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The cost of sprawl: an Italian case study

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The cost of sprawl: an Italian case study
Laura Fregolent, Stefania Tonin

By

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Abstract

In this paper we describe and analyze an Italian case of urban sprawl and its urban growth for understanding the development of a “metropolitan sprawled system”. The portion of Veneto Region that is part of our case study covers about 3700 square km, for a total of 145 municipalities. The main aim of our paper is to find out if low-density development patterns are more expensive and if local public spending is influenced by different urban forms expansions. We measure sprawl with some indicators suggested by the literature such as urban density, population density and the territorial fragmentation.

Data for the economic analysis come from local balance sheets of 145 municipalities for the year 2007. In particular, we collect the costs of the main public services sustained by the municipalities such as public transport, road and street maintenance, waste management, and water and sewer services. Adopting regression analysis, we estimate the impact of urban sprawl on different current expenditures, controlling for other variables such as local taxes paid by citizens, central government aids, territory characteristics, and more others.

We find that low density development patterns are in general more expensive, in particular when municipalities have to provide education services, solid waste collection and other environmental and urban management services.

Our analysis wants to highlight the threats posed by sprawl in terms of urban sustainable development patterns and to put in evidence the costs of an unbalanced growth in order to let public government to re-orient their policies versus the containment of the urban growth process.

Keywords: urban sprawl, local public spending, regression analysis

1. Introduction and Motivation

Urban sprawl is characterized by low density, unlimited peripheral extension of new development, spatial segregation of different types of land uses through zoning regulations; leapfrog development, non centralized ownership of land or coordinated planning of development, private-car dependence, fragmentation of governance authority over land uses between many local governments, great variances in the fiscal capacity of local governments, and widespread commercial strip development along major roadways (Burchell et al., 1998).

It is commonly argued that low-density development patterns result in a higher cost of providing public infrastructure such as road, public transportation, water and sewage systems, solid waste collection and police protection, to mention just a few.

Given that previous empirical analysis on this issue are scarce and are generally focused on the US case studies, we want to contribute to the existing literature and provide evidences for the Italian situation.

The case study area covers an area of about 3,700 square km in Veneto Region and it is composed by 145 municipalities, which are part of the administrative provincial territory of Padua, Treviso, Venice and Vicenza. These four territorial areas are quite similar in social composition and economic growth and are recognized as part of the industrial and developing model, "Italian Northeast phenomenon", also called by many people "the Italian locomotive".

Our study aims to analyze how urban development, especially low-density urban pattern, affects the costs of public services provision. Generally, the increasing of built-up areas, together with rapid dynamics on population, raise the requirement for infrastructure investments, social services and other facilities to support the current and the projected needs; costs that are mostly borne by local government. If the urban development is poorly planned, scattered and disorganized these costs can be even higher creating troubles on the local spending capacity of municipalities.

Figure A1 in the Appendix shows how in Central Veneto Region built-up land area increased very fast in the last forty years. The entire area, on average, between 1970 and 2007 experimented an increase of almost 130% of built-up land, while in general the population

increase on average only by 17%. Caution must be used when interpreting this data. First of all because data related to built environment in 1970 derive from GIS elaboration made with the available cartographies of the selected areas (IGM), while more precise georeferenced data on land use are available for the year 2007 (Regione Veneto, 2009). Second of all, in the last 40 years, the whole area has experimented profound structural, morphological and economic changes that cannot be understood only through basic estimates on urbanized land but have to be well analyzed taking into account the distribution of the built-up areas, the different type of urbanization and the dynamics of population and economy.

To carry out our analysis, we collect the municipalities' balance sheets for the 145 municipalities of the Veneto area. In particular, we analyze the costs of the main public services sustained by the municipalities such as public transport, road and street maintenance, waste management, and water and sewer services.

This paper introduces empirical results obtained by implementing regression analysis. We estimate the impact of urban sprawl on different current expenditures, controlling for other variables such as local taxes paid by citizens, central government aids, territory characteristics, and others. We find evidence that low density urban development is more expensive for public government than compact development, and that municipalities can realize economy of scale in some areas of spending such as education, solid waste collection and environmental and urban management, where population density can substantially affect cost savings.

In the next Section we present an overview of the urban dispersion phenomenon in Veneto Region and we discuss some results of previous studies. Next, we provide a brief literature review of sprawl costs, and in Section 3 we illustrate the case study in more details. Section 4 describe the basic features of the data gathered and the construction of urban sprawl variables included in the regression equations and Section 5 explains our empirical models and the main results obtained. Finally, in Section 6 we discuss the main conclusions.

2. Urban sprawl in Veneto

Urban dispersion is a relatively recent phenomenon, both in the Italian and in the European contexts. Initially, traditionally compact historical cities were characterized by a progressive

growth of their outskirts around compact nucleuses, but only recently urban sprawl has become quite pervasive.

The term sprawl has often been associated with phenomena such as “diffusion”, “dispersion”, “peripheral-urbanization”, “éparpillement”, ignoring the different origins (social, cultural, economic, historical), the various evolutionary factors (agricultural, industrial, urban), and the different life models that determine dissimilar uses of territory, as well as various formal and morphological manifestations of the built environment. Moreover, the Anglo-Saxon taxonomy and the interpretative parameters are used to explain many phenomena of (sub-) European urbanization, even if the characteristics are really different.

