Regional Spatial Changes in the Slovak Agriculture

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Abstract
This paper discusses the Slovak regional economy structural changes, development and factors of regional economic specialisation and geographic concentration of sectors with a focus on agriculture from 1995 to 2012. Specialization and sector geographic concentration were quantified by Herfindahl and Entropy indices. At the national level we found steadily growing share of crop production at the expense of animal production. Regional concentration of both, crop and animal production and animal production specialisation has been increasing. Spatial clusters of similar specialised regions were detected for crop production. Linear panel models were used to estimate the effect of selected factors on regional crop and animal production specialisation. The agricultural policy instruments, including the CAP had significant effect on regional crop and animal production specialisation patterns. Provision of the complementary national direct payments (CNDP) and investment support had positive effect on regional crop production diversification. Density of regional road network, average annual temperature in the growing season, average annual rainfall in the growing season and provision of the LFA payments had positive effect on both regional crop and animal production diversification.

Key words: agriculture, specialization, cluster, regions, econometric model, panel, CAP, Slovakia

JEL classification: R12, R15, Q18, C23

Introduction

The accession of Slovakia into the EU single market led to changes in the economy structure and reallocation of economic activities. Traditional trade theory suggests country specialisation in activities, in which it has a comparative advantage and predict a monotonic relationship between income and economy diversification. There is insufficient empirical evidence on specialization and sector concentration pattern in the EU New Member States as a result of the EU integration. Most of the studies analyse industry specialisation and geographic concentration patterns. Moreover, findings on sector geographic concentration development in the New Member States differ by studies.

Studies on agricultural production specialisation and geographic concentration trends are rare. They stress natural conditions, policies and recently climate change effects on agricultural production allocation, land use, specialisation and agricultural sector geographic concentration. Studies on the EU agricultural changes are usually conducted at national level, although the national averages tend to hide country regional diversity.

The aim of our study was to investigate the Slovak regional economy specialisation and sector geographic concentration development with a focus on agriculture. Regional crop and animal production specialisation and geographic concentration pattern, changes in spatial distribution of specialised regions on crop and animal production, and drivers of the regional specialisation are examined. Along with traditional theory we expect parallel development of specialisation and sector geographic concentration, and clustering of specialised regions. We further expect a significant effect of agricultural policies instruments (especially after the SR accession to the EU) and effect of climate change on agricultural production diversification.

Economic specialisation and sector geographic concentration in empirical studies
A general concern of the process of European integration was associated with growing regional specialization, making regions more vulnerable and prone to adverse shocks (**Amiti, 1999, WIFO, 1999 Hallet, 2000**). Traditional trade theory suggests country specialisation in activities, in which it has a comparative advantage and predict a monotonic relationship between income and diversification. Several empirical studies however found U-curve development of country specialisation depending on country income per capita (**Kalemli-Ozcan, Sorensen and Yosha, 2003; Imbs and Wacziarg, 2003**). At higher levels of GDP per capita trend of diversification slows down and re-specialization is observed. Some studies argue that the process of diversification continues and there is no re-specialization of production (**De Benedictis, Gallegati and Tamberi, 2007**). Conclusions on sector geographic concentration development differ by studies. **Amiti (1999), Hallet (2000) and Midelfart-Knarvik et al. (2000), Barrios – Strobl (2002)** argue that sector geographic concentration is likely to increase as a result of integration. **Midelfart-Knarviket al. (2000)** found geographic concentration growth of industries in peripheral areas of the EU with cheap labour-intensive and less skilled labour force in the EU before 2004. Labour-intensive industries with strong vertical relations were allocated to the central regions. **Midelfart-Knarvik et al. (2000), Landesmann (2003)** analysed trade pattern of industry in the Central and Eastern Europe in the period 1995-2000. They indicated Slovakia, together with Hungary, the Czech Republic, Estonia and Poland as countries specialized in technology-intensive industries. According to several studies, the Slovak economy was more specialized than the EU average already before the accession to the EU.

