicity of country name-dictionaries methods, they have several limitations that we would like to highlight. First of all, such methods assume that gender is a binary variable which is a simplifying assumption. Secondly, we point out geographic limitations of the approach given that i) information on a country may not reflect the country of origin of a person in case an individual moved to another country and ii) lower accuracy when used with non-European names (Jadidi et al. 2018; May, Wachs, and Hannák 2019). Furthermore, name-gender methods have issues with treatment of double names such as Mary-Jane, Anna-Maria etc. (Santamaría and Mihaljević 2018). Despite these limitations, we suggest that gender-guesser is an additional method to check the accuracy of the gender variable in the dataset and we will not rely solely on it.

In order to be able to use “gender guesser” package we have to first get names of individuals only, this is complicated by national differences, format inconsistency, namely:

- ✘ **Format.** In most of the cases the format of a full name is 'first name + surname', but sometimes there are mistakes and the order is changed (a surname goes first); this is specifically a problem with Hungarian and Romanian names (Pavel Andras, for example);
- ✘ **Individuals with middle names/double names.** Sometimes the full name is very long, and the one that goes first (that we take for analysis) doesn't have a strong gender connotation or is absent from an algorithm's dictionary;
- ✘ **Residents with foreign roots.** The most frequent problematic cases of names of EU citizens were Asian, Arabic, and Indian names. The algorithm cannot define a gender because a) these names are absent from a dictionary designed for this specific country (but for this case we programmed gender guesser to define a gender without a country

specification); b) it is very difficult to understand what is an actual first name, the order is different all the time; c) a lot of names are androgynous.

- ✘ Rare names. The algorithm is not dealing well with some rare names, it is difficult for even manual check to understand what a gender is – sometimes I had to use fb for that purpose to find that specific person that turned out to be the one in the database. That's why we might consider dealing with more or less frequent names only.
- ✘ Country-specific features. Gender guesser performs poorly with Baltic countries – especially Latvia and Lithuania.

In the table 4 presented below one can see the results of Manual check vs Gender guesser output vs BvD cross checks:

Table 4. Results of gender variable check

A) Manual check vs. BvD

Manual check	BvD gender		Accuracy = 98.46%
F	F	2727	
	M	55	
M	F	30	
	M	2725	
Unknown	F	43	
	M	20	

B) BvD vs. Gender guesser

BvD	Gender guesser gender		Matched = 89.90%
F	andy	1	
	female	2385	
	male	16	
	mostly_female	121	
	mostly_male	1	
	unknown	258	
M	andy	6	
	female	10	
	male	2443	
	mostly_male	29	
	unknown	267	

C) Manual check vs. Gender guesser

Manual check	Gender guesser gender		Accuracy = 89.71%
F	andy	1	
	female	2385	
	male	16	
	mostly_female	121	
	mostly_male	1	
	unknown	258	
M	andy	6	
	female	10	
	male	2443	
	mostly_male	29	
	unknown	267	
Unknown	andy	7	
	female	4	
	male	11	
	mostly_female	2	
	unknown	39	

From the performed analysis we see that the accuracy of gender guesser model is lower than the data already present in the BvD database due to the quality of the column 'Full name' as it is not satisfactory to be used for an algorithm-based gender identification due to format inconsistencies and country-specific features/rare names etc. As a result, we keep an existing gender variable for further analysis and calculations. Using this variable, we calculate gender characteristics of firms - share of women in a board of directors, whether there is any/at least one/only one/majority of/all women in management – that will be extensively discussed further.

General economy benchmark: Weighting

Weighting of BvD dataset is done with the help of auxiliary variables – the ones that are present in the sample as well as have an available measurement of population distribution. The idea of weighting is to adjust the distribution of auxiliary variables in a sample according to population distribution. Possible auxiliary variables in case of company data weighing could be country, industry, size, year of activity etc.

As a source of the population distribution of auxiliary variables, we chose Annual enterprise statistics by size class for special aggregates of activities by Eurostat (Eurostat n.d.) which contains annual information on number of firms in each EU member state by sector as per NACE Rev.2 classification as well as by size of an entity. Out of all available years (2005 - 2017) we took data for the year 2016 given that for some years data was sparsely populated and distribution of missing values was not random, therefore we would not be able to ensure a consistent time series necessary for accurate weighting. As a result, instead of having time series we ended up taking the most recent snapshot of companies' distribution with acceptable data quality.

