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Environmental commitment in public spending: a green index for Italian procurement*

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Abstract

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Keywords: *green public procurement, environmental index, text-analysis, policy*

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1 Introduction

Green Public Procurement (GPP) is widely regarded as a key policy instrument to support the green transition by leveraging public demand to promote environmentally sustainable goods and services. Despite its prominence in European and national policy agendas, empirical evidence on the effective implementation of GPP and on the extent to which contracting authorities actually integrate environmental considerations into procurement procedures remains limited.

In Italy, GPP underwent a major institutional shift with the adoption of the 2016 Public Procurement Code, which made the use of Minimum Environmental Criteria (MEC) mandatory for a wide range of goods and services. While this reform strengthened the regulatory framework, several barriers continue to hinder the effective implementation of green procurement, including limited technical expertise within public administrations, weak political support, and budgetary constraints. As a result, formal compliance with GPP requirements may not fully reflect the intensity or quality of environmental commitment in procurement practices.

Existing empirical studies on GPP largely rely on self-reported survey data, which may overstate actual levels of adoption and are potentially affected by selection and reporting biases. Moreover, there is limited systematic evidence on the actual use of MEC in procurement documents. This paper contributes to the literature by proposing a novel text-based measure of environmental commitment in public procurement, the Green Intensity Index (GII or the Index hereafter). The Index captures the extent to which environmental criteria are embedded in tender documentation by measuring the relative frequency of green-related keywords defined by legislation.

We focus on public procurements in the food and catering services sector, which represents a substantial share of public spending and is associated with significant environmental impacts. Despite strong policy endorsement of green practices in this sector, implementation remains uneven across contracting authorities and regions, making it a particularly suitable setting to assess both actual GPP commitments and barriers to adoption. By exploiting large-scale procurement data over time and across regions, our study provides new evidence on the evolution and heterogeneity of green procurement

practices in Italy.

The paper is organized as follows. Section 2 contains a review of the relevant literature. Section 3 describes the sample and presents descriptive statistics. In Section 4, we introduce the methodology used to construct the Green Intensity Index. Section 5 summarizes the results of the analysis. Finally, we draw the conclusions in Section 6.

2 Related literature

The European Union constitutes the largest public procurement market worldwide (Trybus, 2006) and green procurement is increasingly emerging as a cornerstone policy at both the central and member state levels (Testa et al., 2012). Nevertheless, green procurement remains a relatively recent and underexplored area of research within the economic literature (Testa et al., 2012), based on the early contributions of Gordon Murray (2000), Warner and Ryall (2001) and Zhu and Geng (2001). Therefore, its effectiveness as an environmental and industrial policy instrument is still the subject of ongoing debate. On the one hand, GPP is credited with the potential to act as a market trigger (Testa et al., 2012) and to expand markets for greener production and consumption (Li and Geiser, 2005; Testa et al., 2012). On the other hand, its efficiency have been challenged due to the similarity with command-and-control policies (Lundberg et al., 2015, 2016; Lundberg and Marklund, 2018). In line with most of the existing literature where theoretical contributions are limited, our investigation adopts an empirical approach. Our main contribution is the construction of a Green Intensity Index for Italian public procurement in food and canteen services.

By developing a sector-specific measure grounded in the Italian MEC framework, we add to the relatively scarce evidence that assess the "greenness" of call for tenders (Faith-Ell and Balfors, 2005; Nissinen et al., 2009; Sporrong and Bröchner, 2009; Varnäs et al., 2009; Testa et al., 2016). Italy is a particularly suitable setting for our analysis because its regulatory environment offers a clear benchmark for assessing implementation. A well-structured legislative framework plays a pivotal role in promoting and incentivising environmentally sustainable procurement (Cheng et al., 2018), and, unlike in many EU Member States where minimum environmental criteria often operate as non-binding