Most of existing studies on economy specialisation and sector geographic concentration are focusing on industries, manufacturing (**Ellison - Gleaser, 1997; Aiginger - Rossi-Hansberg, 2006; Ezcurra - Pascual and Rapún, 2006**. There is insufficient empirical evidence **(**e.g **Tsiapa, 2013)** on specialization and sector geographic concentration pattern as a result of the EU integration. Furthermore, there has been less attention devoted to agricultural production allocation, specialisation and geographic concentration trends. Studies are conducted usually at the national level, examine particular agricultural sector, commodity, land use, or they assess an impact of specific driver, usually ignoring the spatial dimension. Most empirical studies on specialization, geographic concentration and localization of agri-food activities are based on Von Thünen concept and traditional well defined distinctions of rural and urban districts.

Spatial dimension of agricultural activity allocation can be viewed from several perspectives. The **OECD (2009)** study analysed the effects of diverse policies on farmland conversion and developed a generic typology of three spatial zones. A central hypothesis of the study is that agriculture is essentially a spatially specific activity, as both the returns from agriculture and the opportunity costs of keeping land in agriculture vary across space. Specialisation or mix of produced commodities, land use, management choices can be affected by agricultural, agri-environmental, land-use and regional policies, and many non-policy factors such as climate change, demographic change and globalisation (**OECD, 2009**).

There are several studies on regional and spatial developments of selected agricultural commodities production in the EU using different methods. **Elhorst and Strijker (2003)** and **Strijker (2008)** analysed wheat, tobacco, and further arable and animal productions regional spatial geographic concentration and centre of gravity of production in the EC-9 over the post-war period. Geographic concentration and specialization of agricultural production in the EU in between 1983-1995 analysed

Daniel (2003). She found that the Common Agricultural Policy (CAP) support reduces comparative advantage effect, by allowing crop production in less competitive conditions. Subsidized products are more sensitive to economic openness and their production is more dispersed throughout the country. Increasing openness of markets can enhance subnational geographic concentration of production. Impact of the Common Agricultural Policy instruments on farm income geographic concentration analysed **Severini - Tantari (2013).** They found that the direct payments and farm income in Italy are both concentrated and regional implementation of direct payments would enable to reduce farm income concentration.

F**ertő (2007)** analysed spatial changes in cultivation and land use of wheat, maize and oilseed in Hungarian regional (county) agriculture from 1990 to 2005. He found that spatial geographic concentration increased significantly for wheat and maize production and maize land use. While there was no significant relationship between policy support and spatial geographic concentration development, share of private farms in the production of certain crops had positive and significant effect on these crops spatial geographic concentration.

There is a growing number of studies on potential drivers and assessment of their impact on changes in the EU agriculture. Special attention is devoted to climate change impact and adoption of strategies mitigating its adverse effect. Factors affecting changes in structure of the EU agriculture investigated SASSPO **(Brouwer, 2006)**. They found that biophysical and climatic conditions have a major impact on agricultural production, but important factors were also access to markets, logistics and transportation infrastructure. The Alterra study identified abiotic and climate factors as driving forces for spatial change in agriculture and regions in Europe and assessed impact of scenarios on wheat, potato and dairy farming (**Hermans – Verhagen, 2008**). Factors of regional dynamic and spatial distribution of agricultural production in France analysed **Arfa et al. (2011).**

The impact of climate change on agricultural production analysed in marginal areas of the EU **Mestre-Sanchis - Feijóo-Bello (2009**). Adaptation of crop production to climate change in 26 countries of Europe addressed **Olesen et al. (2011).** Their results suggest that farmers across Europe can adapt to climate change, they are altering the timing of cultivation and selection of individual crop varieties. **Shrestha et al. (2013)** investigates the medium term economic impact of climate changes on the EU agriculture. Stronger impact was found at regional level, particularly in the Central and Northern EU and smaller impacts were observed in Southern Europe. According to this study the technical adaption of crops to climate change may result in a change production and land use by a factor between 1.4 and 6 relative to no-adaptation situation.

Climate change risk and potential adaptation options at the national level in agriculture are discussing in the **OECD (2015)** study**.** Among a wide range of potential adaptation options to address the climate change risks (**Ignaciuk and Mason-D'Croz, 2014**) are changing planting dates, use of new varieties, diversification and sustainable soil and water management techniques.

