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MEASURING THE EU STRUCTURAL FUNDS' IMPACT ON LATVIA'S AGRICULTURAL SECTOR: A MALMQUIST INDEX APPROACH

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Abstract

This Thesis examines how well the funding from the European Agricultural Fund for Rural Development, a part of the European Union Structural Fund, for the period of 2007 - 2013 has been absorbed by the crop growing farms in the agricultural sector in Latvia both on a regional and on a county level by applying a mixed methodology involving the nonparametric DEA Malmquist total factor productivity index approach and Welch t-tests. Each region's set of counties was analysed with its peers and the respective Malmquist Productivity indices were acquired. It was concluded that while counties in the regions of Pierīga, Vidzeme and Latgale experienced economic convergence it was mostly not due to the European Union's funding. Similar conclusions were drawn regarding the developments of county productivity and efficiency levels. Finally, based on a division of the EU funding in four groups (objectives) an alternative optimal division of the EU funding was proposed for the subject period, with the potential to be applied in the next budgeting period of 2014 – 2020.

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Table of Abbreviations

BSEPC	Baltijas Starptautiskais Ekonomikas politikas Studiju centrs (The Baltic International Centre for Economic Policy Studies)
CAP	Common Agriculture Policy
CF	Cohesion Fund
CL	Cultivated Land
CRS	Constant Returns to Scale
CSB	Central Statistics Bureau
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EAFRD	European Agricultural Fund for Rural Development
EFFCH	Efficiency change
EGTC	European Grouping of Territorial Cooperation
EMFF	European Maritime and Fisheries Fund
ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
HMI	Hicks-Moorsteen Index
MPI	Malmquist Productivity Index
MTFPI	Malmquist Total Factor Productivity Index
PECH	Pure Efficiency
RSS	Rural Support Service
SECH	Scale Efficiency Change
SF	Structural Fund
SLS	State Land Service
SME	Small and Medium sized Enterprises
STSA	State Technical Supervision Agency
TECH	Technical Change
TFP	Total Factor Productivity
TFPCH	Total Factor Productivity Change
VRS	Varying Returns to Scale

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1. Introduction

Since even before the creation of the European Union (EU) there have been economic disparities between its member states. In order to attain economic convergence and achieve improved development in the poorer member countries a type of Nation-wide wealth redistribution was implemented with the name of EU Structural Funds (SF). These funds are subdivided into five categories based on their specialization: the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD), the European Grouping of Territorial Cooperation (EGTC) and the European Maritime and Fisheries Fund (EMFF) (European Commission, n.d.). Each of these entities operate based on their own sub-goals that mostly reflect on their particular investment sector. However, there are common goals that these funds must aim to achieve in the long-term: generally 1) to spur economic convergence among the EU member states, 2) promote innovation, environmental protection and the labour market development and 3) improve cross-border cooperation and support the economic development and communication between small and medium-sized enterprises (SMEs) (Europa, n.d.).Since the EAFRD funding is basically a part of the Structural funds and this work will not focus on other SF subgroups then in the following sections the EAFRD funding will be generalized as Structural Funds.

Throughout the last period of 2007 - 2013, Latvia has received 5.70 billion EUR in total, out of which 18.5% were transferred by the EAFRD and absorbed by Latvia's agricultural sector – an industry that employs 7.5% of working-age population and is considered to be one of the cornerstones of the Latvian economy. Appendices D and E illustrate the agricultural sector's share of GPD and the employment situation in the agricultural sector for the whole Europe respectively.

Having announced the investment sums of the EU budget 2014 – 2020, where Latvia is expected to receive EUR 4.5 billion(European Commission, 2014), it was deemed noteworthy to analyse how efficiently these funds have been allocated in the previous years and whether there is any way to improve the fund effectiveness. This could indicate the counties and regions which have been more successful in applying these funds as well as expose those underperforming, thus illustrating the current situation in the sector.

Despite the fact that one fifth of all funding went to agriculture, since 2006 labour employment in this industry has almost halved and there have been speculations about the structural funds actually expediting economic divergence between regions within Latvia. This seems to be a striking phenomenon that is taking place right in front of everyone and should definitely require more attention. These developments should be analysed not only by the academics but also emphasized by the Ministry of Finance and the Ministry of Agriculture in order to ensure that these finances are redistributed more competently to promote economic convergence, both on a national and on a regional level.

