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Sub-national PPPs: Country case studies

Publications, experiments and projects on the computation of spatial price level differences in Italy
(Draft)

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1. Introduction

The paper has been prepared taking into account the contributions of the research papers on the topic published by the authors in scientific journals (in particular in: Biggeri et al., 2017 and Laureti and Rao, 2018) and the contributions in reports published by the Italian National Statistical Institute (Istat).

The aim of this paper is to present selected experiments and projects carried out in Italy by Istat and academic researchers on the computation of Spatial Price Indexes (SPIs) over the last 20 years. The focus is on data sources, results and uses of sub-national price indexes.

The paper is organized as follows. Section 2 describes research at Istat and the activities carried out in order to compute Spatial price Indexes (SPIs) in three different areas. First, the computation and publication of Sub-national Purchasing Parities for households consumption; second the computation of Spatial Adjustment Factors (SAFs) as requested by Eurostat for the PPP computation program; and third, the computation and publication of the estimation of Absolute Poverty (AP) threshold at sub-national level, whose values can be used to compute poverty-specific sub-national PPPs for household consumption. Section 3 provides a brief review of the experiments conducted by Istat in cooperation with the University of Florence and the University of Tuscia under the research project aimed at producing spatial indices of consumer prices at regional level on a regular basis. Section 4 focuses on work-in-progress on the computation of spatial price indexes for dwelling rents conducted by some members of the Interuniversity Dagum Centre by using elementary data of the archive on rents estimated by the Real Estate Market Observatory belonging to the Italian Revenue and Tax Agency.

2. Sub-national spatial price indexes for household consumption computed by Istat

2.1 PPP computations for the year 2009

Objective, data sources and methods of computation

At the beginning of the 2000s, several players of the economic and social debate recognized the need for compiling sub-national PPPs for Italy due to the high socio-economic heterogeneity across its geographical areas, shown by different level of per-capita income and of the salaries across the regions[1]. Taking into account this situation, in 2005 the Italian National Statistical Institute (Istat) started a research project to investigate the possibility to calculate a regional consumer price level index, with specific reference to household consumption (Regional Household Consumption Purchasing Power Parities, RHCPPPs). Two experiments have been conducted by Istat and here we refer to the most complete experiment for the year 2009 (De Carli, 2008; Istat, 2010).

The project has been carried out in cooperation with two other research Institutes (Unioncamere and Istituto Tagliacarne), belonging to the Italian National Statistical System. It was decided to use essentially the price data collected for the computation of the Consumer Price Indexes (CPIs). We have to point out that in Italy, as in many other countries, the CPIs are computed only for the chief towns of the regions and of the provinces[2]. The CPIs are computed by using the ECOICOP classification for products and services considering their presence on the Italian consumption markets.

Following the general rule adopted at international level, to compute the RHCPPPs at Basic Headings (BHs) and to aggregate them to groups of products and services and for all items, comparability of products has

[1] The second territorial level of the Nomenclature of territorial units for EU statistics (Nuts2) divides Italy into 19 regions and the two autonomous provinces of Trento and Bolzano, which make up the Trentino-Alto Adige region.

[2] The third territorial level of the European Nomenclature (Nuts3).

been considered as an essential requirement. Therefore, potentiality of the existing CPI dataset was first investigated. For the price data of Food items it was possible to compare the definition of each item in different regions, to fulfill the requirement of comparability. In contrast, it was not possible to use already collected price data Clothing and Furniture products. For these two groups of products it was necessary to carry out supplementary *ad hoc surveys* (that covered more than the 17% of the products).

Two experiments have been conducted and the results of the second more complete experiment for the year 2009 have been published by Istat in 2010 (Istat, 2010). The computations involved 1,865 item products and the collection of 717,200 elementary price quotations. The RHCPPPs, were obtained by means of the GEKS formula and using the weighting system computed for the CPIs based on data coming from the Household Budget Survey (HBS) and the National and Regional accounts. The spatial comparisons of actual rents was carried out using CPD models and HBS data that includes some detailed information about the characteristics of the dwellings.

It is worth noting three limitations of this interesting exercise. Firstly, the experience of conducting ad-hoc surveys was useful where the CPI data do not adequately cover all the products and services consumed by the households, but it was also too costly. Second, the indexes are computed only for the chief towns of the regions and, obviously, no information is provided on the rural-urban price level differences. Third, no attempt was made to integrate computations implemented and the PPPs-ICP computation process.

Main results
Istat published the RHCPPPs for 8 expenditure groups and for the overall household consumption. Results are shown in Table 1 (Istat, 2010).

Table 1 Purchasing Power Parities for Italian regional capital and groups of products

Regional capital	All items	Food, beverages and tobacco	Clothing and footwear	Housing, water, electricity and gas	Furnishings, household equipment, maintenance	Health	Transport and communication	Education, recreation and culture	Other goods and services
	102.7	103.2	102.2	103	99.9	101.4	103.1	104.9	98.9
Aosta	102.4	103.1	98.4	94.4	109.1	112.6	101.4	105.3	94.4
Genova	103.4	103.3	102.4	110.3	103.3	101.4	101.8	101.4	105.4
Milano	104.7	106.8	102.3	102.1	106.5	112	100.6	105.1	103.8
Bolzano	105.6	108	103.1	107.7	109.3	104.6	100.3	104.6	111.2
Trento	103	99	102.6	101.9	109.9	100.3	102.6	105.9	99.6
Venezia	101.8	104.1	94.9	100.9	100.4	101.1	103.1	101.8	106.9
Trieste	103.1	104.5	103.7	97.8	101.4	105.4	101.3	105.8	102.4
Bologna	104.9	105	100.6	106.5	105.5	107.1	99.9	107.2	109.3
Ancona	100.8	100.6	97.5	102.5	89.7	104	102.2	103.4	107.1
Firenze	101	95.8	103.5	111.4	104.4	99.4	97.7	100.3	108.7
Perugia	98.9	101.9	100.5	98.5	92.5	96.9	98.9	97.9	101.9
Roma	100.1	98.5	99	112.8	93.1	103.9	102.3	95.8	101.4
Napoli	93.8	91	100	94.8	96.9	90.3	95.6	92.2	94.2
Campobasso	94.2	95	94.6	92.3	90.5	96.5	98.4	92.9	91.6
Bari	96.1	94.9	98	91.8	102.7	92.3	99.3	96.2	94.3
Potenza	94.7	95.1	94.8	85.6	98.6	99.6	99.5	93.2	91.9
Reggio Calabria	94.9	96.1	102.4	92.8	94.6	88.3	93.5	94.9	94
Palermo	97.4	96.3	99.6	99.3	98.5	91.2	99.1	99.9	90.6
Cagliari	98	100	100.7	98.4	96.9	96	99.9	93.8	96.5
Italia	100	100	100	100	100	100	100	100	100
min	93.8	91	94.6	85.6	89.7	88.3	93.5	92.2	90.6
max	105.6	108	103.7	112.8	109.9	112.6	103.1	107.2	111.2