Urban sprawl is characterized by low-density, suburban style development patterns that have been the dominant model of growth in the United States over the last 50 years. A working definition that has emerged in the urban planning literature is “unplanned, uncontrolled, and uncoordinated single use development that does not provide for a functional mix of uses and/or is not functionally related to surrounding land uses and which variously appears as low-density, ribbon or strip, scattered, leapfrog, or isolated development” (Nelson et al., 1995; Pendall, 1999). Other important characteristics of sprawl include dominance of transportation by private automobiles, fragmentation of powers over land use, and large fiscal disparities among individual communities (Burchell 1998, Downs 1999; GAO 1999, Brueckner 2000).

Together, these features accelerate the spatial expansion of metropolitan areas by creating discontinuous and land use patterns and low overall urban densities (Ewing 1997). Despite these seemingly straightforward characteristics, sprawl remains a difficult concept because it is often a matter of degree, depending on the age, economy, population, and other circumstances of the urban area in question.

Many researchers note that there is a lack of a single, clear and quantitative definition of urban sprawl (Burchell et al., 1998; Ewing et al., 2002; Galster et al., 2001) and this issue contributes to the difficulty of comparison among different geographical contexts.

The Italian case of the Veneto “*città diffusa*” (Indovina, 1990) is a distinguishing example in the field of urban sprawl. The Venetian “*città diffusa*”, the heart of our research area, is distributed on a territory of around 1000 square km with over 50 municipalities belonged to four Provinces (Padua, Treviso, Venice and Vicenza). The low-density cities, defined as “*città diffusa*”, have been studied since 1980, even if the phenomenon began to develop early, during the 1970's. It

has been identified and codified not merely as urban sprawl because it has assumed the economic and social characteristics typical of a city but the form and morphology of a non-city.

Thus, it presents a new territorial model in which social and economic relationships are similar to traditional compact city but the formal and morphological characteristics are completely “new”.

It continues to evolve although the territorial, formal, social and economic qualities are not necessarily homogeneous. The diffusion of residential buildings, services and productive activities of small and medium size companies, which are the model of the Veneto’s economic boom, has taken place within a climate of total indifference toward the structure’s location generating a complex *mixité* of function and interrelations, which are specific characteristics of this urban context. People and human activity have increasingly moved to the “città diffusa”, where the automobile has created rhythms, levels of mobility and commuter patterns that provoke congestion and intensive use of territory: the low density “città diffusa” requires that those who every day must travel for work, study, pleasure, and to reach essential services can move easily.

This specific form of low-density city can be explained by different factors that developed over the past 30 years and which were accelerated thanks to a progressive transformation of the economy of the entire Veneto region and especially of the “città diffusa” and of the study area that we will describe later on. The urban model described offered to people some “immediate advantages” that responded to people’s desires, it was more economically attractive and less restrictive regarding a rational use of the territory.

The Veneto model of development was greatly due to social and cultural features that resulted from very rapid changes in the area’s social structure, to its long history of individual autonomous communities, to the sudden passage from an agricultural to an industrial economy, and the political and normative decisions taken by different political levels.

The poverty and the economic backwardness that had forced Italians to emigrate after World War II to other European countries, had disappeared and with it, a model of social organization that had characterized this region until the late 1960’s. The change, seen from today’s point of view, was not always an improvement of the economy and the society, but also a radical urban and territorial transformations and the beginning of the urban sprawl with a significant increase of built environment and consumption of natural resources.

The average family wished to build its own little house on a lot, with a small lawn or garden; during the 1980's the predominant model was a duplex or triplex often of poor architectural quality, but which satisfied the desire for green area, it has adequate sizes and accessible costs, it is far from the city.

The car became the focus of the new territorial model and the new style life, as happened in US.

In a second phase, from 1990 to 2007 there is a new phase: some important planned infrastructures (Corridor V; high speed trains; highway in Mestre), some important projects (Veneto city; Fashion City; Quadrante di Tessera) but also the planning solutions adopted by the municipalities starting to transform the area. There is a new phase of urban growth: new constructions are encompassing what were once isolated homes and small conglomerations of buildings, forming a connective tissue that suggests the forms and character of a truly metropolitan system.

3. Key Concepts and Previous Literature on sprawl costs

A lot has been written about the causes, the consequences and the negative aspects of urban sprawl but little attention has been devoted to its costs, especially to its impact on local government expenditures. Empirical evidence regarding the economic consequences of sprawl is limited and uncertain (see for example Carruthers and Ulfarsson, 2003, 2006; Ladd, 1992, 1994; Hortas-Rico and Solè-Ollé, 2010).

To this extent, this paper aims to contribute to the empirical literature that examines the impact of urban development on local government budget. Intuitively, we are ready to state that urban sprawl determines larger public costs in terms of infrastructure, management and maintenance but little is known about the real relationship between urban form and the cost of the services.

Previously, scholars have adopted theoretical or engineering approaches to investigate how alternative urban development patterns affect the cost of providing roads, sewers, transports, water systems and other public services to communities located far away the central city. Most of them find that low-density developments are expensive. For example, the most famous of these studies is certainly that of the Real Estate Research Corporation (RERC, 1974). This study aims to calculate the different costs applied to different development patterns, and it indicates whether

the costs are incurred publicly or privately. The research is an investigation of “prototype development patterns, not of actual developments, although many of the data were obtained from empirical studies” (RERC, 1974).

RERC concludes that the three planned development patterns, consisting of higher densities, more diverse dwelling types, and more contiguousnesses, reduce the public infrastructure cost of having 10,000 new units by 47%. Five hypothetical new communities, composed by six different neighbourhood types, ranging from single-family houses to high-rise apartments, were compared to calculate their costs. This research shows that providing the infrastructure to high-density planned development costs about half as much as the cost necessary to develop low-density sprawl (\$5,167 in 1973 dollars vs \$9,776) (Muro and Puentes, 2004).

