

A study on the impact of “Reddito di Cittadinanza” using a multivariate linear mixed model

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Abstract A Multivariate Linear Mixed Model (MLMM), a Multivariate Spatial Linear Mixed Model (Spatial MLMM) with Time-Varying Fixed-Effects and a Multivariate Spatial State Space Linear Mixed Model (Spatial State Space MLMM) are used to analyze the impact of the “Reddito di Cittadinanza” (RdC) on the share of poverty, the Income inequality, and the average per capita income, treated as target variables. The analysis covers the years preceding the introduction of the social policy measure and those following it. Although we did not find a statistically significant impact of RdC at the global Italian level on these variables, at the regional level - and especially for the Southern Italy Regions and the Islands - the analysis shows an effective reduction in the share of poverty in these Regions.

Key words: reddito di cittadinanza, guaranteed minimum income, poverty, multivariate linear mixed model, spatial model, state space model

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1 Introduction

In 2019, the Italian government introduced a measure aimed at reducing poverty and encouraging reintegration into work, called "Reddito di Cittadinanza" (RdC)¹. It is a monthly economic benefit provided to people and low-income families who meet specific requirements. It was possible to access the RdC until the end of 2023; after this date, the RdC was replaced by social and work inclusion measures [6]. There were two primary purposes of the RdC: to bring many families out of a state of absolute poverty and to reintegrate as many people as possible into the world of work. The validity of the RdC is still a topic of political debate in Italy today. The economic literature shows that either with regards to the requirements necessary to access the RdC, but also due to territorial and welfare disparities, the results of this social policy measure are heterogeneous ([1], [5]). Busilacchi et al. ([2]) have instead found that, although the impact of the RdC on the employment rate is not statistically significant, in some Italian Regions characterized by low demand and supply of work, it seems that the RdC has contributed to decreasing active job searching. The work of Tonutti et al. ([8]) presented a first study on the targeting at the local level of the RdC anti-poverty policy in Italy, showing a heterogeneous targeting performance of this socio-economic measure, with a general lower targeting affecting northern regions and rural areas. Given this evidence, this paper proposes an application based on a multivariate linear mixed-effects model (MLMM). Traditionally, a MLMM is an extension of linear mixed-effects models (LMM) that have a more complex, multilevel, hierarchical structure concerning the classical linear regression model ([3]). Observations between clusters are independent in these models, but observations within each cluster are dependent because they belong to the same subpopulation. Moreover, in a mixed effects model there are two sources of variation: the within-cluster variation, and the between-cluster variation. The multivariate model is instrumental in using more response variables and exploiting the information from the link between them. Using the Income inequality, the Average per capita income, and the share of poverty as dependent variables, the number of RdC-perceiving households is one of the covariates of the model, together with the measure of quality of the local institutions, as well as the local employment rate. To account for both spatial and temporal autocorrelation, a Multivariate Spatial Linear Mixed Model (Spatial MLMM) - with Time-Varying Fixed-Effect and a Multivariate Spatial State Space Linear Mixed Model (Spatial State Space MLMM) [4] were also used, respectively. In the next section, the models will be presented briefly. The application to real data shows that although at the global Italian level there is no statistically significant impact of the RdC on the dependent variables used; at the regional level - and especially for the Regions of Southern Italy and the Islands - the analysis exhibits a reduction in the share of poverty for these particular Regions.

¹ Note that, despite its name, RdC is not a universal basic or citizens' income, but it is configured as a minimum income measure.

2 Model, application, and conclusion

For the sake of space, it is not possible to present the three models in detail, so please refer to the literature ([3], [4]). MLMMs describe the relationship between several response variables and independent variables, with coefficients varying concerning one or more grouping variables. The matrix multivariate extension of the LMM is $\mathbf{Y} = \mathbf{XB} + \mathbf{ZU} + \mathbf{E}$, and it is a model made of: fixed effects - $\mathbf{XB}$ - and random effects - $\mathbf{ZU}$. This means that, for a given data matrix $\mathbf{Y}$, the elements of $\mathbf{U}$ are realized (but unobservable [7]) values of random variables. As usually happens in a multivariate context, the model is vectorized by stacking vectors. The multivariate random effects covariance matrix used in the application is a heterogeneous compound symmetry matrix. To take into account also the spatial and the temporal autocorrelations we used a Multivariate Spatial State Space Linear Mixed Model (Spatial State Space MLMM): the "spatial" state-space LMM is then: $\mathbf{y}_t = \mathbf{X}_t\beta_t + \mathbf{Z}\mathbf{v}_t + \mathbf{e}_t$, $\mathbf{y}_t = \underset{1 \leq i \leq m}{col} (y_{it})$ where

