SUB-NATIONAL SPATIAL PRICE INDICES FOR WATER SERVICES IN ITALY: A PRELIMINARY ESTIMATION[1]

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Abstract. Italy exhibits pronounced territorial economic disparities, making an accurate measurement of regional price level differences essential for assessing inequalities in real income, household consumption expenditure, and poverty. To this end, the Italian National Institute of Statistics (Istat) is carrying out a project to compute Sub-national Spatial Price Indices (SSPIs) for the 12 Divisions of the ECOICOP (European Classification of Individual Consumption According to Purpose) classification. These indices are crucial for enabling more robust regional comparisons in economic analysis and for supporting evidence-based policymaking. Initial results, based on 2022 data, have been produced for five divisions and reveal substantial differences in price levels across Italian regions. Work is currently underway for Division 04 "Housing, Water, Gas, Electricity and Other Fuels".
In this paper, we present the first results of SSPI estimation for two Basic Headings (BHs) within Division 4: "Water supply" and "Sewage collection." The analysis is based on 2023 Consumer Price Index (CPI) data, whose characteristics vary depending on the municipality of observation. To ensure the comparability required for SSPI computation, these data are standardized prior to estimation.
The indices are estimated using a Regional Product Dummy (RPD) model, taking into account differences in consumption levels in accordance with Eurostat methodology. Preliminary findings highlight substantial regional disparities in price levels for the services examined, underscoring the importance of sub-national price measurement for understanding real consumption and household living conditions.

1. Introduction

Differences in price levels across Italian regions are widely acknowledged and stem from substantial economic, social, and geographical disparities. These differences can be measured using Sub-national Spatial Price Indices (SSPIs), also referred to as Regional Purchasing Power Parities (RPPPs), which quantify

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differences in the price levels of a common basket of goods and services across geographical areas at a given point in time. Computing such indices is a particularly complex task, requiring large quantities of locally collected data that must meet specific conditions to ensure valid estimation. In particular, price quotations must satisfy two fundamental requirements: comparability and representativeness.

To ensure comparability, prices must be collected for products or services that are identical or, at least, highly similar across all geographical areas so that observed differences can be attributed solely to price variation rather than to differences in product characteristics. As for representativeness, it is essential to collect prices for products that are relevant for consumers in the surveyed areas. At the international level, purchasing power parities are calculated by the International Comparison Program (ICP), coordinated by the World Bank in collaboration with the OECD, Eurostat, and other organizations (World Bank, 2020).

In recent decades, several experimental studies have been carried out by researchers and national statistical offices (Biggeri et al., 2017; Laureti and Rao, 2018). More recently, the importance of regional (subnational) purchasing power parities or spatial price indices has been formally recognized by the World Bank within the United Nations Statistical Commission. As a result, the ICP has published specific guidelines for the computation of spatial consumer price indices (ICP, 2021).

The Italian National Institute of Statistics (Istat) is among the few national statistical institutes that have officially undertaken experimental calculations of subnational purchasing power parities. The first experiments were conducted in 2008 (Istat, 2008) and 2010 (Istat, 2010) for three and then all expenditure divisions of the ECOICOP, using both CPI data and ad hoc surveys. The introduction of scanner data into the CPI production process in 2018 has further strengthened research efforts in this field (Laureti et al., 2017; Laureti and Polidoro, 2022).

Growing demand for subnational indicators at both the national and European levels has prompted Istat to launch a project to routinely estimate regional spatial consumer price indices. Due to the large volume of data needed, a multi-source approach has been adopted to identify the most suitable information available for each product. The data used in the analyses include scanner data, traditional CPI data, and ad hoc surveys. Results for five expenditure divisions of the ECOICOP classification, referring to the year 2022, have already been published (Istat, 2024). The forthcoming release will update these results and include Division 4, “Housing, Water, Gas, Electricity and Other Fuels,” which is characterized by the presence of tariffs and rents.

In this paper, we present the analysis and initial findings of the SSPI estimation for two Basic Headings (BHs) of Division 4: “Water supply” and “Sewage collection.” The analysis is based on 2023 CPI data, whose characteristics vary

across municipalities. To ensure the comparability required for SSPI computation, the data are standardized prior to estimation.

