DISCUSSION PAPER

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SPATIAL DEVELOPMENTS OF HUNGARIAN AGRICULTURE IN THE TRANSITION: THE CASE OF CROP PRODUCTION

IMRE FERTŐ

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Theodor-Lieser-Straße 2, 06120 Halle (Saale), Germany
Phone: +49-345-2928 110
Fax: +49-345-2928 199
E-mail: iamo@iamo.de
Internet: http://www.iamo.de

Imre Fertő is a researcher at the Institute of Economics, Hungarian Academy of Sciences, Budapest, Hungary.

E-mail: ferto@econ.core.hu

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ABSTRACT

The paper investigates spatial changes in cultivation and land use of wheat, maize and oilseed in Hungarian agriculture using different methods to measure these changes. The results suggest that spatial structure of crop productions has remained fairly stable during analysed period. The spatial concentration increased significantly for wheat and maize production and maize land use, whilst the changes were not significant for other cases. Estimates confirm the presence of spatial autocorrelation for all cases. The degree of spatial autocorrelation has no unambiguous pattern over time, except for maize production. Finally, we have not found significant relationship measured by PSE index between agricultural support and spatial concentration, but estimates show positive and significant effects of the share of private farms in the production of certain crops on spatial concentration.

JEL: Q13, Q18

Keywords: Agricultural production, land use, spatial analysis, Hungary.

ZUSAMMENFASSUNG

RÄUMLICHE ENTWICKLUNGEN DER UNGARISCHEN LANDWIRTSCHAFT IM TRANSFORMATIONSPROZESS AM BEISPIEL DER PFLANZENPRODUKTION

Diese Arbeit untersucht räumliche Veränderungen des Anbaus und der Bodennutzung von Weizen, Mais und Ölsaat in der ungarischen Landwirtschaft, wobei verschiedene Methoden für die Messung dieser Veränderungen genutzt werden. Die Ergebnisse zeigen, dass die Raumstruktur der Pflanzenproduktion über den untersuchten Zeitraum relativ stabil war. Die räumliche Konzentration der Weizen- und Maisproduktion und der Bodennutzung für Mais erhöhten sich signifikant, während die Veränderungen in den anderen Fällen nicht signifikant waren. Die Untersuchungen belegen weiterhin eine räumliche Autokorrelation zwischen den verschiedenen Fällen. Gleichzeitig kann man aber kein eindeutiges Muster bei der räumlichen Autokorrelation über den Zeitverlauf erkennen. Eine Ausnahme stellt die Maisproduktion dar. Weiterhin haben wir keinen signifikanten Zusammenhang zwischen einer Unterstützung der Landwirtschaft und räumlicher Konzentration gefunden (gemessen durch den PSE Index), aber die Berechnungen zeigen einen positiven und signifikanten Effekt des Anteils von privaten Firmen an der Produktion von bestimmten Saaten auf die räumliche Konzentration.

JEL: Q13, Q18

Schlüsselwörter: Agrarproduktion, Landnutzung, räumliche Analyse, Ungarn.