Another issue we encountered was related to the data quality of BvD dataset. BvD data has two variables that could potentially capture the size of an entity. These are a number of employees and a category of a firm (small, medium-sized, large and very large). On the other hand, Eurostat data has only one variable that describes the size of a company. This is a categorical variable with the following categories: from 0 to 9 employees, from 10 to 19, from 20 to 49, from 50 to 249, and 250 persons employed or more. Given that categories of firms in BvD and Eurostat are different, we face the need for redesigning this particular variable in BvD data based on a number of employees. However, a number of employees variable is sparsely populated and does not allow us to do so, therefore we exclude size of a company from the list of potential auxiliary variables given poor quality of this aspect of sample data.

Other available auxiliary variables – country and sector (as per NACE-2) – are of good data quality given a minimal number of missing values as well as standardized categories that could be easily used for weighting. Considering the assessment of data quality of both BvD data as well as benchmark Eurostat dataset, variables that we will use for further weighting are country and double-digit NACE industry code (which narrows down sector split to 68 industries).

When we compare the distribution of companies by country between BvD and Eurostat, we get the following picture: once we dropped countries that are not present in the benchmark dataset, but are available in BvD and the other way around, some countries such as France, Greece, Ireland, Lithuania, and Portugal are underrepresented, conversely, Belgium, Denmark, Finland, Netherlands, Norway, Romania, and Switzerland are overrepresented in BvD as compared to the Eurostat (table 5).

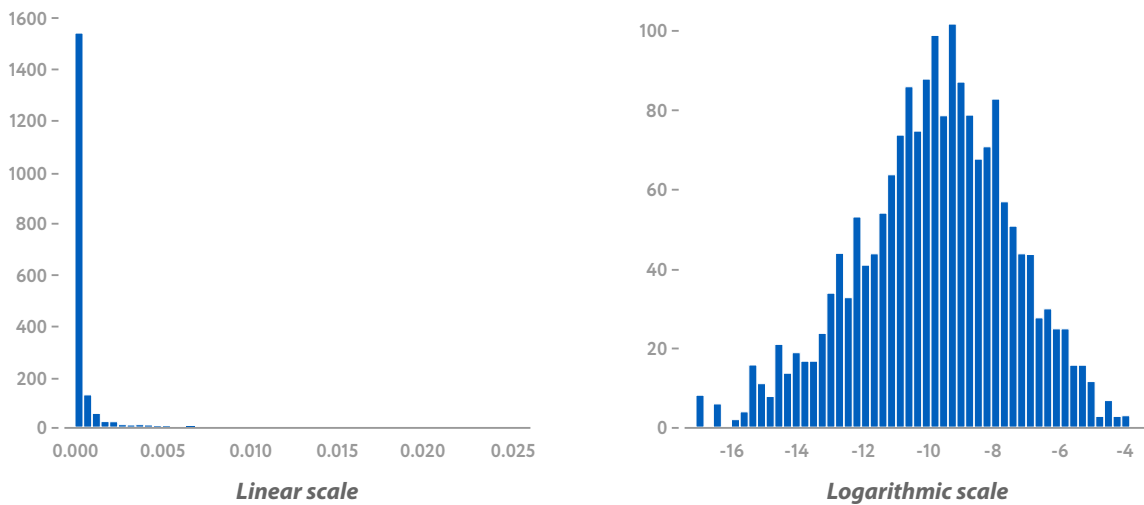
Table 5. Comparison of company representation in BvD and Eurostat (2016)

Country	# of firms in BvD	% in sample data	# of firms in Eurostat	% in population	Share BvD / share Eurostat
Austria	1 044 189	2,25%	323 912	1,32%	1,7
Belgium	2 638 229	5,68%	611 708	2,50%	2,3
Croatia	309 174	0,67%	147 481	0,60%	1,1
Cyprus	63 992	0,14%	49 743	0,20%	0,7
Czech Republic	1 993 682	4,30%	1 018 473	4,16%	1,0
Denmark	1 155 297	2,49%	218 549	0,89%	2,8
Estonia	240 737	0,52%	70 617	0,29%	1,8
Finland	1 179 425	2,54%	228 616	0,93%	2,7
France	2 686 194	5,79%	3 058 076	12,49%	0,5
Germany	2 944 912	6,34%	2 467 661	10,08%	0,6
Greece	92 594	0,20%	793 942	3,24%	0,1
Hungary	1 594 332	3,43%	551 173	2,25%	1,5
Ireland	168 054	0,36%	236 832	0,97%	0,4
Italy	4 870 145	10,49%	3 719 596	15,19%	0,7
Latvia	244 095	0,53%	115 477	0,47%	1,1
Lithuania	153 145	0,33%	192 557	0,79%	0,4
Luxembourg	33 984	0,07%	32 251	0,13%	0,6
Netherlands	4 836 798	10,42%	1 134 681	4,63%	2,2
Norway	1 403 737	3,02%	296 423	1,21%	2,5
Poland	2 215 033	4,77%	1 694 912	6,92%	0,7
Portugal	676 257	1,46%	833 028	3,40%	0,4
Romania	1 769 570	3,81%	465 607	1,90%	2,0
Slovakia	556 992	1,20%	446 230	1,82%	0,7
Slovenia	385 458	0,83%	138 923	0,57%	1,5
Spain	2 965 683	6,39%	2 682 907	10,96%	0,6
Sweden	1 714 118	3,69%	703 035	2,87%	1,3
Switzerland	842 866	1,82%	141 383	0,58%	3,1
United Kingdom	7 638 774	16,46%	2 116 117	8,64%	1,9
Total	46 417 466		24 489 910		