$$\begin{aligned}\theta_t &= \mathbf{X}_t\beta_t + \mathbf{Z}\mathbf{v}_t, \quad \mathbf{Z} = \text{diag}(\mathbf{Z}_1, \dots, \mathbf{Z}_m)(\mathbf{I} - \rho_s \mathbf{W})^{-1}, \\ \mathbf{v}_t &= \rho_t \mathbf{v}_{t-1} + \eta_t, \quad \eta_t \stackrel{iid}{\sim} N(\mathbf{0}, \sigma_v^2 \mathbf{I}_m)\end{aligned}$$

The ρ_s and the ρ_t are the spatial and the temporal correlation parameters, respectively. When $\rho_t = 0$, and $\alpha_t = \alpha + \mathbf{A}\zeta_t$, $\mathbf{A} = \mathbf{I}_{p+m}$, we obtain the third model used in this work, the Multivariate Spatial Linear Mixed Model (Spatial MLMM) - with Time-Varying Fixed Effects. In our study, we consider the years 2015-2022 to have a comparison between the situation before the introduction of the RdC measure and after its introduction. In particular, the dependent variables are the share of poverty (share of the population with an income of fewer than 10,000 euros), the income inequality (the Gini index on declared income obtained by aggregating data from different Region income groups), and the average per capita income (computed as the ratio between the total amount of income declared in each Region and the total number of taxpayers). The MLMMs can simultaneously capture the impact of the RdC on economic variables of high relevance. The nature of the MLMMs allows us to see the impact of the RdC from two different points of view. Firstly, it concerns the national scenario, and secondly, what happens in each region of Italy. From the evaluation of the fixed effect estimates, the analysis does not show a significant impact of RdC on the $\mathbf{Y}$ variable at the national level. Nevertheless, some random effects predictions are statistically significant in the local (administrative Region) context. This points out that the RdC had an impact at the regional level. Nevertheless, this did not lead to a global improvement of the three target variables in the years 2015-2018 (before the introduction of RdC) and 2018-2022 (after the introduction of the measure studied). The results for the model covariance parameters are in Table 1. Even using the temporal and spatial correlation, the results are very similar to that of model MLMM, this might be because random effects by region already capture spatial correlation. Future works will focus on diagnostic measures to understand whether RdC influences the estimate of random effects and which

Table 1 The table reports the results for the model covariance parameters for the three models and the p-values wrt a set of Wald Likelihood ratio tests for the models covariance parameters; the Moran and Geary's tests for the spatial correlation, and the Durbin-Watson test for the time autocorrelation. All the parameters are significant.

Covariance parameter	MLMM		Spatial MLMM		Spatial State-Space MLMM	
	value	p-value	value	p-value	value	p-value
ρ (spatial)	-	-	0,5088	< 0,0001	0,5679	< 0,0001
ρ (UCH Covariance matrix)	-0,5000	< 0,001	-0,4124	< 0,001	-0,4044	< 0,001
σ^2 (Gini)	0,0001	< 0,001	0,0142	< 0,001	0,0305	< 0,001
σ^2 (Per Capita Income)	5,6316	< 0,001	3,9991	< 0,001	4,1262	< 0,001
σ^2 (Share of Poverty)	0,0019	< 0,001	0,0092	< 0,001	0,034	< 0,001
ρ (time)	-	-	-	-	-0,01265	< 0,0001
σ^2	0,0035	< 0,001	0,0460	< 0,001	0,0955	< 0,001

variables can improve the measure and ensure that all target people can benefit from it, this also with respect the new measure introduced by the Italian Government after the RdC.

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