guidance, the Italian MEC are legally mandatory for relevant procurement categories. This institutional feature makes it possible to evaluate implementation against an unambiguous regulatory standard. The focus on food procurement is also warranted since canteen contracts are a high-impact component of public procurement: they involve recurrent, high-volume purchasing and also generate sizeable environmental externalities related to food sourcing, packaging and food habits (Mendoza et al., 2019; Bizarro and de Fátima Ferreiro, 2022). At the same time, most existing research on food procurement concentrates on primary school and university canteens, settings in which environmental criteria appear to be used only to a limited extent (Fuentes-Bargues et al., 2018; Bizarro and de Fátima Ferreiro, 2022). Our study differs crucially from this literature by analysing food procurement across all types of canteens rather than restricting attention to a single institutional context, which allows us to provide a broader assessment across contracting authorities (Bizarro and de Fátima Ferreiro, 2022). Methodologically, our empirical strategy builds on the established use of content analysis in the GPP literature, which codes procurement texts to measure the uptake of environmental criteria (Kippo-Edlund et al., 2005; Bouwer et al., 2006; Parikka-Alhola et al., 2006). Our contribution is twofold. First, we apply text analysis to tender documents using a keyword list derived from Italian procurement regulation, rather than from buyer-defined notions of "green". This improves cross-buyer comparability and makes the measure less sensitive to heterogeneity in how sustainability is articulated in tender documents. It is an issue documented, for instance, in procurement for university canteens, which often relies on idiosyncratic criteria even when EU guidance is progressively incorporated (Bizarro and de Fátima Ferreiro, 2022). It also enables a more reliable assessment of the actual implementation of environmental criteria and supports more robust policy evaluation.

Second, unlike studies that rely mainly on contract and tender notices or on limited sections of tender texts, we analyse the entire call for tenders. This allows us to capture sustainability content embedded throughout the procurement documentation, which is important because green procurement often operates through binding minimum standards, not only through award criteria. Focusing on the full set of tender documents therefore improves measurement and reduces the risk of omitting relevant clauses (Fuentes-Bargues et al., 2018; Bizarro and de Fátima Ferreiro, 2022; Rosell, 2023). By combining

a legally grounded keyword framework with comprehensive tender documentation, our Green Intensity Index provides a robust empirical tool to assess whether canteen procurement reflects the type of standardised regulatory framework that the literature argues is needed to harmonise procurement practices (Fuentes-Bargues et al., 2018; Bizarro and de Fátima Ferreiro, 2022; Rosell, 2023).

We also connect our measurement strategy to the broader "text-as-data index" tradition (Rosell, 2023). In particular, we follows the methodology pioneered by the Economic Policy Uncertainty Index (Baker et al., 2016), which converts a predefined set of words into frequency-based indicators. This framework has been extended to environmental domains, most notably through the Climate Policy Uncertainty Index, Sustainability Uncertainty Indexes and Climate Risk Indexes, which apply the same logic to quantify climate-policy uncertainty, sustainability-related uncertainty and climate-risk (Gavriilidis, 2021; Gavriilidis et al., 2023; Bua et al., 2024; Ongan et al., 2025). Our contribution fits within this index tradition but shifts both the object and the data source: instead of measuring uncertainty or risk, we construct a procurement-focused index by mapping legally mandated sustainability requirements into a dictionary and measuring their incidence across the full tender dossier. This yields a measure that is directly suited for aggregation and econometric analysis across tenders and contracting authorities.

By doing so, we address two limitations commonly found in the empirical literature on green public procurement. First, our methodology mitigates concerns about arbitrary tender classification (Parikka-Alhola, 2008) by systematically selecting keywords linked to legally defined technical specifications and standards used in bid screening (Melissen and Reinders, 2012). In our application, we place particular emphasis on technical specifications and contract requirements, which determine admissibility and compliance before the award stage and therefore provide a stringent measure of regulatory implementation. Second, we move beyond the survey-based approaches that dominate the empirical literature. While informative, data collected through questionnaires and interviews are subject to selection and reporting biases since voluntary respondents are typically more committed to green practices (Cheng et al., 2018). As a result, survey-based evidence may overstate both the relevance and the effectiveness of green procurement. Applying the Index, instead, we capture the intensity of environmental content in tender documents

measure contracting authorities' responsiveness to GPP obligations and track adoption over time and across regions. This is particularly relevant because, despite substantial legislative progress, public authorities continue to face significant challenges in adopting and improving green procurement practices (Testa et al., 2012). These challenges are not unique to Italy and reflect broader barriers identified worldwide, including limited environmental expertise, organisational inertia, weak political commitment, and financial constraints, often most acute during downturns when environmentally sustainable products are perceived as more costly (Warner and Ryall, 2001; Preuss, 2007; Lindgreen et al., 2009; Brammer and Walker, 2011). Additional obstacles include limited awareness among public officials and insufficient guidance or technical support (Testa et al., 2012, 2016; Lindgreen et al., 2009; Erridge and Hennigan, 2012; Igarashi et al., 2015). Smaller authorities are particularly affected, as they often lack the capacity to dedicate specialised resources to GPP implementation (Michelsen and de Boer, 2009; Testa et al., 2012). Nonetheless, regional, national, and local initiatives can help mitigate these barriers, together with the commitment and expertise of individual procurers (Erridge and Hennigan, 2012; Guenther et al., 2013; Hall et al., 2016). By systematically capturing the level, temporal evolution and regional variation of environmental requirements in tender documents, our index provides a robust tool for measuring GPP implementation across Italian regions over time.

