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Labour productivity of agricultural business companies and cooperatives in the Czech Republic: A micro-regional level analysis

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Abstract

Drawing on empirical evidence from the Czech Republic, differences in agricultural labour productivity at the micro-regional level are examined. The role of geographical factors: natural conditions, landscape fragmentation, localisation and urbanization economies, are discussed. In addition, we also test the effects of farm size structure to capture the results of internal scale economies. The key importance of natural conditions is confirmed: they were significantly more important than farm characteristics such as size structure, ownership status and mode of production. Regional agricultural labour productivity was positively influenced by the nominal price of agricultural land and population density. Surprisingly, micro-regions dominated by large farms performed at lower productivity levels than micro-regions with fragmented farm size structure in the Czech Republic.

Keywords: *agriculture, labour productivity, micro-region, localisation economies, urbanisation economies, Czech Republic*

1. Introduction

Agricultural productivity has been studied extensively both at an (inter)national level (e.g. Hayami and Ruttan, 1970; Retortillo and Pinnila, 2005; Headey, et al. 2010; Alexiadis et al., 2013; Giannakis and Bruggeman, 2015) and at a farm level (e.g. Alvarez and Arias, 2004; Helfand and Levine, 2004; Bojnec and Latruffe, 2013). There is a well-developed theoretical framework and empirical tests considering the question why and how states differ from each other in terms of agricultural productivity or what are the most important factors of a farm´s productivity. On the other hand, little has been written about agricultural productivity at the regional level. This is quite surprising, considering the persisting importance of the Common Agricultural Policy in the European Union (EU) and claims about regional convergence and cohesion. Although in the majority of rural regions agriculture is only one of the drivers of economic and employment growth (Terluin, 2003), and despite the focus on non-production functions of agriculture, competitive agricultural production is still of strategic importance (Giannakis and Bruggeman, 2015).

Recent studies concerning the issue of regional agricultural labour productivity level (Ezcurra et al., 2011; Esposti, 2011; Cuerva, 2012; Latruffe et al., 2012) were performed at the NUTS2 or NUTS3 levels. While Esposti (2011) provided a comprehensive analysis of regional agricultural productivity in Italy (focusing on total factor productivity), Latruffe et al. (2012) compared regional productivity levels of farms in France and Hungary without considering geographical factors. Cuerva (2012: 255) defined the group of less productive regions as those with smaller farm size, less skilled labour force, more aged workers and lower degree of mechanization. Similarly, Ezcurra et al. (2011: 130) found positive relationships between agricultural labour productivity and per capita GDP, investment per worker and mean farm size, and negative effects of the share of less favoured areas, the farm owner's age, the percentage of non-owned land and regions specializing in field crops and grazing livestock.

Therefore, we identified three current gaps in the research on regional agricultural labour productivity in the European Union. Firstly, none of the above-mentioned authors studied the effect of agglomeration economies on farm productivity. Second, except for the case study of Hungary (Latruffe et al., 2012), there is a lack of knowledge about regional differences in agricultural labour productivity in Central and Eastern Europe. Thirdly, as far as we know, there has been no systematic research carried out on agricultural labour productivity at a micro-regional level to date.

There are several arguments why analyses of this kind could improve our understanding of agricultural labour productivity and its factors. The micro-regional level allows for more detailed analyses of the following relationships:

a. the effects of natural conditions and land-use on agricultural labour productivity since NUTS2 and NUTS3 regions can be internally too heterogeneous for such an assessment;
b. localisation and cluster economies resulting from the spatial concentration of farms or the co-localisation of farms and the food processing industry;
c. urbanisation economies that may increase agricultural labour productivity in metropolitan regions and their hinterlands; and
d. geographical descriptions that link the quality of the good to its geographical origin (Belletti et al., 2015: 94), where the particular locality with its natural resources, know-how, culture and traditions may be the key source of competitive high value-added agricultural production.

In this paper, we aim to fill the gaps and evaluate the importance of geographical factors in explaining differences

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in agricultural labour productivity at the micro-regional level[1]. Our research goal is to describe and explain current micro-regional disparities in agricultural labour productivity in the Czech Republic. We focus on the labour productivity of agricultural business companies and cooperatives. Private farms were excluded from the analysis because there are no available data covering economic indicators for private farms at a micro-regional level. We test the effects of natural conditions (measured by the nominal price of agricultural land), population density as a proxy for urbanization economies and farm density, and employment in the food processing industry and regional specialization in agriculture as proxies for localisation economies. In addition, farm size structure is evaluated in order to compare the effects of internal and external scale economies. This discussion begins with a brief list of selected factors of regional agricultural labour productivity, and the formulation of hypotheses for statistical testing.

2. Theoretical departures and hypotheses

Even in countries close to the technological frontier, agricultural productivity still responds significantly to natural conditions (Ruttan, 2002). In general, natural conditions for agriculture are defined by the sum of multiple natural factors, in particular by the characteristics of geological relief, soil preconditions and the climatic characteristics of the area (Bičík and Jančák, 2005). All other things being equal, the combination of mild climate, flat terrain and high quality soils should translate into higher yields, and therefore to higher labour productivity. Conversely, agricultural labour productivity in mountainous areas would suffer from a harsh climate and steep slopes, limiting the use of machinery and increasing the risk of soil erosion (Grigg, 2003) and slope deformations (Hradecký and Pánek, 2008).

The highest agricultural labour productivity can be therefore expected in fertile lowland areas, which allow for intensive agricultural production with high capital inputs in terms of machinery and fertilisers. On the other hand, extensive agriculture in higher altitudes oriented to pastoral farming can also exhibit relatively high labour productivity levels due to low labour inputs into such kinds of activity. In general, the effects of natural conditions on agricultural productivity can be operationalized through a synthetic variable: "mean nominal price of agricultural land"[2] (Bičík and Jančák, 2005; Martinát and Klusáček, 2014). Our first hypothesis states that:

- *H1: There is a positive relationship between the nominal price of agricultural land and agricultural labour productivity at the micro-regional level.*

Farm size as a proxy for internal scale economies is one of the most common predictors of farm productivity (Alvarez and Arias, 2004). There are no conclusive findings relating these two variables. Many studies propose an inverse relationship between farm size and productivity (e.g. Bardhan, 1973; Bhalla and Roy, 1988). Considering the low likelihood of decreasing returns to scale (Vollrath, 2007), an inverse relationship between farm size and productivity can be explained by the costly monitoring of workers (Binswanger and Rosenzweig, 1986), or by the lower average quality of land owned by large farmers, who often buy (even low quality) land from smaller farmers to become monopolists in local land markets (Vollrath, 2007).