The results show significant differences in the level of consumer prices across regional capitals, price levels in the Northern regional capital are generally higher than those in the Centre and especially in Southern Italy. The minimum and maximum values for the overall index - considering the value of Italy = 100 - are 93,8 and 105,6, while higher differences in the level of prices have been found for Housing, water, electricity, gas and other fuels (85,6 and 112,8) and for Health products and services (88,3 and 112,2).

Uses of the computed RHCPPPs

The first use of RHCPPPs computed and published by Istat, was done by researchers at the Bank of Italy (Cannari and Iuzzolino, 2009). They referred to the results of the first Istat experiment (Istat, 2008), to compute a more complete picture of differences in price levels, integrating those data with information on house prices and rents obtained by the Italian Revenue and Tax Agency and from the Bank of Italy Household Budget Survey and other sources of data.

Successively, other academic researchers used RHCPPPs extensively for various purposes. Firstly, to verify how the household income distribution in Italy is "reshuffled" after controlling for the purchasing power of households residents in the different regions (Pittau et al., 2011). Recently these indexes have been used to carry out "real" comparison of the estimates of the household consumption expenditures at local level in Italy (Secondi and Marchetti, 2017) and of poverty indicators (Giusti et al., 2017; Biggeri and Pratesi, 2017; Biggeri et al., 2018). The interest of these researches is related to the fact that sub-national PPPs are used more frequently in the estimation of household consumption, income and poverty indicators (and poverty lines) at local level by using the Small Area Estimation (SAE) methods conducted to satisfy the needs of the policy makers.

2.2 Computation of the Spatial Adjustment Factors (SAFs)

As established in the Eurostat-OECD documents, within the Program for the PPP computations, countries are required to, every six years, determine and provide to Eurostat Spatial Adjustment Factors (SAFs) for each basic heading included in the country survey.

SAFs are needed in order to establish differences in price levels between the capital of the country and the price level for other locations within the economic territory and so to adjust average prices usually obtained for the country capital city to national average prices. The methodology to compute SAFs should be consistent with the approach used by Eurostat in the calculation of PPP, and computed by using the GEKS formula and CPI data. Should CPI sources prove to be insufficient, further price collections for this specific purpose can be taken into consideration. Such a price collection should aim to measure relative differences in regional consumer price levels and can provide a good basis for the calculation of spatial adjustment factors. However, price surveys are resource-intensive. In practice, a combination of available CPI data and additional price collection for areas where comparable CPI data are lacking may be a good solution. Usually Basic headings with national pricing policy, such as tobacco, motor cars, fuels, etc. need not be considered in the survey.

This method would yield sub-national or regional PPPs. If the regional PPPs are expressed with country = 1, the spatial adjustment factor would be the inverse of the PPP for the capital region.

Istat computes and provides Eurostat with SAFs for the regional capital cities by using only CPI data, which are not published because the publication of international PPPs is not foreseen in the dissemination channels of Istat and the Institute considers the SAFs just a "by-product" of the computation of PPP for Italy. Obviously, the lack of publication of the Italian SAFs prevents the knowledge of the differences in the level of prices among the Italian regional capital cities and their evolution during successive waves the International PPP computation.

2.3 Computation of Spatial Price Indexes using the estimation of absolute poverty

Data sources and methodology

Istat computes and publishes official data on absolute poverty (AP) annually. These data highlight differences in the levels of prices paid by poor families, providing very interesting information in this field of research.

The absolute-poverty estimation methodology, developed in 2005 (Istat, 2009), is based on the monetary value of a basket of goods and services that are considered essential to avoid severe forms of social exclusion[3]. It is calculated for several family types (38 in total, stratified by number of components, age, etc.) whose consumptions provide the same level of satisfaction or utility for each type of family. The assumption is that the primary needs, and the goods and services that satisfy them, are homogeneous throughout the national territory. The monetary assessment of these baskets (Absolute Poverty Threshold, APT) depends on the prices paid by families in the various areas of the country, for which ISTAT performs the calculations, taking into account the size of the municipality of residence[4] (metropolitan area, large municipalities and small municipalities) and geographical distribution[5] (North, Central and South).

More formally, let i (i = 1, ..., i, ..., n) be the generic product/service, j (j = 1, ..., j ..., 38) the type of family, and t (t = 1, ..., j ..., 9) the territory (type of municipality and geographical distribution), it is then possible to define a generic poverty threshold (APTs) with respect to the type of families and to the various territories, as follows:

$APT_{jt} = C\ (q_{1j}.p_{1t},...,q_{ij}.p_{it},....,q_{nj}.p_{nt};\ U),$

where C is a cost function and U the constant overall "utility" level that the family obtains with the consumption of the basket of goods and services.

The APTjt are therefore calculated for each of the 38 types of families and the 9 territories (type of municipality in each of the three geographical areas).

The relationship between poverty thresholds referring to similar family types in different areas is clear, and can allow to computing spatial differences on the level of prices payed by poor. For example.