This study will focus on the funding transferred by the EAFRD for structural projects, which is meant to co-finance various development programmes in the EU. Through the application of the Malmquist productivity index approach, the accomplishments of the EU fund absorption by the crop growing farms in Latvia's agriculture sector (further in text: agriculture) will be analysed. In order to determine these effects the following research question has been developed: *How the productivity and efficiency in agriculture has changed in different counties of Latvia since the acquisition of the EU Structural funds?* Furthermore, in order to ascertain that there has been a positive movement to the long-term goals, declared by the European Union just before launching the EU structural fund program, one of the chosen sub-questions was formed as follows: *How the absorption of EU Structural fund has affected disparities in agriculture between different counties of Latvia?* Finally, for a more in-depth analysis the changes in productivity indices with actual sums of money that have been attracted for each of these counties in the period of 2007-2013 will be compared in order to answer the second sub-question: *How the EU Structural funds should be restructured to be utilized more efficiently by the recipient region and generate better returns.?* After answering the second sub-question, other studies will be analysed, looking for additional arguments, which could support the resulting conclusions.

The following sections of the work will be organized starting with section 2, literature review, with a clear depiction of other works in this field of study as well as a short analysis of alternative methods, with a reasoning why they were not applicable in this work. Section 3 will expand more on the data availability and the sources used to acquire them. Afterwards, section 4 depicts the methodology of the work and a detailed walkthrough of the Malmquist index calculation. Finally, section 5 contains the results of the analysis followed by suggestions on the structural fund application, section 6contains the main conclusions of this study and section 7 elaborates on possible improvements and suggestions on further studies.

2. Literature Review

As with any investment that is based on long-term periodical payments, the analysis of EU structural fund absorption efficiency and effects on countries' economies is vital for strategic planning of new fund acquisition and further application. The EU Structural funds and their impact on countries' economies have been widely discussed, putting a great emphasis on general country-macro-data analysis. There are many studies analysing how the acquisition of these funds has stimulated the convergence of EU economies (Alexe & Tatomir, 2012; Rivza, Cingule, & Latviete, 2010). The most important findings of these reports are that although economies of new member states tend to converge to the average EU levels, there is a weak relationship between Structural Fund absorption rates and real convergence. Similar conclusions can be drawn from reports that analyse the convergence of regions in the same country after absorption of the EU Structural Funds has started. Locally, Cingule and Latviete (2011) have analysed the EU Structural Fund absorption (2004-2006) outcomes on the regional development in Latvia. The main conclusion was that uneven allocation of resources between the regions has led to even higher regional disparities. On the other hand, Eijffinger and Beugelsdjik (2005) by applying the growth equation approach proved that in the period 1995-2001 acquisition of Structural Funds has led to decreased disparities between EU-15 countries. On top of that, BSEPSc (2007) estimated that for each EUR received from the EU Structural Funds, Latvia was able to generate 3.14 EUR, proving the existence of significant multiplier effects that affect various sectors of the country's economy. Knowing the main goals of the EU Structural Fund usage, previously mentioned conclusions of these studies and their contradictions raises doubts about the efficiency of the EU Structural Fund allocation.

Theoretically, one of the most common models used for evaluating the effects of the EU Structural Funds on countries' economies is the HERMIN model. Originally, the model was designed in the 1980s by the European Commission (d'Alcantara and Italianer, 1982); the HERMIN model allows to measure the economic effects of EU assisted investment programs, given a very limited data availability. Throughout time this model has been enhanced several times, however, the main concept has remained – the model shows how an increase in short term demand in the economy affects long term supply. Changes in demand, which are fostered by Structural Funds, are measured by abnormal growth of public expenditures, public consumption, investment, stock changes, exports and imports. The long-term changes in supply are quantified by increased GDP, caused by five production segments: manufacturing, construction, agriculture, market services and public services. The end result is measured by generation of abnormal GDP growth, unemployment reduction and labour productivity increase. In one of such reports where the HERMIN model is used (Opritescu, 2012), the author analyses the Structural Fund absorption process in Romania during the period 2007-2013. The main conclusion was that Structural Funds helped to create more than 750’000 more job-places in 6 years’ time, leading to GDP growth of 2% annually, just as a result of Structural Fund absorption. The HERMIN model has also been applied when evaluating the possible effects of Structural Fund absorption on the economy of Latvia (Bradley, Kearney, Morgenroth, 2000), however, the modelled results are outdated and, thus, unreliable. Unfortunately, in our analysis usage of this method would not be beneficiary, as it portrays the Structural Funds’ effects on a general country macro level, not clearly indicating the results on particular industries.

