



Correction to: Exploring land use determinants in Italian municipalities: comparison of spatial econometric models

Gennaro Punzo¹ · Rosalia Castellano² · Emma Bruno¹

Accepted: 22 August 2022 / Published online: 14 October 2022
© The Author(s) 2022

Correction to: Environmental and Ecological Statistics <https://doi.org/10.1007/s10651-022-00541-8>

The original version of this paper erroneously reported the tables' layout, compromising the paper reading and results' visualisation.

Table 1 Direct and indirect effects of different model specifications

	Direct effects	Indirect effects
OLS	β_k	0
SDM	Diagonal elements of $(I - \rho W)^{-1}(\beta_k + W\theta_k)$	Off-diagonal elements of $(I - \rho W)^{-1}(\beta_k + W\theta_k)$
SDEM	β_k	θ_k
SAC	Diagonal elements of $(I - \rho W)^{-1}\beta_k$	Off-diagonal elements of $(I - \rho W)^{-1}\beta_k$

Below is reported the proper layout of Tables [1](#), [3](#), [4](#), [5](#), [6](#), [A1](#), [A2](#), [A3](#), [A4](#), [A5](#), and [A6](#).

The original article can be found online at <https://doi.org/10.1007/s10651-022-00541-8>.

✉ Gennaro Punzo
gennaro.punzo@uniparthenope.it
Rosalia Castellano
lia.castellano@uniparthenope.it
Emma Bruno
emma.bruno@studenti.uniparthenope.it

¹ Department of Economic and Legal Studies, University of Naples Parthenope, via Generale Parisi 13, 80132 Napoli, Italy

² Department of Management and Quantitative Studies, University of Naples Parthenope, via Generale Parisi 13, 80132 Napoli, Italy

Table 3 Descriptive statistics

Variable	Min	Max	Mean	St. deviation	Moran's I (W ₁)	Moran's I (W ₂)	Moran's I (W ₃)	Moran's I (W ₄)
LC%	0.296	89.726	10.488	10.141	0.765	0.684	0.640	0.758
Overall Surface	11.990	1,28,583.54	3813.48	5078.96	0.440	0.359	0.309	0.331
Elevation above sea	0	2035	357.173	298.088	0.784	0.702	0.706	0.765
Population Density	0.008	122.750	3.044	6.496	0.735	0.632	0.548	0.722
Per capita housing	0.046	19.191	0.758	0.725	0.456	0.355	0.355	0.384
Employment Rate	18.000	74.020	44.927	7.942	0.820	0.794	0.806	0.801
Per capita GDP	14,505.50	53,231.32	26,628.31	7750.85	0.654	0.649	0.659	0.655
Per capita enterprises	0.002	0.718	0.066	0.027	0.287	0.233	0.202	0.256
IQI	0	1	0.607	0.210	0.797	0.764	0.804	0.829
Dummy variable	Min	Max	%					
Metropolitan Area	0	1	16.59	83.41				

Table 4 Spatial dependence tests

OLS vs. SEM		OLS vs. SAR		OLS vs. SAC	
$H_0: \lambda = 0$		$H_0: \rho = 0$		$H_0: \lambda = \rho = 0$	
LM lag:	11,753***	LM error:	2225.9***	LM lag + error:	12,070***
RLM lag:	9844.6***	RLM error:	317.5***		
SDM vs. SAR			SDM vs. SEM		
$H_0: \theta = 0$			$H_0: \theta + \rho\beta = 0$		
LR SDM vs. SAR:		138.59***	LR SDM vs. SEM:		2119.7***

Table 5 Estimates of spatial models using first order binary contiguity matrix, row-standardised