We performed the same check on a country-industry level, and it demonstrated a similar situation of significant mismatch of distributions in sample data and benchmark. We do not present a table with results in this report given its lengthy size.

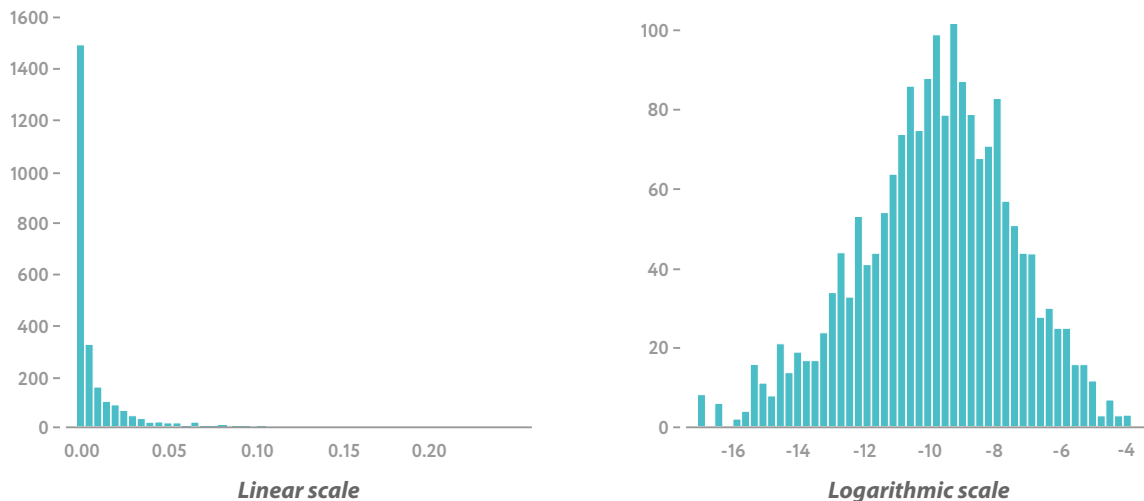
The distribution of the share of companies in a specific country and industry in BvD dataset is presented in figure 8:

Figure 8. Distribution of share of companies per country + industry in Eurostat, all European countries (2016)



As one can see, the distribution is highly skewed with a long right tail, most of company & industry combinations have a very small share in the entire EU population; due to such distribution we present it in a log scale to reduce the skewness and transform it in a more readable format. A similar picture could be observed in Eurostat benchmark data as well (figure 9):

Figure 9. Distribution of share of companies per country + industry in unweighted BvD, all European countries (2016)



Despite a very similar pattern found in both distributions, there are significant differences on an industry level. For instance, if we list top-10 country-industry combinations with the highest share of companies in the sample, we will see that country-industry groups that are the largest in BvD do not match those of Eurostat (table 6):

Table 6. Largest country-industry groups in Eurostat and BvD (2016)

Eurostat				BvD			
Country	NACE	# of firms	% of firms	Country	NACE	# of firms	% of firms
Italy	47	606 224	2.44%	United Kingdom	82	890 855	1.92%
France	47	506 635	2.04%	Italy	1	634 121	1.37%
Spain	47	486 684	1.96%	Italy	47	623 832	1.34%
France	43	437 710	1.76%	Netherlands	64	532 499	1.15%
Italy	43	384 821	1.55%	United Kingdom	47	492 300	1.06%
Italy	46	383 304	1.54%	United Kingdom	62	453 137	0.98%
Germany	47	333 294	1.34%	United Kingdom	43	435 001	0.94%
Germany	43	324 804	1.31%	United Kingdom	70	411 124	0.89%
Italy	69	292 099	1.18%	Italy	46	391 147	0.84%
Poland	47	283 420	1.14%	France	47	389 336	0.84%

