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A relative measure of urban sprawl for Italian municipalities using satellite Light Images

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Sommario

At the local level, the lower the urban density, the higher the per-capita length of collector roads and the area covered by buildings and infrastructures. It follows that the lower the urban density, the higher the municipal luminosity. For this reason, night-time light is often used in order to evaluate the degree of urbanization and urban sprawl in a specific territory by means of specific indicators. However, to the best of our knowledge, these indicators are based on an absolute evaluation of the urban sprawl, without taking into account the peculiar economic and demographic characteristics of the urban centres.
In this paper we propose a regression-based measure of urban sprawl "relative" to the economic activity and to other socio-demographic characteristics of municipalities. We apply this methodology to the Italian context, considering all Italian municipalities inside the 15 ordinary regions over the period 2004-2012. The measure we propose, thus, takes into account also a time element.

Parole chiave: DMSP OLS, urban sprawl, Italian municipalities.

1. Introduction

Urban sprawl is a phenomenon associated with the rapid low-density outward expansion of cities and it causes low-density development, large outward expansions, and leapfrog growth patterns that are likely to produce a number of negative effect on the economic activity (Clawson 1973). Dating back to the early part of the 20th century, it has been determined by the rapid growth of private car ownership and the preference for detached houses with gardens.

The existing literature shows that, at the local level, high urban density is correlated to small per-capita length of collector roads, water distribution lines, or sewer collection lines and, consequently, the lower the per capita public expenditure in infrastructures (Carruthers and Ulfarsson 2003). Consequently, sometimes national governments choose not to invest sufficiently in internal transport, especially in less populated regions (Henderson and Kuncoro 1996), due to the high cost of provision of infrastructures.

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Urban sprawl has important effects on the industrial sector too. In fact, manufacturing is much more efficient when concentrated in dense business-industrial districts in cities. Furthermore, spatial proximity promotes positive information spillovers amongst producers that make labour markets more efficient. Furthermore, many empirical studies (Capello e Nijkamp 1996, Henderson 1988, Ciccone and Hall 1995, Glaeser et al. 1992) provide evidence on the existence of localized scale externalities.

Urban sprawl may also cause high distortionary local taxes or subsidies. In fact, local taxes or user fees that are generally independent to location, causing remote development to be subsidised (Brueckner 2000, Heimlich and Anderson 2001, Wasserman 2000), often finance the increased cost of infrastructures and public services. Furthermore, high urban density can give some advantages on raising local taxes. In particular, tax compliance is less expensive in the presence of high population density in urban areas. On the other hand, since people live close to their neighbours in big cities' urban setting, informal transaction (tax evasion) become more feasible (Kau and Rubin 1981). It follows that the overall effect of urban sprawl on local revenues is ambiguous.

Urban sprawl may also cause a number of environmental damages. Sprawled development decreases the amount of forest area and woodland (Macie and Moll 1989; MacDonald and Rudel 2005, Hedblom and Soderstrom 2008), fragments farmland's ecosystems and habitats (McArthur and Wilson 1967, O'Connor et al. 1990, Lassila 1999) and finally may be harmful for economic growth (Di Liddo 2015).

Finally, some studies focus on the negative impact of urban sprawl on the infrastructure cost of provision within the national area (Burchell et al. 2005).

In fact, transport savings due to high urban density are a central topic in the new economic geography literature (Fujita, Krugman, and Venables 1999).

In Europe, cities have traditionally been much more compact than in the US, developing a dense historical core shaped before the emergence of modern transport systems. Compared to most American cities, their European counterparts remain in many cases compact. However, European cities were more compact and less sprawled in the mid-1950s than they are today, and urban sprawl is now a common phenomenon throughout Europe. The new sprawling nature of Europe's cities is critically important because of the major impacts that are evident in increased energy, land and soil consumption. For this reason, in recent times, the containment of urban sprawl is an important topic in the political agenda of many national government across Europe.

Differently to other European countries, for some reason, the urban sprawl in Italy is not seen as a negative phenomenon (Gibelli and Salzano 2006).

In fact, Italy is characterized by a lack of coordination in planning policies aimed to harmonize the urban expansion and the farmland use (Di Iacovo et al. 2010) and uncontrolled urban expansion and land use are causing serious damages to the specific public functions of the farmland, such as food production; land fertility; water cycle etc. (Rovai et al. 2010). In addition, Italian 'dispersed cities' are characterized by air pollution generated by cars, traffic congestion and demand for transport infrastructures (Camagni et al. 2002).