3 Data and Summary Statistics

The empirical analysis relies on a comprehensive dataset of public procurement procedures for food and catering services in Italy, covering the period from 2011 to 2024. The procurement data, obtained from Telemat, include all tender calls issued by regional contracting authorities. The raw data are organized by year, with a dedicated folder for each procurement, identified by a unique code. For each procedure, information on both the tender and the winning bid is available, often accompanied by multiple documents referring to the same tender. In total, 49,864 procurements were initially considered, associated with 307,961 documents. Data for 2011 are excluded from the analysis, as coverage for that year is only partial.

The textual content of each document is extracted either through a PDF reader in Python or, when this yields unsatisfactory results, by first converting the document into a set of images and then identifying the text using Tesseract OCR. For each document, the extracted information includes the year of the procurement, its unique identifier, its precise location within the Telemat database, the file name, and the full textual content. Using a dictionary-based approach, specific keywords are identified and the frequency of green-related terms is computed for each document (see Section 4 for further details).

The final dataset comprises 46,143 procurement calls and 215,556 associated documents, corresponding to an average of roughly 3,000 to 4,000 calls per year. These data are merged with information from the National Anti-Corruption Authority (ANAC) on contract awardees, enabling a detailed characterization of procurement outcomes.

Table 1 reports summary statistics for the main variables of interest. The share of keywords classified as "green" is around 1%. Although this figure may appear low, it should be interpreted in light of the minimal pre-cleaning applied to the raw text. In practice, the total word count of each document includes many so-called "stop words" (e.g., "the", "or", "but"), which carry no semantic meaning. We have chosen not to construct a more refined measure, since this would require explicit and arguably arbitrary assumptions about which parts of the text to exclude and for what reasons.

On average, each procurement consists of slightly more than six documents. Approximately 2,500 procurements include at least one document that cannot be read by the machine, but only 86 procurements lack any readable document. Amendments to the original tender documentation are relatively common: about 21% of procurements are modified at some later stage, for instance to correct errors or provide clarifications. The average contract duration is around four years, though this information is occasionally missing.

Italian tenders may be divided into multiple independent parts, known as lots ("lotti"), each corresponding to a specific service type, product category, or geographical area. Firms may choose to bid only for the lots relevant to them rather than for the entire contract. More than 97% of the procurements in the dataset consist of a single lot. Among the remaining 2.5%, the average number of lots per procurement is four.

Table 1: Descriptive statistics at procurement level

	N	Mean	SD
Green-related keywords per procurement	49,830	168.45	292.37
Words per procurement	49,830	16,115.81	26,754.27
Keywords / total words	49,741	0.01	0.01
Documents per procurement	49,830	6.18	7.46
Procurements with some unreadable documents	49,830	0.05	0.22
Procurements with all unreadable documents	49,830	0.00	0.04
The procurement was amended (1/0)	49,830	0.21	0.41
Duration of the contract (in years)	34,313	3.80	4.17
Number of lots per procurement	49,830	1.08	0.67
Total value of the procurement (M Eur)	30,307	5.80	187.19
Contracting authority in the North (%)	49,830	45.36	49.78
Contracting authority in the Center (%)	49,830	16.82	37.41
Contracting authority in the South (%)	49,830	36.07	48.02
Other/missing location of the contr. authority (%)	49,830	1.75	13.10

The average total value of a procurement is close to six million euros, with substantial variation across procurement types, regions, and years. Most contracting authorities are located in Northern Italy, followed by the South and the Center. Only a small share of observations (1.8%) involve mixed locations or missing information.

Figure 1 displays the average number of keywords identified in each procurement, both in absolute terms and as a share of the total number of words. The graph reports yearly averages from 2012 to 2024. The descriptive evidence indicates a steady increase in the use of green-related keywords over time, surpassing 1% of all words in 2017. The year 2020 stands out as an outlier: the Covid-19 pandemic led to periods of lockdown, during which many contracting authorities were forced to reduce or temporarily suspend their activities.