Diseconomies of scale were, however, documented in developing rather than in developed economies and rather for land productivity than for labour productivity. The latter should be positively related to farm size (for empirical evidence, see for example: Ezcurra, 2011; Cuerva, 2012; Adamopolous and Restuccia, 2013). Increasing farm size reflects indirectly a more efficient division of labour, higher capital endowments and easier access to raw materials (Karagiannis and Sarris, 2005). Higher and increasing capital/labour ratios capture embodied technological change, which is tightly positively related to labour productivity (Ball et al., 2001; Sakellaris and Wilson, 2004). Higher capital endowments in terms of machinery, fertilizers or irrigation should translate into higher levels of labour productivity (Retortillo and Pinilla, 2005). In addition, small farms may have alternative sources of income, therefore putting less effort and investment into farming compared to larger farmers (Coelli and Battese, 1996).

Our second hypothesis is that:

- *H2: Micro-regions with a concentrated farm size structure (dominated by large farms) exhibit higher agricultural labour productivity than micro-regions with a fragmented farm size structure (many smaller farms).*

Relationships between farm size structure and agricultural labour productivity at a regional level may be ambiguous however. A fragmented farm size structure may reflect the spatial clustering of many small agricultural enterprises producing the same commodity. These farms can benefit significantly from the spatial density of economic activities (Ciccone and Hall, 1996) through the effects of localisation economies in terms of labour market pooling, developed supplier networks and localized knowledge spillovers (Henderson, 2003). A higher labour productivity of farms can be also spurred by the effects of reduced transport costs. Moreover, a combination of agglomeration effects, local tradition, highly specialized and contextual know-how and predominantly incremental technological innovations, is a powerful source of regional path-dependence and increasing returns (Martin, 2006). Highly persistent and successful wine clusters in California (Porter and Bond, 2008) or Chile (Giuliani and Bell, 2005) document this kind of positive development.

Therefore, the spatial concentration of farms can be used as a proxy for the effects of localisation economies in agricultural production. Nevertheless, farm density can be significantly distorted by natural conditions. In micro-regions with high shares of mountainous or environmentally-protected areas, farm density will be relatively low despite the possibility of high spatial concentration of farms in lowland areas. This is the reason why we decided to test two other proxies for localisation economies: the relative regional specialization in agriculture measured by the share of agriculture in regional employment, and the share of the food processing industry in regional employment.

The relationship between regional specialization in agriculture and agricultural labour productivity is also ambiguous (Ezcurra et al., 2011). On one hand, high shares of agriculture in regional employment may result from the

[1] Municipalities with extended competences (small districts) – administrative units that roughly correspond with nodal regions

[2] For definition and discussion see Section 4

inability of a region to attract and develop manufacturing or service activities. On the other hand, specialization may result from a high level of investment in the agricultural sector (Ezcurra et al., 2011), a shift towards high value- added agricultural products or the development of a functioning ecosystem, working simultaneously as a supply system, a local labour market matching system, and also a context for knowledge diffusion (Kemeny and Storper, 2015: 5). Regional specialization in the food processing industry may boost localisation (cluster) economies through local backward linkages and potential for localised technology spillovers. As such, we test the possibility that:

- *H3: Agricultural labour productivity at a micro-regional level is positively related to farm density, the share of agriculture in regional employment, and the share of the food processing industry in regional employment.*

Apart from natural conditions, urbanization rate, population and firm density are key geographical factors influencing agricultural productivity levels. The relationships between these variables are complex and there are various mechanisms through which urban proximity and population density alter productivity rates of farms. In general, urban proximity increases the productivity of farms, which are pressured by high rents to improve their efficiency or move towards the production of higher value-added and high yield commodities (Sokolow, 2003). Heimlich and Barnard (1992: 50) argue that "…farms in metro areas are generally smaller, produce more per acre, have more diverse enterprises and are more focused on high value production than non-metro farms". Farmers may also capitalize on urbanization economies, such as proximity to large markets for their commodities and the opportunity to sell directly to final customers (such as restaurants) without incurring high transaction costs (Heimlich and Barnard, 1992).

The higher rate of competition in the labour market in metropolitan regions is another factor, which pushes the farms to a higher labour productivity. The agricultural labour force has a wider possibility of asserting itself in sectors with higher average wages (e.g. in the services sector). Besides the competition in the labour market, the higher average wages of the metropolitan labour market also have an impact on the higher personnel costs of farms. As a result of the above-mentioned cost factors, the farms are pushed to achieve higher labour productivity in order to retain their competitiveness (Grigg, 2003).

On the other hand, there also some limits to agricultural productivity in highly urbanised and densely populated areas. Farmers may be legislatively constrained in their activities. For example, night farming can be prohibited because of noise. Correspondingly, aerial and ground spraying can be prohibited in order to protect the health of local residents (Sokolow, 2003). In addition, farmers in highly urbanised areas often avoid high capital investment in anticipation of selling their land for urban development, which lowers their productivity levels (Sokolow, 2003: 295). Although both positive and negative effects of the urbanisation rate and population density on agricultural labour productivity have been identified, we expect that positive effects will prevail and our next hypothesis is that:

- *H4: There is a positive relationship between population density and agricultural labour productivity at the micro-regional level.*

These four hypotheses can now be tested for the case of the Czech Republic.

3. Agriculture in the Czech Republic

The most recent analysis of agricultural productivity in the European Union (Giannakis and Bruggeman, 2015) classified the member countries into two clusters – the highly-performing "Northern-Central European countries" (around the North Sea) on one hand and poorly-performing "continental peripheries" on the other. The second group included the Mediterranean, East-Central, Northern Scandinavian and Celtic (Ireland) countries. Perhaps surprisingly, the Czech Republic was a member of the first cluster of high performers – together with Belgium, Denmark, Germany, France, Luxembourg, Netherlands and the United Kingdom. All other East-Central European (ECE) countries fell into the group of the lower productivity 'continental peripheries'.