As there is relatively little literature on Structural Fund or EAFRD funding impact on the particular industry and efficiency of investment usage, the authors will look for studies that measure the effects of public investment on agriculture industry, as public investment, by its nature, is the closest one to EU Structural Funds. What is more, the government of Latvia has committed to cover part of the costs, involved in development of particular agricultural projects, being part of Agricultural Development Program (Lauku Attistibas Programma).

During the last three decades various methods have been developed, allowing analysing multifactor agriculture productivity and its change throughout time. One of the simplest forms of analysis is focused on standard Total productivity index (Solow, 1957), which measures the shift in the production function at predetermined levels of capital and labour. Through adding prices of output and inputs (wages and cost of capital), the model could be applicable to make a simplified evaluation of performance of a company. Eventually, the model became more complicit and new interpretations were added, including new types of inputs. One of them, and one of the most famous, is Laspeyres index with fixed weights of inputs, which allowed to analyse how efficiently companies (or countries) can improve the level of operations and increase output with the same set of inputs. Unfortunately, the main drawback of the model lies within the false incentives created by it, as this version stimulates discovery of cheaper inputs of the same category, contrary to the expected output maximization (Advisory Commission, 1996).

Solow (1957) already argued that productivity of companies is driven by attraction of new investments. In order to see the full effects of investments on production frontiers and their shifts, new models had to be developed and new variables had to be accounted for.

2.1. Data Envelopment Analysis

The Data Envelopment Analysis (DEA) method has been a popular tool for analysing various entities' efficiency and operations. Since this method can be applied to an enormous spectrum, the organizations or any kind of projects subject to evaluation are called decision making units (DMU). Some of the main benefits of using the DEA include that it is not data demanding, namely there are no prerequisites on price data, it is not restricted in the number of inputs and outputs one may want to analyse, the observable DMU is compared with the best performing DMU and there are no requirements of a beforehand defined production function (Rayeni & Saljooghi, 2013).

What is more, the DEA can be applied to panel data and calculate the changes in productivity of a particular DMU over a given time period. For instance, Fare *et al.* (1994) also used the DEA by applying the Malmquist index when they analysed the change in efficiency of Swedish hospitals. The Malmquist productivity index is basically derived from the DEA and can thus be calculated with a DEA approach by assigning efficiency scores. Lin, Hsu and Hsiao (2007) applied the DEA Malmquist productivity approach to measure the efficiency of banks in Taiwan. They applied the DEA-Charnes, Cooper and Rhodes (CCR) model to assess the development in managerial performance. The DEA models applied in the Malmquist productivity index (MPI) method can be oriented in either an input or output approach, while the MPI requires fixed inputs or outputs if the index is either output or input focused respectively.

2.2. Malmquist Index

Malmquist index has been widely used when evaluating the public investment effects on agriculture industries in both Europe and outside it. Nkamleu (2004) used MPIs to compare how the efficiency of the agricultural sector has progressed over the period of 1970-2001 for 16 African countries. Although the total factor productivity index for the whole period in most of analysed countries indicated positive development, these changes were primarily caused by positive technical efficiency coefficients. Surprisingly, technical progress indicators, which were mainly below 1, thus negative, were the main constraints of significant growth of the agriculture sector in Africa, indicating the urgent need of new investment attraction. Similar time period (1987-2002) was used in a study by Coelli, Perelman and Lierde (2006), which analysed the effects of CAP reforms on Belgium's agricultural sector. Through the usage of Malmquist indexes, it was calculated that the overall technical change for the whole country in the given period has been approximately 23%, however, technical efficiency change had dropped by two percent. In another European country, Serbia, the same method was applied by Ljubanovic-Ralevic, Anokic and Rajic (2013) to evaluate the changes in agricultural productivity in 16 areas during the period from 2008 to 2011. Similarly to Belgium, in Serbia investments in the industry's development led to total productivity increase in 14 out of 16 regions, mainly stimulated by technological changes. Interestingly, also this study observed negative development of technical efficiency, implying that the business culture in the country should be improved. Through analysing the already published studies that apply Malmquist productivity indexes, it can be clearly seen that there are almost no cases when both technical efficiency indexes and technical progress indexes increase simultaneously.