Figure 1: Green-related keywords - average share (left) and number (right) per year

A similar pattern emerges in Figure 2, which plots the number of procurements issued each year. The pandemic year clearly deviates from the otherwise remarkably linear and increasing trend observed between 2014 and 2022.

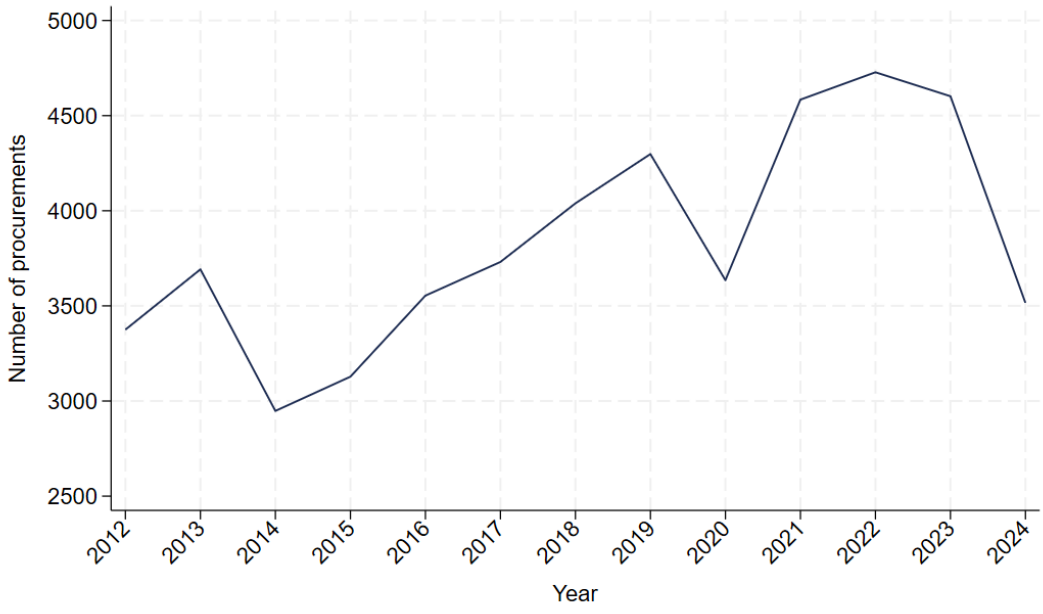


Figure 2: Number of procurements per year

4 Methodology

The core methodological contribution of the paper is the construction of the Green Intensity Index. The GII is a normalized measure of environmental commitment based on a dictionary approach applied to tender documents. For each procurement procedure, the Index is defined as the proportion of green-related keywords relative to the total number of words in the associated documentation. The set of green keywords is derived from relevant legislation and policy documents and includes terms explicitly linked to environmental sustainability, such as references to reusable materials, organic products, and environmentally sustainable practices.

We define the Green Intensity Index G_i for tender i as:

$$G_i = \frac{\sum_{w \in W} f_i(w)}{N_i} \tag{1}$$

where W denotes the set of green keywords identified on the basis of the relevant legislation, $f_i(w)$ is the number of times keyword $w \in W$ appears in tender i, and N_i is the total number of words in the body of tender i. The Index $G_i \in [0, 1]$ therefore represents the proportion of green-related terms in the tender documentation, providing a normalized measure of the tender's environmental orientation based on keyword frequency.

The construction of the Index follows three steps. First, all procurement documents are processed to detect and count occurrences of green keywords. Second, keyword counts and total word counts are aggregated at the procurement level. Third, the Green Intensity Index is computed as the ratio between the green keyword occurrences and the total number of words. This procedure yields a continuous measure bounded between zero and one, capturing both the presence and the intensity of environmental content in procurement documentation.

The present version of the GII relies on a dictionary of keywords identified from the legislation, without imposing any specific assumptions on text pre-cleaning. In particular, keywords are detected by searching for their plain-text occurrences in the documents, without the use of automatic lemmatization or stemming algorithms. Restricting keyword identification to exact case-insensitive matches represents the most conservative

approach.[1]

Moreover, the computation of N_i is based on the full text of all documents associated with each procurement. Stop words (such as "the", "and", or "for") are not removed from the total word count, even though they do not contribute semantic content. This choice avoids the need to make additional assumptions about which words should be considered "meaningful" and further reinforces the conservative nature of the measure. As a result, the estimated GII should be interpreted as a lower bound of the 'true' measure of the frequency of green-related keywords.