According to these authors, the Czech Republic performed better than other ECE countries due to higher technical efficiency, human capital and a larger average size of farms. Although Czech agriculture has certainly not completely shaken off the socialist legacy of poor management and an interrupted tradition of rural entrepreneurship, these results caution researchers about 'one-size-fits-all' approaches to agricultural productivity in East-Central European transition countries. At this point, a brief contextualisation of regional differences in factors influencing agricultural labour productivity at the micro-regional level is necessary.

While the share of less favoured areas (LFAs) in the Czech Republic is lower than in the majority of EU28 countries, 42% of all Czech municipalities (Pelucha et al., 2013) and almost one half of the agricultural areas are located in LFAs (Giannakis and Bruggeman, 2015): see Fig. 1. Therefore, overall, natural conditions in the Czech Republic are generally not very favourable for intensive crop production, because hilly areas and highlands prevail (Bičík and Jančák, 2005).

At the same time, there is relatively high regional variability in the nominal price of agricultural land as a synthetic variable of natural conditions for agricultural production (Fig. 2). The most important distinction is between fertile lowlands along the main rivers and their catchment areas – Labe (micro-regions such as Roudnice nad Labem, Kolín, Nymburk, Hradec Králové), Ohře (e.g. Žatec, Louny), Morava (e.g. Olomouc, Prostějov, Přerov, Kroměříž, Vyškov, Břeclav) and Dyje (Znojmo) on the one hand, and mountainous borderland areas (e.g. Prachatice, Český Krumlov, Semily, Šumperk), together with the highland "Vysočina", on the other (see Fig. 1 and Appendix 1). The former allow for highly intensive crop and livestock production. Mountainous areas in the borderlands combine high average altitude with sloping relief, limiting the use of machinery and providing better conditions for extensive livestock production (Věžník et al., 2013), as well as ecological farmers (Hrnčiarová et al., 2010: 173).

Moreover, Vysočina and some other inland hilly areas (Strakonice, Písek, Jindřichův Hradec, Beroun, Benešov) exhibit a relatively high intensity of livestock (mostly pig) production (Hrnčiarová et al., 2010: 173). It is important to note that intensive production of pigs and poultry is significantly less constrained by natural conditions than other types of agricultural production. This may disturb any observed relationship between the nominal price of agricultural land and agricultural labour productivity. Nevertheless, in 2012 the share of pig production in Czech agricultural production overall was only 7.6%, and the share of poultry production stood at 4.8% (CSO, 2013a).

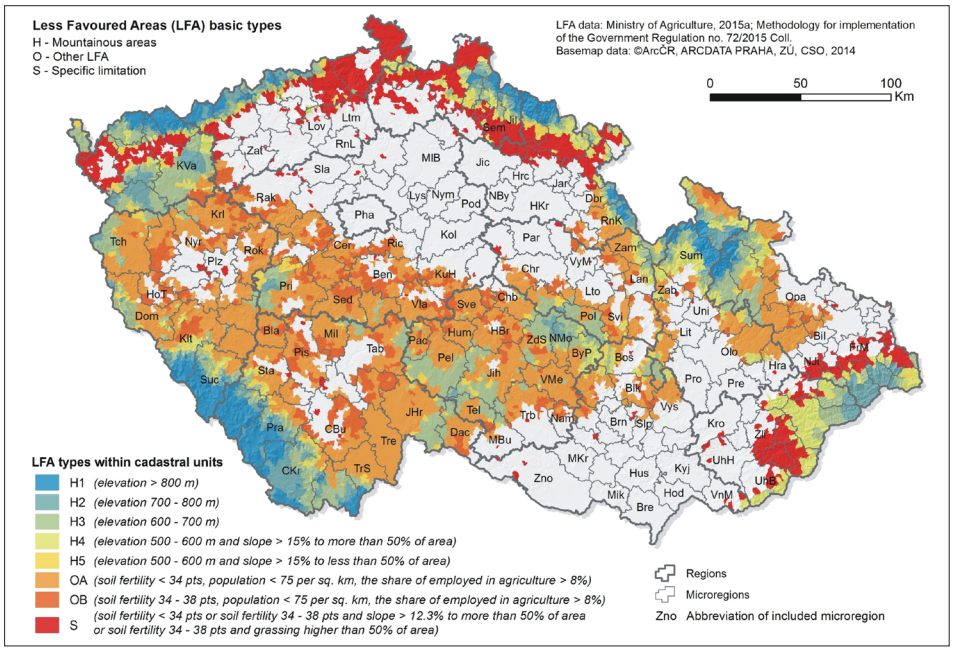

Fig. 1: Less favoured areas (LFAs) in the Czech Republic (2015)
Sources: Ministry of Agriculture, 2015a; Ministry of Agriculture, 2015b