The RERC study was criticized for different causes, mainly because it is not based on a theoretical analysis and in the same time is not an actual experience. Moreover, the study fails to isolate density and planning from other important sources of variation in development costs or impacts, particularly floor area (Windsor, 1979).

Later, Frank (1989) reviews the literature on the costs of alternative development patterns by examining the main studies that influenced the debate on the cost of sprawl. He concludes that it costs more to service homes in low-density developments located far from public service centers. In fact, the per-dwelling-unit cost of providing streets, sewers, water systems, storm drainage and schools to new residents varied sharply from \$20,300 (1987 dollars) in the densest, most centralized location to \$92,000 for houses 10 miles from central facilities on 1 dwelling unit-per-four acres ‘estate’ zoning” (Muro and Puentes, 2004).

In two different reports, Burchell et al. (1998; 2002) present a comprehensive review of sprawl literature, they highlight all the main costs of benefits of sprawl, providing also their own estimate on sprawl costs. They calculate that sprawl would result in \$227 billion in additional costs for uncontrolled vs controlled growth. Uncontrolled growth leads to greater costs for land consumption and physical infrastructure and creates fiscal costs that exceed revenue. Moreover, the auto dependence of sprawl development increases the private travel costs, both in economic terms and time consumed.

Finally, Speir and Stepherson (2002) simulate engineering cost models for public expenditures on water and sewer system. Under certain hypotheses, such as a hypothetical medium-size town of

30,000, an area with a flat topography, and an average of 3.5 people for each house, they assume that the existing water and sewer services would be expanded to 3,000 new single-family detached houses developing 60 different scenarios. The study confirms the findings of previous research in the field that “smaller lots, shorter distances between existing centers, and lower tract dispersions reduce water and sewer costs”.

These engineering-type studies, though very well designed, estimate costs for hypothetical developments of differing densities and other characteristics without considering the actual costs sustained by local governments. Moreover, uncertainties exist regarding the appropriate use of cost concepts and measures, and regarding the quality level and technology considered when estimating the different situations.

Another different set of studies has adopted regression analysis approach for investigating the relationship between sprawl or population and urban density, and public sector costs. One of the first studies to our knowledge is Ladd (1992). Ladd wants to demonstrate that increased density affects per capita public spending. Her idea is that higher density could increase per capita spending because more services are to be provided by public than the private sector, but an opposite force would work reducing per capita costs because of economies of densities in the production of the public services. She utilizes cross-sectional model based on data on spending by local governments in 247 US counties. Ladd estimates three different equations for three different categories of spending: total current operations, capital outlays and public safety using a piecewise linear regression. She finds that population density exerts a U-shaped impact on current account spending. At very low levels of density, lower than 250 people per square mile, population density shows a decrease in public safety spending. But at higher levels, the costs show an increase.

A review study by McGuire and Sjoquist (2002) describes very well, though in qualitatively terms, the potential impacts of sprawl on state and local government finances. Among the major impacts described, are the increased cost of providing public infrastructure, increased operational costs, impacts on the level and geographic distribution of property tax bases, and impacts on quality of life.

More recently, Carruthers and Ulfarsson (2003) analyze how characteristics of urban development affect twelve categories of public expenditure in a cross section of 283 metropolitan US counties during the period 1982 – 1992. The analysis evaluates how density, spatial extent of

urbanized land area, property value, and political fragmentation affect the cost of services. Contrary to the work of Ladd, their empirical analysis show that the per capita cost of most services declines with density and rises with the spatial extent of urbanized land area, indicating that urban sprawl undermines cost effective provision of public service and contributes to support planned growth management or smart growth strategies.

Similarly, Cox and Utt (2004) examine the actual data on municipal expenditures deriving from the database of the United States Bureau of the Census for the year 2000 for more than 700 municipalities. They estimate a regression model for explaining the relationship between local expenditures and some explanatory variables such as population density, crime rate, total of state and federal aid per capita, property values, etc. Results of their analysis demonstrate that the “actual data indicate that the lowest expenditures per capita tend to be in medium- and lower-density municipalities; medium- and faster-growing municipalities; and newer municipalities”.

In Europe, to our knowledge, very few examples of this kind of analysis exist. For example, in Italy, Camagni et al. (2002) and Travisi et al. (2009) have provided an estimate of collective costs of sprawl investigating the impact of different urban forms on land consumption and on urban mobility. The results of the analysis prove that low density, recent urbanization development and residential specialization are associated to higher environmental impact of mobility.

Analogous to our research objective, Hortas-Rico and Solè-Ollè (2010), investigate the impact of urban sprawl on the costs of providing local public services in Spain. They estimate a series of different aggregate and disaggregate local public spending functions that can be more influenced by urban sprawl, regressed to a set of accurate exploratory variables. Their results indicate a non linear impact of low-density pattern on the costs of providing public services. Moreover, economies of scale for certain public services are not realized by more spatially extensive urban development.

3. Case Study area

The case study, as shown in Figure A1 in the Appendix, covers an area of about 3.700 square kilometres – which extends beyond the area of “*città diffusa*” previously described but shows the same characteristics of it – occupied by 145 municipalities which are part of the administrative

provincial territory of Padua, Treviso, Venice and Vicenza. These four territorial areas are similar in social composition and economic growth, but differ for several other characteristics such as morphology and geography, landscape and environment—whose environmental character, cultural and historical landscape values sometimes are not been respected by the development and the growth process—and for urban sprawl quality, not completely homogeneous.

Our research area has been analyzed and described in its evolution and dynamism in two distinct phases (Indovina, 2009; Fregolent, 2005). The first explains the development between 1970 and 1990, which characteristics are the growth of the urban sprawl in the entire area and around the historic polycentric structure peculiar of the area and the Veneto region. The second describes the area between 1990 and 2007 and put in evidence the new essential characteristics of the sprawl, a densification around the polycentric urban structure.