By relying on objective textual evidence rather than self-reported measures, the GII offers a transparent and scalable tool for tracking the implementation of GPP across regions and over time. This methodology enables a systematic assessment of heterogeneity in environmental commitment and provides a foundation for future analyses linking green procurement intensity to procurement outcomes and policy effectiveness.

5 Results

This section presents the main empirical patterns emerging from the GII computed on Italian public procurements for food and catering services. The evidence points to a gradual strengthening of the environmental content of tender documentation over time, although with substantial heterogeneity across years and regions.

5.1 Time trend in the Green Intensity Index

The first main result is the existence of a positive time trend in the use of green-related terminology in procurement documents. As already suggested by the descriptive evidence, the average share of green keywords increases over the sample period, indicating that environmental considerations have become progressively more embedded in tender documentation (see Figure 3). This pattern is consistent with the progressive institutionalization of Green Public Procurement in Italy and with the increasing relevance of MEC in public tenders.

[1]For example, while "food waste" is included as a keyword, expressions such as "waste of food" are not classified as green-related terms.

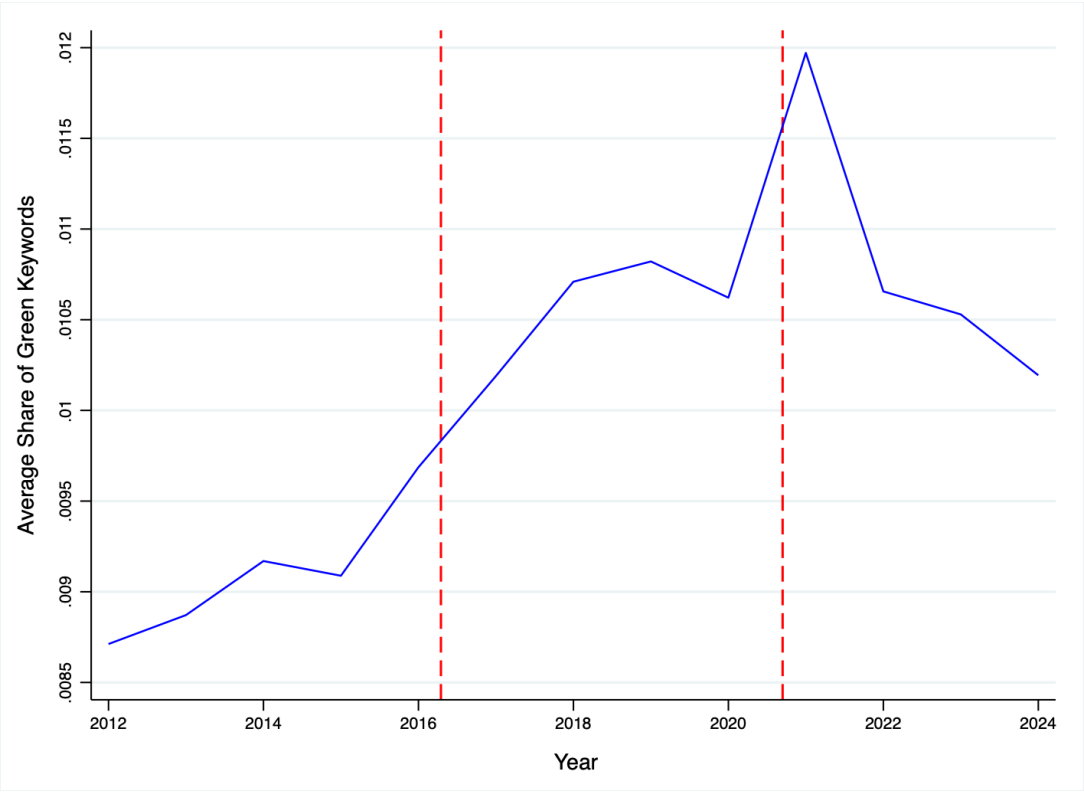


Figure 3: Share of average green keywords.

A particularly relevant discontinuity appears around 2016. The increase in the Index becomes more pronounced after the introduction of the new Public Procurement Code, which made MEC mandatory for a broad range of procurement categories. This result is in line with the interpretation that the strengthening of the legal framework translated into a greater salience of environmental requirements in actual procurement practice. The upward trend culminates in 2021, when the Index reaches its highest level in the sample. The timing of this peak is coherent with the update of the MEC for food and catering services introduced by Decree No. 65/2020, which appears to have reinforced the environmental content of tender documents.