$APT_{j,1} / APT_{j,t} = C(q_{1j}.p_{11},...,q_{ij}.p_{i1},....,q_{nj}.p_{n1};U)/C(q_{1j}.p_{12},...,q_{ij}.p_{i2},....,q_{nj}.p_{n2};U)=SPI^{AB}_{jt}$

provides a binary economic spatial price index (the so-called cost of living index) as it compares the cost paid by each type of families residing in different territories to obtain a basket of goods and services that provides the same level of utility. These indexes can be obtained for all types of families and territories for which the poverty thresholds are calculated.

[3] The basket represents the set of goods and services that is supposed to guarantee a minimum acceptable standard of living in the Italian context.

[4] Type of municipality: metropolitan area - municipalities with over 250,000 inhabitants; large municipalities - municipalities of the suburbs metropolitan area and municipalities with 50,000 inhabitants and more; small municipalities - municipalities with less than 50,000 inhabitants

[5] Regions: North (Piedmont, Valle d'Aosta, Lombardy, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Liguria, Emilia-Romagna), Center (Tuscany, Umbria, Marche, Lazio), South (Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicily, Sardinia).

Istat publishes every year the data for the SPI^{AB}_{jt} mentioned above, updating the values calculated for the base year, using data on prices obtained through surveys for the measurement of the Consumer Price Index[6],[7].

Some results

Although the SPI^{AB}_{jt} are based on rather strong assumptions and obtained from poverty thresholds affected by sampling errors, we have calculated them for 2016. These refer to three geographical areas and the types of municipalities (Biggeri and Pratesi, 2018).

In Table 2, the calculations are summarized using the maximum and minimum value of the percentage differences in the price level obtained from the indexes, subtracting 1 from the index value and multiplying the result by 100.

Table 2 Differences (in %) of the ratio between Absolute Poverty Thresholds in the geographical areas and for typology of Municipalities

	North/South			Center/ South		
Community Type*	A	B	C	A	B	C
Max	35,8%	33,8%	34,5%	31,9%	29,3%	29,3%
Min	26,9%	24,8%	24,2%	19,2%	16,6%	15,6%

*A= Metropolitan area; B= Large municipalities with more than 50.000 inhabitants; C= Other municipalities up to 50.000 inhabitants.

One difference in particular gives an overall idea: in Northern Italy, the product basket costs at least 24.2% more than in the South. The territorial variability of implicit prices appears to be significant and at least higher than the one resulting from the parities (RHCPPPs) referred to the year 2009, calculated by Istat for all households (presented in Table 1). Families with only one person older than 75 are generally associated with the highest differences, while larger families experience smaller differences. Therefore, it seems that families in absolute poverty, who reside in Northern and Central Italy, face higher levels of prices. The typology of the Municipality of residence has an effect: the differences between North / South and Center / South seems to be mitigated in smaller municipalities and outside the metropolitan suburbs. The data may indicate that people living in metropolitan areas can hardly find outlets and outdoor markets that usually offer lower prices.

3. Istat projects from 2011 up to now: experiments, main results and future development

Research projects: organization and objectives

The sub-national PPP (RHCPPPs) results obtained for the year 2009, mentioned before, have encouraged Istat to implement the project regularly producing spatial indices of consumer prices at regional level.

[6] The consistency between the items of the absolute poverty basket and the aggregates used for their revaluation over time was obtained by taking into account the characteristics of the consumer prices measurement and their comparability over time.

[7] Istat has decided to implement a project to revise the definition of the absolute poverty thresholds

Further research studies have been implemented by Istat in cooperation with the University of Florence and the University of Tuscia (Biggeri *et al.,* 2017; Laureti and Polidoro, 2017; Laureti *et al.,* 2017). The research studies have the following objectives: (i) to establish a data warehouse with various available sources of data (to avoid the need to conduct ad hoc surveys that are costly), (2) to verify if and how much sub-national PPPs computation are affected by the type of data, and (3) to examine the possibility of using scanner data for the prices of some products purchased by the households.

More specifically, within the European Multipurpose Price Statistics project, which is an important EUROSTAT project to which the NSOs are contributing, Istat is attempting to build a database suitable for constructing sub-national PPPs as well as temporal comparisons of consumer prices. Within a data warehouse approach which integrates various sources of data, compilation of sub-national spatial price indices will be based on four main kinds of data: i) traditional CPI data (already representative and in some cases also comparable), ii) scanner data obtaining from retail trade chains of the modern distribution, and iii) ad hoc collected data for certain groups of products by means of electronic devices and a dedicated software[10] data collected on the web also through web scraping techniques.

Research conducted using traditional CPI data

In order to use traditional CPI data, an in-depth analysis of the basket and the micro data was carried out. This analysis was aimed at identifying all the products which are comparable by definition and therefore can be used for compiling spatial price indexes. Indeed, products whose prices are collected for compiling CPIs may not be comparable or representative across different areas due to differences in consumer behavior.

Within the frame of the research project a first group of experiments were conducted with the aim of understanding whether the use elementary price quotes or average prices obtained by averaging individual price quotes across outlets affect the results in terms of computed PPPs, and with the aim of exploring the performance of various CPD models and analysing to what extent the type and characteristics of the data affect the estimates obtained (Biggeri et al., 2017). This experiment focused on 7 Basic Headings (groups of products) belonging to the Food and non-alcoholic CPI group, that is: fresh meat, all fresh fish species, all types of fresh fruit and vegetables, which account for 5.2 % of the entire basket (Biggeri et al., 2017). RHCPPPs for the above mentioned BHs were estimated by using a dataset composed of 218,228 monthly price quotes collected in the 19 regional capitals considered in 2014 CPI survey. Although the varieties available in the various regional markets may vary due to distinct consumption behaviour, the products considered were characterized by a high degree of overlap across the Italian regional capitals. After having obtained annual individual price quotes for each product in the 7 BHs, hedonic CPD models, which include characteristics of the outlet where products are sold, were estimated for compiling regional price indexes for Italy. The statistical uncertainty associated with the ranks derived from the regional PPPs was calculated by means of a simulation procedure.

