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Land fragmentation and other determinants of agricultural farm productivity: The case of Estonia

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ABSTRACT

The rising population of the world increases the need for raw materials and food. The more efficient production methods help to reduce the shortage of production and to mitigate climate change. This paper analyses the relationship between land fragmentation and farm productivity. The results show that land fragmentation measured using the Januszewski index has U-shape relationship to farm productivity: there are larger farms with many parcels which are productive, but their parcels are scattered and smaller farms, with few parcels that are also productive. We found an indicator which describes the differences in farms' productivity based on their land use – the area-weighted mean size of the parcels of one farm. This indicator is a statistically significant determinant of farm productivity. Other significant variables that are related to higher productivity are farm owners' education, farm size, farming system and production type. Agricultural land policies should consider multiple indicators and analyse different production types to intervene more effectively.

1. Introduction

The demographic changes in the world put pressure on policy-makers to make necessary reforms for agricultural transformation and efficiency. The rising population expects 70% higher food production (by the year 2050) and sustainable land management. At the same time, some regions face the collapse of productive capacities (land and water availability), climate change, and changes in land tenure. The scarce resources demand not only changes in the physical aspects of existing or potential agricultural land – reform of land tenure, improvement of infrastructure and productivity of farms – but also other aspects such as agricultural sector access to markets, finances, knowledge, research and also the collaboration and education of farmers (FAO, 2011). The improvements in agricultural productivity regarding more effective land use have a positive impact also on the environment, helping to mitigate climate change – less extensive fuel consumption and therefore decreased demand for fuel production. On the EU level, it is important also to decrease the farmer's dependence on public support from the EU and the national budget. According to the Estonian Farm Accountancy Data Network[1] (FADN) data, the output-input ratio has been below one from 2008 to 2016, which was the lowest, i.e. 0.81 in 2016 (Rural Economy Research Centre, 2017).

Due to the factors mentioned above, it is clear that farmers continually make changes in their production processes. There is constant pressure to make such adaptations to increase productivity. Farms in Europe and Estonia try to increase their land holdings. By analysing the structure of Estonian farm households based on the data of the Ministry of Rural Affairs (2014), it is possible to notice two distinct groups of households. One group uses less than ten hectares (54% of total households and 5% from total agricultural land). The other group has more than 100 ha of land (9% of households and 73% of total agricultural land). The main factors that hinder the increase of farms' economic productivity in Estonia, compared to other regions of the EU, are a lower level of public support compared to other EU countries, locational disadvantages (higher cost in winter, more expensive farm buildings, shorter period of vegetation and lower yields) and smaller internal market (higher input costs and lower output prices).

Several factors hinder the increase of productivity. Some of them – climatic conditions, market size – cannot be solved by any intervention measures. However, by analysing land fragmentation effects on productivity, it could be possible to justify land policy intervention

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[1] The overview of Estonian FADN database could be found here: http://www.maainfo.ee/index.php?page=7

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measures (land planning or consolidation), which can improve the productivity of existing farmers. Overcoming problems created by land fragmentation also increases the willingness of farmers to innovate (Niroula and Thapa, 2005). To increase farmers' land holdings, it is necessary to have available parcels suitable for agricultural production. It depends on how many land plots are on the market. The available parcels are usually scattered, and the land use is fragmented internally (van Dijk, 2004). The result could be that separate landowners parcels are mixed up, land plots are situated far away from each other and farm centre (Sikk and Maasikamäe, 2015). Our article addresses fragmentation occurring when farmers' land plots are dispersed over a wide area (King and Burton, 1982).

Land fragmentation can be caused by different drivers such as traditions relating to inheritance or economic processes (King and Burton, 1982). Meanwhile, land fragmentation can be the epiphenomenon in countries in Central and Eastern European which have recently implemented land reform (Hartvigsen, 2015, 2014a; van Dijk, 2003). It happened in Estonia as well, and the result is that land fragmentation on the plot level is even higher than it was after the land reform implemented in 1919–1926 (Jürgenson, 2016). The purpose of recent land reform in Estonia has been the establishment of private land ownership and the transition of kolkhozes and state farms to small private farms. The results for agricultural producers have been quite diverse. Some farmers use only a few hectares of land, while others use more than 5 000 ha, according to ARIB database. Some of that is owned and some leased. The recent proportion of leased land is approximately 64% of all the land used for farming (EU FADN, 2016), and it has increased over the years, from 45% in 2001. The share of leased land in Estonia is higher than the EU average, which is 54%. In contrast, the share of leased land in Western European countries is lower: 18% in Ireland, 39% in the Netherlands, 42% in the United Kingdom, and 54% in Luxembourg (EU FADN, 2016).