At the same time, the trend is not monotonic over the entire period. After 2021, the average share of green keywords declines somewhat. The presentation materials suggest two possible explanations for this reversal: a reduction in the number of calls and an uneven degree of compliance across contracting authorities. While the current evidence does not allow us to fully disentangle these mechanisms, the post-2021 decline indicates that the consolidation of greener procurement practices remains incomplete and

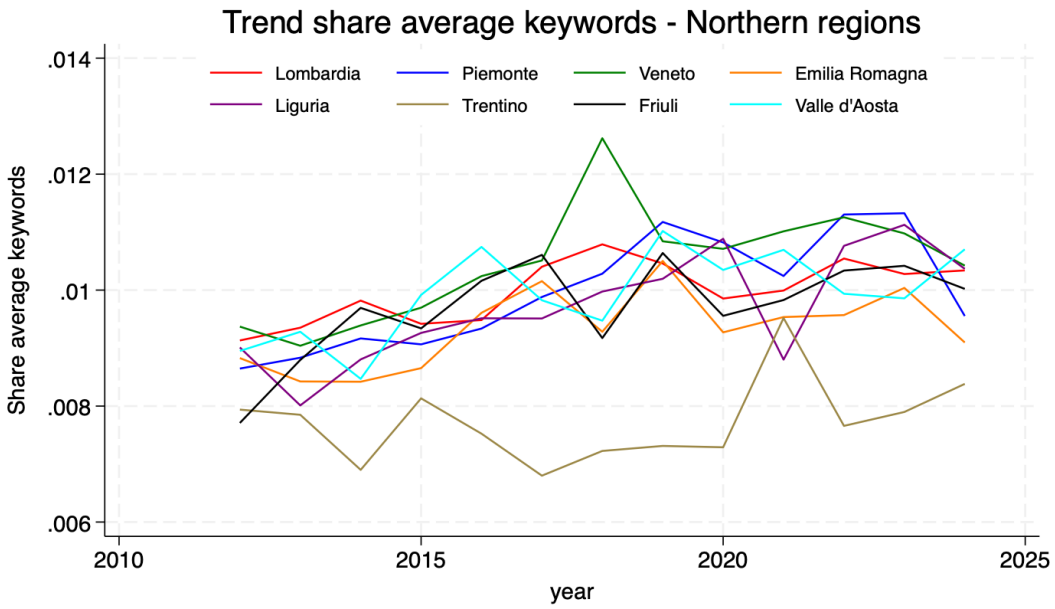


Figure 4: Share of average green keywords in Northern regions.

potentially fragile.

5.2 Regional heterogeneity

The second main result concerns the strong regional variation in the greenness of procurement. Although most regions display an increase in the share of green keywords after the early 2010s, the timing and intensity of this growth differ substantially across the country.

Figure 4 shows that Northern regions generally exhibit higher and more stable levels of greenness. In particular, Veneto and Valle d'Aosta stand out as regions where the Index reaches relatively high peaks, while other Northern regions show a more gradual but persistent increase over time. This pattern is consistent with the idea that contracting authorities in these regions may have been better equipped to incorporate MEC requirements into procurement practice, possibly because of stronger administrative capacity or greater familiarity with green procurement tools.

In the Center, the dynamics are more heterogeneous. Lazio and Umbria record relatively high levels of green keyword intensity, while other regions display greater year-to-year variability. Nevertheless, the evidence shown in Figure 5 also suggests some

convergence in the final years of the sample, especially from 2022 onward.