The two phases can be better described and developed through specific points. During the 1970s, the area begun to suffer evident urban growth transformations that are well caught in few aerial photographs showing some parts of the territory. Changes occurred especially in the rural landscape, whose characters were deeply modified, altered and partially destroyed by the new urban diffusion. The agrarian plains landscape slowly but progressively urbanized, were transformed and assumed the character of the low density city and the agricultural economy, with its distinctive way of life dating back hundreds of years, lost its importance, while the housing, productive, commercial and infrastructural urbanization, drawn a new landscape. The cities lost inhabitants that moved initially to the nearest surrounding area and than to the second belt, which resulted in an increase of urban sprawl.

In the 80's we can see even better the changes occurred in the urban and rural character of the area, extremely modified and altered, and in part destroyed by the new wave of building.

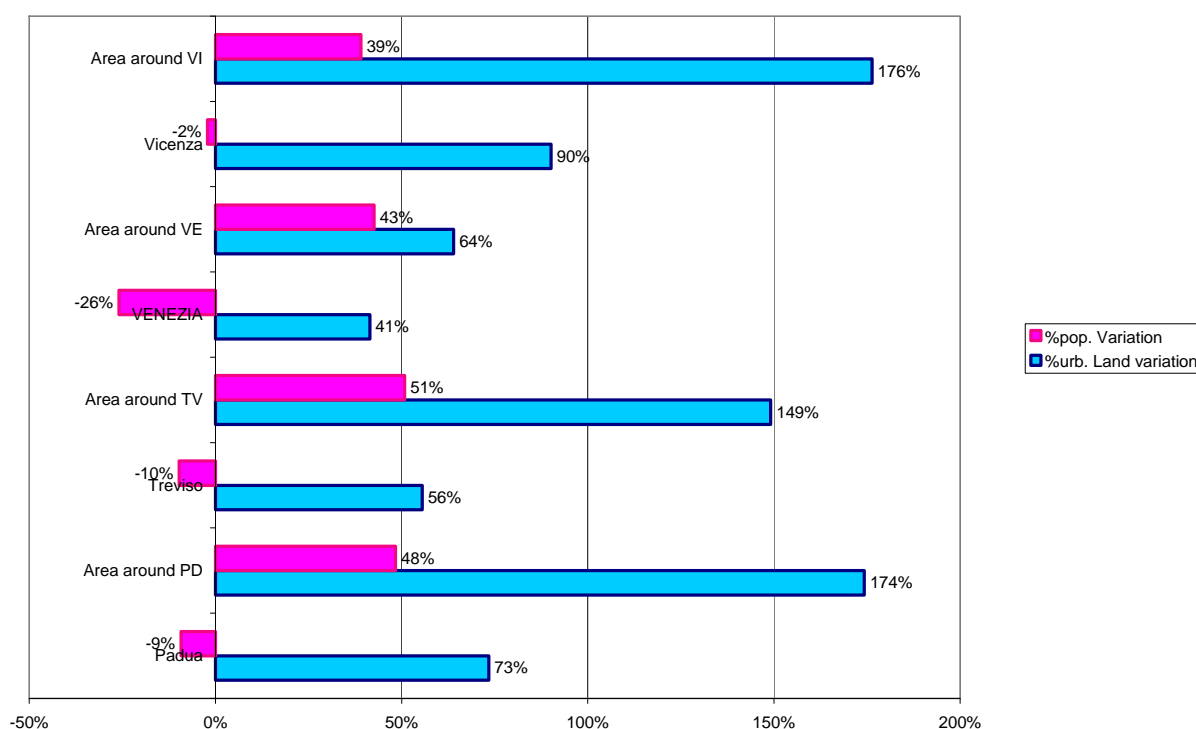
During the 1990s, several municipalities enjoyed a new phase of urban growth, specifically a phenomenon of “filling in” of vacant land inside the built-up area; new land parcels were created encompassing those once were isolated homes and small conglomerations of buildings.

The analysis of the area and the comparison between the urbanization in 1970 and 2007 shows clear and quick transformations of the territory. A great development of infrastructure networks has made possible these transformations, determining significant changes on economic level,

facilitating the localization of firms and business everywhere, and sprawling urbanization of dwellings, mostly single family and factories.

Finally, our analysis confirms a decline in population for the main cities and an increase on urbanization land. In particular, between 1970 and 2007 the capital cities of the main provinces show a decrease in population of -26% (Venice), -9% (Padua), -2% (Vicenza) and -10% (Treviso), while on average, in the same period, the cities have experience an increase in built-up area of 65.15%. Figure 1 shows a comparison among the main cities and the areas around them. Figure 1 shows a comparison among the main cities and the areas around them. We can see that capital cities have negative population variation between 1970 and 2007, while each provincial area, excluded the capitals, have a positive growth variation. Moreover, urban land in all the provincial areas presents rate of built-up areas higher than their respective capital cities.

Figure 1: Variation in population and urbanized land



4. Data

The empirical analysis aims to trace the effects of certain variables on the local public spending. We collect data on different public costs functions for 145 municipalities of the central area of the Veneto Region (representing about the 22% of the whole region) for the period 1998-2007. Data come from annual balance sheet of each municipality. In addition to information to current expenditures, we also collect data on capital outlays but we decide to focus only on the current operations because capital expenditures represent not the annual costs of using capital but rather the amount of investment in public sector infrastructure planned for both current and future residents.