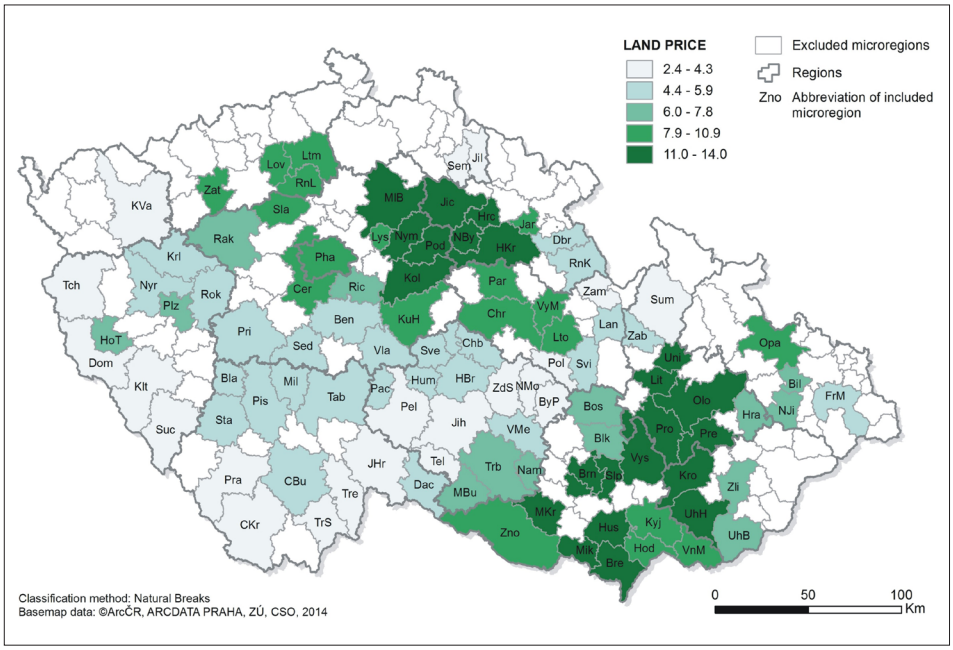

Fig. 2: Nominal price of farmland (CZK per m^2). Source: VUMOP, 2014

When considering the structural characteristics of farms, it is possible to identify three basic features of Czech agriculture:

a. the dominant position of large farms (Grešlová et al., 2015);
b. a high share[3] of agricultural cooperatives in agricultural employment; and
c. a relatively low share of utilised agricultural area operated by private farmers (CSO, 2013b).

The lowest share of agricultural cooperatives and the highest share of private farmers can be found along the borders with Germany – a belt stretching between Tachov and Liberec (Věžník and Bartošová, 2004). Before 1989, agricultural production in this area was dominated by state-owned farms, which were established in order to farm the land obtained by the state after the exodus of the German speaking population in 1945–1946 (Bičík and Jančák, 2005). For the same reasons, these and other mountainous boundary micro-regions also exhibit the highest share of large farms in agricultural employment. In contrast, the densely inhabited areas of large inland cities such as Prague or Hradec Králové (Fig. 3) and some highly fertile lowland areas (Znojmo, Přerov), are characterised not only by a smaller average size

[3] In 2009 it was roughly one third in agricultural employment, when excluding individual farmers (RES 2009).

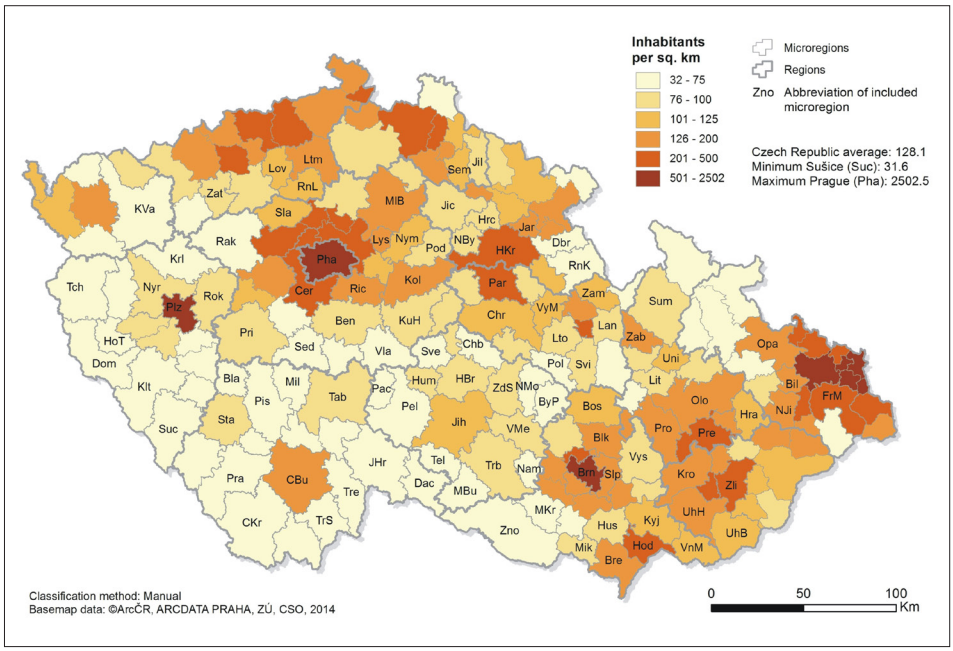

Fig. 3: Population Density in the Czech Republic (2014)
Sources: ARCDATA PRAHA and CSO, 2014

of farms (in terms of employment), but also by a high level spatial concentration of farms per hectare of agricultural land.

The Czech Republic (and Slovakia) are characterised by the largest share of agricultural land tilled by large farms (Eurostat, 2011). As such, these countries provide an excellent case (Kofroň, 2012) for studying the effects of internal scale economies on regional agricultural productivity. In other words, if internal scale economies are really a relevant factor in regional labour productivity, they should be manifested in the Czech Republic and Slovakia.

4. Material and methods

We draw on the unique database collected by the Czech Statistical Office (CSO, 2009b), compiled from raw microeconomic firm level data aggregated into 206 administrative micro- regions, the so-called municipalities with extended competence. The data cover agricultural employment and financial indicators such as production, value-added, and wages for the year 2009. We use this source to calculate our dependent variable – agricultural labour productivity, defined for our purposes as annual agricultural production per employee.

Data were available only for business companies and agricultural cooperatives; individual farmers were not included. The share of utilised agricultural area operated by private farmers in the Czech Republic, however, is only 30.5% (CSO, 2013b), and they dominate in micro-regions along the Czech-German borders – units with low agricultural employment that were excluded from our analysis. For determining the mean nominal price of agricultural land we used the data of the VUMOP (2014) – the Research Institute for Soil and Water Conservation – including the so-called system of evaluated soil ecological units (SESEU). The valuation of the agricultural land is determined from the specific characteristics of the land (in particular by its fertility), which were surveyed in the framework of the land resources valuation. The valuation comprises the basic natural characteristics like the climate, soil types, slope inclination, granularity, and the topsoil depth for each specific plot.