The indices are estimated using the Regional Product Dummy (RPD) model, taking into account different consumption levels according to Eurostat methodology. The experimental results are presented and discussed in the rest of this paper: the data source is illustrated in Section 2; Methodological aspects are addressed in Section 3; Section 4 provides an overview of the results. Lastly, concluding remarks are given in Section 5.

2. Collection of Domestic Water Tariffs in the Consumer Price Index Survey

As part of the CPI compilation process (Istat, 2023a), the Istat collects data on domestic water tariffs using a structured and nationally harmonized methodology, in line with European guidelines. These tariffs contribute to the estimation of the Italian Harmonised Index of Consumer Prices (HICP).

Within the CPI basket, water-related services are represented by two product aggregates: water supply and sewerage collection. These services fall under the ECOICOP Division 4, "Housing, water, electricity, gas, and other fuels."

In 2023, water tariffs were collected in 91 provincial capitals. This survey covers 90% of the provincial population. Full participation is recorded in 10 regions (Piemonte, Valle d'Aosta, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Umbria, Abruzzo and Basilicata), while lower participation levels are observed in other regions, notably Puglia (56.3%), Sardegna (56.6%) and Marche (65.2%) (Istat, 2023b).

Water tariffs are established by local authorities or other entities designated under regional regulations and must be approved by the national regulatory authority, ARERA (Autorità di Regolazione per Energia Reti e Ambiente), based on supporting technical documentation. These tariffs, along with the consumption tiers, can vary significantly across different areas of the country. This territorial variation reflects local conditions, including the cost of service management, water availability, infrastructure characteristics, and environmental priorities specific to each region.

Each household receives a bill consisting of a fixed component, independent of consumption, and a variable component based on the volume of water used (measured in cubic meters). The variable component includes charges for water supply, sewerage, and wastewater treatment.

The water supply charge system is structured based on consumption brackets (or tiers) and the number of individuals in the household. Consumption brackets vary according to household size, with rates increasing as consumption rises. Lower water consumptions corresponds to lower rates and higher consumptions incurs

progressively higher rates. This tiered structure, defined according to household size, was introduced by ARERA through Resolution 665/2017/R/idr with the aim of enhancing the equity of the tariff system. In contrast to water supply charges, sewage and wastewater treatment tariffs are applied uniformly across all consumption volumes.

In addition to consumption-based fees, the bill may include equalization charges, which serve to offset costs incurred for the general benefit of the water system.

Finally, a 10% VAT is applied to the total of both fixed and variable charges.

3. Regional product dummy model

The calculation of SSPIs is carried out using recognized methodological tools employed in numerous studies at international level. The model used for the two BHs considered is the RPD, as recommended by the ICP, which in 2021 published guidelines (ICP, 2021) for the calculation of regional purchasing power parities.

The RPD model is the regional version of the Country Product Dummy (CPD) utilized for international comparisons. The idea behind this method (Rao, 2013; Rao and Hajargasht, 2016) is that the price p_{nr} of an item n (n=1...N, where N are the items belonging to the same BH) in an area r (r=1...R) is a function of an area-specific factor $SSPI_r$ (parity or general level of prices of the area considered with respect to other areas), of the average price of the item P_n and of a random error u_{nr}:

$$p_{nr} = P_n * SSPI_r * u_{nr} \quad (1)$$

Considering the logarithms, the previous expression can be written as:

$$ln\, p_{nr} = \sum_{r=1}^{R} a_r D_r + \sum_{n=1}^{N} b_n D_n^* + v_{nr} \quad (2)$$

Where:

D_r is the dummy variable that takes value equal to 1 if the price quotation is from area r and 0 otherwise,

D_n^* is the dummy variable for product n which takes value equal to 1 when item considered is n and 0 otherwise,

a_r and b_n are, the differences in the effects associated with the areas and the product type, respectively,

v_{nr} are random error normally distributed with a zero mean and variance σ^2.

Parameters of this model can be estimated using ordinary least squares, imposing a restriction, that a coefficient corresponding to a specific area is set equal to zero

(a_1=0) or equivalently $SSPI_1$=1 thus considering it as a reference area to which the coefficient estimates are referred.

