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Application of spatial econometric approach in the evaluation of rural development policy: the case of measure Modernisation of agricultural holdings

The paper analyses targeting and spatial impacts of investment support on agricultural holdings in Slovenia within the national Rural Development Plan for the period 2007-2013. The measure *Modernisation of agricultural holdings* primarily tackles the problem of low labour productivity in Slovenian agriculture. Achievement of the stated objective of productivity enhancement in agriculture is monitored by the relevant Common Monitoring and Evaluation Framework indicator, standard output (i.e. approximated revenue) per annual work unit SO/AWU. Municipalities (LAU2) are the territorial units of the analysis. Non-spatial and spatial econometric models are developed in order to determine to what extent the estimated labour productivity is affected by intensity of investment support and other factors (measure-specific variables, agricultural structures, socio-economic conditions and geographical conditions). Effectiveness of spatial targeting has been analysed by testing the assumption of a positive relationship between the intensity of implementation of the analysed measure and the productivity. The presence of spatial effects (spatial autocorrelation and spatial heterogeneity) has been examined by including the spatial weight matrix to the ordinary least squares regression. The results confirm a positive relationship between farm investment support and agricultural labour productivity and spatial spillovers in agricultural labour productivity.

Keywords: Rural development policy 2007-2013, farm investment support, modernisation of agricultural holdings, agricultural productivity, spatial econometrics.

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Introduction

The rural development policy (RDP) of the European Union (EU) is designed to promote and guide economic restructuring of rural areas, to promote sustainable management of natural resources and to help rural areas to meet future economic and environmental challenges (Klug and Jenewein, 2010). A common legal basis and financial framework is established to achieve these objectives. EU Member States and regions carry out this policy through their rural development programmes. Owing to the large range of attributed tasks on the one hand and increasing budgetary restrictions on the other, it is important that the limited budgetary resources are effectively used. In a spatial context, this means effective targeting of supported activities and positive spatial spillovers of impacts.

Regarding the effectiveness of public expenditure on rural development, RDP should demonstrate a clear connection between supported activities and their impacts in rural areas. Cause-effect relationship between the choice of measures, the way they are implemented and their effects are complex. Within the common policy framework, a system of evaluation and monitoring has been established to address these questions. Designation of the Common Monitoring and Evaluation Framework (CMEF) for the EU programming period 2007-2013 (CMEF, 2006) is often regarded as a major step towards a more effective RDP planning for the future. The establishment of the CMEF is an important step towards the unification of the monitoring of RDP. On the other hand, the methodological framework of evaluation resulting from the CMEF (EENRD, 2009) is much less defined. One of the concerns is the implied assumption of the CMEF of a simple linear relationship between the funds invested and result achieved (Figure 1).

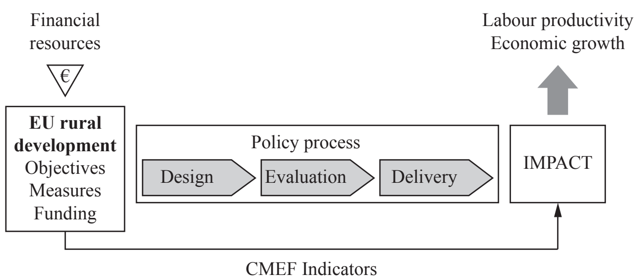

Figure 1: The concept of a simple linear relationship between the funds invested and result achieved through European Union Rural Development Policy (adapted from RuDI, 2010).