In Table 1 we summarize the main variables referred only to year 2007, period of time we used for our analysis, with a brief definition and the main descriptive statistics for each of them. We need to specify that the current research regards only this year because, at the moment, are still not available data necessary to measure urban sprawl, such as the urbanized land in each period e for each municipality.

We use municipalities' accountability system because they are in charge of managing a certain number of services that are directly influenced by a low-density urban development pattern. In fact, municipalities must produce important services to the citizenry, including public transport, solid waste collection, street cleaning, urban planning, local policy, waterworks, school lunches and transport, the management of public green areas, day nurseries, and the management of nursing homes for the elderly. These services are provided partly free of charge and partly against payment of a sum, which is usually lower than production cost (Caperchione, 2003).

Municipalities are allowed to (1) increase local taxes and (2) charge tariffs for the services they provide, but a large percentage of their inflows (about 30%) is still represented by transfers from higher levels of government.

In our case study, the average total current expenditure for the 145 municipalities is about 490,00 euro per capita and the average total amount of transfers (State plus Region) is about 138,00 euro per capita. The average total amount of local taxes paid by citizens is about 300,00 euro per person, comprising the municipality property tax (Imposta Comunale sugli Immobili, ICI), tax on waste collection (TARSU), income tax on resident (IRPEF), use tax, license and permits.

Municipalities in our sample range from very small towns of a thousand of inhabitants to other like Venice and Padua with more than 200,000 inhabitants, so the average population of the sample is 14,500 people, with a mean population density of 5,27 people per hectare. We provide also a variable describing population change measured as an average annual rate of change over the 10 years period, 1998 to 2007 in order to better capture the demographic dynamic and movement of the whole period of analysis. The idea is to verify if municipalities with higher growth rates influence the amount of public spending or not.

We construct also a dummy variable (*central*) to take into account the fact that municipalities with a population higher than 20,000 inhabitants may sustain higher costs due to higher densities, larger amounts of urbanized land, greater expenditures on infrastructure and different taxation behaviour.

4.1 Urban sprawl variables.

There is no consensus about the variable that better than others describes urban sprawl. Even so, population density is the most widely used indicator of sprawl because of its simplicity (Hortas-Rico and Solè-Ollè, 2010; Galster et al., 2001).

In addition to the common indicator of population density, already defined, we also measure urban density as the number of employees and residents per hectare of developed land (Carruthers and Ulfarsson, 2003). We do this because the amount of urbanized land depends on both residential and non residential land uses. The mean value for our sample is 29.54 per hectare.

Another important indicator of sprawl is the spatial extent of developed land surface in a municipality, given by the total amount of urbanized hectares. The total average of urbanized land is 566.32 ha, and the mean urban density is equal to the 23% of the total municipality surface.

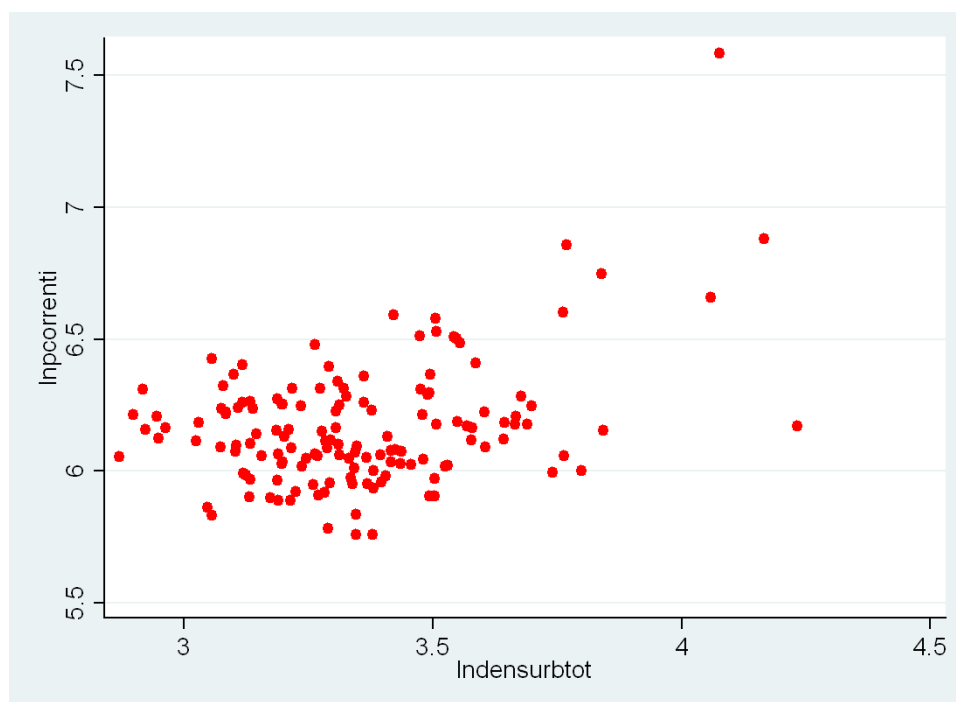
Finally, using the geographical information system (GIS) application we calculate what we call municipality's "territorial fragmentation"— even if we know that landscape literature has a precise definition for this type of indicator— as the number of sub-urbanized areas, or polygons, in which a municipality can be visually decomposed and for each of them we provide the total urbanized surface. The more polynuclear is a municipality, the more sprawling is its territory. After having identified the number of polygons of urbanized land by municipality, we create 3

different groups of urban development pattern according to the size of developed land (< 30 ha; comprised between 30 and 250 ha; and > di 250 ha). Then, we create a variable called “*varfram*” as share of total number of the smaller urbanized centres relative to the total number of polygons in each municipality. The higher the ratio, the higher is the probability that the municipality is a sprawling territory. Figure A2 in the Appendix illustrates the number and distribution of the different polygons in the area.