Agriculture in the Slovak national and regional economy

Agriculture in 2014 accounted for 4% of the Slovak GDP and employed about 3% of the labour force (down from 10.2% in 1994) (**SO SR, 2015**). As a result of the 'Hungarian inheritance system' land ownership in Slovakia is fragmented. There were around 12.5 million of parcels with shared ownership of 12 - 15 owners on average and 0.45 hectares per owner in 2008 (**MPaRV SR, 2009)**. 90% of the total area of utilized

agricultural land has been rented depending on district (**MPaRV SR, 2014**). In the Slovak agriculture a dual farm structure persists, when approx. 15% of agricultural holdings cultivate around 93% of UAA (**FSS, 2013**).

Slovakia is a predominantly mountainous country with a high share of low production quality of soil and areas facing natural and other specific constraints. The LFAs constitute more than 50% of the utilised agricultural area (UAA). According to the OECD definition, more than 50% of population of the region live in mostly rural regions; less than 15 % of population live in mostly urban regions (**MPaRV SR, 2014**).

There have been significant changes observed in the Slovak agriculture over the period 1997-2012. Gross agricultural output (GAO) of the Slovakia, as well as regional GAO fall down and their structure has changed in favour of crop production (Fig. 1). Over the observed period, the Slovak agriculture is characterised by declining regional number of farm animals (except for sheep); by declining crop growing areas and crop yields (except for oilseeds).

The position of agriculture in regional employment improved in the lagging Eastern Slovakia regions. In the Western and Central Slovakia developed regions, with prevailing best conditions for agricultural production, agriculture lost its position and its share on regional employment fall down.

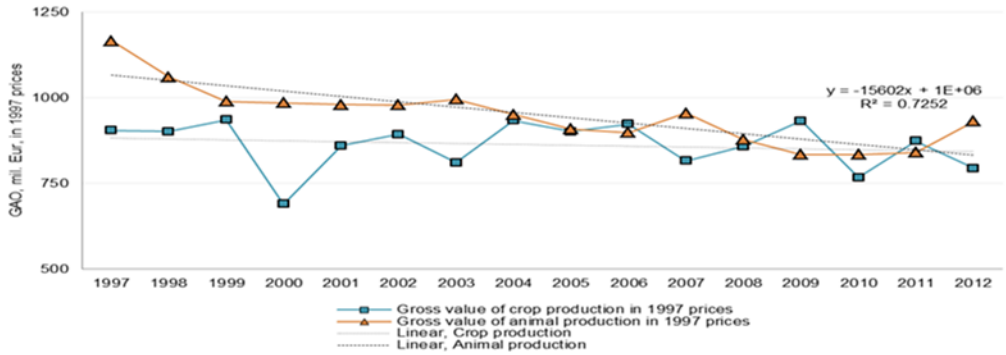


Figure 1. Gross value of crop and animal production in 1997 prices, 1997-2012
Source: Own calculation based on SO SR data

Data and Methods

We used yearly data of employment and gross value added by sections of economic activities, classified according to the high-level aggregation (11 aggregates), which aggregates the ISIC Rev. 4/NACE Rev. 2 (**European Commission, 2008**) at the national, NUTS II (4 regions), NUTS III (8 regions) and NUTS IV (79 regions) levels from 1995 to 2012 (**SO SR, RegDat, 2014**). Further we used yearly data on regional agricultural indicators of period 1997-2012 from the Information letters of **MPRV SR (2014)** and data on regional climatic conditions (**SHMU SR, 2015**).