Furthermore, in Italy, new urban areas are "outward oriented", while the old existing urban system is "inward oriented". The result is a system of highly "dispersed cities" (Calafati 2003). A clear example of the Italian outward oriented urban sprawl is provided (Turri 1990, 2004) by the river Po' Valley characterized by a very complex network of small-medium urban centres not contiguous but strictly interconnected (see Fig. 1). [1]

This lack of interest in planning policies is unjustified. In fact, the Italian National Institute on Environmental Research (ISPRA) shows that in Italy, during the period 2000 - 2006, peripheral and sub-urban areas increased four times faster than city centres (ISPRA 2013). This trend is in contrast to what is happening in the rest of Europe (EEA 2010). In addition, the "Land Use and Cover Area frame Survey" of Eurostat (Eurostat 2013) shows that the percentage of soil covered by artificial activities (buildings, roads, housing, recreation and open pit mining) is about the 7.8% of the national territory, while the European average is the 4.6%. More precisely, Italy is ranked at the fifth position among European countries, after Malta (32.9%), Belgium (13.4%), Netherlands (12.2%) and Luxembourg (11.9%).

Galster et al. (2001) argue that sprawl as a process should be distinguished from the causes that bring such a process about. This statement clearly says that analysis of the pattern and of the process should be differentiated from the analysis of the causes. Furthermore, impacts of development present a specific development patterns as undesirable, not the patterns themselves (Ewing 2008).

Figure 1: Satellite image of Italy (NASA).

According to Bhatta (2010), the causes of urban sprawl are quite similar with those of urban growth and, in most of the instances, we can not discriminate them since urban growth and sprawl are highly interlinked. Some of the causes, for example population growth, may result in coordinated compact growth or uncoordinated sprawled growth. Whether the growth is good or bad depends on its pattern, process, and consequences. Some causes are especially responsible for sprawl because they can not result in a compact neighbourhood (for example, country-living desire), others may result in either compact growth or sprawled growth. That is, population growth, economic activity, number of family nucleus and other geographical factors (Bhatta 2010).

[1] The image in Fig. 1 is in the public domain because it is a detail of an image solely created by NASA. NASA copyright policy states that "NASA material is not protected by copyright unless noted". See http://www.jsc.nasa.gov/policies.html#Guidelines for further details.

The aim of this paper is twofold. From a methodological point of view, using data provided by the US Defense Meteorological Satellite Program's Operational Linescan System (DMSP OLS) on Night-time Light Images, we propose a regression-based measure of urban sprawl "relative" to the economic activity and to the other factors listed above that may lead to urban sprawl due to their nature. In practice, we aim to measure the degree of urbanization that exceed that predicted by our regressions. We interpret this "excess" in term of urban dispersion that is not correlated to the presence of some specific causes cited above.

To the best of our knowledge, it is the first attempt to compute an index of urban sprawl "relative" to the economic characteristic of urban centres instead of an "absolute" measure that takes into account only the dispersion of cities computed without taking into account the "normal" degree of dispersion due to the economic nature of the single municipalities.

Furthermore, since there is still a lack of empirical estimates on the degree of urban sprawl for a large sample of Italian municipalities, we apply the computation of our measure to the Italian context, considering all Italian municipalities inside the 15 ordinary regions[2] over the period 2004-2012.

The rest of the paper is organized as follows: section 2 provides a brief literature review on urban sprawl measures based on DMSP OLS Night-time Light Images, section 3 presents the data and the empirical strategy, section 4 shows the main results, and section 5 concludes. The appendix contains the full results of our estimates.

2. Urban development and urban sprawl measurement

Despite the wide literature on the *effects* of urban sprawl, there is no unanimous consensus on the exact *definition* of urban sprawl and its *measurement* using statistical data.

Whyte (1958) firstly defined urban sprawl as ''the leapfrog nature of urban growth'', others have defined urban sprawl basing simply on the aggregate population density of a given urban area (Fulton et al. 2001, Kolankiewicz and Beck 2001). These aggregate measures of sprawl suffer from at least two problems: problems associated with measurements of the areal extent of an urban area, and the nonlinear variation of the aggregate population density of urban areas as a function of total population (Sutton 2003).