The results obtained show significant consumer price level differences across various Italian regions and support the notion that price levels are higher in the Northern-Central regions than in the South, especially for the Fresh or chilled fruit BH and Fresh or chilled vegetables other than potatoes BH.

With the aim of understanding whether to use elementary quotes or average prices obtained by averaging individual price quotes, Biggeri et al (2017) explored to what extent the type and characteristics of the data affect the estimates by comparing various CPD models based on data characterized by different levels of aggregation. In order to summarize the differences between the results obtained with the CPD models using average prices, with and without weights, and the individual price quote CPD model, a synthetic measure was used which indicates the average percentage difference between the BH price indexes. The results show that the greatest difference, equal to 8.78 %, was observed when setting the unweighted CPD against CPD using individual price quotations. Contrastingly, there was a relatively small difference (2.86 %)

between using ungrouped data and the Weighted Least Square (WLS) estimation method. These findings suggest that when the available data are average prices, information available on the number of quotations and the standard deviations should be included in CPD model estimation in order to reduce the impact of switching from using individual price quotes to geometric average price. Therefore, the WLS approach should be used instead of the OLS for constructing sub-national PPPs. These results confirm that, in general, the application of CPD models on ungrouped data is preferable compared to the basic approach on average data.

In addition, Biggeri *et al.* (2017) estimated CPD models with a spatial first-order autoregressive process for the error terms in order to explore the issue of spatial dependence in consumer prices. The spatial error CPD model, in which the spatial weights matrix W was based on an economic distance, produced point estimates of sub-national PPPs that were almost the same as those obtained using the CPD model but with lower standard errors.

Research conducted using scanner data and other sources of data

As regards scanner data, it is worth noting that Istat started a project in 2014 with the aim of carrying out a massive revision of the CPI production process in order to replace the on-field data collection for food and grocery products in supermarkets and hypermarkets with prices obtained from this new data source.

According to an agreement with the Association of Modern Distribution, Istat can obtain scanner data through the market research company ACNielsen, which provides data on a monthly basis by uploading the data files on to a dedicated ISTAT web portal. In 2017, ISTAT has received data from 1,470 stores belonging to 16 retail chains (Coop Italia, Conad, Selex, Esselunga, Auchan, Carrefour, Finiper, PAM, etc.), that cover approximately 93.7% of the turnover of total modern distribution and 37 Italian provinces.

Each record represents weekly sum of turnover and quantity for a GTIN (Global Trade Item Number, formerly EAN code) sold during the week in a single store. Also provided are classification tables for mapping GTINs to ECOICOP classification and specific elementary aggregates. Moreover, additional information are provided regarding stores and GTINs, such as product descriptions, geographic location, etc. Therefore, these data can be effectively used for compiling sub-national PPPs for food and grocery groups of products since they enable to compare representative and comparable items across regions.

Laureti and Polidoro (2017a and 2017b) explored this new source of price data in order to compute Italian sub-national BH level. After a process of data cleaning and trimming outliers, unit value price per item code were computed by dividing total turnover for that item by the total quantity sold over the week. Several analyses were carried out in order to understand how best to aggregate the detailed information contained in the Italian scanner data for constructing spatial price indexes. More specifically, by referring to each Italian regional capital, ANOVA and t tests on a sample of items were carried out in order to verify if the price of the same item could reflect auxiliary services provided by the seller. Indeed, within each city, the same item is found in different supermarket chains and in different stores which belong to the same retail chain. Results showed significant differences in prices of the same items thus suggesting product differentiation which is embodied in the range or quality of services offered by different retailers across chains.

Therefore, with respect to item groupings, the authors used the finest classification of item that is available within the BH, i.e. the product code, which is identical across the Italian territory. As regards the time dimension, annual regional average prices for each GTIN code and outlet were used. In order to compile spatial price index for the 20 regional capitals at BH level, 931 points of sale of the six most important modern distribution chains (Coop Italia, Conad, Selex, Esselunga, Auchan, Carrefour), that cover approximately 57% of the turnover of total modern distribution were considered. The dataset used consists

of 3,659,286 annual price quotes from the 20 regional chief towns concerning 69 BHs for a total of 49,489 products (GTIN code).

In order to account for the economic importance of each item in its market, which is essential in index number literature, Laureti and Polidoro (2017) estimated weighed CPD models using expenditure share as weights. In this way it may be possible to mitigate the effects of the large fluctuations in quantities purchased in response to price discounts which still emerge using monthly average prices. Moreover, in order to explore the effects of including information on the type of outlet and retail chain hedonic weighted CPD models were estimated. Significant differences were observed between the results obtained from the unweighted CPD and weighted CPD models.

Within the Istat project, Laureti *et al.* (2017) carried out interesting experiments using both scanner and CPI data. More specifically, they focused on the issue of compiling regional spatial price indexes for perishables and seasonal products such as vegetables, fruit and meat since these products are sold at price per quantity and are not pre-packaged with GTIN codes. Therefore scanner data cannot be used for these products and traditional CPI data obtained from the large -scale retail trade should be considered. The authors integrated scanner data with prices for fruit and vegetables which are traditionally collected for CPI production in modern distribution. After data quality controls and preliminary analyses of the basket, the CPI dataset used includes annual average prices for 151 vegetable products collected in 20 regional capitals and include information on chains. Sub-national PPPs were estimated by using unweighted CPD models since CPI data do not include information on expenditure.

Finally, this year, Laureti and Polidoro (2018) completed a research project with the aim to explore the potential of using scanner data for computing SPIs, to deal with methodological and empirical issues caused by this new data source, and to estimates HCPPPs both at regional and provincial territorial level using 2017 scanner data.

The various and consistent computations showed the feasibility of using scanner data to compute sub-national also at local provincial level. The feasibility of implementing various aggregation methods has been proved but the weighted Regional Product Dummy model is preferable when product overlaps exhibit a chain structure.