Specialization of regional economies and geographic concentration of economic activity in the regions were assessed by the Herfindal index (H) (Eq. 1) and entropy index (Eq. 2).

$$H_j = \sum_i \left(\frac{E_{ij}}{\sum_i E_{ij}}\right)^2 \qquad H_i = \sum_j \left(\frac{E_{ij}}{\sum_j E_{ij}}\right)^2 \tag{1}$$

$$SPEC_j = -\sum_i \left(\frac{E_{ij}}{E_j}\right) ln\left(\frac{E_{ij}}{E_j}\right) \qquad CONC_i = -\sum_j \left(\frac{E_{ij}}{E_i}\right) ln\left(\frac{E_{ij}}{E_i}\right) \tag{2}$$

Where: H_j and $SPEC_j$ index of specialization; H_i and $CONCi$ index of geographic concentration; Eij employment in economic activity i in region j; $Ej = \Sigma i\ Eij$ total employment in all economic activities in the region j; $Ei = \Sigma j\ Eij$ total employment in all regions in the economic activity i.

The global Moran's I (**Moran 1950**) statistics (Eq. 3) was used to describe spatial autocorrelation of regional specialisation. *I* is an index of linear association between a set of spatial observations $x_i\, x_j$ (index of specialization) and a weighted average w_{ij} of their neighbours.

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})(\sum_{i=1}^{n}(x_i - \bar{x})^2)} \quad (3)$$

Where n is the number of regions, w_{ij} denotes the elements of a matrix W of spatial weights. The neighbourhood weights, *wi,j*, were determined using the first-order spatial contiguity matrix (Queen).

The Local Indicators of Spatial Association (LISA) statistics (**Anselin, 1995)** (Eq. 4), Moran Scatterplots and Local Moran's *I* were used to explore the spatial structure and to detect the regional clusters.

$$I_i = \frac{n}{\sum_{i,j}^{n} w_{ij}\sum(x_{i-}\bar{x})^2})((x_i - \bar{x})\sum_{j=1}^{n} w_{ij}(x_j - \bar{x})) \quad (4)$$

A positive LISA indicates a spatial clustering of similar values. The Moran scatter plot (**Anselin, 1996**), is divided into four quadrants and summarize all spatial associations between observations. The most important in detection of clusters are HH (LL) quadrants of positive spatial autocorrelation, constituted of regions with high (low) specialisation surrounded by regions with high (low) specialisation.

We investigated effect of selected factors representing regional climatic conditions, market prices, factor endowments, infrastructure and agricultural policy instruments, on regional commodity specialization of crop and livestock production (Eq. 5) by estimation of parameters of linear panel models using annual data (IL MPaRV, SHMU). Due to inconsistency of policy support instruments before and after accession to the EU, we constructed panels, models and analysed the periods 1997-2012 and 2004-2012 separately. The dependent variable - regional commodity specialization of crop and livestock production was expressed by Herfindahl index.

H = (PRTVO; PRUZVO; TRRV; TRZV; CRV; CZV; POP; PLP, LP; INFR; EUA; SUP; SINV; SNEINV; LFA; SAPS; DNPP; SUP_1; SINV_1; SNEINV_1; LFA_1;SAPS_1;DNPP_1; HRV_1; HZV_1) (5)

Where:

H Herfindahl index of regional plant production (livestock production) specialization (Eq. 1)
PRTV average regional annual temperature in growing season, ° C;
PRUZVO average regional annual rainfall in growing season, mm;
TRRV plant production receipts per ha of arable land;
TRZV animal production receipts per ha of utilized agricultural area (UAA);
CRV seeds costs per ha of arable land;
CZV livestock feed costs per large animal unit (LU);
POP share of arable land;
PLP share of meadows and pasture;
LP agricultural land price tiers, 1-20;
INFR density of the road network in km per km^2, market access;
EUA accession to the EU, dummy variable 0 to 2004, 1 since 2004
SUP subsidies per ha of UAA;
SINV investment support per ha of UAA;
SNEINV non-investment support per ha of UAA;
LFA less-favoured areas payments per ha of UAA;
SAPS single area payment per ha of UAA;
DNPP complementary national direct payments per ha of UAA;
SUP_1 subsidies per ha of UAA with a time lag of one year (_1);
SINV_1 investment support per ha of UAA (_1);
SNEINV_1 non-investment support per ha of UAA (_1);
LFA_1 less-favoured areas (LFA) payments per ha of UAA (_1);

SAPS_1 single area payment per ha of UAA (_1);
DNPP_1 complementary national direct payments per ha of UAA (_1);
HRV_1 regional commodity specialization of plant production (_1);
HZV_1 regional commodity specialization of livestock production (_1).