The economic SESEU valuation is based on a parametrized subsistence yield of the ten main field crops (winter wheat, rye, oats, barley, grain corn, potatoes, sugar beet, silage corn, perennial fodder plants, rape), and normative costs spent on their production (see Novotný et al., 2013, for details). As a criterion for determining the official prices of the agricultural land, we used the economic "HRRE" (gross annual rental effect) valuation of the vegetable production in the given agro-ecological conditions with normatively determined farming efficiency. It is important to note that the prices of agricultural land are nominal and can be used only as a synthetic variable of the soil quality. As such, they do not correspond with market prices (Bičík and Jančák, 2005), which may be significantly influenced by the proximity to larger cities (Sklenicka et al., 2013), food processing plants, markets or state borders.

To account for farm size structure, we applied the Herfindahl-Hirschmann Index (HHI) calculated from the relative employment shares of particular firms in the total employment at a micro-regional level. The Herfindahl-Hirschmann Index is formally expressed as:

$$HHI = \sum_{a} e_a^2$$

where, e_a is the relative share of a firm in micro-region a in total employment in the particular micro-region. A concentrated farm size structure is reflected by high values of HHI.

We also employed several variables to cope with the fact that various kinds of agricultural activities may have differential impacts on labour productivity (Ezcurra, 2011; Cuerva, 2012). Our list of independent variables (see Tab. 1) includes the share of arable land in the total agricultural land to distinguish between plant and animal production, and also the share of agricultural land farmed by conventional farmers, to distinguish between intensive commercial and extensive ecological agriculture. Finally, we added the share of agricultural land located in less favoured areas with respect

to the total agricultural area as another synthetic indicator of natural conditions (Ezcurra et al., 2011), reflecting also the potential effects of agricultural subsidies.

The share of business companies in the total agricultural land of a particular micro-region was also added as another control variable. The ownership status of agricultural enterprises is another possible factor of farm labour productivity (Deininger, 1995), and business companies are generally more productive than agricultural cooperatives (Chrastinová, 2008).

We calculated four simple OLS regression models with micro-regional level agricultural labour productivity as the dependent variable (Tab. 3). In all models we employed logarithmic transformations of the independent variables that violated the assumptions of normality. After several empirical tests, we decided to exclude[4] all micro-regions with low agricultural employment (less than 300 employees). These units disturbed any observable regional patterns of labour productivity. Our final sample therefore included only 102 micro-regions. As a result, it was not possible to use spatially weighted regression models to cope with potential spatial autocorrelation because we were not analysing a geographically compact area (i.e., an area without the 'missing' micro-regional data points).

The first model tested the effects of only one (but key) geographical variable – natural conditions – represented by the average nominal land price of 1 m^2 of agricultural land ('Land price'). We ran several regression models, which combined the variable 'Land price' with other explanatory variables such as 'Population density' or 'Farm size structure', but we decided to exclude these models from our analysis because of problems with high multicollinearity.

The second model included 'Population density' as a proxy for urbanization economies, 'Farm size structure' representing internal scale economies, and the share of 'Employment of manufacture of food products in regional employment' ("Food"), capturing potential cluster economies stemming from the co-localisation of agriculture and manufacture of food products. The third model was very similar – the only difference was that localisation economies were represented by the variable 'share of agriculture in regional employment' ("Agriculture"). The variable 'Farm density' was excluded from all models due to extremely high values of the multicollinearity condition number. To summarize, models 2 and 3 attempted to test the effects of internal scale economies, localisation economies and urbanization economies in regional agricultural production, at the same time.

The last model tested the effects of structural variables: 'Farm size structure', the 'Share of business companies in agricultural employment' ("Ownership status"), and the 'Share of conventional farmers in the total number of farmers' ("Conventional farmers"). Therefore, this model attempted to capture the effects of structural farm characteristics with regard to farm size distribution, ownership status and mode of production. Unfortunately, it was not possible to merge the first and the last regression model into a single model that would test the effects of geographical and structural independent variables at the same time. The small number of cases (n = 102) did not allow for a complicated regression model with more than three independent variables, because the problems of multicollinearity, heteroscedasticity and an extremely high value of the Akaike criterion occurred.

5. Results

The basic statistical relationships listed in the correlation matrix (Tab. 2) can be discussed briefly. Surprisingly, almost no statistical relationship was found between the key variable 'Agricultural' productivity on the one hand and the proxies for localisation economies, 'Farm size structure', 'Conventional farmers', and 'Arable land' on the other. Therefore, neither external nor internal scale economies seem to be related to the patterns of agricultural productivity at a micro-regional level. Furthermore, a negative significant correlation (although weak) between 'Agricultural' productivity and 'Ownership status' was documented. This means that micro-regions with higher shares of agricultural cooperatives are on average more productive than micro-regions dominated by business companies.

Table 2 also documents the relatively strong role of other geographical factors. 'Land price' exhibited the strongest positive correlation with 'Agricultural' productivity: better natural conditions in terms of climate, soils and morphology are associated with higher agricultural labour productivity at the micro-regional level. Correspondingly, a weak but significant negative effect of the variable 'LFA share' was found. 'Population density' showed a relatively strong and significant positive relationship with 'Farm density' and 'Land price', but a negative relationship with 'LFA share'. A higher urbanisation rate is thus associated with a higher spatial concentration of farms, which may capitalize on the large market area. There is also a higher share of business companies ('Ownership status') in highly urbanized regions, while agricultural cooperatives dominate in the mountainous borderlands (e.g. Rožnov pod Radhoštěm, Vsetín, Sušice) or the inner peripheries with hilly georelief (e.g. Pacov, Milevsko).