We are aware that researchers have adopted other sophisticated indicators (see for instance Ewing, 2002; Burchfield et al., 2006; Frenkel and Ashkenzi, 2008; Torrens, 2008) to measuring sprawl, but those data they utilized are not still available in Italy at a disaggregated territorial level¹. We hope next future researches will be addressed to solve this lack of data and allow us to construct better measure for urban sprawl.

In figure 2 below we show the comparison between the per capita current expenditures in logarithmic term and the urban density calculated as the total population and workers divided by the urbanized surface in logarithmic terms.

Figure 2: Per capita current expenditure vs. urban density (residential + occupational)



1. Some variables, such as number of residential buildings, number of firms, population, etc. are provided by ISTAT, the national institute of statistics, at census tract level. Last data of this type are available only for 2001, the last nation-wide census of dwellings.

Table 1: Variables: definition and means (145 municipalities)

Variables	Description of main exploratory variables	Media	Dev. std.
employee06	Number of employees	5528.9	13022.4
%pop98-07	% change in population between 1998-2007	0.14	0.09
pttransfer	Total public transfers (State and Regional aid) per person	137.85	54.61
ptax	Total value of local tax paid by citizens per person	305.28	98.51
supurbha	Total number of hectares of urbanized land	566.32	710,37
densurbha	Average number of urbanized land per ha	0.23	0.09
denspop	Average number of people per ha	5.27	3.23
densurbtot	Average number of people and employee per ha of urbanized land	29.54	8.41
population	Average population of the municipality	14570.17	29697.79
purfee	urban fee, per person	63.15	46.24
pstreetsm	Street network in meters per person	12.11	4.87
central	Dummy variable, takes on value 1 if the municipality has more than 20000 people	0,12	0,32
Description of dependent variables			
Public current expenditure	Average spending on current operations	492.87	165.19
Education	Average cost of public education, per person, in euro	59.41	17.51
Roadways and public transport	Average cost of road construction and public transportation, per person, in euro	49.40	29.60
Environmental and land management	Average cost of land management and environment, per person	47.71	39.93
Public housing	Average cost of housing, per person	1.15	2.87
Waste collection	Average cost of public waste collection, per person	20.36	33.63
D03 (denpop <3 per ha)	Dummy variable, takes on value 1 if population density is < 3 people per ha	0.2	0.4
D05 (denpop >= 3 e < 5)	Dummy variable, takes on value 1 if population density is between 3 and 5 people per ha	0.33	0.47
D07 (denpop >= 5 e < 7)	Dummy variable, takes on value 1 if population density is between 5 and 7 people per ha	0.28	0.45
D10 (denpop >= 7 e < 10)	Dummy variable, takes on value 1 if population density is between 7 and 10 people per ha	0.09	0.29
Dsup (denpop >= 10)	Dummy variable, takes on value 1 if population density is higher than 10 people per ha	0.10	0.31

5. Empirical model and results

In order to investigate the relationship between public service expenditures and the explanatory variables described in table 1, we use the following model:

$$\text{expenditure} = f(\mathbf{L}, \mathbf{R}, \mathbf{T}, \varepsilon)$$

where expenditure, current total expenditure or the single public spending functions already defined, is a function of **L**: the characteristics of land or territorial features, including density, urbanized land area, population density, if a municipality can be considered as a centrality, etc.; **R**: the revenue of local government including per capita state and regional aids, **T**: local tax, user fees and other sources of fiscal imposition, and ε is a vector of unobserved effects.

The basic model is displayed in table 2. The dependent variable is the Municipality's total current expenditure per capita.

Table 2: Results of the basic model

Variable	Coeff.	tstat
Const.	-743.445**	-1.98
D_9807	-107.141**	-2.03
supurbha	0.051**	4.97
densurbtot	-0.074	-0.11
ptransfer	1.092**	9.67
central	-4.434	-0.25
Ptributi	0.869**	15.01
Varfram	826.333	2.23**
N. of obs.: 143		
F(6,136)= 196.77 (prob >F =0.000)		
R-squared=0.91		
Adj R-squared=0.91		

The growth rate of population in the period 1998-2007 is negative and significant as expected. Municipalities that grow faster are expected to save some costs.

Spatial extent of urbanized land is positive and significant, indicating that the spread of a municipality area plays an important role in determining public service expenditures (Total number of acres of urbanized land).

The parameter estimate for *density* (employees and population together) is negative, as expected, but not significant. The negative effect suggests that it might create economies of scale: the per capita cost decreases as densities increase, with the greatest savings realized in areas with high densities.

The variable *central*, indicating if a municipality has a population higher than 20,000 inhabitants, is negative but not significant. It seems that our empirical investigation is in line with previous researches stating that because most municipalities are too small in size to capture the increasing returns to scale in the provision of local public goods and services, the per-capita public spending is on average considerably larger than those of bigger municipalities (Bordignon, 2000). Empirical estimates of per capita expenditures as a function of population size usually show a U-shape, with per capita public expenditure being higher at the two extremes, and the least cost size being in the range between 50,000 to 100,000 inhabitants (see for example, Ambrosanio et al., 1999).

The coefficient of *ptributi* (total local taxes paid by citizens) and *ptransfer* (total monetary aid from higher government level) are both significant and positive, meaning that per capita total current expenditure is a function of municipality revenues. Greater transfers from central governments imply greater willingness for local spending.

Finally, territorial fragmentation, calculated as ratio between the number of polygons with low-density urban pattern and the total polygons identify in each municipality, is positive and significant, demonstrating that urban fragmentation is associated with higher public expenditure. After providing explanation for the basic model, we also estimate several different type of public spending functions, whose main results are reported in table 3 below².