Model parameters estimation and econometric verification was done in Gretl. Assumption of homoscedasticity was tested using White's test (White, 1980). Presence of autocorrelation was detected by Durbin - Watson test (Durbin - Watson, 1950). Multicollinearity was diagnosed by the variance inflation factor VIF. To deal with heteroskedasticity problem in the panel we applied weighted least squares (WLS) method. Software used for spatial analysis was ArcGis, GeoDA.

Preliminary Results and Discussion

We found increasing diversification and sector geographic concentration of the Slovak economy (NUTS I) over 1995-2010 (Fig. 2). Growing diversification is in line with classical theory of diversification growth along with GDP growth and supports conclusions of **De Benedictis, Gallegati, and Tamberi (2007).** Bratislava region, the most developed in Slovakia, had the most diversified regional economy, with growing specialization over time. This development supports theories of U-curve specialisation development.

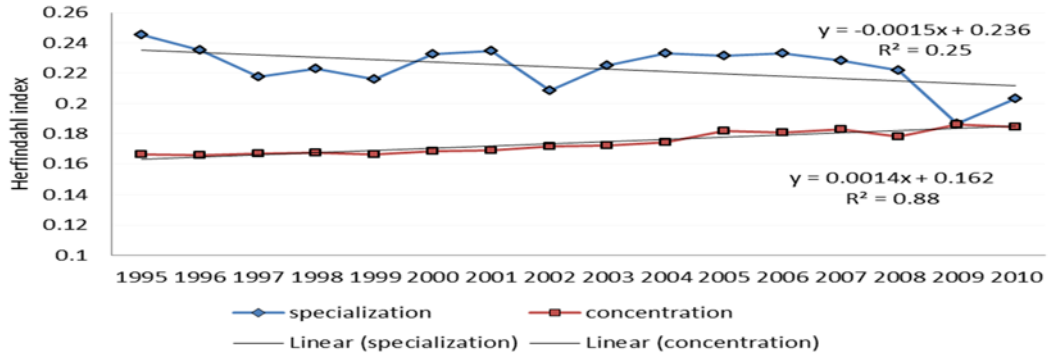


Fig.2 Development of the Slovak economy specialisation and sector geographic concentration, Herfindahl index, 1995-2010
Source: Own calculation based on SO SR data

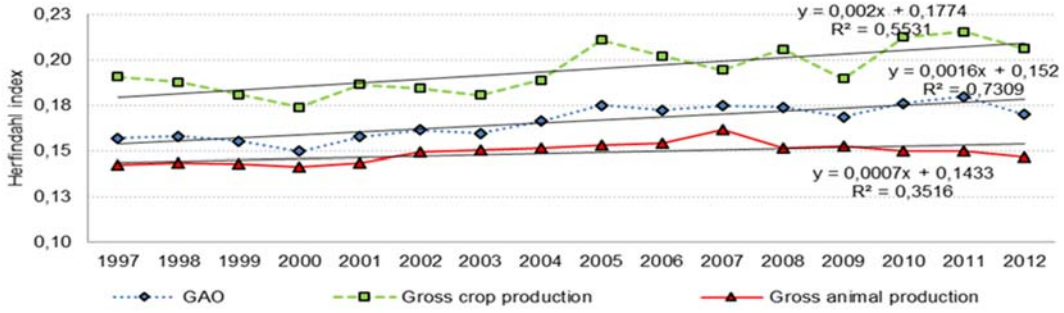


Fig. 3 Development of regional GAO geographic concentration, Herfindahl index, 1997-2012
Source: Own calculation based on SO SR data

Regional contribution to gross agricultural output (GAO) in the Slovakia was relatively evenly spread, with slightly growing geographic concentration (Fig. 3). At the regional level, regional GAO specialization has been increasing, especially in Žilina region with high share of LFA and prevailing animal production. Regional GAO diversification growth was observed in formerly typical agricultural region Nitra and less developed Košice NUTS III regions (Fig. 4). Animal production in Slovakia was in the period 1997-2012 spread across the country. However, there was significantly growing geographic concentration of poultry and pig production.