The purchasing power parity between an area r and the reference area is $\widehat{SSPI}_r$=exp ($\widehat{a_r}$). The parities thus estimated satisfy the property of transitivity and invariance of the basis.

Having weights in terms of value or quantity for each product, the model can be written as:

$$\sqrt{w_{nr}}\, ln\, p_{nr} = \sum_{r=1}^{R} a_r \sqrt{w_{nr}} D_r + \sum_{n=1}^{N} b_n \sqrt{w_{nr}} D_n^* + \sqrt{w_{nr}} v_{nr} \quad (3)$$

where w_{nr} are the weights in terms of value or quantity that reflect the economic importance of the different products consumed in the area.

In this analysis, we use data coming from CPI data collection referred to 2023, taking into account data for a resident family of three members and excluding any social bonuses for households in conditions of economic and social hardship.

In accordance with the definition adopted by ARERA, the standard household is composed of three individuals. For the purposes of the present analysis, the SSPIs are computed using an unweighted RPD model, applied to three consumption levels: 100 m³, 200 m³ and 300 m³. The use of identical consumption levels across all cities ensures adherence to the comparability principle required for SSPIs and aligns with the methodological guidelines established by Eurostat for the construction of international Purchasing Power Parities (PPPs).

Building on ARERA's estimate that a typical Italian household of three members consumed approximately 150 m³ of water in 2023, although with marked geographical variability, the selected consumption levels allow us to assess whether provincial price structures exhibit differential behaviours as demand increases. The unweighted RPD model is therefore implemented twice: first using two consumption levels (100 m³ and 200 m³), following the standard Eurostat approach, and subsequently using all three consumption levels. In both specifications, the consumption levels are treated as distinct products.

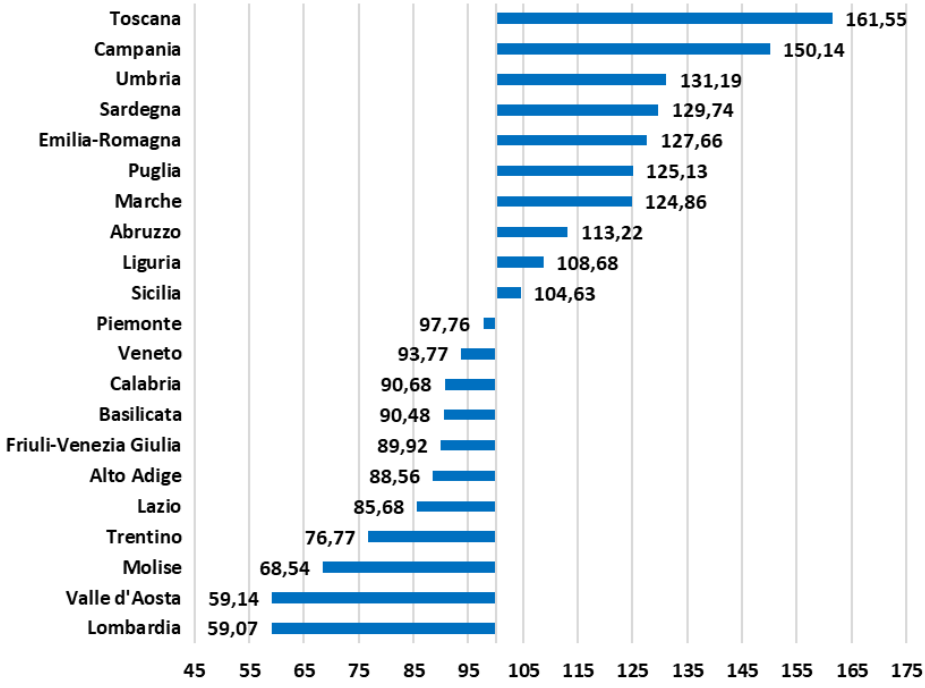
The regional prices per cubic meter employed in the model are computed as a weighted average of provincial tariffs, where the weights correspond to the resident population of each province.

4. Results

The objective of this analysis is to present the SSPIs for each Italian region, estimated relative to the national average, which is conventionally set to 100. A regional price level index above 100 indicates that the region is relatively more

expensive than the national average, and vice versa. Similarly, if the price level index of one region exceeds that of another, the former is relatively more expensive for the product categories considered.