Boame and Obeng's (2005) study, which researched the productivity of transit systems in the USA between 1985 and 1997, found that there was a statistically strong and positive correlation between received public investment and technical change; on the other hand, there is a statistically strong and negative correlation between public investment and technical efficiency change. By indirectly proving that there is a negative correlation between technical efficiency change and technical change, the authors concluded that there is no significant correlation between received public subsidy and total Malmquist productivity index. A similar idea is confirmed by Lissitsa and Rungsuriyawiboon (2007), who measured Malmquist index changes for European countries in the period of 1992-2002. As it turns out, countries with significant technical change improvements suffer from decreased technical efficiency indexes, which partly offset positive effects from public investments. For countries and industries that need to catch up to the rest, this might be a significant obstacle.

If foreign investors, banks and governments are continuously stimulating acquisition of new technologies and new capital units, it takes time to adapt to these new changes, thus causing technical efficiency to drop. One of the ways of making new technology acquisition more efficient is by investing a part of the money in improvement of this technical efficiency factor. Luckily, one of the main goals of EU Structural Funds is to develop county's business climate. In BSEPSc (2007), which evaluates the absorption of Structural Funds and their effects on the economy of Latvia, the authors have divided all Structural Funds' separate investments into the Solow model production function's variables – investments in labour, capital, technologies and overall factor productivity. Likewise, in this work this division is assumed to be appropriate to distinguish EU Structural Fund investments that are related to improvements of the Malmquist technical efficiency factor and those that are related to improvements of the Malmquist technological changes index.

2.2.1. History

The Malmquist index has more than half a century of historical background. As indicated by Boame and Obeng (2005) Total Factor Productivity (TFP) change measures can be assessed with parametric and non-parametric methods. The parametric method was first known as the Divisia (1926) index when the growth rate of the TFP was measured by subtracting proportionally-weighted rates of input growth rates from the output growth rates. However, with primitive adjustments it became clear that this index is inaccurate if market imperfections, technical changes and scale economies are accounted for (Deny, Fuss & Waverman, 1981; Boame & Obeng, 2005)

Shephard (1953) upgraded the conventional production analysis by implementing the input distance function. In the same year another improvement with the help of the input distance function was achieved in the field of consumption analysis by Malmquist (1953). While Shephard presented homotheticity and Shephard's lemma to the economics field, Malmquist introduced an input quantity index consisting as a proportion of distance functions. As indicated by Berg, Forsund and Jansen (1992) Malmquist managed to develop a method that allows the consumer to maintain a fixed utility level in transiting periods. There is also a corresponding output index that is in a similar manner expressed as a proportion of output distance functions made by Shephard (1970). A few years later, Caves, Christensen and Diewert (1982a) introduced the MPI named after Professor Sten Malmquist. The index was focused on the parametric method and developed the initial idea to encompass productivity measurement. Caves *et al.* (1982a) also noted that there are two methods to calculate productivity differences- output and input based productivity indexes – with both indexes optimizing a situation in which either the output is maximized or the input is minimized respectively everything else being held constant. In 1988 Fare, Grosskopf, Lindgren and Ross identified a slight setback in their work with the application of the Tornqvist index when analysing Swedish hospital productivity. Due to having limited data about prices the index could not be applied and the team decided to have a look at the underlying Malmquist index, which required no such price data or behavioural assumptions about optimization of profits or minimization of costs (Grosskopf, 2005). After having their initial idea rejected due to issues with variable economies of scale, the team's decomposition of the index was finally published by Fare *et al*. (1994;Grosskopf, 2005).As indicated by Lovell (2003), this decomposition has made the MPI more popular than the Malmquist total factor productivity index. This could also be attributed to the fact of the MPI being introduced ten years earlier and connected to the Tornqvist and Fisher index.

For similar reasons the Malmquist index was chosen as a productivity measurement tool also in the current study, as the decomposition of efficiency and technology change provides for an easy to measure and identify method of productivity development analysis, which would allow to effectively ascertain how the situation in the Latvian agriculture sector has changed and how it was influenced by the EU funds. Additionally, it does not require extensive amount of data regarding prices, revenues and costs and with directly applying the DEA the MPI can be easily calculated. Furthermore, in case of identification of varying returns to scale (VRS) there is a further decomposition of the MPI proposed which does take also VRS into account (Fare *et al,* 1994; 1997). However, it was noted that increased attention should be paid if one is to empirically estimate this decomposition, since it combines both Constant returns to scale (CRS) and VRS in its formula (Ray & Desli, 1997).