Evaluators follow a formal evaluation procedure that usually leads to the display of time-series data and its interpretation. Therefore, the analytical potential of the CMEF remains largely untapped, and this represents a challenge for applied research of rural development measures. The paper accepts this challenge by utilising the CMEF data framework for analysing investment support on agricultural holdings in Slovenia. The measure (code 121), formally called *Modernisation of agricultural holdings* (EC, 2005), is designed to help agricultural holdings to improve their economic performance through better use of the production factors including the introduction of new technologies and innovations as well as improving the protection of the environment (RDP, 2007). The measure offers the potential for improvement of agricultural production in Slovenia, which is characterised by low productivity and a weak competitive position (Erjavec *et al.*, 1999; Juvančič *et al.*, 2004; Juvančič and Erjavec, 2005). The measure is financially strongly represented in the current national rural development programme (EUR 103.006 million planned in the period 2007-2013 or 8.7 per cent of the overall planned budget). The interest for investment support from this measure is high; 2,230 applications were approved up to the end of the first half of 2011.

A relevant CMEF impact indicator for this measure is *labour productivity in agriculture*. From the abovementioned logic of the CMEF, the indicator implies a linear causal relationship in terms 'money in, productivity up'. The paper aims to verify this assumption. In addition, it investigates spatial aspects of this measure. By doing so, the paper analyses the spatial distribution of the measure and analyses spatial interactions in agricultural labour productivity. It analyses whether productivity level is affected by farm investment support and other relevant factors.

The paper is organised as follows. In the following section, we present the description of the study area and the organisation of data. Spatial econometrics techniques used for the empirical applications are described in the third section. In section four, we apply spatial econometrics models to determine which factors influence labour productivity (SO/AWU). The final section concludes with a discussion and policy implications of the key findings.

Study area and data

With a total area of 20,273 km^2, Slovenia is one of the smallest EU Member States (Anon., 2007). In a territorial sense, the municipality (LAU2) is the basic unit of the local self-government, while rural development (RD) programming, consultation and implementation takes place only at the national level (Juvančič and Jaklič, 2008). Municipalities are also the basic geographical units of observation in our analysis; the analysed area consists of 193 (out of 210) Slovenian municipalities with approved applications for the measure *Modernisation of agricultural holdings* in the period 2008-2011. Therefore, the analysis covers 95.7 per cent of the surface of Slovenia.

According to CMEF (2006), *labour productivity in agriculture* (an impact indicator) is expressed in Gross Value Added at basic prices per annual work unit (GVA/AWU). Unfortunately, this indicator is monitored only at the national level. We looked for possible alternatives in the secondary statistics at LAU2 level where we found labour productivity proxy expressed as economic size (in SO[1]) per annual working unit (AWU[2]). This indicator has been calculated from the Agricultural Census 2010 data.

The core of the analysis deals with the non-spatial and spatial econometric methods. The explanatory data entering in the econometric models have been merged into four meaningful groups (equation 1) and organised at municipality level.

Labour productivity (SO/AWU) =
$b_0 + b_1X_1$ (Measure 121 specific data)
$+ b_2X_2$ (Agricultural structural data) (1)
$+ b_3X_3$ (Socio-economic conditions)
$+ b_4X_4$ (Geographical conditions) + e

[1] The standard output (SO) of an agricultural product (crop or livestock) is the average monetary value of the agricultural output at farm-gate price, in EUR per hectare or per head of livestock. There is a regional SO coefficient for each product, as an average value over a reference period (five years). The sum of all SO per ha of crop and per head of livestock in a farm is a measure of its overall economic size, expressed in EUR.

[2] AWU is based on the relationship between the number of hours worked on an agricultural holding in a year and the extent of work done by one fully employed person in one year (1,800 hours). The calculation of AWU takes into account the total annual labour input on the farm. In addition to work done by the holder, other family members and people regularly employed on the farm, hired labour is also covered.

The main database for the analysis (Measure 121 monitoring table) was collected from the approved applications for the measure *Modernisation of agricultural holdings*. These data were provided by the Agency for Agricultural Markets and Rural Development of Slovenia. The database contains information on all supported agricultural households, which means that the data are arranged on individual farm level. We have aggregated the individual applications at municipality level and over time – the data are from 2008, 2009, 2010 and first half of 2011. In total we have 2,230 approved applications, of which 2,160 are from the period 2008-2010. The database contains a large number of variables (47; e.g. RDP support, farms engaged in integrated production, market orientation of farms etc.) and has been augmented by three other groups of secondary data: Agricultural census 2010[3] (with 22 variables), general socio-economic data[4] (with 12 variables) and geographical data (with 3 variables). These three groups of secondary data were already collected at municipality level.