In order to evaluate urban sprawl for a large number of urban areas, starting from the late 90's, a number of studies made use of night-time satellite imagery. Data are usually provided by the US DMSP OLS, to measure the areal extent of the urban area in different ways (Imhoff et al. 1997, Small et al. 2005), in general making use of regressions of the light intensity vs. population relationship (Sutton 2003, Zhang and Seto 2011).

A number of studies (Chen and Nordhaus 2011, Doll et al. 2006, Elvidge et al. 2012) have confirmed the positive correlations between DMSP OLS night-time light data and socioeconomic variables at regional to global scales. It follows that the main difficult with the use of night-time light is to jointly evaluate the impact of demographic (population size) and economic (economic activity, income etc.) variables on the

[2] Besides the Central Government, the local tiers of government in Italy are ordinary and special Regions, Provinces and Metropolitan Cities, and Municipalities.

brightness of a given region, in order to estimate the degree of urban dispersion in a given area.
However, one problem associated with using the night-time satellite imagery as a proxy measure of urban extent is the question on what light intensity should be used to characterize an area as urban (Sutton 2003).
Ma et al. (2012) used weighted light areas, using DMSP OLS images for China's cities from 1994 to 2009. Weighted light area is defined as the weighted sum of areas of lit pixels multiplied by the normalized annual visible band digital numbers (DN) value.[3] For a given city, all pixels spatially contained within the administrative boundary of the city have been collected by overlaying the administrative unit map onto DMSP OLS images based upon a uniform geo-reference system. Weighted light area are then calculated by summing corrected pixel areas multiplied by the normalized DN. These data have been used in OLS regressions using population, GDP, urban land cover and electric power consumption as dependent variables in order to test the correlation between urban brightness, population and economic activity.
In order to estimate urban areas, the use of night-time light brightness as urbanization parameter for a given region has been also used counting the area covered by lit pixels (i.e. the area of lighting) or summing total radiances of pixel light (i.e. the sum of night-time radiance) exceeding the pre-chosen threshold (Zhang and Seto 2011, Zhou et al. 2015, Gao et al. 2016). This technique enable to examine overall responses of night-time light to urban development. For our purposes, in our empirical investigations we adopt a similar dependent variable, the total night-time light brightness of the municipal surface. The exact definition will be provided in the next section, regarding data and empirical strategy.

3. Data and empirical strategy

In order to construct our dependent variable, the degree of urbanization of Italian municipalities, we employ high-resolution data on night-lights intensity measured by satellites at night. These data come from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (US Department of Commerce) and we use the "Average Visible, Stable Lights, and Cloud Free" images taken from two satellites: F16 for the years from 2004 to 2009 and F18 for 2010 to 2012. The luminosity of each municipality is computed taking the average luminosity (DN) of all pixels corresponding to the surface of the municipality. We then multiply the average luminosity to the municipal surface of each municipality in order to obtain the total luminosity of each municipality, or dependent variable.[4]

The econometric specification follows equation (1):

$$(1) \qquad L_{it} = \beta X_{it} + \gamma Z_{it} + \delta M_{it} + \alpha_i + \varepsilon_{it}$$

where *L* is the total municipal luminosity and the vector *X* includes the economic and demographic variables that influences the total luminosity (urbanization) of each municipality, i.e. the natural logs of municipal population, average income, and

[3] The satellite images are composed of grid-based annual visible band digital numbers ranged from 0 to 63 with spatial resolution of 30 arc-seconds (approximately 1 km at the equator and 0.8 km at 40°N).
[4] Data on municipal surface are provided by the Italian Institute of Statistics at: https://www.istat.it/it/archivio/82599

residential estate market value. Vector *Z* includes context variables, that can be time-varying or time-invariant, that also include, among others, time dummies and territorial dummies for each Italian region. Variable α_i is the municipal fixed eff ect, while ε_{it} is the idiosyncratic error component.

We have estimated a random effect model by Feasible Generalized Least Squares (FGLS) estimator with the Mundlak (1978) correction in order to avoid the problem of possible correlation between the explanatory variables and the error term. As a consequence, we have included among the regressors the vector *M*, i.e. the mean of each time-varying variable that have been assumed to be correlated with the unobserved heterogeneity α_i. This correction provides an indication of the relative contribution of each variable to the overall fixed effect.

Although our coeffcients' estimates are mathematically equivalent to those obtained from a fixed effect model (using, for example, a within-the-group estimator), with the Mundlak approach we can estimate the impact of time invariant variables.

Table 1 shows the main descriptive statistics of the variables included in our regressions.