Variable	OLS		SDM		SDEM		SAC	
	Coef	St. error	Coef	St. error	Coef	St. error	Coef	St. error
Intercept	− 0.3253	(0.1981)	0.2366	(0.1586)	0.824**	(0.3847)	0.366	(0.3778)
Elevation above sea	− 0.0004***	(0.00001)	− 0.00002	(0.00002)	− 0.0001***	(0.00002)	− 0.0002***	(0.00002)
Population density	0.5422***	(0.0038)	0.5077***	(0.0044)	0.509***	(0.0042)	0.5097***	(0.0044)
Per capita housing	0.0922***	(0.0103)	0.1555***	(0.0101)	0.1468***	(0.01)	0.15***	(0.0102)
Metropolitan area	− 0.1335***	(0.0105)	− 0.0701***	(0.0186)	− 0.0651***	(0.0218)	− 0.1032***	(0.016)
Employment rate	0.1636***	(0.0335)	0.1109***	(0.0303)	0.1039***	(0.0325)	0.1166***	(0.0335)
Per capita GDP	0.2072***	(0.0237)	0.1648***	(0.0209)	0.1103***	(0.0398)	0.1206***	(0.0375)
Per capita enterprises	0.1008***	(0.0109)	0.1108***	(0.0087)	0.1228***	(0.0094)	0.1124***	(0.0096)
IQI	0.0138	(0.0291)	− 0.1017*	(0.0575)	− 0.0585	(0.0712)	0.0461	(0.0485)
W* Elevation above sea			− 0.0001***	(0.00002)	− 0.0004***	(0.00004)		
W*Population density			− 0.3316***	(0.0077)	0.0726***	(0.0085)		
W*Per capita housing			− 0.1402***	(0.0141)	− 0.0424*	(0.0224)		
W*Metropolitan area			0.0233	(0.0196)	− 0.0733**	(0.0286)		
W*Employment rate			− 0.0783*	(0.0414)	0.02	(0.0744)		
W*Per capita GDP			− 0.1141***	(0.0171)	0.0152	(0.0303)		
W*Per capita enterprises			− 0.0379***	(0.0145)	0.0422*	(0.0238)		
W*IQI			0.099*	(0.0585)	0.1252	(0.084)		
ρ			0.6899***	(0.0098)	−	−	0.1661***	(0.0100)
λ			−	−	0.7126***	(0.0098)	0.635***	(0.0136)
Number of observations	7998		7998		7998		7998	
Log likelihood	−		353.2774		435.8007		256.1629	
AIC	−		− 668.55		− 833.6		− 488.33	
Adjusted R-squared	0.8834		−		−		−	

First order binary contiguity matrix, row-standardised

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table 6 Direct, indirect and total effects of spatial models using first order binary contiguity matrix, row-standardised

	SDM	SDEM	SAC
<i>Direct effects</i>			
Elevation above sea	− 0.0001***	− 0.0001***	− 0.0003***
Population density	0.5116***	0.509***	0.5124***
Per capita homes	0.1486***	0.1468***	0.1508***
Metropolitan area	− 0.0753***	− 0.0651***	− 0.1037***
Employment rate	0.1105***	0.1039***	0.1172***
GDP per capita	0.1647***	0.1103***	0.1212***
Per capita enterprises	0.1188***	0.1228***	0.113***
IQI	− 0.0958**	− 0.0586	0.0464
<i>Indirect effects</i>			
Elevation above sea	− 0.0005***	− 0.0004***	− 0.00003***
Population density	0.0561***	0.0726***	0.0988***
Per capita homes	− 0.0993***	− 0.0424*	0.0291***
Metropolitan area	− 0.0757**	− 0.0733**	− 0.02***
Employment rate	− 0.0054	0.02	0.0226***
GDP per capita	− 0.0015	0.0152	0.0234***
Per capita enterprises	0.1162***	0.0422*	0.0218***
IQI	0.0868	0.1252	0.0089
<i>Total effects</i>			
Elevation above Sea	− 0.0005***	− 0.0004***	− 0.0002***
Population density	0.5677***	0.5816***	0.6112***
Per capita homes	0.0494	0.10442***	0.1798***
Metropolitan area	− 0.1511***	− 0.1384***	− 0.1237***
Employment rate	0.1051	0.1239	0.1398***
GDP per capita	0.1632**	0.1255**	0.1446***
Per capita enterprises	0.235***	0.165***	0.1348***
IQI	− 0.0089	0.0666	0.0553

First order binary contiguity matrix, row-standardised

*Significant at 10%; **Significant at 5%; ***Significant at 1

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

Appendix A

Table A1 Estimates of spatial models using second order binary contiguity matrix (including first order neighbours), row-standardised