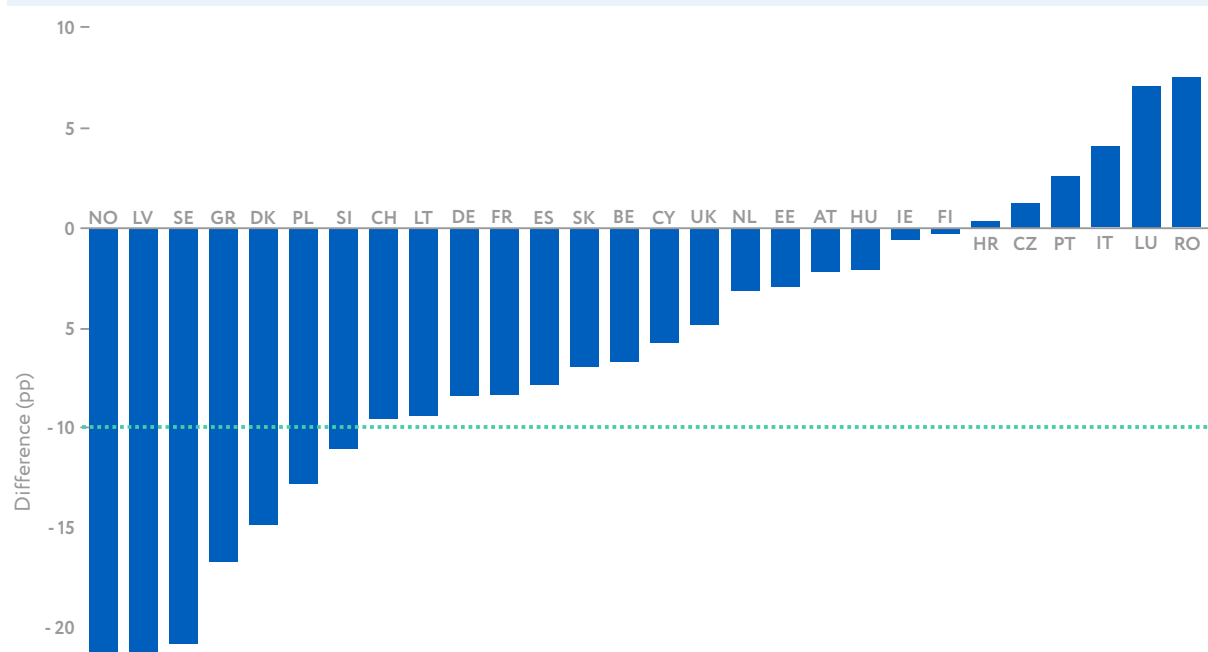
The weighting technique aims at making BvD data representative of the statistical population measured in Eurostat by aligning distribution of country-sector groups in BvD to Eurostat benchmark. For that, we assign a share of a specific country-industry group of firms in Eurostat to the same country-industry group of companies in BvD and perform a weighted random sampling with replacement to match the total number of firms in Eurostat (~24.5 million) and their distribution. As a quality check for weighted sampling, we compare the distribution of the share of women managers in a country-sector in a weighted sample of BvD data to another external benchmark of the statistical population – "Female share of employment in senior and middle management" data for 2017 in World Development Indicators by the World Bank.

As one can see in the graphs below, we present existing gaps between the share of women managers in a country in BvD and WDI that was calculated as share in BvD deducting share in WDI in percentage points (figure 10) as well as the gaps we calculated after the performed weighting (figure 11).

While in most of the countries in BvD sample share of women managers is relatively close to the benchmark (within -10pp; 10pp), some countries that are presented on the left hand side such as Latvia, Norway, Sweden, Greece, Denmark, Poland, Slovenia, and Lithuania are initially significantly far from WDI values. One of the possible explanations could be that

some countries are considerably underrepresented in BvD which is the case with Norway, Greece, Denmark, and Lithuania, and available observations do not allow us to recreate fairly similar to a benchmark distribution. Furthermore, even if the relative weight of a country in BvD is close to the benchmark, there could be a distorted distribution of industry weights within a country. This could be checked by looking at i) whether the final distribution of country-industry in a weighted sample is similar to the benchmark and ii) whether some particular companies got high weights, thus ended up in the final sample with a significant number of repetitions (5-10 times) due to the lack of other available firms in a country-sector group.