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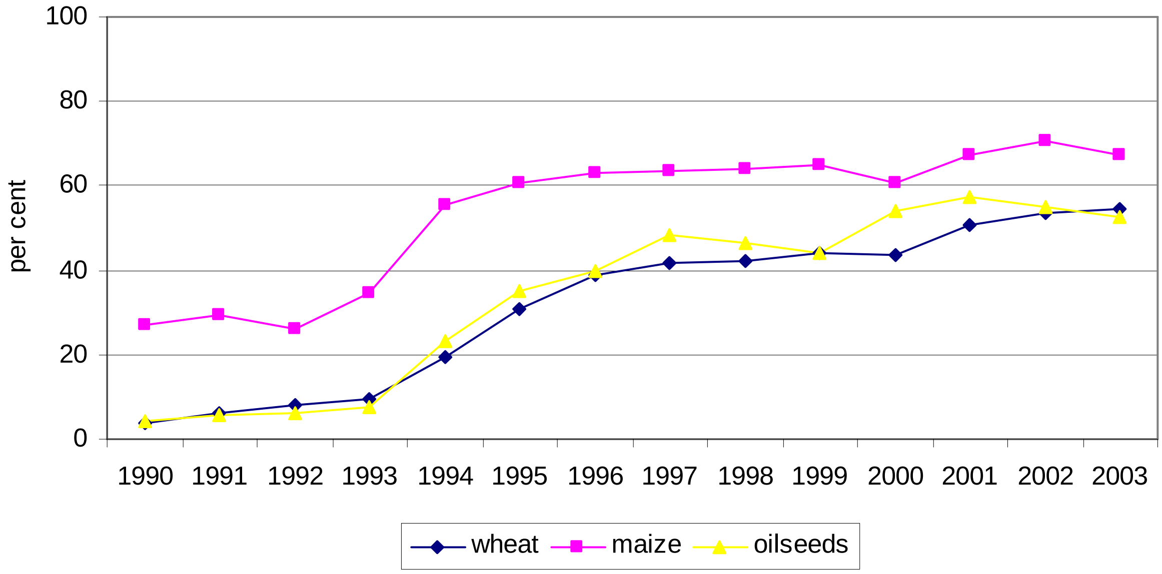
1 INTRODUCTION

There is a continuously growing literature on the agricultural transformation in Central an Eastern European countries (see survey BROOKS and NASH, 2002; ROZELLE and SWINNEN, 2004). The research has focused on various aspects of transition, including land reform, farm restructuring, price and trade liberalisation and etc. However, until now the spatial aspects of the change in agricultural production in CEE countries were neglected. Last decade the Central European countries have been considerable transformed, including transition from planned economy to market economy, increasing trade openness, FDI etc. The Central European agriculture was also a subject a profound transformation affecting by land reform, trade and price liberalisation. Therefore, it is reasonable assume that powerful changes in the agriculture should have effects on the evolution of spatial pattern of agricultural production. The aim of the investigation of regional development of agricultural production is to finding out which regions have been able to grow their share in the production, and which regions lost their positions. Regions with increasing share may or may not be neighbours suggesting that the results based on regional perspective may be different from the estimations employing spatial framework. When agricultural production is highly concentrated in certain regions, it may be a considerable difference whether these regions are adjacent or spread across the space.

In this paper, spatial changes in cultivation and land use of wheat, maize and oilseed are analysed in Hungarian agriculture using different methods to measure these changes. The Figure 1 illustrates the changes in land use by organisations form. The share of individual farmers in land use has increased rapidly in the first half of nineties. Their proportion for wheat has exceeded the 60 percent already in 1995.

Figure 1: Share of individual farmers in land use



Source: Own calculations based on various issues of Statistical Yearbook of Agriculture, Central Statistical Office.

The analysis based on a dataset on agricultural production and land use covering 19 counties of Hungary during 1990 and 2005. Following ELHORTS and STRIJKER (2003) we apply various methods to analyse the spatial changes in Hungarian agriculture. First, we employ the Gini coefficients to identify the degree of regional concentration of agricultural production and land use. Second, whether or not a position of the counties has changed can be analysed by the Spearman correlation coefficient. In addition, we use transition mobility matrix and related mobility indices to check the mobility of ranking of the counties. Third, to detect spatial patterns or trends in the regional values, we use Moran's I statistic for spatial correlation. Finally, we check the dynamics of spatial changes using regression analysis.

2 METHODOLOGY

The Gini coefficient is a widely used measure to identify the degree of *regional* concentration of a particular activity. Lets describe X the size of an agricultural activity and Y is the size of agricultural land whithin a county, n denotes the number of counties being investigated. The Gini coefficient G of the agricultural activity can be defined as follows:

$$G = 1 - 2\sum_{i=1}^{n}(S_{X_i}\sum_{j=1}^{n}S_{Y_i}) + \sum_{i=1}^{n}S_{X_i}S_{Y_i} \qquad (1),$$

where

$$S_{X_i} = \frac{X_i}{\sum_{j=1}^{n}X_j},\ S_{Y_i} = \frac{Y_i}{\sum_{j=1}^{n}Y_j},\ \text{(i=1,…,n) and } \left(\frac{X}{Y}\right)_1 \le \ldots \le \left(\frac{X}{Y}\right)_n,$$

that is, counties are ranked according to increasing intensity. The Gini coefficient equals zero when activity is evenly distributed over the regions, and equals one if the activity is fully concentrated in one county. The changes in Gini coefficient over time provide information on the extent to which activity has become regionally more concentrated or less concentrated.

