The determinants of land use in Italy from a spatial perspective: A re-interpretation at the time of COVID-19

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1. Aim of the work

The ever-widening conversion of natural lands to artificial areas is increasingly exposing sustainability at risk, with severe implications for the environment, the economy and society at large. Given the pervasiveness of the impact of the Covid-19 pandemic on the different dimensions of sustainable development, urban planning programs and local development policies are likely to be radically rescheduled. The question arises whether the Covid-19 pandemic will be a stimulus to change the current development model in the direction suggested by the 2030 Agenda for Sustainable Development Goals (SDGs), or whether the policies aimed at tackling the resulting economic damage will overshadow the environmental aspects.

Based on the latest available data, Italy is the fifth country in Europe for land use (after Malta and Benelux countries, and above Germany, Denmark and the United Kingdom) with a high heterogeneity across regions. Five out of eight Italian regions with the greatest land use are in central-northern Italy (Lombardy, Veneto, Emilia Romagna, Friuli-Venezia Giulia, Latium, Liguria), two in southern Italy (Campania, Apulia). Equally high levels of land use heterogeneity are found within most regions.

This work aims at providing a deeper understanding of the main determinants of land use in Italy by using a large dataset drawn from official sources for 2016 (ISTAT, ISPRA, SIEPI). The analysis is carried out at the municipal level (n= 7,798), corresponding to the NUTS-4/LUA level of the Eurostat classification, because in Italy each municipality is the main decision-maker of territorial planning strategies and tools. Moreover, as land use activities impact the environment with inevitable relationships between local agents, the analysis also investigates the effects of local neighbouring factors on land use decision-makers, as well as spatial interactions among local agents distributed in space.

2. Method

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We use the Spatial Durbin Model (SDM), which allows us to consider the spatial effects both endogenously through the spatial autoregressive term to reflect the impact of land use in neighbours and exogenously to reflect the consequence for each unit of the change in the exogenous variables. Formally:

$$y = \rho W y + \alpha \iota_N + X\beta + WX\theta + \varepsilon \qquad \text{with} \qquad \varepsilon \sim N(0_{nx1}, \sigma^2 I_n) \tag{1}$$

where the dependent variable (y) is given by the land use rates (LURs) observed on all Italian municipalities, β is the vector of parameters associated with the set of exogenous covariates X (grouped by geomorphological, demographic, socio-economic, and institutional characteristics), α is the intercept (i_N is the vector of ones), W is the spatial weight matrix[1], ρ is the scalar for the endogenous interaction effects (WY) referred to as spatial autoregressive, θ is the vector of the parameters for the exogenous interaction effects (WX), and ε is the vector of independently and identically distributed error terms with zero mean and constant variance.

The choice of SDM is statistically supported by the LM-lag test (LMρ=2,225.9) and the Robust LM-lag test (RLMρ=317.5) – both provide significant evidence of the autoregressive term (p-value<2.2e-16) due to the presence of spatial autocorrelation in the LURs – and by the LR test ($\theta + \rho\beta \neq 0$), which also detects a significant spatial autocorrelation in the covariates (LR SDM, SAR=2,119.7, p-value=2.2e-16).

In the presence of the spatial autoregressive term, the direct (2) and indirect (3) effects – being different for each unit – were averaged for all municipalities. Formally:

$$Diagonal\ elements\ of \qquad (I - \rho W)^{-1}[\beta_k + W\theta_k] \tag{2}$$

$$Off - diagonal\ elements\ of \qquad (I - \rho W)^{-1}[\beta_k + W\theta_k] \tag{3}$$

While the average direct effect can be interpreted as the β coefficients of linear OLS models, the average total effect is the average of the n effects due to the change of one unit of the variable X in the *i-th* area across all areas. The average indirect effect is given by the difference between the average total effect and the average direct effect.

3. Main results

LURs are strongly spatially correlated (global Moran's I is 0.684). This means that the dynamics of land use in a municipality directly affect those of neighbouring municipalities. The results of the SDM show the crucial role of the demographic, socio-economic, and institutional characteristics of a specific territory in determining its land use dynamics. As expected, the spatial autocorrelation

[1] We use a second order binary contiguity matrix which also includes the first order neighbours. Two municipalities are adjacent (wij = 1) if they share an administrative boundary of non-zero length or have borders that touch the first-order neighbours.

coefficient (ρ) is highly significant and positive as well as the spatial spillover effects. This means that interactions between municipalities play a crucial role in sketching the land use profile in Italy and that local land use patterns are mutually dependent on those of neighbouring municipalities.

First, higher population density and greater economic development of a municipality lead to greater land use, while these forces move in the opposite direction if they come from neighbouring areas. This partially explains why belonging to a metropolitan area tends to directly decrease land use. Metropolitan regions are more integrated internally as municipalities would favour cooperation to maximise the positive effects of agglomeration advantages. Second, the direct effects of the quality of local institutions as a proxy for virtuous management of public affairs are significantly negative, implying that the higher the institutional quality, the lower the land use.

The results suggest that: *i*) monitoring land use over time is the prerequisite for preserving environmental quality and ecosystem services throughout the Country; *ii*) cooperation, skill- and responsibility-sharing between metropolitan and non-metropolitan cities should be promoted to develop greater awareness of land use management and to safeguard resources' sustainability; *iii*) the strengthening of the qualitative characteristics of local institutions is essential to narrow the regional divides and to better manage land use projects.

Such a high spatial resolution analysis is crucial when investigating land use, as it highlights the actual local characteristics that planners cannot ignore in managing the future of sustainable cities, especially in the present times characterised by the problematic coexistence with the dreadful threat of Covid-19. As suggested by ASVIS (Italian Agency for Sustainable Development), given the key role of sustainable land use in attaining many SDGs, newly designed policies could help mitigate the inevitable slowdowns in their achievement caused by the pandemic.

Policies should be consistent with social distancing, which requires the planning of new spaces or, at least, the re-organisation of existing ones to avoid overcrowding. In this context, it may be necessary to rethink the role of metropolitan areas in light of their usually higher infection and mortality rates due to greater connectivity, and, at the same time, also consider that, in more densely populated municipalities, the risk of a more rapid spread of Covid-19 is usually offset by better access to healthcare facilities. In short, the difficulty of predicting the future scenario of the impact on land use will likely require a learning-by-doing period in spatial policies as well.