Several authors note that land fragmentation (LF) negatively impacts agricultural production (Hartvigsen, 2014b, Thomas, 2006; van Dijk, 2007, 2003), for example, if the farmland is divided into numerous parcels, which are usually small and not of a good shape (Gonzalez et al., 2007), their cultivation requires higher production costs (Gonzalez et al., 2004). Therefore, the potential income may be lower than the costs of cultivation (Janus et al., 2016), which is the situation in Estonia.

However, LF can be diminished through land management tools including land consolidation (FAO, 2004; Hartvigsen, 2015; van Dijk, 2007; Vitikainen, 2004). Hiironen and Riekkinen (2016) demonstrated that land consolidation improves the property structure and can reduce average production costs by as much as 15%. Currently, no land consolidation projects are operational in Estonia (Jürgenson, 2016), so it is not possible to conduct an investigation for Estonia like the one in Finland by Hiironen and Riekkinen (2016). However, it is quite essential to know if LF affects farm productivity. This question was analysed by several authors, for example, Latruffe and Piet (2014), and Rahman and Rahman (2008), whose research also provides an overview of current studies in this field. Existing studies on the LF effects on farm performance give different results, in which the relationship between those two indicators are negative or positive depending on the specific unit of analysis, different countries and production types, different productivity and fragmentation indicators, which are calculated based either on region or farm-level data.

Latruffe and Piet (2014) found that LF indicators used in previous literature (number of parcels and their average size) do not show all the aspects related to LF, for example, distance, which could be better captured by using grouping index. Their results (based on the French NUTS2 region of Brittany) show that higher LF decreases farm performance (various components), crop yields, income and profits and increases production costs. At the same time, Latruffe and Piet (2014) found that some of the results are not based on economic reasoning and are opposite to expectations, so several LF indicators are needed to understand the relationship between LF and productivity. The study of Rahman and Rahman (2008) is based on data from Bangladesh, the results also show the negative impact of LF on farm efficiency. The detrimental impact of LF is revealed in many ways – farms with a higher number of parcels have smaller output, lower technical efficiency, and slower diffusion of new technology. Additional factors were included to analyse the causes of increased efficiency: there was a positive relationship between those factors – farmers' ownership of critical resources, the number of family members involved in farming activities, number of livestock, and adoption of modern technology. Education did not have a significant impact on technical efficiency.

The relationship between LF and productivity has been studied, but it is still necessary to find comprehensive LF measurement techniques (Demetriou et al., 2013), without which it is challenging to evaluate the LF impacts. As discussed in Latruffe and Piet (2014), LF is measured by the number and average size of parcels belonging to one farm or located on a specific territory, using indexes like Januszewski (Januszewski, 1968) and Schmook (Schmook, 1976) index. Studies usually lack empirical testing of whether the LF impact on productivity remains positive or negative if other control variables, which are not related to land fragmentation are included in the model.

The objective of this article is to analyse the influence of farm LF on farm productivity in the Estonian agricultural sector. In this article, we use control variables in regression analysis to determine the importance of the LF effect. We included variables like education of farm owners, the production type and Herfindahl diversification index.

2. Data and methodology

In this study, the term "farm" is used to denote a variety of agricultural producers (e.g. companies, sole proprietors, natural persons). The "land holding" is considered as a set of all land plots that are operated by one farm and for which the subsidies were applied from the Agricultural Registers and Information Bureau (from now on ARIB[2]). From now on the term "parcel" is used to denote the plots that are used in the ARIB fields register. Such land parcels can coincide with the cadastral parcels, but it is not necessarily the case. No distinction was made between land in ownership and leasehold land[3].

Two kinds of data sources were needed for the study. The first was about the economic activities of the farms, the second considered the spatial properties of the farms' land holdings.

The FADN databases were the primary data sources for the characterisation of the economic activities of Estonian farms in 2015. The availability of FADN[4] data was the main criterion for the formation of the study sample. The following indicators were calculated to analyse the farms' economic activities:

- Productivity per working hour
- Net value added[5] per working hour

A farm's level of productivity is calculated based on the value of total production[6] divided by working hours[7]. Total production value is

[2] About ARIB http://www.pria.ee/en/about

[3] The share of leased land does not impact the results of our study. The correlation between the share of the farm's leasehold land and farm LF indicators and between leasehold land and productivity indicators is smaller than 0.2

[4] The Estonian FADN data (for the year 2015) is provided by Rural Economy Research Centre. The methodology of FADN is described in European Commission (2010), Farm Accounting Data Network: an A to Z of methodology. http://ec.europa.eu/agriculture/rica/pdf/site_en.pdf

[5] Farm Net Value Added (FADN code SE415) is defined as total output minus intermediate consumption and depreciation plus subsidies on outputs and costs.

[6] Sum of total output of crops and crop production (in EURO, FADN code SE135) and total output of livestock and livestock products (in EURO, FADN code SE206)

[7] FADN code SE011 Total labour input - Time worked in hours by unpaid and paid labour input on farm