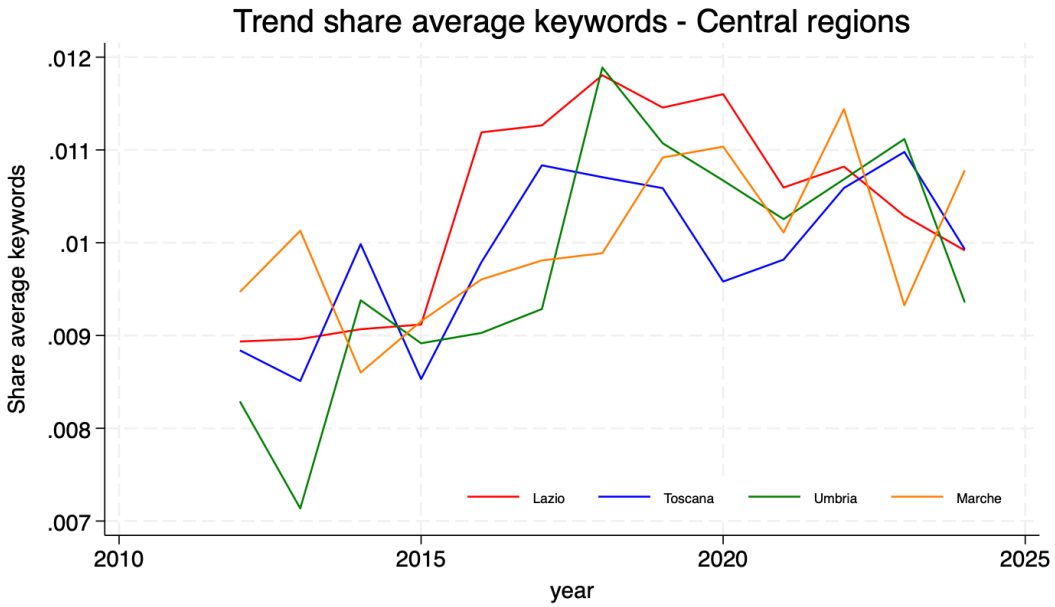


Figure 5: Share of average green keywords in Central regions.

Southern regions show a different pattern. On average, the South starts from lower levels of green intensity and follows a more uneven path over time. In particular, Figure 6 shows that Basilicata and Campania exhibit sharp temporary peaks around 2020 and 2021, followed by a return toward levels closer to the rest of the macro-area. This suggests that some of the increases observed in the South may have been driven by isolated episodes or a limited number of highly green tenders rather than by a broad and persistent shift in procurement behavior. Overall, the regional analysis reveals both gradual convergence and persistent territorial disparities in the implementation of green procurement criteria.

5.3 Interpretation of the Index

A third result concerns the interpretation of the level of the Index itself. In absolute terms, the GII remains relatively low throughout the sample, since green-related keywords account for only a small fraction of total words in tender documents. However, this should not be interpreted as evidence of negligible environmental commitment. By construction, the Index is conservative: it is based on exact keyword matching and uses the total number of words in the full procurement documentation, including non-informative words. As a

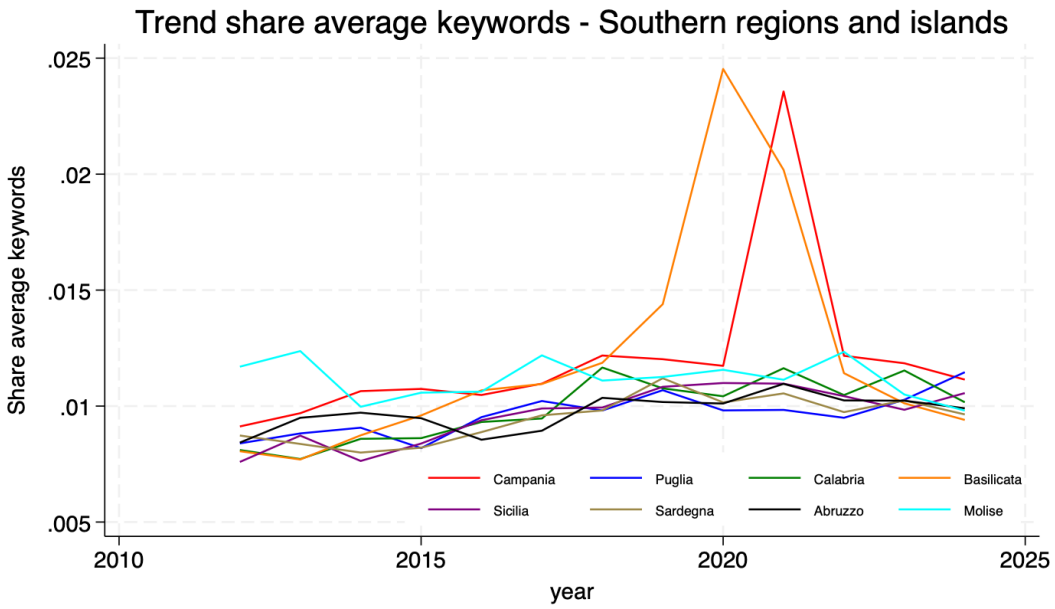


Figure 6: Share of average green keywords in Southern regions and islands.

result, even relatively small changes in the Index can capture economically meaningful differences in the extent to which environmental criteria are explicitly incorporated into tenders.