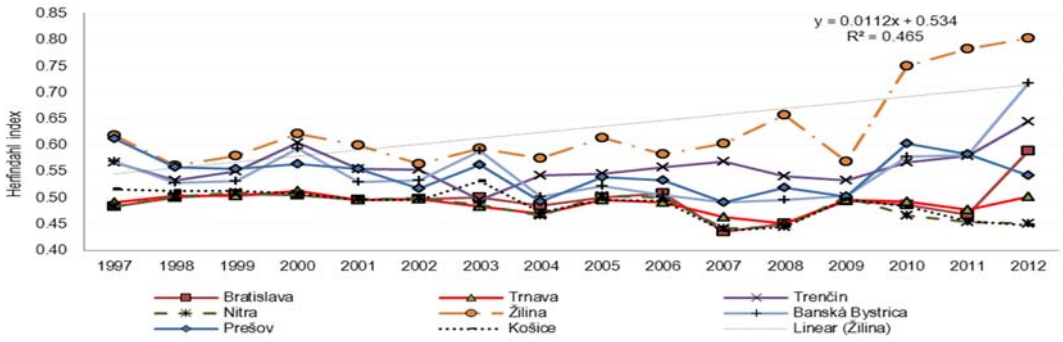


Fig. 4 Development of NUTS III regional GAO specialization, Herfindahl index, 1997-2012
Source: Own calculation based on IL MPRV SR data

In the period 1997-2012 regional crop production specialization significantly declined, while specialization of regional animal production increased. Regional animal production was more specialised and specialised regions became more dispersed across the country, compare to the regions with specialised crop production (Fig.5). In 1997 we detected low negative spatial autocorrelation in district crop production specialisation, what indicates dissimilar neighbouring region crop production specialisation. In 2012 there were positive spatial autocorrelation of regional specialisation. We found statistically significant cluster of regions in the South Slovakia with a high specialisation on crop production, where the best soil quality prevails (Fig. 6). The second cluster of regions was formed in 2012 out of the North Slovakia regions, with low level of crop production specialisation (LFA mountainous regions).

In 1997, slightly positive spatial autocorrelation of higher regional animal production specialization was detected in the North Slovakia (LFA regions). A significant cluster of districts with a low degree of specialization were formed in the South Slovakia (high soil quality). In 2012 the spatial distribution of regions with high animal production specialisation increased (negative spatial autocorrelation).

In the period 1997-2012 regional crop production specialization significantly declined (diversification increased), while specialization of regional animal production increased. We estimated effect of selected factors on regional crop and animal production specialization using linear models and panel data. Due to inconsistency of the policy instruments, parameters of models for post-accession period 2004-2012 were also estimated. After the accession to the EU, regional animal production specialisation has been significantly declining.

In the overall period (Tab. 1) we found a significant negative impact of average annual rainfall in the growing season (GS) on regional (NUTS IV) crop production specialization. The effect of average annual temperature (GS) on regional crop production was insignificant, while it had significant effect on regional animal production diversification.

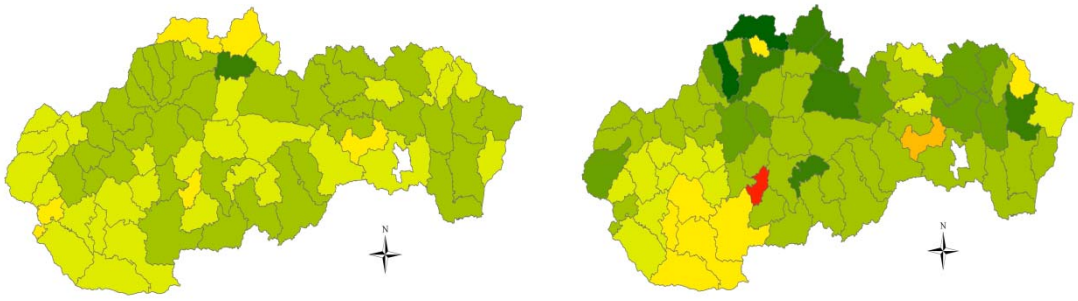
Input prices had significant positive effect on animal production diversification. This finding can be explained by low market price of particular animal products and therefore higher risk of specialized livestock production. Market prices and growing receipts of crop production had a significant positive effect on both, regional crop and animal production specialization in the overall period. After the accession to the EU, agricultural price volatility contributed to diversification of regional crop production.