The evaluation of the urban sprawl of each municipality has been obtained by means of a *Relative Measure* of the Urban Sprawl (RMUS) that corresponds to α_i, the municipal fixed effect, that represents the amount of luminosity that is not explained by the regressors included in equation (1) and that represents the urbanization "unjustified" by the demographic, geographic and economic parameters of each municipality. Note that a positive (negative) value of α_i indicates that the municipality *i* is above (below) the regression line and then more (less) sprawled than expected due its economic, geographic and demographic characteristics.

Table 1 - Regression sample, descriptive statistics. Years 2004-2012.

VARIABLE	***N***	***MEAN***	***SD***	***MIN***	***MAX***
AVERAGE LUMINOSITY	59,119	0.63	1.24	0.00	70.96
POPULATION	59,119	7,570.32	43,540.78	31.00	2,761,477.00
TOTAL INCOME - EURO	59,119	103,222,743.54	784,301,757.28	0.00	4,950,7852,288.00
RESIDENTIAL ESTATE MARKET VALUE - EURO SQM	58,591	1,146.39	574.64	0.00	12,082.00
RATIO FAMILIES/POPULATION	58,849	0.58	8.44	0.00	494.17
MUNICIPAL AREA - 1,000 SQKM	59,119	0.03	0.05	0.00	1.29
ALTIMETRIC SCALE	59,119	2.92	1.54	1.00	5.00
RELIEF DEGREE	59,119	1.89	0.95	1.00	3.00
MOUNTAIN SURFACE - (HA)	59,119	17.20	33.08	0.00	525.08
SISMIC RISK	59,119	2.74	1.24	1.00	5.00

4. **Results**

Table 2 shows the detail of the coefficients point estimates of the model described by equation (1), regarding our variables of main interest. As we can see, we estimate positive and statistically coefficients associated to the natural logs of municipal population, average income, and residential estate market value.

Table 2 - Coefficients point estimates. Dependent variable: total municipal luminosity. FGLS estimator with Mundlak correction.

VARIABLES	
Log population	0.013877***
	(0.002)
Log average total income - real euro	0.002719**
	(0.001)
Log residential estate market value (real euro/sq.meter)	0.035685***
	(0.006)
Observations	58,313
Number of municipalities	6,588

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Column 1 of table 1A in appendix reports the whole results of our estimates. As we can see from table 1A, the municipal area and relief degree are positively correlated to the total municipal luminosity, while the mountain surface and the altimetric scale are negatively correlated to luminosity.

Table 1A also reports rubustness checks of our estimates. In particular, column 2 reports coefficients point estimates obtained restricting the regression sample to the sole capitals of Italian regions, and column 3 reports results excluding capitals from the regression sample. As we can see, in both cases results remains qualitatively the same.

Table 3 provides the estimates of RMUS for Italian capitals of Regions, all capitals register a positive value of RMUS, i.e. the municipal fixed effect, i.e. are more sprawled than the average. Furthermore, Perugia, Venice and Roma are the most sprawled capital cities in our sample, while Catanzaro, Ancona and Campobasso are at the bottom of the ranking.

Table 3 – RMUS estimates for Italian capitals of Regions – Year 2012.

Capital of Region	**RMUS**
Campobasso	1.02
Ancona	1.14
Catanzaro	1.99
Bologna	2.95
Genoa	2.93
Florence	2.93
Naples	2.98
Potenza	2.82
Turin	3.21
Bari	3.39
L'Aquila	3.52
Milan	5.21
Perugia	5.33
Venice	8.36
Rome	31.32

Table 4 provides descriptive statistics of RMUS and RIUS for the full sample of municipalities of ordinary regions. Furthermore, it provides statistics for the subsamples constituted by the capitals of Italian provinces and the remaining municipalities, respectively.

As we can see from table 4, the capitals of the Italian provinces are more sprawled than other municipalities, with an average RMUS equal to 1.56 against the -0.02 of the other municipalities. It is apparent that capitals of provinces, usually the biggest Italian cities, are the more sprawled on average.

Table 4 – RMUS and RIUS estimates: descriptive statistics.

VARIABLE	OBS.	MEAN	SD	MIN	MAX	MUNICIPALITIES
RMUS	58,313	-0.00	0.64	-7.68	31.32	Full sample
RMUS	780	1.56	3.75	-5.73	31.32	Capitals of the provinces
RMUS	57,533	-0.02	0.44	-7.68	2.51	Other municipalities

We can now compare our results to those provided by the Italian National Institute on Environmental Research (ISPRA) by means of four measures of urban sprawl computed using GIS software. In particular, ISPRA (2015) reports[5] the levels of the measures listed in Table 5, computed for year 2012, for the Italian regional capitals.