Moreover, our analysis indicates that the upper tail of the distribution is particularly informative. While the average procurement displays a limited incidence of green-related terms, the top 1% of calls is characterized by a much higher keyword frequency, revealing the existence of a subset of tenders with especially strong environmental content. This suggests that, although the broad diffusion of green procurement is still incomplete, some contracting authorities already display a high degree of compliance and commitment. The coexistence of a low average level with a pronounced upper tail is therefore consistent with an uneven implementation across buyers and territories.

The results suggest that the environmental orientation of Italian public procurement in food and catering services has strengthened over time, especially after the regulatory shift that made MEC mandatory. However, the process has been far from uniform. The evolution of the GII shows that legal obligations have translated into greater environmental content in procurement documents, but also that this translation depends importantly on local implementation capacity and remains characterized by marked regional heterogeneity.

The evidence therefore points to a mixed picture. On the one hand, the increasing trend in the GII provides support for the view that mandatory environmental criteria can affect actual procurement practices. On the other hand, the persistence of wide territorial differences and the partial reversal after 2021 indicate that formal regulation alone may not be sufficient to ensure homogeneous and stable implementation. In this respect, the GII proves useful not only as a descriptive indicator of greenness, but also as a tool to identify where the adoption of green procurement remains limited and where additional policy support may be needed.

6 Conclusions

This paper proposes a novel text-based measure of environmental commitment in public procurement, the Green Intensity Index (GII), and applies it to public tenders for food and catering services in Italy between 2012 and 2024. By relying on the frequency of sector-specific green keywords drawn from the legislative framework on Minimum Environmental Criteria (MEC), the Index provides a transparent and scalable way to measure the extent to which environmental considerations are incorporated into procurement documents.

Our analysis delivers three main findings. First, the environmental content of tender documentation increases over time. The upward trend is especially visible after the strengthening of the Italian regulatory framework and becomes more pronounced following the introduction of mandatory MEC under the 2016 Public Procurement Code. Second, the Index reaches its highest values around 2021, a pattern that is consistent with the update of the MEC for food and catering services introduced by Decree No. 65/2020. Third, the adoption of green procurement practices is far from homogeneous across the country. While many regions display a gradual increase in the greenness of tenders, the intensity and persistence of this pattern vary substantially, with stronger and more stable dynamics in several Northern regions and more volatile trends in parts of the South.

These findings contribute to the literature on Green Public Procurement in at least two ways. On the methodological side, the paper shows how procurement documents can be used to build an objective indicator of environmental commitment that does not rely on self-reported survey evidence. On the empirical side, the analysis provides new

evidence on the concrete implementation of MEC in a sector that is both environmentally relevant and economically important. More generally, the results suggest that the shift from voluntary guidance to mandatory environmental criteria has been associated with a greater integration of green content into tender documentation, although this process remains incomplete and uneven.

At the same time, the paper has some limitations. The present version of the GII is intentionally conservative, since it is based on exact keyword matching and on the full text of procurement documents without removing stop words or applying more advanced linguistic processing. As a result, the Index should be interpreted as a lower-bound measure of environmental intensity rather than as an exhaustive representation of all sustainability-related content. In addition, while the GII captures the textual salience of environmental criteria, it does not by itself measure the quality of implementation, the strictness of enforcement, or the actual environmental effects of greener procurement.

These limitations also point to promising directions for future research. A first extension would be to refine the text-analysis procedure by improving document selection, handling outliers more systematically, and expanding the dictionary in a way that remains closely linked to the legal framework. A second step would be to link the GII to procurement outcomes, contract performance, and environmental indicators, in order to assess whether greener tender documentation translates into measurable effects on suppliers, service quality, emissions, or health outcomes. Finally, the same methodology could be extended to other procurement sectors, making it possible to compare patterns of green implementation across markets and contracting authorities.

Overall, the Green Intensity Index provides a useful empirical tool to monitor the implementation of Green Public Procurement in Italy. By transforming legislative requirements into a measurable text-based indicator, it helps bridge the gap between formal regulation and actual procurement practice. In this respect, the Index can support both research and policy analysis by identifying where environmental criteria are effectively integrated into tenders and where additional administrative capacity, guidance, or monitoring may still be needed.

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