Further research is underway for computing RHCPPPs by using all the information contained in scanner data and integrating scanner data with other new data sources (i.e. web scraping) as well as traditional data collection (traditional retail trade).

In summary, experiments conducted up to now show that scanner datasets provide both opportunities and challenges for price statisticians.

The advantages are:

- It is recorded what is actually sold and universe of all transactions is considered, in modern distribution chains
- Prices available every day of the month and for 1,781 outlets
- Detailed information on turnover and quantities for each item code (GTINs)
- Territorial coverage is high (all Italian provinces)
- A wide range of methods may be used due to availability of quantities and expenditure data.

The issues are:

- Lack of coverage of overall household consumption expenditure, just expenses done in the outlets of the modern distribution chains
- Hard discounts are not included

- Several sub-classes of food products cannot be considered since these products are sold at price per quantity and are not pre-packaged with GTIN codes (i.e. vegetables, fruit, meat and fresh fish)
- High variability of products sold among cities.

4. The computation of spatial price indexes for housing dwellings rents

Objectives and data source

The importance of measuring regional differences in dwelling rents is crucial in the evaluation of cost of living, in assessing and comparing poverty, in comparing salaries and household disposable income and, finally, in designing housing policies at a local level (Renwick, 2009; Aten, 2017; Bishop et al., 2017). Over the last few years, demand for measures of differences in dwelling rents has increased in Italy, from both academic researchers and policy makers, to compare provincial salaries and to design sub-national interventions policy on housing.

The Dagum Centre[8] and in particular some of its members, Luigi Biggeri and Tiziana Laureti and their collaborators, have implemented a project for the computation of Spatial Price Indexes for House Rents (SPIHR) by using the data produced by the Real Estate Market Observatory (OMI, *Osservatorio del Mecato Immobiliare Italiano*), which is part of the Italian Revenue and Tax Agency[9].

The computations of SPIHRs carried out until now use the OMI data-base available for research purposes that provides for each Italian municipalities (more then 8,000), on a biannual basis, a minimum - maximum range of market and rent values, specified per square meter, type of dwelling and conservation status (OMI, 2016). Since location is the characteristic with the greatest impact on rent value, the quotations refer to zones. Therefore, every Italian municipality is divided into homogeneous zones (OMI zones) within the municipality territorial areas having uniformity of economic and socio- environmental conditions. More specifically, the territorial delimitation of a homogeneous market area is obtained through the analysis of the homogeneity of the economic and socio-environmental as well as the geographical location of dwellings within the municipality. Various characteristics are considered: first of all the territorial areas within the municipality which are classified as B=central area, C=semi-center, D= outskirts, E=suburbs and R=rural and extra-urban, the presence and accessibility to public and private facilities and services; the quality of urban and suburban transport services, road connections, the presence of educational, health, sports, commercial and tertiary facilities.

In this way, the OMI zones indicate a portion of the territorial area of each municipality that reflects a homogeneous sector of the local real estate market, in which there is a substantial homogeneity of economic and socio-environmental conditions. This socio-economic homogeneity is translated into homogeneity of the market values of the real estate units included in a range with a deviation between the minimum and maximum values, as a rule, not higher than 50%.

According to the classification used by the Real Estate Market Observatory the OMI zone are defined for different groups of dwelling defined by considering the use of properties: i) residential, ii) offices, iii) commercial, iv) industrial and the type of dwelling: i) Well-finished dwelling-houses ii) Economic and Cheap dwelling-houses, iii) detached houses, iv) villas v) houses and dwellings typical of the area, etc.)

[8] The Dagum centre is an Inter-university Research Centre on Advanced Statistics for the Equitable and Sustainable Development (ASESD) devoted to promote multidisciplinary cooperation in the study of the different dimensions of poverty and deprivation, both from a methodological and applied perspective .

[9] The Italian Revenue Agency is a non-economic public body that operates to ensure the highest level of tax compliance. It is mainly responsible for collecting tax revenues, providing services and assistance to taxpayers and carrying out assessment and inspections aimed at countering tax evasion. It also provides cadastral and geocartography services.

The data on rent are obtained through an appraisal process conducted by specific technical committees of OMI, which use both data included in the cadaster (land and housing register) data-base and specific surveys on regular sample surveys on market rents (OMI, 2016). The valorization process is based on the suggestions specified in International standards (International Valuation Standards and Council, 2013).

It is well known that constructing spatial indexes of rents is usually a difficult task due to data unavailability of suitable data. Since every house is different, ideally what is required is a quality adjusted index that compares like with like from one region (or territorial area) to another. For example this can be done by using an hedonic model that controls for basic unit characteristics such as the type of structure, the number of bedrooms, the total number of rooms, when the structure was built, its location and so on (Aten, 2017). In our case, the comparability is guaranteed by considering the OMI zones in the evaluation process and distinguishing by types of homogeneous dwellings[10].

In order to carry out the first experiment of computing spatial price indexes for house rents (SPIHR) in Italy we refer to 2017 data and consider only two types of dwellings (Well-finished dwelling-houses; Economic and Cheap dwelling-houses).

Methodology of SPIHR computation

Taking into account that we have only the minimum and maximum values for rents of dwellings in each municipality and OMI zone, we estimate three different models by type of dwellings (residential houses: i) Well-finished dwelling-houses ii) Economic and Cheap dwelling-houses): 1) models based on the minimum values; 2) models based on the maximum values; 3) models based on the averaged values of min-max rents obtained using geometric mean weighted by using range as measure of variability[11].