Figure 10. Difference in female share of employment in senior and middle management (WDI vs BvD) by country (2016)



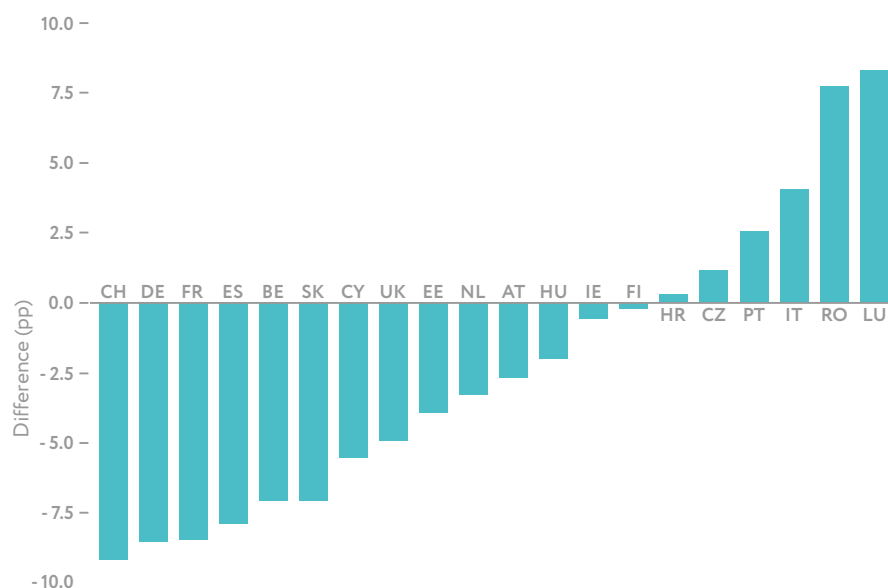
Those companies that due to the underrepresentation of countries and industries in BvD got high weights and ended up in the final sample with a significant number of repetitions are distorting the picture. If we list companies with high weights (that ended up in the final sample 5 and more times), there are 655 474 cases; those companies are registered in 17 different countries, however out of the problematic cases that have large gaps as compared to the benchmark after the weighting (8 countries on the left-hand side of the graph 3 presented above) one could find only Greece, Norway, Poland, and Sweden. The list of sectors with companies with high weights is presented below (table 7).

Table 7. Sectors and countries that will be excluded

Country	NACE
Greece	46, 47
Norway	68
Poland	47, 43, 49, 46, 45, 41, 25, 69, 73, 71, 70, 62
Sweden	43, 68, 47, 70, 46, 45

As one can see, these are 21 different country-industry groups listed in the table 7, and we could consider excluding them from the sample in order to get rid of biased results we got after the weighting for some of the countries due to the lack of available companies. However, it seems that Poland has a large number of sectors with overrepresented companies, and thus we drop this country from the analysis and try to get better results for other problematic cases – Sweden, Greece, Norway – by dropping sectors with a large number of repeated observations. Once we exclude Poland and the above sectors from Swedish, Norwegian and Greek subsamples, we end up with 23 million observations as compared to 24.5 million initially. If we plot gaps between the share of women managers in a country in BvD and WDI on a new sample with exclusion of some problematic industries and countries, one can see that the picture has slightly changed, however we did not manage to significantly improve situation for countries with modified sample - Greece, Sweden, and Norway. Thus, we make a decision to exclude problematic countries from the further analysis and in the graph below (figure 11) you can see differences in female share of employment in senior and middle management between WDI measurement and weighted BvD sample:

Figure 11.
Difference in female share of employment in senior and middle management (WDI vs BvD weighted) by country (2016)



Such a result demonstrates that the performed weighting to some extent helped us to bring the sample we are working with closer to the statistical population, however, there are still subsamples that are significantly different from a population⁸ given that with the two available auxiliary variables we used – country and industry – we could not capture all unobserved noise in the data. Therefore, we will exclude those countries from further analysis to be able to draw more reliable conclusions on relationship between firm-level characteristics and their public procurement activity based on weighted BvD dataset. In a final weighted BvD sample that we got after all the manipulations we have information on 20 countries with 22.7 million companies.

⁸. We note that we were not able to exclude the above-mentioned sectors from the population given that it is aggregated on the country level only.



Research paper_Gender in Public Procurement