As a starting point in the selection of explanatory variables, we have excluded the variables that do not correlate to the dependent variable. To determine the most suitable explanatory variables, we checked each of them individually. Selection was based on various criteria. We checked the theoretical relevance of included variables, the significance of variables and the regression equation that explains the most variance (highest R^2). Once we had chosen all the relevant explanatory variables, we estimated the econometric models using standard ordinary least square (OLS) procedure. Multicollinearity, which increases the standard errors of the coefficients and leads to misleading results, was checked using the test Variance inflation factors (VIF). To investigate the role of space, spatial models were developed. Based on the large number of data included in the analysis, summary statistic is reported for the dependent and significant explanatory variables in the model (Table 1).

Methodology

To develop a productivity model, we first used a non-spatial, classical linear model with ordinary least squares (OLS) method. The next step of the analysis consisted of spatial exploration. The Exploratory Spatial Data Analysis (ESDA) approach was our main tool to check whether spatial patterns exist. With the principles of ESDA we performed LISA[5] significant map, LISA cluster map and Moran's I statistic (for more details see Anselin, 1995; Anselin *et al*., 1996; Florax *et al*., 2002). The value of Moran's I ranges from -1 and +1, where 0 represents a random spatial pattern (high and low value are randomly distributed in space). The two extremes indicate two types of spatial clustering, if the value approaches +1 we have strong positive spatial autocorrelation (a clusters of similar values, high-high or low-low), but if it goes down to -1 we have strong negative

[3] Source: Statistical office of the Republic of Slovenia, Agricultural Census 2010 Database: http://pxweb.stat.si/pxweb/Database/Agriculture_2010/Agriculture_2010.asp

[4] Source: Statistical office of the Republic of Slovenia, Statistical Yearbook 2011: http://www.stat.si/letopis/LetopisPrvaStran.aspx?lang=en

[5] LISA – Local Indicators of Spatial Association

Table 1: Summary statistics for significant variables in the models using data from Slovenia.

	Mean	Min	Max	Standard deviation
Labour productivity (SO* in EUR 1000 / AWU**) (EUR/AWU)	12.2	4.9	30.7	4.7
RDP expenditure per farm - from measure 121 (EUR/farm)	1,277	35	19,903	2,282
Participation in agr. pension & disability insurance (num.)	11.6	0	91.0	14.8
LFA***, % of hilly areas	25.6	0	100.0	36.6
Type of production, % of integrated	22.1	0	100.0	28.3
Average LSU†, only on farms with livestock breeding	7.55	0.56	30.38	3.96
Purpose of agricultural production, % of sale	41.6	14.1	86.0	13.3
Average UAA†† per farm (ha)	6.72	1.78	26.54	2.51
UAA, % of medium farms (5 < 10 ha)	33.3	0	63.6	7.3
UAA, % of large farms (> 10 ha)	23.8	0	47.3	8.1

* Standard Output; ** Annual Work Unit; *** Less Favoured Areas; † Livestock Unit; †† Utilised Agricultural Area