We use the region-product-dummy-method (RPD) method, which is the regional version of the country-product-dummy (CPD) method used in international comparisons[12], to compute SPIHR. The RPD method suggests that rent levels are estimated by regressing logarithms of rents on regional capital and OMI area dummy variables. The model is given, for each kind of dwellings, by:

$$\begin{aligned}\ln r_{ij} &= \ln SPIHR_j + \ln R_i + \ln u_{ij} \\ &= \pi_j + \eta_i + v_{ij} \\ &= \sum_{k=1}^{M} \pi_k D^k + \sum_{i=1}^{N} \eta_i D^i + v_{ij}\end{aligned}$$

where r_{ij} is the rent of dwelling i in D^k is a regional capital-dummy variable that takes value equal to 1 if the rent observation is from *k-th* regional capital; and D^i is a OMI area -dummy variable that takes value equal to 1 if the rent observation is for *i-th* OMI area (*i=1,…,310*). The random disturbance is assumed to satisfy the standard assumptions of a multiple regression model. Parameters of this model can be estimated once one of the parameters of the model is set at a specified value. Two possible normalization are the following:

a) π_1=0 when region 1 is taken as the reference or numeraire region then π_1 is set at zero and remaining parameters are estimated. In this case π_k is the difference of (fixed) effects associated with the regions with respect to the base region. Then, if $\hat{\pi}_j\ (j=1,2,...,M)$ are estimated parameters the SPIHR of area (or region) k with respect to a base area is given by $SPIHR_k = e^{\hat{\pi}_k}$.

[10] It is worth noting that the Dagum Centre is implementing an agreement protocol with OMI in order to obtain detailed data obtained by a questionnaire that collects information on all the characteristics of dwellings.

[11] In this paper we do not report estimation results from this method.

[12] Details of the CPD method and its properties are discussed in detail in Rao (2004)

b) $\sum_{k=1}^{M} \pi_k = 0$ this normalization treats all regions in a symmetric manner. In this case π_k is the difference of (fixed) effects associated with the regions with respect to the average value of all regions. In this study we choose normalization b) therefore if $\hat{\pi}_j$ $(j = 1, 2, ..., M)$ are estimated parameters the SPIHR of area (or region) k with respect to Italy as a whole is given by $SPIHR_k = e^{\hat{\pi}_k}$

First Results

We estimated RPD models considering Italian regions as well as Italian provinces which define a more detailed territorial classification. Table 3 reports results obtained by estimating a RPD model at regional level and using data on Well-finished dwelling-houses and Economic and cheap dwelling-houses. SPIHR are reported for minimum and maximum values of rents and considering as base Italy=100.

Results show significant rent level differences across various Italian regions and support the notion that dwelling rents are higher in the Northern-Central regions than in the South, with the exception of Piemonte and Friuli-Venezia Giulia. Indeed, dwelling rents in Southern regions, such as Basilicata, Sicily, are below the national average while Northern-Central regions, such as Liguria, Trentino-Alto Adige, Toscana and Lazio, are above the national average. Basilicata proved to be a less expensive region regarding housing rents while Liguria shows the highest cost of rents. As expected SPIHRs show higher level differences than those estimated by RHCPPPs. The high variability of SPIHRs across regions, may depend on the presence of municipalities with a high propensity for tourism (i.e., sea, mountains, lake, etc.). There are slight differences between the two types of dwellings.

Spatial differences in housing rents show similar territorial patterns regardless of considering the minimum values or maximum values of rents observed for municipalities in the various regions with the exception of Friuli-Venezia Giulia. In fact, this Northern region shows higher rent levels than the national average when maximum values of housing rents are considered.

Table 3- Spatial price indexes for house rents (SPIHR)-Italy=100 (Well-finished dwelling-houses and Economic and cheap dwelling-houses)

	Well-finished dwelling-houses				Economic and cheap dwelling-houses			
	Minimum rent		Maximum rent		Minimum rent		Maximum rent	
	SPIHR	Std. Err.	SPIHR	Std. Err.	SPIHR	Std. Err.	SPIHR	Std. Err.
North								
Piemonte	87.20	0.00704	89.14	0.00702	97.33	0.00825	101.33	0.00808
Valle d'Aosta	123.14	0.03357	121.09	0.03345	122.78	0.03782	117.57	0.03705
Liguria	142.81	0.01267	140.29	0.01263	158.18	0.01289	159.93	0.01262
Lombardia	117.39	0.00545	114.14	0.00543	133.61	0.00718	127.87	0.00704
Trentino-Alto Adige	153.00	0.00988	147.37	0.00985	213.32	0.18653	200.24	0.18275
Friuli-Venezia Giulia	100.01	0.01424	106.85	0.01419	101.78	0.01686	110.86	0.01652
Veneto	115.04	0.01147	112.02	0.01143	135.38	0.02278	127.14	0.02232
Emilia-Romagna	117.16	0.01088	116.07	0.01084	126.20	0.01300	124.35	0.01274
Centre								
Toscana	141.74	0.01058	143.49	0.01054	151.72	0.01358	150.02	0.01331
Lazio	124.43	0.01169	123.37	0.01165	141.01	0.01616	142.56	0.01583
Umbria	88.89	0.02045	90.49	0.02038	95.66	0.02640	95.25	0.02586
Marche	104.96	0.01202	105.97	0.01198	110.22	0.01321	108.98	0.01294
South								
Abruzzo	75.30	0.01293	80.55	0.01288	79.29	0.01288	84.10	0.01262
Molise	66.60	0.03524	73.38	0.03511	70.03	0.03554	75.85	0.03482
Campania	78.49	0.00782	78.03	0.00780	84.94	0.00792	83.66	0.00776
Basilicata	58.61	0.01815	57.32	0.01808	51.66	0.01875	51.16	0.01837

Puglia	81.94	0.01345	81.16	0.01340	90.63	0.01318	87.45	0.01291
Calabria	62.34	0.01273	62.82	0.01268	70.80	0.01138	70.55	0.01115
Sicilia	68.37	0.01080	71.41	0.01076	67.30	0.00959	69.26	0.00940
Sardegna	80.05	0.01416	80.94	0.01411	87.09	0.01747	86.03	0.01711

To explore spatial heterogeneity in housing rents within Italian regions we estimated RPD models by considering Italian provinces. Table 4 shows a high degree of heterogeneity in spatial price indexes for house rents within Italian regions. For example, considering well-finished dwellings-houses and maximum values, SPIHR range from 83.79 for Frosinone to 143.13for Rome in Lazio region. As expected SPIHRs at provincial level show higher level of heterogeneity than those estimated at regional level. There are slight differences between the two types of dwellings. Northern and Central regions proved to have higher levels of heterogeneity in rent levels.