The Gini coefficient yield information only about the degree of regional concentration. However, if two counties switch positions, the Gini coefficient remains the same. For the investigation of changes in ranking of counties can be employed by ranking order correlation coefficient, such as the Spearman coefficient:

$$r_s = 1 - \frac{6}{n(n^2-1)}\sum_{i=1}^{n}D_i^2 \qquad (2),$$

where D_i is the difference in ranking number of county i between two periods. The value of r_s is one if the ranking of the counties remains the same, and minus one if the ranking in the end period is the opposite of the ranking in the beginning period.

In addition, we employ transition probability matrices to identify the persistence in the ranking of each county. We classify counties into quartiles and then we investigate the chance of moving of a county from one quartile to another one. The degree of mobility in patterns of ranking can be summarised using indices of mobility. These formally evaluate the degree of mobility throughout the entire distribution of ranking and facilitate direct cross-commodity comparisons. The Markov index (M_1), following Shorrocks (1978), evaluates the trace (tr) of the Markov transition probability matrixThis index thus directly captures the relative magnitude of diagonal and off-diagonal terms, and can be shown to equal the inverse of the harmonic mean of the expected duration of remaining in a given cell.

$$M_1 = \frac{K - tr(P)}{K - 1} \qquad (3),$$

where K is the number of cells, and P is the transition probability matrix. In M1 indices, a higher value indicates greater mobility, with a value of zero indicating perfect immobility.

We calculate Moran's I statistics for spatial autocorrelation to evalute of spatial patterns in the regional values. Data (zi) are spatially autocorrelated if neighbouring values are more alike than those further apart. If data shows spatial autocorrelation, the locations of the counties provide information about the spatial pattern of variation in these data. Moran's I statistics is defined as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(z_i - \bar{z})(z_j - \bar{z})}{\left(\sum_{i=1}^{n}(z_i - \bar{z})^2 (\sum_{i=1}^{n}\sum_{j=1, j\neq i}^{n} w_{ij})\right)} \qquad (4),$$

where w_{ij} is the $(i,j)^{th}$ element of the matrix W, describing the spatial arrangement of the counties in this study.

3 RESULTS

Table 1 shows the Gini coefficients for the production and land use of wheat, maize and oilseeds. In general, the values of both Gini coefficients are relatively low for all products (mostly below 0.4) indicating that crops cultivation widely spread over the counties. In other words, regional concentration of crops production is low. The difference between coefficients for production and land use is small without unambiguous trend. The degree of regional concentration is somewhat higher than that of land use for wheat and maize, while the picture is mixed for oilseeds.

Table 1: Gini coefficients for production and land use between 1990 and 2005

	Wheat		Maize		Oilseeds	
Year	**Production**	**Land use**	**Production**	**Land use**	**Production**	**Land use**
1990	0.25	0.25	0.38	0.31	0.30	0.32
1991	0.28	0.25	0.34	0.30	0.53	0.53
1992	0.23	0.54	0.35	0.30	0.34	0.36
1993	0.26	0.27	0.36	0.30	0.33	0.33
1994	0.29	0.25	0.33	0.30	0.35	0.34
1995	0.27	0.27	0.35	0.31	0.39	0.42
1996	0.29	0.27	0.36	0.31	0.41	0.38
1997	0.27	0.26	0.36	0.31	0.38	0.39
1998	0.29	0.28	0.37	0.32	0.40	0.40
1999	0.32	0.31	0.36	0.33	0.36	0.34
2000	0.27	0.26	0.39	0.34	0.38	0.40
2001	0.29	0.28	0.43	0.34	0.39	0.38
2002	0.28	0.27	0.43	0.35	0.38	0.40
2003	0.30	0.28	0.39	0.33	0.42	0.43
2004	0.32	0.28	0.38	0.34	0.40	0.41
2005	0.28	0.28	0.36	0.33	0.36	0.38

Source: Own calculations based on various issues of Regional Statistical Yearbooks, Central Statistical Office.