Figure 1 – *SSPI for "Water supply" considering two levels of consumption (100 m^3 and 200 m^3) – Year 2023, Italy=100.*



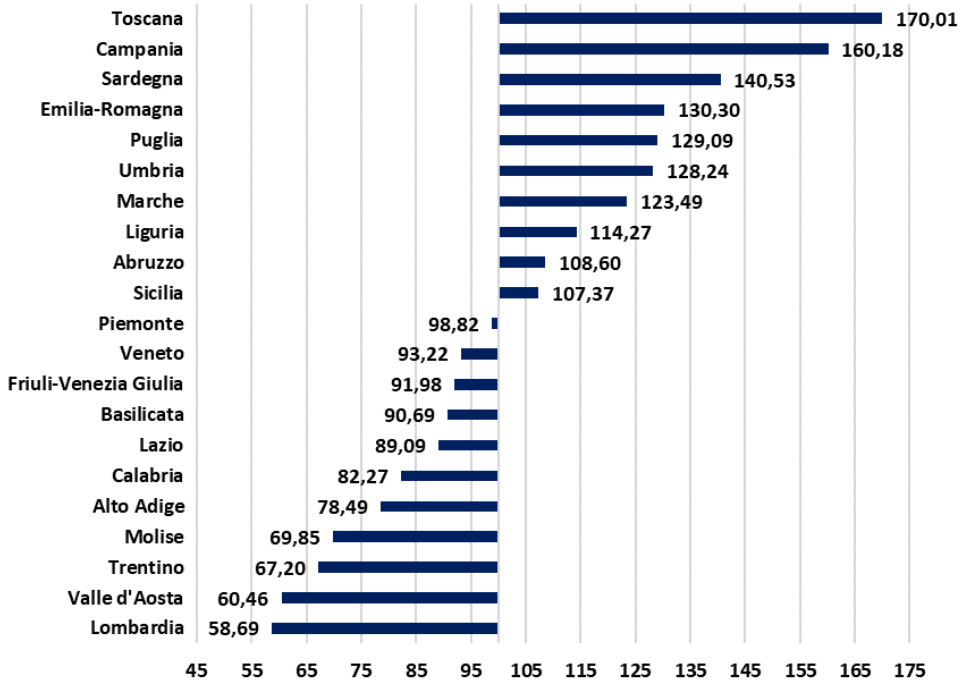
Source: Istat.

The results for the BH "Water supply," taking into account two consumption levels, reveal substantial regional disparities in the SSPI values (Fig. 1). Toscana emerges as the most expensive region, with a price level more than sixty percent above the national average, whereas Lombardia is the least expensive. Notably, no clear geographical pattern emerges for this Basic Heading: among the most expensive regions, there are areas from the North, Centre, and South of the country. The difference between the most expensive and the least expensive is very large 102.48 percentage points.

The heterogeneity of potable water tariffs across Italian regions is primarily determined by structural and operational disparities within the Integrated Water Service. Key drivers include different infrastructure conditions, particularly network

age and leakage rates, which influence maintenance and investment requirements. Differences in water source characteristics (surface versus groundwater) and the associated treatment needs further contribute to cost variability. Tariffs also reflect the complexity of the organizational model of service provision, which ranges from large-scale single operators to fragmented local utilities. Geographic and hydro-morphological factors, such as elevation and energy requirements for pumping, additionally affect operational expenditures. Finally, region-specific investment plans approved by local regulatory bodies under the national ARERA framework introduce further differentiation. Together, these factors generate significant spatial variability in the cost of providing potable water across the country.

Figure 2 – *SSPI for "Water supply" considering three levels of consumption (100 m^3, 200 m^3 and 300m^3) – Year 2023, Italy=100.*



Source: Istat.