Table 4- Provincial spatial price indexes for house rents (SPIHR)-Italy=100 (Residential buildings: low-cost houses)

		Well-finished dwelling-houses				Economic and cheap dwelling-houses			
		Minimum rent		Maximum rent		Minimum rent		Maximum rent	
Region	Prov	SPIHR	Std. Err.	SPIHR	Std. Err.	SPIHR	Std. Err.	SPIHR	Std. Err.
North									
Piemonte	AL	83.64	0.016	77.81	0.016	98.66	0.016	92.73	0.016
Piemonte	AT	44.19	0.019	45.46	0.019	57.61	0.019	56.78	0.019
Piemonte	BI	74.35	0.028	76.76	0.028	70.06	0.028	72.21	0.028
Piemonte	CN	98.25	0.012	99.24	0.012	106.43	0.012	111.78	0.012
Piemonte	NO	72.49	0.022	74.44	0.022	48.33	0.022	46.76	0.022
Piemonte	TO	111.62	0.013	119.35	0.013	72.82	0.013	73.97	0.013
Piemonte	VB	90.08	0.025	92.66	0.025	98.02	0.025	106.83	0.025
Piemonte	VC	94.29	0.033	104.24	0.032	119.59	0.033	143.34	0.032
Valle d'Aosta	AO	123.04	0.028	120.94	0.028	124.37	0.028	118.95	0.028
Liguria	GE	118.59	0.024	123.65	0.024	127.08	0.024	115.90	0.024
Liguria	IM	164.69	0.020	172.46	0.020	64.34	0.020	70.29	0.020
Liguria	SP	150.36	0.027	156.49	0.027	70.16	0.027	73.65	0.027
Liguria	SV	140.17	0.019	122.11	0.019	88.69	0.019	90.94	0.019
Lombardia	BG	147.03	0.015	140.49	0.015	163.11	0.015	154.88	0.015
Lombardia	BS	115.63	0.011	110.87	0.011	166.43	0.011	160.50	0.011
Lombardia	CO	105.17	0.021	107.44	0.021	118.51	0.021	118.24	0.021
Lombardia	CR	78.53	0.021	84.81	0.021	85.77	0.021	91.95	0.021
Lombardia	LC	132.95	0.022	127.46	0.022	69.85	0.022	65.61	0.022
Lombardia	LO	136.61	0.031	128.95	0.031	132.78	0.031	135.13	0.031
Lombardia	MI	146.77	0.012	135.28	0.012	73.83	0.012	80.09	0.012
Lombardia	MN	84.77	0.017	87.58	0.017	132.17	0.017	134.98	0.017
Lombardia	PV	95.34	0.027	83.70	0.027	52.96	0.027	52.15	0.027
Lombardia	SO	123.32	0.015	113.06	0.015	192.71	0.015	199.95	0.015
Lombardia	VA	103.60	0.017	112.74	0.017	89.00	0.017	88.72	0.017
Trentino-Alto Adige	BZ	173.93	0.012	174.47	0.012	222.85	0.012	202.89	0.012
Trentino-Alto Adige	TN	130.36	0.013	119.16	0.013	114.20	0.013	120.29	0.013
Friuli-Venezia Giulia	GO	125.67	0.024	115.40	0.024	170.04	0.024	179.07	0.024
Friuli-Venezia Giulia	PN	86.64	0.026	100.18	0.026	235.21	0.026	231.86	0.026
Friuli-Venezia Giulia	TS	136.10	0.051	179.45	0.051	175.83	0.051	178.50	0.051
Friuli-Venezia Giulia	UD	91.60	0.017	99.02	0.017	115.00	0.017	120.08	0.017
Veneto	BL	97.69	0.021	94.89	0.021	120.09	0.021	114.17	0.021
Veneto	PD	121.00	0.020	107.99	0.020	105.47	0.020	109.85	0.020
Veneto	RO	92.62	0.033	91.37	0.032	84.85	0.033	85.11	0.032
Veneto	TV	125.24	0.016	126.98	0.016	94.28	0.016	102.24	0.016
Veneto	VE	132.17	0.085	143.09	0.085	154.39	0.085	149.68	0.085
Veneto	VI	129.34	0.059	130.73	0.059	65.35	0.059	63.68	0.059
Veneto	VR	138.85	0.067	132.54	0.067	100.00	0.067	100.00	0.067
Emilia-Romagna	BO	135.54	0.022	130.62	0.022	165.98	0.022	159.78	0.022
Emilia-Romagna	FE	95.23	0.040	97.44	0.040	120.00	0.040	115.34	0.040
Emilia-Romagna	FO	142.79	0.030	134.57	0.030	157.92	0.030	146.11	0.030
Emilia-Romagna	MO	127.92	0.026	130.68	0.025	195.82	0.026	199.10	0.025