The changes in regional concentration do not exhibit a clear trend. To evaluate more formally the changes in regional concentration in crop production we regress the log of the Gini coefficients on a simple time trend (see, for example, AMITI, 1998). Our results suggest that there is a significant growth in regional concentration of production for wheat and maize and for the land use of maize. Calculations also indicate that there are no significant changes in regional concentration of oilseeds.

Table 2: Changes in spatial concentration for production and land use between 1990 and 2005

		Constant	Year	Adjusted R^2	n
Wheat	Land use	5.602	-0.003	-0.0359	16
	Production	-4.803**	0.003**	0.2644	16
Maize	Land use	-5.259***	0.003***	0.6075	16
	Production	-5.770*	0.003**	0.2092	16
Oilseeds	Land use	-1.604	0.001	-0.0622	16
	Production	-1.577	0.001	-0.0622	16

Source: Own calculations based on various issues of Regional Statistical Yearbooks, Central Statistical Office.

Table 3: Spearman coefficients for production and land use between 1990 and 2005

	Wheat		Maize		Oilseeds	
Year	**Production**	**Land use**	**Production**	**Land use**	**Production**	**Land use**
1991	0.9754	0.9912	0.8662	0.9860	0.9030	0.9298
1992	0.8907	0.8719	0.7907	0.9772	0.9443	0.9614
1993	0.8895	0.9596	0.8504	0.9807	0.8993	0.9632
1994	0.9333	0.9684	0.6713	0.9719	0.9443	0.9228
1995	0.9632	0.9719	0.7222	0.9386	0.8741	0.9018
1996	0.9684	0.9632	0.7907	0.9667	0.8890	0.8982
1997	0.9526	0.9649	0.7758	0.9632	0.9014	0.8807
1998	0.9228	0.9719	0.7626	0.8947	0.9422	0.9298
1999	0.7825	0.8614	0.8135	0.9544	0.7971	0.8667
2000	0.8754	0.9491	0.8056	0.9281	0.8204	0.8333
2001	0.9421	0.9667	0.8469	0.9561	0.8473	0.8088
2002	0.8491	0.9456	0.7073	0.9614	0.8596	0.8877
2003	0.8211	0.9088	0.7442	0.9368	0.8535	0.8719
2004	0.9246	0.9544	0.8355	0.9368	0.8906	0.8982
2005	0.9140	0.9456	0.7073	0.9140	0.8741	0.8912

Source: Own calculations based on various issues of Regional Statistical Yearbooks, Central Statistical Office.

The Spearman coefficients are very high (>0.85) for land use of all crops, meanwhile corresponding values are somewhat lowest for production, but they are still relatively high (>0.8) indicating a fairly stable pattern in the ranking of counties over time (Table 3).

Table 4: Markov matrices of the county rank for production and land use between 1990 and 2005

Wheat			**Production**				**Land use**	
Quartiles	1	2	3	4	1	2	3	4
1	0.80	0.20	0.00	0.00	0.80	0.20	0.00	0.00
2	0.25	0.50	0.25	0.00	0.25	0.50	0.25	0.00
3	0.00	0.20	0.60	0.20	0.00	0.20	0.60	0.20
4	0.00	0.00	0.20	0.80	0.00	0.00	0.20	0.80
M1		0.43				0.43		
Maize		**Production**				**Land use**		
1	0.60	0.40	0.00	0.00	0.67	0.17	0.17	0.00
2	0.33	0.33	0.33	0.00	0.33	0.67	0.00	0.00
3	0.17	0.17	0.33	0.33	0.00	0.20	0.40	0.40
4	0.00	0.00	0.40	0.60	0.00	0.00	0.40	0.60
M1		0.71				0.56		
Oilseeds		**Production**				**Land use**		
1	0.80	0.20	0.00	0.00	0.80	0.20	0.00	0.00
2	0.25	0.50	0.25	0.00	0.25	0.50	0.00	0.25
3	0.00	0.20	0.60	0.20	0.00	0.20	0.80	0.00
4	0.00	0.00	0.20	0.80	0.00	0.00	0.20	0.80
M1		0.43				0.37		