2.2.2. Other Malmquist productivity index types

Among the developments of the most popular form of the Malmquist index there have been several adjusted versions made in order to account for some specific situations and to propose new ways of the index's application and decomposition.

Daskovska, Simar and Bellegem (2010) proposed a new decomposition of the Malmquist index and a new projection method for the MPI. Oh and Lee (2010) integrated the metafrontier approach into the MPI in order to account for the fact that different producers functioning with dissimilar technologies are impossible to compare and devised the metafrontier Malmquist productivity index, a different productivity index method that is decomposable in more detail with the addition of change in technical leadership. Chung, Fare and Grosskopf (1997) introduced a unique form of productivity index to incorporate environmental effects and named it the Malmquist-Luenberger productivity index. Pastor and Lovell (2005) introduced the global Malmquist productivity index, which does not depend on a base period and is aligned with the circularity assumptions.

2.3. Tornqvist and Fisher index

As it was already mentioned in the Malmquist index's part there were also other indices designed for measuring productivity, such as the Tornqvist index. The index was first introduced by Loe Tornqvist (1936) and is sometimes referred to as the Tornqvist-Theil price index. The data required is just the prices and quantities in the two time periods over which the analysis is to be made. One of the major drawbacks is that the index does not fulfil the essential requirement of transitivity for multilateral comparisons. A generalized Theil-Tornqvist index was introduced by Caves *et al.* (1982b), which is sometimes referred to as CCD, while it does pass the transitivity requirement it is still criticized on several occasions.

The Fisher index is simply a geometric mean of Laspeyre's and Paasche's indices, which surprisingly satisfies almost all of the index number properties and is even called the ideal index number for that same reason (Jazairi, 1972).The Tornqvist index is in a sense similar to the Fisher index as their calculations are usually incredibly close.

A drawback for these indices and also the reason why they were not chosen for this paper is their excessive reliance on price and quantity data.

2.4. Hicks-Moorsteen index

The Hicks-Moorsteen index (HMI) was initially introduced by Diewert (1992) and is being popularized by O'Donell (2011) stating that different distance functions used in the Malmquist index result in different results. The HMI proposes a different aggregator function of a geometric mean of two separate indexes, which were proposed by Hicks (1961) and Moorsteen (1961). O'Donell (2010) disputed that the MPI is not a valid method for efficiency calculations unless operated under the assumption of constant returns to scale and thus is not a part of the TFP indexes that are multiplicatively complete. This was confirmed by other field works, which concluded that the Malmquist index may incorrectly calculate TFP changes if there are varying scale economies (Coelli & Rao, 2005; Grifell-Tatje & Lovell, 1995).

However, this is not an obstacle as it was already mentioned in the previous section the MPI can also be decomposed further to account for VRS.

2.5. Cobb-Douglas production function

The Cobb-Douglas production function was first mentioned by Cobb and Douglas (1928) and is very frequently used to represent the interrelatedness of labour, capital and technological efficiency in terms of output. The production function simply illustrates the different possibilities of output an economy or company could have given a specific productivity level A, capital used K and labour employed L, which are weighted by the usage intensity. The standard formula as we know it is $Y = AK^{\alpha}L^{(1-\alpha)}$ where α represents how capital intensive is the particular entity and (1- α) respectively shows how labour intensive it is, while Y is the produced output. A more detailed decomposition and derivation of the production function has been provided by Border (2004).

This simplified model will not be applied due to the risk of multicollinearity and possibility of acquiring biased data due to outliers (Enaami, Muhamed, Ghani, 2013), which unfortunately cannot be corrected in the current case, for the specific nature of the work. Likewise, the Cobb-Douglas production function does not decompose as well as the Malmquist productivity index and illustrate where exactly the economy is focusing and what is being compromised in the process.

2.6. Conclusion of the Literature Review section

The review of already written literature covered the basic framework of this work. The section was introduced with an overview of the general method used to calculate various DMU productivity and efficiency development, followed by a more detailed view on the Malmquist index, its history and other derivations. Finally, the section covered some of the most popular alternative indices in the field and argued against their applicability in this work and is closed with a short summary.

The previously written works contributed in the development of this work's methodology in the following ways: i) they gave insight in the index's heritage and development over the years, ii) pointed out the issues with the index and solutions to them, iii) provided a division framework for the EU structural funds, iv) offered alternative ways how to approach the situation with both their benefits and drawbacks v) Špička and Machek (2015) provided the basic methodology for the work with the adjustment of omitted linear regressions vi) Mohan and Matsuda(2013) supported with the choice of input and output variables.