2. Other estimates were attempted but results were not satisfactory, but if interested are available from the authors upon requests.

Table 3: results of the empirical models

	Roadways and transport		Education		Public Housing		Waste collection		Environmental and land management	
	Coeff.	tstat	Coeff.	tstat	Coeff.	tstat	Coeff.	tstat	Coeff.	tstat
Const.	-156.519	-1.45	-14.649	-0.12	-32.511**	-2.42	-281.226	-1.43	-96.906	-0.45
D_9807	9.342	0.62	-8.724	-0.52	-1.571	-0.83	-18.786	-0.69	-51.567*	-1.72
supurbha	0.021**	6.98	0.002	0.66	0.002**	6.41	0.026**	-4.56	0.015**	2.44
densurbtot	0.097	0.41	-0.352*	-1.81	0.055**	2.19	-0.856**	-1.97	-1.110**	-2.30
ptransfer	0.161**	4.62	0.118**	3.31	-0.001	-0.18	0.175	2.75	0.142**	2.02
central	-17.698**	-3.52	-8.616	-1.53	-0.478	-0.75	14.140	1.54	25.114**	2.48
Ptributi	0.099**	6.04	0.019	1.03	0.006**	2.68	0.224	7.49	0.277**	8.27
Varfram	138.972	1.29	64.581	0.55	30.258**	2.28	250.276	1.27	76.155	0.35
pstreetsm	0.253	0.65					0.363	0.51	-0.207	-0.26
purbfee					-0.004	-1.26			0.133**	2.47
N. of obs.:	143		143		143		143		143	
F	F(8,134)=59.4367.(0.000)		F(7,135)= 5,48 (0,00)		F(8,134)= 27.36 (0,00)		F(8, 134) =12.54 (0.00)		F(9,134) =15.49 (0,00)	
R-squared	0.78		0.20		0.62		0.43		0.51	
Adj R-squared	0.768		0.16		0.60		0.40		0.48	

Results of different models confirm that total urbanized land surface is positive and significant for all the equations, except for education (coefficient non statistically significant). The same happens for the amount of local taxes paid by citizens, meaning that higher revenues favour local public spending in services and infrastructures.

The parameter estimates for *density* are negative and significant in several models, suggesting it creates economy of scale for: public spending on education, solid waste collection and environmental and land management. The positive coefficient for public housing and road infrastructure and public transport indicates that more people needs more houses and roads, parking, and other facilities, increasing the costs of providing these services and infrastructures.

The parameter state and regional aid is positive and significant for all the equations, excluding public housing function for which it assumes a negative sign and it's not statistically significant. The sign make sense because only a low share of governmental funding is invested in public housing. The greater the monetary transfers from higher governmental levels, the greater the per capita spending in transportation, education, trash collection and environmental and land management by local government within each municipality.

A new exploratory variable, taking into account the street network per person in meters (*pstreetsm*), was added in some models, such as roadways, waste collection and environmental and land management. We believe that the length of urban and suburban streets can also explain expenditures related to these functions. For example, the longer the distance has to travel a waste collection vehicle, the higher the costs related to waste management. Similarly, larger road networks imply higher costs of construction, maintenance, and management. Results of our models show that the coefficient of *pstreetsm* is positive but not statistically significant for roadways and waste collection, and it is surprisingly negative and not significant for the model "environmental and land management".

In two models, housing and environmental and land management, we include impact fee revenues (*purbfee*) as exploratory variable. Development impact fees are intended to transfer a fraction of the capital cost for new infrastructure from the public to the private sector. Environmental and land management activities are positively and significantly influenced by *purbfee*. We speculate that greater impact fee revenues lead to better provision of infrastructure and consequently higher investments and higher expenditures supported by municipalities. Vice

versa, the coefficient of impact fee is negative and not significant for housing service, meaning that higher impact fee revenues imply minor public investment in housing infrastructure.

The coefficient of the territorial fragmentation – *varfram* – significant and positive for the total current expenditure function, is positive but not statistically significant for the majority of models. The only exception is for per capita spending on public housing. Even if not supported by statistical results for all models estimated, the fact that the sign is always positive means that the presence of higher little urbanized centres increases local public spending of municipalities for services and infrastructures. More evidences will be provided in future when more disaggregated data for low territorial level, such as census tracts or either lower levels will be available.

6. Discussion and conclusions

The Central Veneto area has experienced a rapid growth in suburban development not supported by a comparable population growth in the last 40 years and the effect of this change has a price in terms of efficiency and cost effectiveness. In addition to regression analysis, we use ARCGIS to put in comparison two different time period: years 1971 and 2007. We calculate that in the whole area of research, the urbanized land has increased on average by 192%, in comparison to an average increase in population by 47%.

The trend of growth continues but with different dynamics: there is a tendency to densification around the polycentric network of the area, together with a process of fragmentation due to different reasons. New mobility infrastructures seem to support a new form of sprawl, pushing up the construction of new centralities (Veneto City, Fashion city, Quadrante di Tessera), where sprawl does not completely affect the area.

The Veneto Regional Plan, instead of contrasting the consumption of soil – as explicitly written and underlined in the document– favours the construction of new road infrastructures altering the original features of the Region, enforcing urban sprawl and encouraging the conversion of rural areas into built-up land. Thus, instead of promoting new form of control and contrasting the current municipalities urban plans – voted to strengthen urbanization – the recent regional policy

seems to generate once again urban development patterns not sustainable and environmental degrading.