'Farm size structure' correlated (positively) only with the 'share of agriculture' and 'manufacture of food products' in regional employment. Although one could expect that larger farms (in terms of employment) will be concentrated in the fertile lowland areas with high nominal 'Land price', the results did not confirm this initial expectation. Figure 5 reveals the complicated regional patterns of farm size structure, with relatively smaller farms in the borderlands and larger farms in the metropolitan hinterlands of large cities, and in some micro-regions with smaller urban cores, such as Litovel, Lanškroun or Humpolec. Metropolitan regions are characterised by a higher spatial density of farms. Not surprisingly, densely populated areas combine higher average 'Land price' with a lower 'Share of agriculture in regional employment' (with the developed sectors of industry and services) and higher 'Employment in manufacture of food products', reflecting also population size. Therefore, there is relatively strong negative relationship between two possible indicators of localisation economies - regional specialisation in agriculture and employment in the food processing industry. Micro-regions with high employment in the food processing industry are mostly larger cities and their hinterlands, but also some sparsely populated peripheral

[4] We also tried to exclude the largest urban regions, Prague and Brno, that may distort regional patterns of agricultural labour productivity (following Věžník and Konečný, 2011), but the results did not change. Our regression models therefore include Prague and Brno, because both cities had more than 300 employees in agriculture in 2009. The threshold of 300 employees was set empirically after several regression trials.

Variable	Proxy indicator (year)	Abbreviation	Mean	St. Dev.	Data source
Agricultural productivity	Production per employee in thousands CZK (2009)	PROD	958	265	CSO 2009b
Population density	Population density per km (2009)	POPDENS	146.6	291.785	CSO 2009a
Farm density	Number of farms per km2 (2009)	FARMDENS	2.52	1.90	CSO 2009c
Farm size structure	Herfindahl-Hirschmann Index of farm employment (2009)	FARMSIZE	10.36	6.612	CSO 2009c
Ownership status	Share of business companies in agricultural employment (2009)	OWNER	0.71	0.252	RES 2009
Conventional farmers	Share of conventional farmers in total number of farmers (2010)	CONVENT	0.96	0.195	LPIS 2010
Land price	Mean nominal land price in the microregion in CZK per m2 (2014)	PRICE	7.43	3.321	VUMOP 2014
LFA share	Share of LFAs in total area of the microregion (2010)	LFA	0.50	0.502	SZ 2010
Arable land	Share of arable land in agricultural land (2011)	ARABLE	0.75	0.185	CUZK 2011
Agriculture	Share of agriculture in regional employment (2009)*	AGRIC	0.076	0.048	CSO 2009b
Food	Employment in manufacture of food products (2009)	FOOD	6.60	9.05	CSO 2009b

Tab. 1: Variables employed in the statistical analyses (n = 102 micro-regions)
*Note: * The share of agriculture was not calculated from total regional employment in 2009 (not available), but from regional employment excluding industries not covered by reliable micro-regional level data – mining and quarrying; distribution of water and energy, sewerage and waste management; wholesale and retail trade; repair of motor vehicles and public services. Source: authors*

	PROD	POPDENS	FARMDENS	FARMSIZE	OWNER	CONVENT	PRICE	LFA	ARABLE	AGRIC	FOOD
PROD		0.204*	− 0.082	− 0.154	− 0.225*	0.149	0.496**	− 0.296**	0.188	− 0.059	0.169
POPDENS	0.204*		0.668**	− 0.095	0.380**	0.156	0.595**	− 0.607**	0.327**	− 0.570***	0.414***
FARMDENS	− 0.082	0.668**		0.037	0.466**	0.082	0.360**	− 0.433**	0.143	− 0.323***	0.318***
FARMSIZE	− 0.154	− 0.095	0.037		0.118	− 0.046	− 0.062	0.044	− 0.111	0.230*	− 0.560***
OWNER	− 0.225*	0.380**	0.466**	0.118		0.055	0.262**	− 0.253*	0.061	− 0.116	0.081
CONVENT	0.149	0.156	0.082	− 0.046	0.055		0.162	− 0.202*	0.613**	0.094	0.022
PRICE	0.496**	0.595**	0.360**	− 0.062	0.262**	0.162		− 0.703**	0.270**	− 0.196*	0.175
LFA	− 0.296**	− 0.607**	− 0.433**	0.044	− 0.253*	− 0.202*	− 0.703**		− 0.330**	0.225*	− 0.199*
ARABLE	0.188	0.327**	0.143	− 0.110	0.061	0.613**	0.270**	− 0.330**		− 0.040	0.177
AGRIC	− 0.059	− 0.570***	− 0.323***	0.230**	− 0.116	0.094	− 0.196**	0.225**	− 0.040		− 0.500***
FOOD	0.169	0.414***	0.318***	− 0.560***	0.081	0.022	0.175	− 0.199*	0.177	− 0.500***	

*Tab. 2: Correlates of Micro-regional Level Agricultural Labour Productivity (Spearman's rho) Note: *p < 0.05; **p < 0.01; ***p < 0.001. Source: authors*

	MODEL 1		MODEL 2		MODEL 3		MODEL 4	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Log_POPDENS			0.080	0.050	0.120*	0.057		
Log_AGRIC					0.054	0.048		
Log_FOOD			$-4{,}12e^{-6}$	$1{,}83e^{-5}$				
Log_PRICE	0.281***	0.048						
Log_FARMSIZE			– 0.062	0.056	– 0.068	0.050	– 0.057	0.046
Log_OWNER							– 0.103*	0.047
Log_CONVENT							0.468***	0.137
R^2	0.256		0.057		0.068		0.161	
Multicollinearity condition number			22.347		32.948		20.753	
Akaike criterion			– 153		– 154		– 164	

*Tab. 3: OLS Regression Models: Micro-regional Agricultural Labour Productivity as the Dependent Variable. Note: *p < 0.05; **p < 0.01; ***p < 0.001. Source: authors*

regions such as Vlašim, Klatovy or Příbram. On the other hand, there are two different types of micro-regions with high levels of specialization in agriculture:

1. hilly peripheral micro-regions with unfavourable conditions for intensive agriculture such as Pacov, Dačice or Pelhřimov; and
2. fertile lowland areas with favourable conditions for intensive crop production, such as Lysá nad Labem, Hodonín or Znojmo.

OLS regression models showed mixed results (Tab. 3). Most importantly, the first model with only one independent variable explained 25.6% of variance of the dependent variable, significantly more than other regression models. Therefore, the effects of natural conditions seem to be related to agricultural labour productivity to greater extent than farm structural characteristics, mode of production and scale economies at the micro-regional level. The 'Nominal price' of agricultural land is a synthetic variable with high explanatory power, not only because of its complexity, but also because it correlates with other factors of regional agricultural labour productivity such as population density, the share of arable land and the share of business companies.