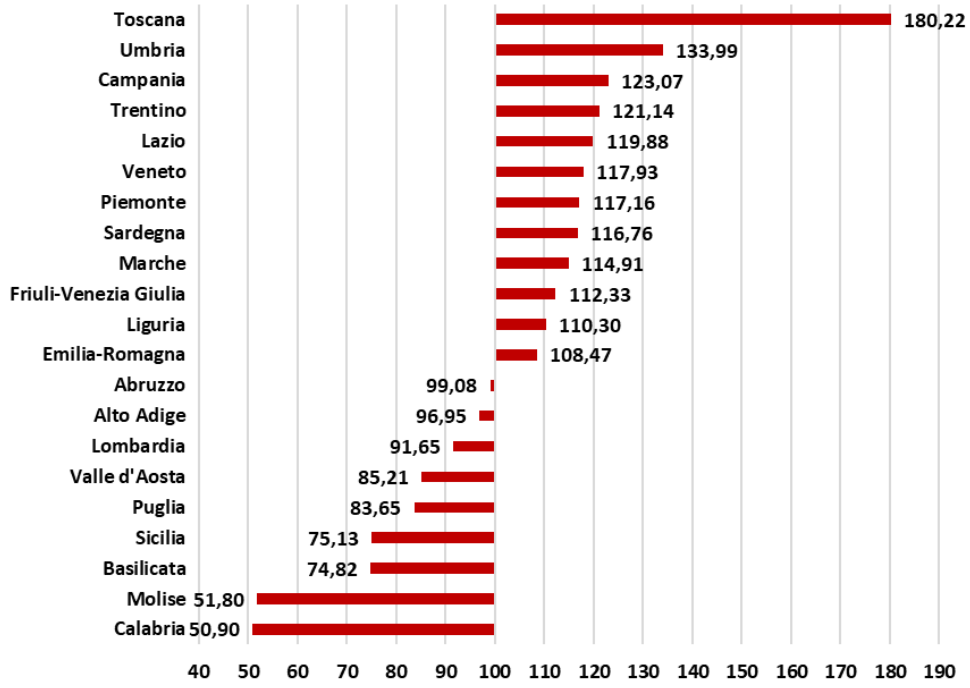
The same analysis, conducted across three consumption levels, yielded similar results regarding the most and least expensive regions (Fig. 2). Toscana and Campania consistently appear among the highest-cost regions, whereas Valle d'Aosta and Lombardia rank among the lowest. However, the gap between the most

and least expensive regions appears substantial, greater than in the previous analysis, amounting to 111.32 percentage points.

The inclusion of a higher consumption level was intended to assess how regions respond when exposed to varying consumption levels, holding all other factors constant. The substantial discrepancies observed across regions suggest the existence of markedly different tariff structures associated with these three consumption levels.

The estimated SSPI for the BH "Sewage collection" considering two levels of consumption shows similar differences as for Water collection for the most expensive regions (Fig.3), but in this case, the dispersion of results is even greater. In this BH, the least expensive regions are located in the South. The rates reflect the complexity of the organizational model as well as the water collection, but also the efficiency of the wastewater collection and treatment systems. Regions with more advanced systems or more stringent environmental standards have higher costs.

Figure 3 – *SSPI for "Sewage collection" considering two levels of consumption (100 m³ and 200 m³) – Year 2023, Italy=100.*



Source: Istat.

5. Conclusions

As part of the analyses conducted to calculate the SSPIs for the fourth ECOICOP expenditure division, we focused on the BHs "Water supply" and "Sewage collection." The reprocessing of CPI data for water supply and sewerage services, carried out in accordance with the specific data requirements for SSPIs, enabled the computation of these indices.

The resulting price levels exhibit substantial differences across geographical areas. No clear geographical pattern emerges for Water supply, whereas for Sewage collection the lowest price levels are observed in the southern regions. The analysis could be further refined by examining the role of different water consumption levels across cities and incorporating appropriate weights for these consumption tiers within the model. Additional investigations could also explore the effects of the large number of water management entities operating in Italy, 2.110 in 2022 (Istat, 2025), including the type of management (local public bodies such as municipalities, or dedicated water service companies) and the characteristics of the distribution network.

In the coming years, these scenarios are expected to evolve as a result of the increased investments required in certain areas to modernize infrastructure, comply with regulatory standards, and mitigate the impacts of climate change. Divergent demographic trends will also play a role, potentially disadvantaging regions experiencing depopulation, where the distribution of costs across a shrinking user base may lead to higher tariffs (Utilitaris, 2025).

This preliminary analysis will be complemented by further in-depth studies and the results for the fourth expenditure division will be published together with an update of the indicators for the divisions already reported, with a view to providing ever greater information on the territorial differences in price levels.

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