Variable	SDM		SDEM		SAC	
	Coef	St. error	Coef	St. error	Coef	St. error
Intercept	0.1894	(0.1841)	1.1162**	(0.4516)	0.7602**	(0.3322)
Elevation above sea	–	(0.00001)	–	(0.00002)	–	(0.00002)
Population density	0.5392***	(0.0042)	0.5365***	(0.0043)	– 0.0001***	(0.0043)
Per capita housing	0.1507***	(0.0103)	0.1445***	(0.0103)	0.5373***	(0.0103)
Metropolitan area	–	(0.0182)	–	(0.0219)	0.1449***	(0.0178)
Employment rate	0.1326***	(0.0334)	0.1257***	(0.0341)	–	(0.0326)
Per capita GDP	0.1387***	(0.0209)	0.0472	(0.0457)	– 0.0809***	(0.0334)
Per capita enterprises	0.101***	(0.0094)	0.1062***	(0.0095)	0.1287***	(0.0093)
IQI	–	(0.0654)	– 0.1214*	(0.0727)	0.085**	(0.0006)
W* Elevation above sea	–	(0.00001)	–	(0.0001)	0.1039***	
W*Population density	0.000001		0.0003***			
W*Per capita housing	–	(0.0091)	0.025	(0.0153)	– 0.0006	
W*Metropolitan area	0.437***					
W*Per capita housing	–	(0.0168)	–	(0.0419)		
W*Metropolitan area	0.1574***		0.1012**			
W*Employment rate	0.0476**	(0.0211)	– 0.0599	(0.0412)		
W*Per capita GDP	–	(0.05)	– 0.1451	(0.1356)		
W*Per capita enterprises	0.1129**					
W*IQI	–	(0.0212)	0.0776	(0.0557)		
ρ	0.1157***					
λ	–	(0.0208)	– 0.0047	(0.0477)		
Number of observations	0.0637***					
Log likelihood	0.1768**	(0.0717)	0.2924**	(0.1138)		
AIC	0.8138***	(0.0118)	–	–	0.1237***	(0.0149)
	–	–	0.8294***	(0.0119)	0.8089***	(0.0138)
	7998		7998		7998	
	125.3751		167.9819		96.5445	
	– 212.75		– 297.96		– 169.09	

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table A2 Direct, indirect and total effects of spatial models using second order binary contiguity matrix (including first order neighbours), row-standardised

	SDM	SDEM	SAC
<i>Direct effects</i>			
Elevation above sea	− 0.0001***	− 0.0001***	− 0.0001***
Population density	0.5394***	0.5365***	0.5378***
Per capita homes	0.1470***	0.1445***	0.1451***
Metropolitan area	− 0.0746***	− 0.0518**	− 0.081***
Employment rate	0.1321***	0.1257***	0.1288***
GDP per capita	0.1384***	0.0472	0.085***
Per capita enterprises	0.103***	0.1062***	0.104***
IQI	− 0.166***	− 0.1214*	− 0.0006
<i>Indirect effects</i>			
Elevation above sea	− 0.0004***	− 0.0003***	− 0.00002***
Population density	0.0087	0.025	0.0754***
Per capita homes	− 0.1828***	− 0.1012**	0.0203***
Metropolitan area	− 0.0632	− 0.0599	− 0.0114***
Employment rate	− 0.0266	− 0.1451	0.0181***
GDP per capita	− 0.0151	0.0776	0.0119***
Per capita enterprises	0.0969	− 0.0047	0.0146
IQI	0.2022	0.2924**	− 0.0001
<i>Total effects</i>			
Elevation above sea	− 0.0005***	− 0.0004***	− 0.0001***
Population density	0.5481***	0.5615***	0.6132***
Per capita homes	− 0.0358	0.0432	0.1654***
Metropolitan area	− 0.1379**	− 0.1117***	− 0.0924***
Employment rate	0.1055	− 0.0194	0.1468***
GDP per capita	0.1233	0.1248*	0.097***
Per capita enterprises	0.1999**	0.1015**	0.1186***
IQI	0.0361	0.171*	− 0.0007

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table A3 Estimates of spatial models using the distance-band binary matrix based on the centroid distance, row-standardised