Source: Own calculations based on various issues of Regional Statistical Yearbooks, Central Statistical Office.

The transition matrices in Table 4 suggest that ranking of counties are fairly persistent for first and last quartiles from 1990 to 2005. The diagonal elements for these classes are 0.80 for wheat and oilseed, indicating a high probability that a county being in the lowest or highest quartiles at the start of the period will have that same status at the end of the period. The persistence is relatively strong of these classes for maize; the value of cells is 60 per cent. This suggests that once obtaining a low or high rank they will likely maintain it over time. Note, that the values relative to the ends of the distribution on the main diagonal is larger than those in the middle of distribution for all crops. In other words, it is easier maintaining low or high ranks than a weak or medium one. Furthermore, our results suggest that the probability of an observation moving to a lower value cell (a weakening of rank) is much higher than the reverse case. Estimations show that mobility is the highest for maize both in terms of production and land. The values mobility indices are the same for production of wheat and oilseeds, but corresponding value is lower for the land use of oilseeds. This suggests that mobility is the lowest for the land use of oilseeds.

Table 5 reports Moran's I statistics for all crops. First striking feature is that all results significantly differ from zero. For wheat, the degree of spatial autocorrelations of land dropped suddenly in 1992 than stabilised between 0.3 and 0.4 with a slightly decreasing trend. Results show a similar fashion for production with a larger fluctation after the random shock. The estimations indicate that in the second half of analysed period the land use and production of wheat has become less concentrated in contiguous counties.

Table 5: Moran's I statistics for production and land use between 1990 and 2005

	Wheat		Maize		Oilseeds	
Year	Production	Land use	Production	Land use	Production	Land use
1990	0.391	0.378	0.421	0.387	0.401	0.390
1991	0.421	0.404	0.413	0.381	0.038	0.044
1992	0.164	-0.102	0.431	0.414	0.344	0.385
1993	0.263	0.335	0.422	0.393	0.283	0.372
1994	0.403	0.353	0.481	0.361	0.347	0.345
1995	0.299	0.357	0.440	0.343	0.372	0.274
1996	0.420	0.382	0.407	0.389	0.447	0.395
1997	0.354	0.386	0.402	0.378	0.369	0.431
1998	0.383	0.394	0.434	0.405	0.387	0.381
1999	0.334	0.309	0.336	0.323	0.292	0.332
2000	0.221	0.294	0.361	0.350	0.288	0.346
2001	0.373	0.374	0.394	0.381	0.452	0.403
2002	0.292	0.336	0.412	0.352	0.370	0.399
2003	0.248	0.330	0.302	0.379	0.334	0.378
2004	0.356	0.341	0.379	0.358	0.355	0.364
2005	0.251	0.299	0.417	0.381	0.320	0.354

Source: Own calculations based on various issues of Regional Statistical Yearbooks, Central Statistical Office.

The degree of spatial autocorrelations of land use and production of maize show a continuously declining trend. This suggests that during the analysed period the land use and production of maize has become less concentrated in adjacent counties. Moran's I statistics for oilseeds shows that the degree of spatial autocorrelations of land use and production decreased suddenly in 1991 than fluctuated between 0.27 and 0.45 with a slightly increasing trend. It implies that the land use and production of oilseeds has become more concentrated in contiguous counties.