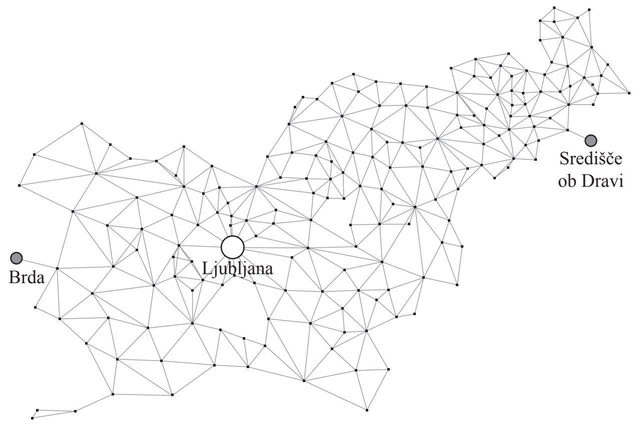

Figure 2: The structure of queen weight matrix among LAU2 municipalities in Slovenia.

spatial autocorrelation. This approach allows us to see how the spatial patterns among municipalities interact (positive spatial correlation could be defined as high-high or low-low interactions). The ESDA revealed spatial patterns in our data, which give rise to the decision to re-estimate the non-spatial models by including spatial weight matrix into standard OLS model, and thus estimating spatial econometrics models.

Spatial analysis of the data, as well as estimation in the case of spatial models, involves a formal definition of the spatial patterns. This pattern is usually represented by a matrix of spatial interactions – weight matrix (W). The matrix defines the relationship among different locations, or in other words it defines the spatial neighbourhood for every location – the elements take the value of 1 if two municipalities share a common boundary, otherwise 0 (Kelejian and Robinson, 1995). There are several choices of spatial matrices, depending on the neighbouring criterion (Anselin, 2002). In the classic example of a regular square, there are three options, only common boundaries (rook matrix), only common vertices (bishop matrix), and both boundaries and vertices (queen matrix). There are also other criteria, especially in the case of islands (Greece, Italy etc.). Here are frequently used the k-nearest neighbour and the distance matrix. Slovenia has many small municipalities, without isolated regions. For this reason, in our study we selected as weight matrix a queen contiguity, which was row standardised so that the sum of each row is equal to one. The philosophy of queen matrix is simple, two municipalities are neighbours if they share a common border (no matter where). With 193 municipalities, our matrix has the dimension 193 by 193 (in total 37,249 weights), with 2.65 per cent of nonzero links. There are two least connected municipalities (Brda and Središče ob Dravi) with one neighbour and the most connected municipality (Ljubljana) has 14 neighbours (Figure 2). The average number of neighbours is 5.11.

According to Anselin (1988a), spatial econometrics deals with two spatial effects, characterised as spatial autocorrelation and spatial heterogeneity, and these spatial effects were included in the empirical research of productivity in Slovenian agriculture. In regression models where analysis is based on spatial data, the two most popular are (equation 2) the mixed regressive spatial autoregressive model, often called the spatial lag model, and (equation 3) the linear regression with a spatial autoregressive error, often called the spatial error model (Anselin, 1988a; Getis, 2010).

$$y = \rho Wy + X\beta + \varepsilon \quad (2)$$

$$y = X\beta + (I - \lambda W)^{-1}\mu \quad (3)$$

where ρ is the spatial parameter that indicates the spatial extent of interactions between observations and λ is also the spatial parameter expressing the intensity of spatial correlation between regression residuals. If ρ and λ are zero, there are no spatial effects. When this condition is met, then the error terms ε and μ are randomly distributed in space. W is n by n spatial weight matrix (usually row standardised), the n by 1 vector Wy is the spatial lag that captures spatial effects through dependent variable and I is n by n identical matrix.

Based on the following assumptions, three different scenarios are possible:

- $\rho = 0$, $\lambda = 0$: The spatial econometric approach is not suitable because there is no spatial dependence in the data. The labour productivity level is randomly distributed across the space;
- $\lambda = 0$: In this case, it makes sense to upgrade the standard regression model with the spatial lag model. In this model, the dependent variable is affected by the values of the dependent variable in the neighbouring regions. Stated another way, the labour productivity level in one municipality both affects and is affected by the labour productivity level in the neighbouring municipalities;

- ρ = 0: In this scenario, the spatial error model should be applied. The interpretation in this case is that the labour productivity level in one municipality is affected by unknown spatial effect. There is spatial correlation between regression residuals.