Variable	SDM		SDEM		SAC	
	Coef	St. error	Coef	St. error	Coef	St. error
Intercept	0.3351***	(0.1301)	1.4572***	(0.3887)	0.9089***	(0.3996)
Elevation above sea	– 0.0001***	(0.00002)	– 0.00008***	(0.00002)	– 0.0001***	(0.00002)
Population density	0.5458***	(0.0044)	0.5418***	(0.0043)	0.545***	(0.0044)
Per capita housing	0.151***	(0.0106)	0.1422***	(0.0105)	0.1464***	(0.0106)
Metropolitan area	– 0.0533**	(0.0225)	– 0.0224	(0.0212)	– 0.0628***	(0.0205)
Employment rate	0.1365***	(0.033)	0.1122***	(0.0343)	0.1208***	(0.0351)
Per capita GDP	0.1254***	(0.02)	0.026	(0.0393)	0.0582	(0.043)
Per capita enterprises	0.0613***	(0.0075)	0.0737***	(0.0081)	0.0631***	(0.0079)
IQI	– 0.0244	(0.0169)	– 0.0273*	(0.014)	– 0.0237*	(0.0136)
W* Elevation above sea	– 0.0001**	(0.00002)	– 0.0004***	(0.0001)		
W*Population density	– 0.4451***	(0.0092)	0.0212	(0.0142)		
W*Per capita housing	– 0.1795***	(0.0175)	– 0.1527***	(0.0394)		
W*Metropolitan area	0.0181	(0.0285)	– 0.1579***	(0.0408)		
W*Employment rate	– 0.1503***	(0.0521)	– 0.2051	(0.1292)		
W*Per capita GDP	– 0.0971***	(0.021)	0.1407***	(0.0534)		
W*Per capita enterprises	– 0.0046	(0.0086)	0.1684***	(0.0398)		
W*IQI	– 0.0043	(0.0078)	– 0.0557	(0.0807)		
ρ	0.8094***	(0.0127)	–	–	0.1246***	(0.0155)
λ	–	–	0.824***	(0.0121)	0.8156***	(0.0139)
Number of observations	7984		7984		7984	
Log likelihood	73.0559		124.0173		33.6553	
AIC	– 108.11		– 210.03		– 43.311	

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table A4 Direct, indirect and total effects of spatial models using the distance-band binary matrix based on the centroid distance, row-standardised

	SDM	SDEM	SAC
<i>Direct effects</i>			
Elevation above sea	− 0.0001***	− 0.0001***	− 0.0001***
Population density	0.5455***	0.5418***	0.5455***
Per capita homes	0.1446***	0.1422***	0.1465***
Metropolitan area	− 0.0561***	− 0.0224	− 0.0629***
Employment rate	0.132***	0.1121***	0.121***
GDP per capita	0.1258***	0.026	0.0583
Per capita enterprises	0.0663***	0.0737***	0.0632***
IQI	− 0.0271	− 0.0273*	− 0.0237*
<i>Indirect effects</i>			
Elevation above sea	− 0.0005***	− 0.0004***	− 0.00001***
Population density	− 0.0179	0.0212	0.0771***
Per capita homes	− 0.2938***	− 0.1527***	0.0207***
Metropolitan area	− 0.1282*	− 0.1579***	− 0.0089**
Employment rate	− 0.2046	− 0.2051	0.0171***
GDP per capita	0.022	0.1407***	0.0082
Per capita enterprises	0.2308***	0.1684***	0.0089***
IQI	− 0.1233	− 0.0557	− 0.0033*
<i>Total effects</i>			
Elevation above sea	− 0.0006***	− 0.0004***	− 0.0001***
Population density	0.5276***	0.5629***	0.6226***
Per capita homes	− 0.1491**	− 0.0105	0.1672***
Metropolitan area	− 0.1844***	− 0.1803***	− 0.0718***
Employment rate	− 0.0726	− 0.0929	0.138***
GDP per capita	0.1479	0.1667***	0.0665
Per capita enterprises	0.2971***	0.2421***	0.0721***
IQI	− 0.1504	− 0.083	− 0.027*

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table A5 Estimates of spatial models using *k*-nearest neighbour (knn) matrix, row-standardised