Emilia-Romagna	PC	104.58	0.028	101.61	0.028	142.52	0.028	128.27	0.028
Emilia-Romagna	PR	83.49	0.032	86.06	0.032	119.18	0.032	116.01	0.032
Emilia-Romagna	RA	114.16	0.036	113.09	0.036	63.80	0.036	66.17	0.036
Emilia-Romagna	RE	93.92	0.022	93.67	0.022	77.18	0.022	83.10	0.022
Emilia-Romagna	RN	178.27	0.033	180.38	0.033	92.33	0.033	92.67	0.033
Centre									
Toscana	AR	119.62	0.027	118.33	0.027	129.38	0.027	120.60	0.027
Toscana	FI	162.29	0.024	168.85	0.024	184.13	0.024	193.85	0.024
Toscana	GR	142.09	0.026	148.67	0.026	156.13	0.026	158.99	0.026
Toscana	LI	201.83	0.029	204.30	0.029	160.22	0.029	146.04	0.029
Toscana	LU	129.94	0.026	124.29	0.026	88.76	0.026	97.12	0.026
Toscana	MS	188.27	0.073	198.58	0.073	50.67	0.073	50.34	0.073
Toscana	PI	147.70	0.034	149.52	0.034	99.10	0.034	114.70	0.034
Toscana	PO	258.75	0.042	238.66	0.042	127.45	0.042	136.00	0.042
Toscana	PT	130.31	0.031	124.43	0.031	333.13	0.031	302.47	0.031
Toscana	SI	103.08	0.022	110.21	0.022	131.36	0.022	122.41	0.022
Lazio	FR	80.04	0.033	83.79	0.033	123.99	0.033	128.53	0.033
Lazio	LT	144.58	0.019	140.04	0.019	133.63	0.019	123.61	0.019
Lazio	RI	114.13	0.033	105.73	0.033	153.88	0.033	160.07	0.033
Lazio	RM	137.26	0.017	143.13	0.017	225.01	0.017	226.13	0.017
Lazio	VT	110.01	0.023	104.37	0.023	100.00	0.023	100.00	0.023
Umbria	PG	84.62	0.021	84.59	0.021	198.18	0.021	197.21	0.021
Umbria	TR	97.48	0.030	102.63	0.030	131.45	0.030	177.34	0.030
Marche	AN	110.67	0.022	113.08	0.022	109.46	0.022	109.50	0.022
Marche	AP	95.90	0.018	95.55	0.017	108.36	0.018	106.21	0.017
Marche	MC	109.91	0.024	115.70	0.024	95.04	0.024	100.42	0.024
Marche	PS	109.64	0.021	107.79	0.021	166.16	0.021	154.80	0.021
South									
Abbruzzo	AQ	63.15	0.021	65.73	0.021	73.31	0.021	76.23	0.021
Abbruzzo	CH	80.38	0.020	88.63	0.020	86.68	0.020	94.06	0.020
Abbruzzo	PE	97.81	0.024	101.98	0.024	96.36	0.024	94.80	0.024
Abbruzzo	TE	64.10	0.024	69.60	0.024	209.19	0.024	225.56	0.024
Molise	CB	66.47	0.031	73.00	0.031	71.44	0.031	77.35	0.031
Molise	IS	66.20	0.101	73.69	0.101	68.33	0.101	68.50	0.101
Campania	AV	82.01	0.011	73.25	0.011	92.23	0.011	82.35	0.011
Campania	BN	129.85	0.024	133.38	0.024	150.98	0.024	153.66	0.024
Campania	CE	48.80	0.019	53.31	0.019	45.98	0.019	50.13	0.019
Campania	NA	90.21	0.016	100.86	0.016	80.95	0.016	82.73	0.016
Campania	SA	70.43	0.014	70.95	0.014	117.12	0.014	124.05	0.014
Basilicata	MT	49.92	0.032	51.72	0.032	83.49	0.032	92.31	0.032
Basilicata	PZ	62.36	0.018	59.74	0.018	117.46	0.018	116.27	0.018
Puglia	BA	105.90	0.020	105.59	0.020	108.05	0.020	107.58	0.020
Puglia	BR	107.91	0.083	98.65	0.083	124.33	0.083	113.31	0.083
Puglia	FG	69.16	0.025	72.38	0.025	121.13	0.025	122.07	0.025
Puglia	LE	63.07	0.020	60.56	0.020	210.73	0.020	199.01	0.020
Puglia	TA	101.74	0.028	101.95	0.028	60.23	0.028	64.09	0.028
Calabria	CS	75.25	0.020	77.17	0.020	80.74	0.020	82.67	0.020
Calabria	CZ	63.31	0.022	58.03	0.021	74.31	0.022	67.93	0.021
Calabria	KR	51.53	0.042	51.50	0.042	128.19	0.042	120.56	0.042
Calabria	RC	53.12	0.019	56.79	0.018	90.43	0.019	88.37	0.018
Calabria	VV	77.91	0.066	79.18	0.065	100.00	0.066	100.00	0.065
Sicilia	AG	56.48	0.031	56.55	0.031	50.84	0.031	52.16	0.031
Sicilia	CL	47.13	0.038	50.32	0.038	38.45	0.038	40.70	0.038
Sicilia	CT	74.59	0.021	79.59	0.021	76.58	0.021	80.86	0.021
Sicilia	EN	77.82	0.034	78.65	0.034	77.97	0.034	79.56	0.034
Sicilia	ME	80.61	0.020	86.87	0.020	170.53	0.020	153.04	0.020
Sicilia	PA	55.12	0.022	55.42	0.022	87.47	0.022	88.32	0.022
Sicilia	RG	65.08	0.053	69.91	0.052	121.61	0.053	112.68	0.052
Sicilia	SR	76.72	0.034	81.85	0.034	124.82	0.034	121.83	0.034
Sicilia	TP	81.10	0.032	82.87	0.032	96.68	0.032	103.71	0.032
Sardegna	CA	91.00	0.023	89.71	0.023	92.01	0.023	90.49	0.023
Sardegna	NU	57.67	0.028	55.07	0.028	91.69	0.028	120.37	0.028

Sardegna	OR	50.41	0.024	54.34	0.024	58.69	0.024	56.63	0.024
Sardegna	SS	136.40	0.024	137.80	0.024	259.32	0.024	229.40	0.024

Potential uses of spatial price indexes for house rents (SPIHR)

The spatial price index for house rents is under use in the Dagum Centre both for computing comparable "real" salaries in the Italian provinces and for designing policy interventions for housing. Actually, further computations of the *SPIHR* will be done by using the detailed information on all the characteristics of dwellings and at a detailed territorial level, that is for Local Labour Systems (groups of Municipality, more than 600 in Italy). The availability of these new estimates allow more detailed analysis and, above all, they could be used to produce, by Small Area Estimation (SAE) methods, Poverty Maps at very detailed territorial level within Italy adjusted by using *SPIHR* (Simler, 2016; De Azevedo and Rodas, 2018).

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