Arable land share and higher soil quality had significantly positive effect on regional crop production specialization. Higher density of regional road network contributed to higher diversification of both, regional crop and animal production. This

finding differs to e.g. **Qin and Zhang (2012)** study in China, where they found that better access to roads facilitates agricultural specialization.

We investigated also the effects of agricultural policy instruments on agricultural specialization development. Agricultural subsidies in the overall observed period had significant effect on growth of regional crop production diversification, and regional animal production specialization (Tab. 1).

Regional crop production specialisation 1997, 2012



Regional animal production specialisation 1997, 2012

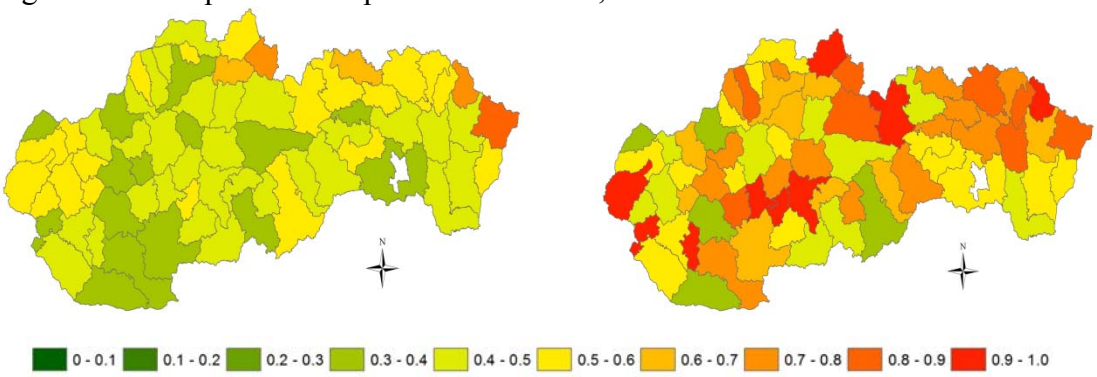


Fig. 5 The Slovak regional crop production specialisation in 1997 and 2012. (Herfindhal index)
Source: Own calculation

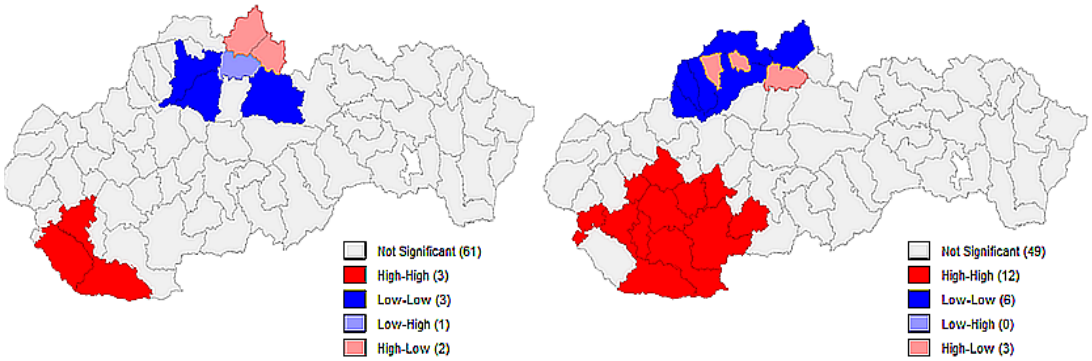


Figure 6 Clusters of regions with crop production specialisation. 1997, 2012
Source: Own calculation

The effect of Common Agricultural Policy (CAP) instruments introduced after the accession to the EU, namely the Complementary direct payments (CNDP) and investment support, contributed to growth of crop production diversification. LFA payments had positive effects on both, regional crop and animal production diversification. The Single area payment scheme (SAPS) had - as expected - no significant effect on regional agricultural production specialisation.