This work is unique in its own manner and provides value to the provided literature in several ways: i) while other works in the field usually are based on regional or country data this work applies data on a very detailed level, namely analysing the counties of each region, which should provide for more precise results, ii) the combination of different methodologies extends the currently available in-depth analysis which usually stops after the index calculation, iii) the application of modern methods gives a detailed view on the fund distribution and effectiveness, iv)the analysis of the Baltic region's member state Latvia will give a better understanding of the situation and supplement the literature written on the country.

3. Data Availability

Mohan's and Matsuda's (2013) report, on which the data set of this work's Malmquist TFP calculations is based, analysed regional total factor productivity growth in the agricultural sector of Ghana. The study was chosen due to the conveniently outlined choice of input and output variables that have been well identified to be adopted in other studies as well. The authors chose the amount of cultivated land, number of people employed in agricultural sector, number of tractors used in the industry, amount of fertilizer applied and a climate indicator of annual amount of rainfall as their input variables. The provided inputs were analysed against a single output - the monetary value of total amount of produced goods in the agricultural sector. Since similar input and output variable choices were observed in other works in the field (Nkamleu (2004); Trueblood & Coggins, (2003); Fulginiti & Perrin, 1997) this work will adjust the choice of variables, as not all of them are available at the required level of detail or are irrelevant to the proposed research question and sub-questions.

The data in this study was collected on an annual basis and both on a regional and county level to more thoroughly analyse the effect of the EU Structural Funds' effect on Latvia's agricultural sector. While the situation before and after the EU SF acquisition is analysed and compared on a regional level throughout the whole period (2000 – 2013), after 2009 this work will deepen its research prospects and add the analysis of counties. This level of detail was not possible in the previous years due to administrative changes that took place in June, 2009, where every parish across Latvia was included in their respective counties and all of the regions and the majority of counties were restructured. From the several hundred parishes Latvia expanded its Riga's region and established 110 counties and nine cities across five regions. Thus county specific data was only available for the period of 2009 – 2013. The annual data for all variables will be collected.

Total amount of registered tractors was acquired from State Technical Supervision Agency (Valsts Tehniskās Uzraudzības Aģentūra) (STSA). As for labour, the only times when the Central Statistical Bureau (Centrālās Statistikas Pārvalde) (CSB) gathered precise amounts of people employed in the agricultural sector was in 2000 and 2010. For other years, the Central Statistical Bureau of Latvia creates an approximation based on the weighted average number of various sized farms in each region and county and the average number of employees reported to be working for the specific size farms.

$$Labour\ employed\ in\ region\ A = Number of x sized farms in region A \cdot avg. number of people employed in x sized farm$$

In this research regional approximations created by the CSB will be used and county-specific approximations will be created based on the same methodology. Accordingly CSB and SUDAT[1] provided the necessary data about number of different size farms and their average number of employees in order to estimate the number of employed employees on a county level. For the amounts of cultivated land, State Land Service (Valsts Zemes Dienests) (SLS) provided the necessary data.

Livestock is the first of the above mentioned variables, which will not be used in this study, as livestock has no effect on efficiency and productivity of crop cultivation. Furthermore, the amount of used fertilizer will be excluded from the dataset since it is only available on a country level and no legitimate division methodology has been developed, which would allow estimating these values on a much detailed scale of regions or even counties. For similar reasons the climate indicator of rainfall will be excluded from inputs as no such data are gathered on county level.

Nonetheless, it should be noted that the climate indicator of annual rainfall and the amount of fertilizer applied are two invaluable factors that affect land productivity and, thus, indirectly affect the crop output. In order to account for these effects, output has to be adjusted, so that it would not be exposed to various product price shocks, and also to shocks, caused by sudden changes in land productivity. The monetary value of output is calculated as follows:

$$Monetary\ value\ of\ output = registered\ cultivated\ area\ of\ crop\ A \cdot (region - specific\ land\ productivity\ data)^* \cdot (region - specific\ cropAprices)^*$$

*Constant at 2013 levels

Each complement of output corresponds to 1 out of 7 of most commonly cultivated crops in Latvia - wheat, rye, barley, oats, triticale, potatoes and rape. Data for output variable calculations were gathered from the SUDAT database, the CSB and The Latvian State Institute of Agriculture Economics (Latvijas Valstsagrārās ekonomikas institūts).