Regression models (2) and (3) tested the effects of urbanisation economies, localisation economies and internal scale economies simultaneously. Surprisingly, these models failed to explain regional disparities in agricultural labour productivity, explaining only 5.7% (6.8%) of the variability of the dependent variable. A positive effect of 'Population density' on regional labour productivity was found, although its regression coefficient was significant only in model (3). This means that agricultural labour productivity was higher in urbanised micro-regions with a higher spatial concentration of farms, and lower in less densely populated micro-regions.

Model 4 showed two basic results. No significant positive relationship between 'Farm size structure' and 'Agricultural' productivity was found. On the contrary, while not statistically significant, there was an inverse relationship between these two variables, suggesting higher labour productivity in micro-regions dominated by smaller farms. As discussed above, we also confirmed the negative significant relationship between 'Ownership status' and 'Agricultural' productivity. This means that micro-regions with higher shares of agricultural cooperatives tend to be more productive than micro-regions dominated by business companies. As expected, agricultural labour productivity increases with an increasing share of conventional farmers on a micro-regional basis.

6. Discussion and conclusions

The first hypothesis anticipating a positive relationship between the nominal price of agricultural land and agricultural labour productivity was confirmed. Natural conditions have retained their key influence on the regional differentiation in the productivity of agricultural production in the Czech Republic. Areas with the most suitable conditions for agriculture are in the lowlands along the rivers (Figs. 3 and 4). These areas are characterised by weakly dissected relief, warm climate and highly fertile soils

Hypothesis – expected relationship		Confirmed?
H1	There is a positive relationship between the nominal price of agricultural land and agricultural labour productivity at a micro-regional level	Yes
H2	Micro-regions with larger farms are more productive than micro-regions with smaller farms	No Negative slope but not significant relationship
H3	There is a positive relationship between the proxies for localisation economies and agricultural labour productivity at a micro-regional level	No
H4	There is a positive relationship between population density and agricultural labour productivity at a micro-regional level	Yes

Tab. 4: Hypotheses: Confirmed or Rejected? Source: authors

(Bičík and Jančák, 2005), which enable a larger variability of planted crops and an orientation on intensive production of crops (cereals, oil plants) and intensive livestock production (breeding of pigs, poultry and cattle: see Střeleček and Lososová, 2005; Hrnčiarová et al., 2010). But a relatively high concentration of intensive livestock production can also be found in large cities and in peripheral areas with less favourable natural conditions, such as the micro-regions in Vysočina. Therefore, the regional distribution of intensive livestock production (mostly the breeding of pigs and poultry) that is relatively less constrained by natural conditions, may partly distort the relationship between the nominal price of agricultural land and agricultural labour productivity at the micro-regional level.

The second hypothesis was rejected (Tab. 4), because we did not find convincing empirical evidence that a higher share of large farms affects the labour productivity at a micro-regional level (see Fig. 5). This finding does not correspond with the results of Ezcurra et al. (2011) for the EU15 countries. Further research is needed in order to determine whether there really is no systematic relationship between farm size structure and agricultural labour productivity at the micro-regional level, or whether the rejection of the second hypothesis was caused by the methodological limitations of our research due to the lack of data accessibility. We are aware that our analysis did not include relevant explanatory variables of agricultural labour productivity such as the type of agricultural production (crop or livestock), and other key factors at the individual farm level, such as production technology and management.

From the perspective of the influence of ownership structure on productivity, the results are in compliance with the findings of Davidova et al. (2003), although their

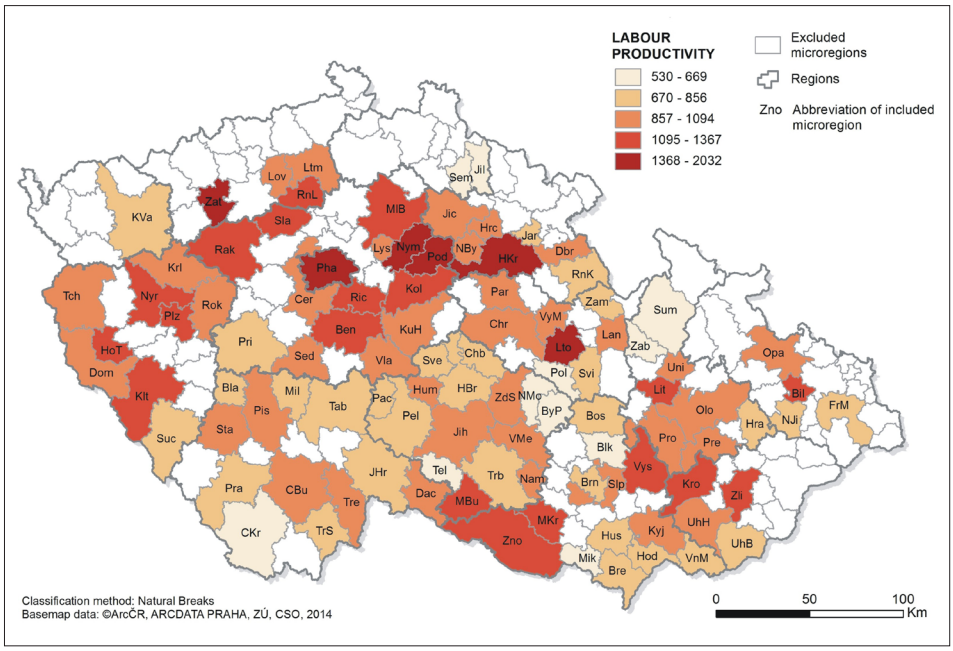

Fig. 4. Agricultural labour productivity at the micro-regional level (2009). Source: CSO, 2009b

