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RIVISTA ITALIANA DI ECONOMIA DEMOGRAFIA E STATISTICA

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INDICE

tests showed – with any matrix – a significant spatial correlation in the residuals of the simple regressions of cross-province new cases. The results of the spatial regressions (Table 3), in turn, show that the association between the coronavirus cases in each province and the cases in the other provinces was always significant, supporting the hypothesis of a spatially-related transmission. Despite being always significant, this association shows varying levels of closeness. These dissimilarities, however, can be traced back to the different construction of the matrices. For instance, when the contiguity regards only the nearest neighbour, the elasticity of the response variable is unsurprisingly lower than that produced by first-order contiguity matrices, which take into consideration all neighbours, not just the nearest one. Second-order contiguity matrices, which concern relatively less near territorial units, show elasticities lower than the first-order ones. However, at the end of the period investigated, these differences evaporated, owing most probably to the progressive territorial spreading of the epidemic. The closest associations are those obtained using the contiguity by inverted distance matrices, in particular those of first order, and of first order = 1 and second order = 0.5. Table 3 shows as well that the lagged cases impact had a decreasing trend over time, in tune with the decrease in the effective reproduction number (Figure 4). A drop involving all spatial matrices materialised as to the elasticity of the 22 March's cases to a change in the 15 March's ones, and a more massive drop came to the fore a week later. The results obtained with the spatial matrices have told us that the coronavirus epidemic had a spatial component. However, it is important to check how this spatial component interacts with the intra-territorial-unit characteristics, i.e. with the possible ecological determinants of the epidemic diffusion. Preliminarily, we inspected the cross-province correlations between the new cases of coronavirus around the peak of the epidemic and the territorial characteristics, including the previous cases. Table 4 shows the associations between coronavirus cases and, respectively, previous cases, latitude (more northerly, more cases), temperatures (higher temperatures, fewer cases), particulate matter (an indicator of vehicular traffic and industrial development), people 6 to 18-year old (an age group with frequent social interactions, and therefore an agent of transmission, even when asymptomatic), people 75-year or older (a group prone to develop more severe health problems when infected, and therefore probably over-recorded by the health services), intra-province commuters (an indirect indicator of social contacts), vehicles (an indicator of mobility, and, indirectly, of social contacts), employment to population ratio and firm workers (both being indicators of social contacts for work reasons), added value (an indicator of development and indirectly a measure of an *organic* labour division, implying a higher level of social interactions), lower-income population's share (an indicator of underdevelopment), and hospital beds (hospitals could be means of secondary transmission). Finally, we analysed these

analyses of the spatial and ecological determinants of that transmission. By using nation-level new cases, we identified a 7 DD interval. On the basis of this interval, the present study analysed the spatial component of the epidemic. The results obtained when employing a broad set of spatial matrices confirmed the significant impact of this spatial component. A secondary transmission *spillover* between contiguous territorial units emerged, but so did the significance of *distance*, a fact implying that transmission went beyond *contiguity*.

Table 5 – *OLS and spatial regressions of cross-province new coronavirus cases in Italy on time lagged cases, spatially lagged previous cases, and other territorial explanatory variables.*

Explanatory variables	Response variable: new coronavirus cases 22/03/2020 per pop.							
	OLS model		Spatial mod. 1		Spatial mod. 2		Spatial mod. 3	
	E	z	E	z	E	z	E	z
Direct impact								
New cases 15/03/2020 pp.	0.661	11.79	0.605	12.02	0.594	11.08	0.590	11.96
Cumulative past cases 08/03/2020 pp.	–0.062	–2.16	–0.057	–2.29	–0.097	–3.65	–0.068	–2.82
Population 6 to18-year old percent	1.213	2.66					1.426	3.67
Firm 250 or more workers pp	0.207	3.48					0.207	4.12
Hospital beds pp	0.133	0.89					0.211	1.64
Added value (per capita)	–0.474	–1.57					–0.684	–2.64
Latitude	3.324	3.32					0.220	0.21
Commercial vehicles pp.	0.276	2.74					0.394	4.46
Pop. density (pop/Km^2)	–0.004	–0.15					–0.020	–0.81
Indirect impact								
W inv. distance (New cases 15/03/2020 pp.			0.461	6.30			0.561	5.30
W cont. by i.v.(New cases 15/03/2020 pp.)					0.193	5.64		
N	107		107		107		107	
R^2 or (pseudo) R^2	0.890		0.871		0.864		0.913	

Note: "pp"= per population; Elasticity = $d\bar{y} \,/\, d\bar{x} \,*\, \bar{x} / \bar{y}$ *. Spatial regression models use a ML estimator.*

The different construction of the various spatial matrices satisfactorily explained the dissimilarities as to the estimations obtained by means of these matrices. Moreover, when the temporal scenario associated with the epidemic varied, also all the estimations obtained by using the various spatial matrices changed in the same direction. It appeared as well that the impact had a decreasing trend over time. This trend could be traced back to decreasing and/or more cautious inter-provinces social contacts, due, in turn, either to fear of contagion or to the government lockdown measures. What is sure is that a first, distinct decrease in the spatial impact on the inter-provinces secondary transmission surfaced in the relationship between the 15 March 2020's infecting cases and the 22 March's infected cases, therefore a few days after the national quarantine was proclaimed (8 March). A further, massive drop in the spatial impact materialised as to the infected cases of 29 March: this seems to resonate well with the *effective reproduction number* trend, which, according to our calculations, passed the turning point of 1 on 27 March 2020.

Lastly, the present study analysed the contribution made to the epidemic secondary transmission by, concurrently, the lagged cases of coronavirus, the spatial component and several territorial features. The vast differences in development and social organisation traditionally existing between the Italian territorial units prompted us to hypothesise that these differences could explain the large disparities in the cross-province epidemic diffusion. The results show, indeed, that a significant statistical contribution to the epidemic reproduction came from the lagged cases of coronavirus, the spatial component but also from the territorial characteristics. Among the latter, indirect indicators of social interactions and mobility emerged as particularly relevant for the secondary transmission.

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SUMMARY

Determinants of the Coronavirus Epidemic Generation in Italy

This study intended to analyse the secondary transmission mechanisms of the 2020 coronavirus epidemic in Italy. To do so, this paper has identified, firstly, the serial interval of the transmission, the premise for further analyses of its spatial and ecological determinants. As for spatial determinants, a broad set of spatial matrices were created and tested. With all these matrices, the existence emerged of a secondary transmission spatial *spillover*. Both *contiguity* and *distance* proved to be significant for this transmission. The spatial component, however, was not the sole significant determinant of the secondary transmission. Various features of the territorial units (provinces) proved to be significant. The results of both OLS and spatial regression models suggested the particular relevance of indirect indicators of social interaction and mobility.

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