Results of our models show how public spending can be affected by different characteristics of urban sprawl. We have measured urban sprawl as total employees and population density in an hectare of urbanized land, also controlling for spatial extent of urbanized land and territorial fragmentation.

The most relevant results of our analysis is that per capita cost of most municipality functions declines with density and increases with the spread of urbanized land area. This provides evidence that low density urban development is more expensive for public government than compact development and that some urban containment policies need to be set for improving the design of future urban settlements. We find that there is the chance to realize economy of scale in some areas, for example education, solid waste collection and environmental and urban management where the extent of urbanized area and people density have a determinant effect on public cost saving.

The possibility to save public money in some areas of public spending is particularly attractive today because of the lack of financial and monetary funds available at local government scale. If local governments are aware that some development patterns cost more than others, they have to act consequently and provide new rules and economic instruments to avoid or limit the waste of land. To this extent, it's even more urgent the implementation of land use policies that aim at a more sustainable use of land, such as growth management policies that try to direct growth to certain areas and away from others. However, critics of this kind of policy state that it reduces the supply of land available for development, which may result in an increase in the price of land throughout the urban area, an increase in residential density, and an increase in the concentration of commercial development in the central city (McGuire and Sjoquist, 2002).

Other scholars suggest increasing impact fees for some urban development uses in order to charge developers of the full cost of new infrastructure projects imposed by sprawl. Impact fees can cover the costs of schools, roads, or other public infrastructure, but who really bears the burden of impact fees? For example, in the case of residential development, developers pass on the burden of impact fees to new home buyers and renters (Wiewer et al., 1999).

Another important policy relates to open space preservation. In fact, open space provides a lot of benefits to people and ecosystems but many of them are not taken into account when land is

converted to urban use (Brueckner, 2000). Assigning a correct value to open space can reverse the actual increasing trend, even if to a diminishing rate with respect to the past, to exploit these areas for residential, productive or commercial development.

Agreement exists among researchers that propose policies that foster the investments in urban central areas can favor the revitalization of older city cores, improve the quality of life of residents and avoid the escape from the inner city to the suburbs, especially if the sprawl cause is attributed to the decline of the city core.

Finally, local governments should provide better quantitative information on energy, economic, and environmental impacts of different urban development patterns to support correctly their planning choices and better informed citizens on real cost of urban development alternatives.

The results of this analysis allow to better understanding the relationship between urban development and public costs, but in the same time point to several directions for future research. First, we are aware that there is a need for additional efforts to incorporate alternative measures of urban sprawl, with the availability of more sophisticated data on lower territorial scale. Second, since we have collected data on municipality public expenditure on a 10 years period of time, we want to complete the current research with a dynamic panel data analysis, as soon as we will be able to construct the main indicators of sprawl and territorial characteristics for another intermediate temporal threshold between 1971 and 2007.

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Appendix

Figure A1: Built-up area in the Central Area of Veneto Region

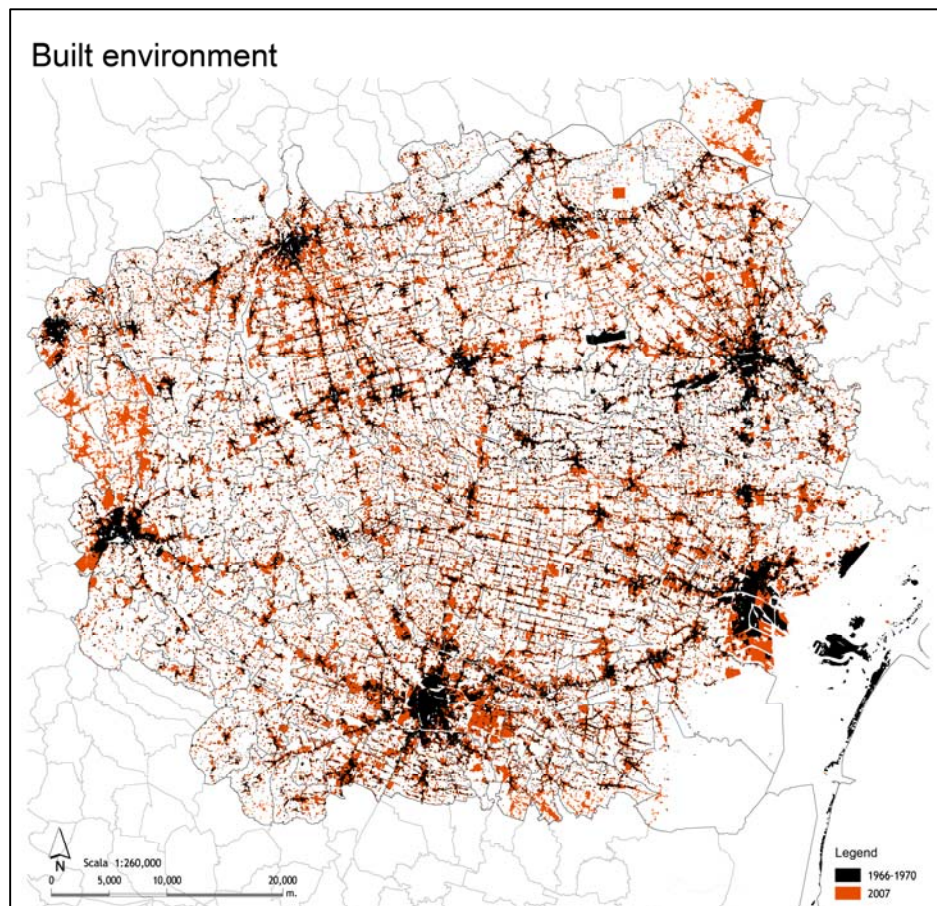


Figure A2: Territorial fragmentation