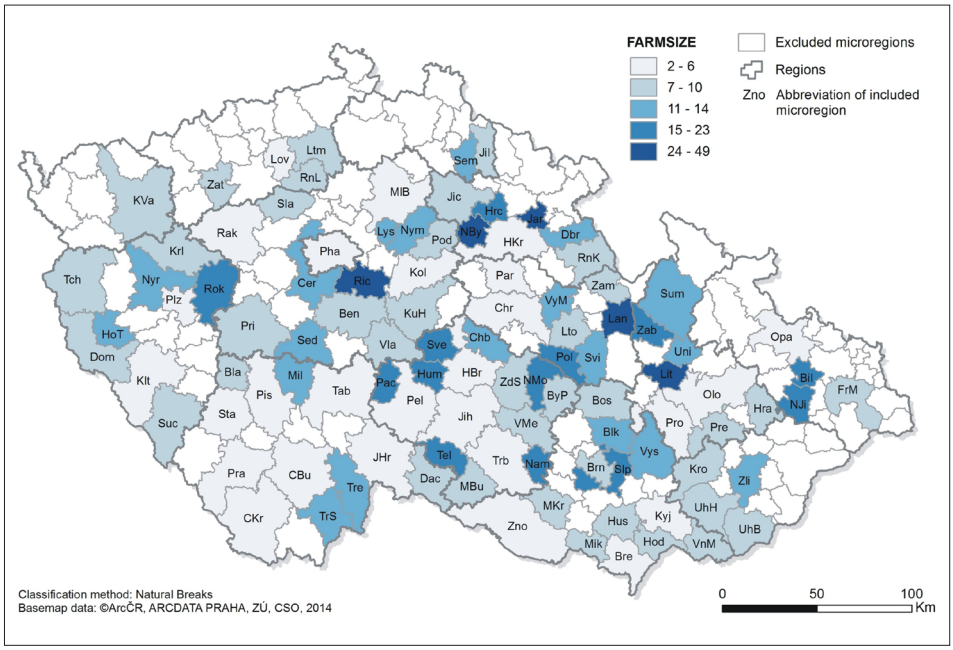

Fig. 5. Farm size structure measured by the Herfindahl-Hirschmann Index (2009). Source: CSO, 2009c

analysis was carried at the firm level. Lower agricultural labour productivity in Czech micro-regions dominated by business companies compared to micro-regions dominated by agricultural cooperatives, can be explained by the lower managerial capacity of business companies compared to the agricultural cooperatives (Davidova and Latruffe, 2007).

Hypothesis 3 was not supported either. We did not find any significant relationships between agricultural productivity, on the one hand, and indicators of potential localisation economies (spatial concentration of farms, share of agriculture in regional employment, and employment in the food processing industry). Although relatively high labour productivity was found in metropolitan regions with a high spatial concentration of farms, peripheral rural regions with high farm densities exhibited relatively low labour productivity. This pattern can be caused by the fact that agriculture in such regions represents a relatively attractive area of farming business because of available subventions for ecological farmers. It has been argued that subventions may negatively affect levels of agricultural labour productivity (Giannakis and Bruggeman, 2015).

Correspondingly, this finding can illustrate the fact that Czech agriculture has become more extensive and ecological (Věžník et al., 2013). High farm density in less densely populated areas is associated predominantly with a high number of ecological farmers. On the other hand, no statistical relationship between urbanisation rate/population density and farm size structure was found. This finding does not correspond with general expectations that highly urbanised areas will be characterised by a dense network of small farms (Sokolow, 2003).

In accordance with Hypothesis 4, we confirmed the positive influence of population density (urbanisation rate) on labour productivity, resulting probably from the higher wages competition in the labour market and an orientation to higher value-added agricultural products. Additionally, labour productivity in metropolitan hinterlands may be pushed up by pressures of the construction development industry on agricultural land (Sklenicka et al., 2013) as a consequence of uncoordinated suburbanisation.

The focus of this article was to describe and explain, with only a time-limited "snapshot", the differences in agricultural labour productivity at a micro-regional level for the case of the Czech Republic. The current results confirm the general hypotheses that geographical factors (natural conditions and population density) have significant effects on agricultural labour productivity. Conversely, we did not confirm the hypotheses concerning the positive influence of internal and external scale economies on agricultural labour productivity. One possible reason for this outcome is the continuing high levels of internal heterogeneity of agricultural labour productivity in the framework of individual micro-regions. Further research on geographical factors affecting agricultural productivity in the Czech Republic will require farm-level analyses.

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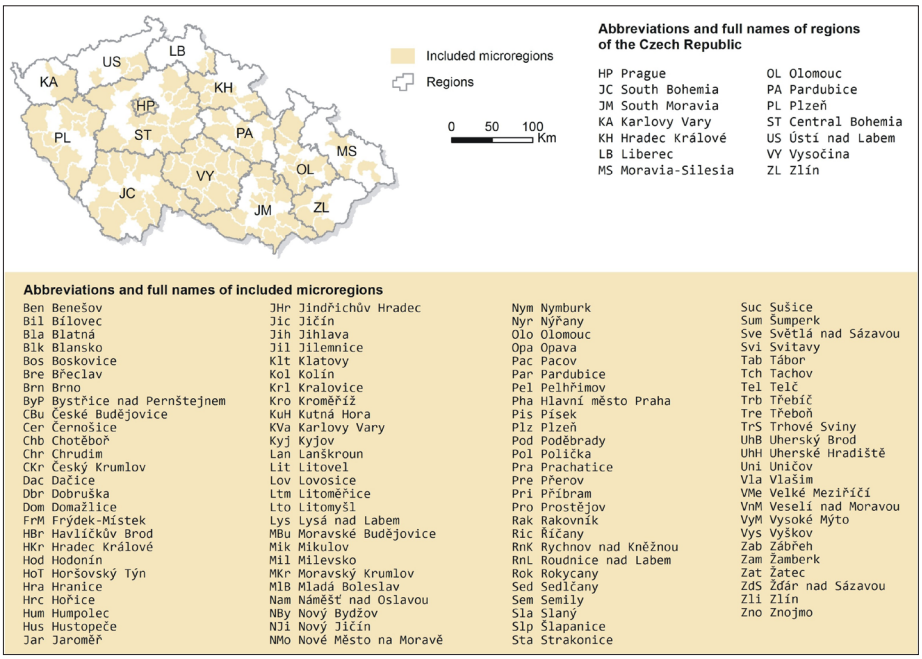

Appendix 1: Full names of NUTS3 regions and micro-regions in the Czech Republic. Source: authors

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