In comparison to the standard regression approach, the spatial models include (among other factors) the effect of space – in our case, the spatial spillovers of labour productivity. If spatial spillovers are captured in ESDA and confirmed by spatial parameters (ρ, λ), it is reasonable to develop the spatial models. The Lagrange Multiplier (LM) test (for more details see Anselin, 1988b; Florax *et al.*, 2002; Anselin, 2005) have been applied to determine which spatial models fit our data better (spatial lag or spatial error). As a final step, we compared standard OLS models with spatial models and interpreted the results.

Results

The LISA cluster map of labour productivity and the Moran scatter plot indicate a low level of spatial autocorrelation (Figure 3). The exception is a (stronger) high-high cluster in north eastern Slovenia.

Given the insight on the spatial dependencies, we first checked the OLS results for spatial dependence using the standard Moran's I test and LM tests (Table 2). The LM test for lag is insignificant (0.0806), while the LM test for error is significant (0.0186). In this case, the labour productivity level in one municipality is affected by unknown spatial effect and we cannot confirm the neighbouring labour productivity effect. We therefore re-estimated the OLS model and considered only a spatial error model. The results from Table 2 attempt to identify factors affecting labour productivity.

The model results revealed a positive relationship between the RDP support for measure 121 and the agricultural labour productivity. Furthermore, the results suggest that labour productivity is higher in areas with higher representation of full-time farms and lower in areas with aggravated produc-

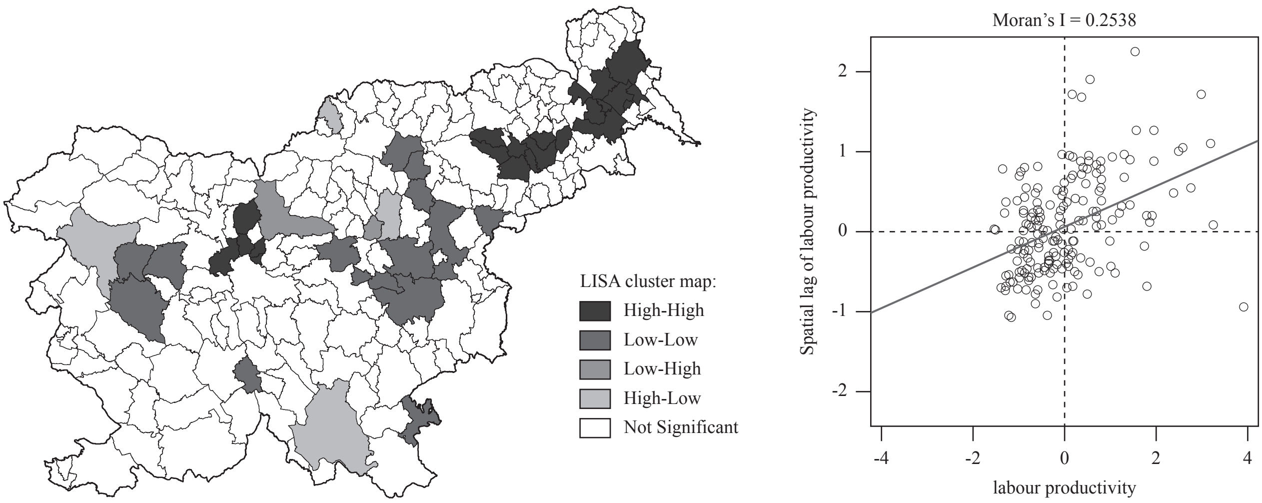

Figure 3: LISA cluster map and Moran's I for labour productivity in Slovenia.

Table 2: The results of the labour productivity model using data from Slovenia.