We use data reported in table 5 to compute correlations (Table 6) and rank correlations (Table 7) between RMUS and the sprawl measures provided by ISPRA (2015).

Table 5 – Sprawl measures provided by ISPRA (2015), for the Italian regional capitals for year 2012.

MEASURE	DESCRIPTION
LCPI	Largest Class Patch Index equals the area of the largest patch of the corresponding patch type divided by total landscape area, multiplied by 100 (to convert to a percentage); in other words, LCPI equals the percentage of the landscape comprised by the largest patch. It is an indicator of **density**.
RMSP	Residual Mean Patch Size equals the average area of all patches excluding the largest one. It is an indicator of **fragmentation** around the central patch.
ED	Edge Density is the ratio between the sum of the perimeters of all patches and their surfaces. It is an indicator of **fragmentation** around the borders.
IUD	Index of Urban Dispersion – Ratio between high-density areas and the total area. It describes the **dispersion** trough the variation of the urban density.

Table 6 – Correlations of RMUS, RIUS and sprawl measures provided by ISPRA (2015). Year 2012.

	RMUS	LCPI	ED	RMPS	IUD
RMUS	1				
LCPI	0.0413	1			
ED	-0.0219	-0.3387	1		
RMPS	0.0256	-0.3263	-0.3486	1	
IUD	-0.0983	-0.1778	-0.1413	0.2123	1

[5] Data are available online for the full sample of Italian municipalities at: http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/consumo-di-suolo

Table 7 – Rank correlations of RMUS, RIUS and sprawl measures provided by ISPRA (2015). Year 2012.

	RMUS	LCPI	ED	RMPS	IUD
RMUS	1				
LCPI	-0.0022	1			
ED	0.0602	-0.3194	1		
RMPS	-0.0662	-0.5062	-0.3575	1	
IUD	-0.1249	-0.2625	0.2264	0.1185	1

Looking at Table 6 we can see that all measures computed by ISPRA (2015) and our measure RMUS result to be uncorrelated. Furthermore, we can note that LCPI, ED, RMPS and IUD are not correlated to each other. Similar results are obtained looking at the rank correlations reported in Table 7. All measures considered show small rank correlations.

These results suggest that each measure computed by ISPRA (2015) and our "relative" measure of urban sprawl capture different aspects of the general phenomenon of urban dispersion and do not provide redundant information. On the contrary, they could be used jointly in order to evaluate the actual degree of urban sprawl in the Italian context.

5. Conclusions

The existing literature (Bhatta 2010) underlines that many variables are correlated to both urban growth and urban sprawl and there is need to sprawl measures that isolate the sprawl phenomenon from the normal urban growth process due to population growth, economic activity, and other geographical variables.

In this paper we have used regression analyses on a large sample of Italian municipalities in order to estimate a "relative" measure of urban sprawl that tries to isolate the effect, on the urban growth pattern, of the demographic and economic characteristics of Italian municipalities. We apply this technique to panel data over the period 2004-2012 and we compare the resulting measure to the "absolute" measures provided by the Italian Institute for Environmental Protection and Research in order to evaluate the contribution of our measure to the knowledge of the sprawl phenomenon. As a result, we obtained that our measure is not correlated to the sprawl measures provided by ISPRA (2015), suggesting that it captures different aspects of the phenomenon.

Despite this fact, we obtain that the capital of the Provinces are more sprawled than the rest of Italian municipalities, in line with other studies of ISPRA (2017) that use absolute measures of urban sprawl (the soil consumption).

Furthermore, our results show that, among Italian regional capitals, Rome is the more sprawled city, followed by Venice, Perugia and Milan. Instead, the less sprawled capitals are Campobasso, Ancona, Catanzaro and Bologna.

As a policy implication, our conclusion is that the focus of future land policies aimed to contain the urban expansion of Italian cities should be on the main municipal centres that appear to be - on average - the most sprawled municipalities, even taking into account their socioeconomic characteristics that are naturally linked to a greater urban growth.