Table 6: Changes in spatial autocorrelation for production and land use between 1990 and 2005

		Constant	Year	Adjusted R^2	N
Wheat	Land use	7.929	-0.004	-0.0127	16
	Production	-6.662	0.003	-0.0502	16
Maize	Land use	3.719	-0.002	0.0482	16
	Production	9.791**	-0.005**	0.2224	16
Oilseeds	Land use	-12.320	0.006	0.0519	16
	Production	-10.546	0.005	0.0041	16

Notes: Significance levels are* 10 per cent; ** 5 per cent; ***1 per cent.

Similarly to Gini coefficients, we regress the log of the Moran's I statistics on a simple time trend to evaluate the changes in spatial autocorrelation. The estimations show a decline in spatial autocorrelation for maize productions and land use, but just former one is significant (Table 6). This confirms our a priori expectations based on previous informal analysis. The coefficients for oilseeds are positive, without significance. For wheat, the results report the opposite signs for land use and production of wheat, but coefficients are not significant.

Next step we try to explain the changes in spatial concentration for various crops. We focus on the possible factors. First, the structural changes in production and land use. The share of private farms increased considerably period in question. So, we expect that this development may affect on the spatial concentration of crops. However, we have no a priori expectations on the direction of impacts. Second concern is the changes in agricultural policy measures. Before 1990 Hungarian agricultural policy supported with special measures the crop production in less favoured areas. These interventions were eliminated during the transition period that may also have impacts on the spatial concentration. To evaluate the effects of these possible factors, we estimate the following simple models:

$$Spatconc_{it}=\alpha_1+ \alpha_2 PSE_{it}+ \alpha_3 Privshare_{it} \quad (5),$$

Where Spatconc is the Gini coefficient for land use or production, PSE denotes PSE index, and Privshare describes the share of private farms in land use or production, i denotes the product and t is the time.

Table 6 shows the results of our estimations. Interestingly, we have not found significant relationship measured by PSE index between agricultural support and spatial concentration for any cases. But estimates show positive and significant effects of the share of private farms in the production of wheat and maize on spatial concentration. In addition, we also find a positive and significant relationship between the share of private farms in land use of maize and spatial concentration.

Table 7: The effects of PSE index and share of private farms on spatial concentration for production and land use

	Constant	PSE	Privshare	R^2	N
			Production		
Wheat	0.2609***	0.0002	0.0554**	0.3821	14
Maize	0.3185***	0.0003	0.1019**	0.2364	14
Oilseeds	0.3869***	0.0005	0.0079	0.4964	14
			Land use		
Wheat	0.3137***	-0.0003	-0.0822	0.7865	14
Maize	0.2796***	0.0002	0.0732***	0.4092	14
Oilseeds	0.3963***	0.0006	-0.0088	0.5529	14

Notes: Significance levels are* 10 per cent; ** 5 per cent; ***1 per cent.

4 CONCLUSIONS

The paper investigates the spatial development of crop production in Hungary between 1990 and 2005. Our results based on Gini coefficients suggest that the spatial concentration of production and land use was nearly the same for wheat and oilseeds, while the spatial concentration of production was higher than land use for maize. Furthermore, the spatial concentration was lower for wheat than other crop products. The coefficients of Spearman correlation were very high for all crops production and land use. It implies that spatial structure of crop productions has remained fairly stable during analysed period. However, transition probability matrices show a higher mobility across quartiles in the ranking of counties. The chances remaining the lowest or highest quartiles are high, while the probability of an observation moving to a lower rank is much higher than the reverse case. The spatial concentration increased significantly for wheat and maize production and maize land use, whilst the changes were not significant for other cases. Moran I statistics confirm the presence of spatial autocorrelation for all cases. The estimations show a decline in spatial autocorrelation for maize productions indicating a less concentrated production in contiguous counties. Finally, we have not found significant relationship measured by PSE index between agricultural support and spatial concentration, but estimates show positive and significant effects of the share of private farms in the production of certain crops on spatial concentration. In sum, despite of significant changes in Hungarian agriculture the spatial structure of crop production shows a fairly stable pattern in last sixteen years.

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