Variable	SDM		SDEM		SAC	
	Coef	St. error	Coef	St. error	Coef	St. error
Intercept	0.1387	(0.1923)	0.7237*	(0.3974)	0.4158*	(0.2481)
Elevation above sea	− 0.0001*	(2.00E−05)	− 0.0001***	(2.00E−05)	− 0.0002***	(0.00002)
Population density	0.5143***	(0.0045)	0.5153***	(0.0042)	0.5151***	(0.0044)
Per capita housing	0.1632***	(0.0102)	0.1527***	(0.0101)	0.1510***	(0.0101)
Metropolitan area	− 0.0597***	(0.023)	− 0.0526*	(0.0221)	− 0.1035***	(0.0161)
Employment rate	0.1295***	(0.0321)	0.1206***	(0.0327)	0.1233***	(0.0307)
Per capita GDP	0.1650***	(0.0256)	0.1116***	(0.0405)	0.1086***	(0.0281)
Per capita enterprises	0.1048***	(0.0086)	0.1137***	(0.0094)	0.1026***	(0.0089)
IQI	− 0.0602	(0.0575)	− 0.0297	(0.0758)	0.0692*	(0.036)
W* Elevation above sea	− 0.0001	(2.00E−05)	− 0.0003***	(4.00E−05)		
W*Population density	− 0.3387***	(0.0075)	0.0573***	(0.0087)		
W*Per capita housing	− 0.1548***	(0.0142)	− 0.0701***	(0.0232)		
W*Metropolitan area	0.0084	(0.0273)	− 0.0957***	(0.0285)		
W*Employment rate	− 0.1129**	(0.0451)	− 0.0448	(0.0746)		
W*Per capita GDP	− 0.1010***	(0.0204)	0.0337	(0.0314)		
W*Per capita enterprises	− 0.0407*	(0.0185)	0.0350	(0.0244)		
W*IQI	0.0566	(0.0663)	0.1044	(0.0892)		
ρ	0.6846***	(0.0096)	−	−	0.1570***	(0.0155)
λ	−	−	0.7013***	(0.0095)	0.6284***	(0.0139)
Number of observations	7998		7998		7998	

Table A5 (continued)

Variable	SDM		SDEM		SAC	
	Coef	St. error	Coef	St. error	Coef	St. error
Log likelihood	329.4344		392.7165		220.6833	
AIC	- 620.87		- 747.43		- 417.37	
Adjusted R-squared	-		-		-	

*Significant at 10%; **Significant at 5%; ***Significant at 1%

Table A6 Direct, indirect and total effects of spatial models using k -nearest neighbour (knn) matrix, row-standardised

	SDM	SDEM	SAC
<i>Direct effects</i>			
Elevation above sea	− 0.0001***	− 0.0001***	− 0.0002***
Population density	0.5171***	0.5153***	0.5176***
Per capita homes	0.1539***	0.1527***	0.1517***
Metropolitan area	− 0.0667***	− 0.0526**	− 0.1040***
Employment rate	0.1242***	0.1206***	0.1239***
GDP per capita	0.1675***	0.1116***	0.1091***
Per capita enterprises	0.1115***	0.1137***	0.1031***
IQI	− 0.0569	− 0.0297	0.0696*
<i>Indirect effects</i>			
Elevation above sea	− 0.0004***	− 0.0003***	− 0.00003***
Population density	0.0395***	0.0573***	0.0935***
Per capita homes	− 0.1274***	− 0.0701***	0.0274***
Metropolitan area	− 0.0959**	− 0.0957***	− 0.0188***
Employment rate	− 0.0717	− 0.0448	0.0224***
GDP per capita	0.0354	0.0337	0.0197***
Per capita enterprises	0.0918**	0.0350	0.0186***
IQI	0.0455	0.1044	0.0126*
<i>Total effects</i>			
Elevation above Sea	− 0.0005***	− 0.0004***	− 0.0002***
Population density	0.5566***	0.5726***	0.6111***
Per capita homes	0.0265	0.0826***	0.1791***
Metropolitan area	− 0.1626***	− 0.1483***	− 0.1228***
Employment rate	0.0525	0.0758	0.1463***
GDP per capita	0.2029***	0.1453***	0.1288***
Per capita enterprises	0.2033***	0.1487***	0.1217***
IQI	− 0.0114	0.0747	0.0822*

*Significant at 10%; **Significant at 5%; ***Significant at 1%