It is important here to underline that the biggest cities, that in Italy coincide with the capitals of Italian provinces, are characterized by higher demand of public transport and that the efficiency of public transport system, combined with the right mix between job and population density, can be useful in order to minimize settlement development in the suburbs (Ambarwati et al. 2014, Capozza 2015).

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APPENDIX

Table 1A - Coefficients point estimates. Dependent variable: total municipal luminosity. (FGLS) estimator with Mundlak correction

VARIABLES	1	2	3
Log population	0.013877***	0.021512	0.008254***
	(0.002)	(0.035)	(0.002)
Log average total income - real euro	0.002719**	12.006437***	0.002946***
	(0.001)	(1.559)	(0.001)
Log residential estate market value (real euro/sq.meter)	0.035685***	0.072004	0.037557***
	(0.006)	(0.263)	(0.005)
Ratio families/population	0.000276***	0.044777	0.000169**
	(0.000)	(0.037)	(0.000)
Log population (average)	0.025506	0.197146	0.140348***
	(0.031)	(1.465)	(0.015)
Log average total income (average)	0.173966***	-10.341517***	0.076474***
	(0.029)	(2.165)	(0.014)
Log residential estate market value (average)	0.083458***	2.418744	0.018912
	(0.031)	(1.546)	(0.015)
Ratio families/population (average)	0.002737	0.389137	0.002663**
	(0.002)	(1.549)	(0.001)
Municipal area - 1,000 squared km	24.996131***	32.770501***	12.165214***
	(0.251)	(2.445)	(0.166)
Altimetric scale, 1 = low	-0.025540***	-0.100992	-0.021582***
	(0.009)	(0.369)	(0.004)
Relief degree, 1 = low	0.197941***	1.626378*	0.075583***
	(0.015)	(0.870)	(0.007)
Mountain surface (ha)	-0.018715***	-0.023039***	-0.007587***
	(0.000)	(0.008)	(0.000)
Sismic risk, 1 = low	0.020001	-0.066823	0.004352
	(0.013)	(0.536)	(0.006)
2005	-0.028922***	-0.321866***	-0.027235***
	(0.002)	(0.092)	(0.002)
2006	0.016201***	-0.377430***	0.014721***
	(0.002)	(0.109)	(0.002)
2007	0.078056***	-0.107893	0.072166***
	(0.003)	(0.119)	(0.002)
2008	0.064596***	-0.027270	0.060131***
	(0.003)	(0.105)	(0.002)
2009	0.062861***	0.059681	0.059882***
	(0.002)	(0.094)	(0.002)
2010	0.240655***	0.956457***	0.226965***
	(0.002)	(0.097)	(0.002)
2011	0.139296***	0.596219***	0.130028***
	(0.002)	(0.093)	(0.002)
2012	0.205020***	1.333217***	0.191398***
	(0.002)	(0.089)	(0.002)
Lombardia	-0.071525***	-0.718143	-0.106630***
	(0.027)	(1.348)	(0.013)
Veneto	-0.004243	0.392781	0.050935***
	(0.038)	(1.557)	(0.019)
Liguria	-0.114983**	-1.835766	-0.109204***
	(0.048)	(1.827)	(0.023)
Emilia-Romagna	-0.282334***	-1.468026	-0.003870
	(0.047)	(1.679)	(0.023)
Toscana	-0.639969***	-2.568184*	-0.213673***
	(0.048)	(1.434)	(0.024)
Umbria	-0.119200	1.358815	0.039617
	(0.078)	(2.662)	(0.038)
Marche	-0.069240	1.038601	0.021791
	(0.055)	(1.973)	(0.027)
Lazio	-0.070291*	1.633826	-0.014267
	(0.040)	(1.869)	(0.019)
Abruzzo	0.019490	1.527854	0.059820**
	(0.052)	(2.046)	(0.025)
Molise	-0.111844*	1.077092	-0.045160
	(0.068)	(2.640)	(0.033)
Campania	-0.070326	0.083153	-0.083631***
	(0.049)	(2.105)	(0.024)
Puglia	-0.423089***	-1.233340	-0.004566
	(0.052)	(1.649)	(0.026)
Basilicata	-0.531500***	-2.136829	-0.237288***
	(0.072)	(3.258)	(0.035)
Calabria	-0.200045***	1.377892	-0.152985***
	(0.056)	(2.194)	(0.027)
Constant	-4.402813***	-56.977993***	-2.743963***
	(0.314)	(15.531)	(0.154)
Observations	58,313	780	57,590
Number of municipalities	6,588	88	6,500

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1