Lagged regional crop and animal production specialization levels had positive effect on specialisation of agricultural production. This can be explained by advance contracting of both crop and animal production.

Table 1 Regional crop and animal production specialisation, 1997-2012

	Crop production		Animal production	
Variable	1	2	3	4
const	+***	+***	+***	+*
Year	-***		+***	
Average regional annual temperature in growing season	+	-	-***	-**
Average regional annual rainfall in growing season	-**	-***	-	+
Plant production receipts per ha of arable land	+***	+	+**	+
Animal production receipts per ha of UAA	-	-**	+	-
Seeds costs per ha of arable land	+*	-		
Livestock feed costs per LU			-***	-
Share of arable land	+*	+	-	+
Share of meadows and pasture	+	-	+	+
Agricultural land price tiers, 1-20	+***	+	+	-
Density of the road network in km per km2	-**	-	-	-**
Subsidies per ha of UAA	-***		+***	
Subsidies per ha of UAA (_1)		+*		+*
Regional plant production specialisation (_1)		+***		
Regional livestock production specialisation (_1)				+***

Note: *, **, and *** stands for significance at the 10%, 5%, and 1% level, respectively.
Source: Own calculation based on IL MPRV SR, SHMU data

Conclusion and Discussion

Some findings at the Slovak regional level correspond with theoretical expectations and complement findings of studies done the EU. We found that the Slovak economy was relatively specialised already in the period before the SR accession to the EU. National economy diversification was growing over observed period 1995-2010. This finding comply with classical theory of diversification growth along with GDP growth and supports conclusions of **De Benedictis, Gallegati and Tamberi, (2007**). The most developed Bratislava region had the most diversified regional economy, with growing specialization over time, which supports theories of U-curve specialisation development. The industry geographic concentration in Slovakia and in most regions had been slightly growing.

Significant changes in the period from 1997 to 2012 have occurred in agricultural output structure. The share of crop production has been steadily growing at the expense of animal production. This trend contributes to increasing vulnerability of agricultural production and the Slovak farm performance. **Olesen et al. (2011)** found clear trends on increasing temperature affecting crop production and crop choice in Europe. Authors and other studies (e.g. **Shrestha et al., 2013)** predict that increasing frequency of droughts will negatively affect crop yield in central Europe.

The geographic concentration of both regional crop and animal productions has increasing trends. North Slovakia (LFA) regions became more specialised on animal production. Regions with medium soil quality on the Eastern and the South West Slovakia with high soil quality had the most diversified agricultural production.

Regional animal production is more specialised and specialised regions became more dispersed across the country compare to crop production. Regions with similar crop production specialisation formed over the observed period two clusters. The important is the South Slovakia cluster of regions with higher crop production specialisation.

Among the factors affecting specialisation, density of regional road network had significant positive effect on regional crop and animal production diversification. Further extension of infrastructure is desired especially in lagging Eastern Slovakia regions. **Qin and Zhang (2012)** however, found that better access to roads facilitates agricultural specialization in China.

Average annual temperature in the growing season and average annual rainfall in the growing season had statistically significant positive effect on both regional crop and animal production diversification. This finding corresponds with results of **Olesen et al. (2011)** that farmers across Europe can adapt to climate change and they are altering their production.

The impact the agricultural policy and the Common Agricultural Policy (CAP) instruments after the accession on the Slovak regional (NUTS IV) crop and animal production specialization was significant. Support payments per hectare (1997-2012) led in districts to crop production diversification and to animal production specialization. Provision of support under the Single Area Payment Scheme (SAPS) had – as expected, insignificant effect on regional agricultural production specialisation. Complementary National Direct Payments (CNDP) and investment support encouraged higher diversification of crop production. We found a positive effect of the Less Favoured Area (LFA) payments on both crop and animal production diversification.

Traditional econometric approach and the obtained results do not account for spatial effects, spatial dependence and spatial heterogeneity. In order to capture the spatial heterogeneity, potential drivers' impact on regional specialisation will therefore be further analysed using spatial panel data models.

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