Economic size (as SO* in EUR 1000) / AWU** (EUR/AWU)	OLS model		Spatial error model	
	coefficient	p-value	coefficient	p-value
RDP expenditure per farm - from measure 121 (EUR/farm)	0.0002	0.0306	0.0002	0.0561
Inclusion in agr. pension & disability insurance (num.)	0.0398	0.0034	0.0427	0.0008
LFA***, % of hilly areas	-0.0144	0.0044	-0.0127	0.0184
Type of production, % of integrated	0.0204	0.0080	0.0209	0.0049
Average LSU†, only on farms with livestock breeding	0.5132	0.0000	0.5290	0.0000
Purpose of agricultural production, % of sale	0.0693	0.0003	0.0700	0.0004
Average UAA†† per farm (ha)	0.5760	0.0000	0.5491	0.0000
UAA, % of medium farms (5<10 ha)	-0.1447	0.0000	-0.1424	0.0000
UAA, % of large farms (>10 ha)	0.0329	0.0184	-0.0751	0.0233
Intercept	5.9002	0.0000	5.7200	0.0000
Number of observations	193		193	
Weight matrix			Queen contiguity	
R^2 (%)	75.65		76.68	
Lambda (λ)			0.2575	0.0085
Moran's I (error)			2.8647	0.0042
Lagrange Multiplier (lag)			3.0520	0.0806
Lagrange Multiplier (error)			2.6018	0.0186

* Standard Output; ** Annual Work Unit; *** Less Favoured Areas; † Livestock Unit; †† Utilised Agricultural Area

tion conditions (LFA). To illustrate, in Slovenia more than three-quarters of the surface belongs to less favoured areas (LFA). Only 10 per cent of municipalities have no LFA within their boundaries (Anon., 2007). The farms engaged in integrated production seem to have higher labour productivity, as do farms that are more market oriented. The latter are farms with predominant market production, which are usually larger and more specialised. The labour productivity is also higher on the farms with higher stocking density. The positive coefficient for average farm size suggests that labour productivity increases with the average farm size. This is also confirmed by the positive coefficient for large farms (owning more than 10 ha).

In comparison to the spatial error model, the RDP expenditure on labour productivity becomes marginally statistically significant (0.0561). Other results are very similar. We also have a small improvement in R^2 (from 75.65 to 76.68 per cent). The data are spatially connected, but we cannot confirm that labour productivity level in one municipality is affected by labour productivity of neighbouring municipalities.

Discussion

The EU Member States must ensure that investment measures included in their rural development programmes are targeted on clearly defined objectives reflecting identified structural and territorial needs. The analytical potential of the CMEF indicator *labour productivity in agriculture* for the measure *Modernisation of agricultural holdings*, which is the key baseline and impact indicator of the analysed measure, was verified. This CMEF indicator is monitored only at the national level, and as such does not allow for spatial analysis at lower geographical levels. With regard to the need for a more evidence-based evaluation of RDP in the coming programming period, it would be worthwhile to consider improving the analytical potential of the monitoring data by establishing a more geographically disaggregated system of data collection.

The results of the econometric models suggest that RDP farm investment support contributes towards the stated objectives in terms of higher labour productivity in agriculture (i.e. the CMEF impact indicator). In this sense, the model results give an indication that public support for farm investments yields positive impacts in terms of labour productivity. The model also reveals a positive relationship between market orientation of farms and agricultural productivity. Furthermore, the results confirm higher labour productivity of farms oriented to agricultural production with higher environmental standards (e.g. integrated production). The results have also confirmed the presence of spatial spillover effects. Spatial aspects have impacts on productivity and should therefore not be neglected. Nevertheless, owing to data limitations, the above-described aspects (agricultural productivity, spatial spillovers) could not be explored in a dynamic setting. Impacts of investment support on agricultural productivity growth therefore remain inconclusive. This remains a challenge for future research, when datasets will allow the dynamic of policy impacts in time to be captured.

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