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[1]https://sudat.lvaei.lv/

Finally, the Rural Support Service (Lauku Atbalsta Dienests) (RSS) was approached for a detailed summary of received and distributed funding from the European Union. The RSS provided a detailed database of the allocated funds to structural projects under the EAFRD for the agriculture sector over the period of 2007 – 2013 systematized by region and the field of usage. A clear summary of the inputs and outputs can be seen in the table 1 below, while a detailed division of the transferred EAFRD funding can be seen in Appendix F.

The data set also experienced minor adjustments due to missing data in some counties. There were in total nine cities and seven counties removed from four different regions. The excluded counties and their respective regions are as follows: from Latgale Viļakas County was removed, from Vidzeme Varakļānu County was removed, from Kurzeme Mērsraga County was removed and ,finally, Pieriga had the most excluded Counties – Garkalnes, Saulkrastu, Stopiņu and Carnikavas county.

Table 1Indicator summary

Variable	Source	Approach
Input indicator		
Tractors (No.)	State Technical Supervision Agency	True value
Labour (No.)	Central Statistical Bureau of Latvia	Approximation
Land (Ha)	State Land Service	True value
Output indicator		
Crop Output Monetary value (EUR)	The Latvian State Institute of Agriculture Economics	Approximation
Control variable		
EU structural funds (EUR)	Rural Support Service	True value

4. Methodology

The methodology part is divided into three sections. The first section will cover the calculations of the Malmquist total factor productivity indexes and its technicalities. At the first stage, the MPI will be calculated for the total area of each region as the production possibility frontier will be constructed for the whole country. At the second stage, MPI will be constructed for different counties belonging to the same region, thus, the production possibility frontier will be constructed for each region. As the chosen time period is purely dependent on the amount of historical information that is available, the MPI for regions will be calculated for the whole period 2000 – 2013. However, county level calculations, as mentioned in the previous section, will be calculated for the period 2009 - 2013. After the calculation of regional Malmquist productivity indexes, comparison will be made between the indexes' values for the EU budgeting period (2007 – 2013) and before the budgeting period (2000-2007).

The second section of methodology will cover a more detailed analysis of the MPI values for counties in the period of 2009 - 2013. Through the usage of one-sided Welch T-tests of various hypotheses, the authors will look for significant differences between the progressive and regressive counties. By defining the common characteristics of the progressive counties, particular interrelationships will be highlighted and suggestions made on which improvements could lead to superior results in terms of the MPI. Another part of applied tests will compare the received amounts of EU SF between both groups of counties, showing whether received amounts have significant effect on MPI change, thus, confirming that the past absorption of EU SF has been successful.

The final section will analyse the absorption efficiency of received EU SF on a county level. In the first stage, the total sums of received funding will be compared with the acquired MPIs, thus, confirming whether the past absorption has significant effect on macro-level results. The second stage will involve the identification of the most optimal division of the received EAFRD funding.

4.1. Malmquist total factor productivity index

The methodology applied will be based on Coelli *et al.* (2006) presented approach on measuring Belgium's agricultural sector's development.

The Malmquist TFP index as presented by Fare *et al*. (1994) calculates the proportional difference of two data points referring to an identical production technology, thus assessing the TFP development between those two points. For the sake of simplicity let us denote the production of a firm as *M* and the respective inputs required to produce that output as *K* and only focus on an output oriented Malmquist TFP index. Also consider *t+1* and *t* as two different periods in time.

For a detailed explanation of the distance functions the work of Johnes (2006) will be referenced. If *t* shall be considered as a time period before *t+1*, namely *t<t+1*. T^t is the technology level of a company at time t, which illustrates the process of how efficiently the specific company manages its inputs x_t in order to produce q_t, thus

$$T^t = ([x_t, q_t]\colon x_t can\ produce\ q_t)$$

The distance function at time *t* is then defined as in Fare *et al*. (1994):

$$d_o^t(x_t, q_t) = min_\theta(\theta\colon [x_t, q_t/\theta] \in T^t)$$

Since the aim is to calculate productivity changes then mixed-period distance functions should be applied as defined by Shephard (1953):

$$d_o^{t+1}(x_t, q_t) = min_\theta(\theta\colon [x_t, q_t/\theta] \in T^t)$$

$$d_o^t(x_{t+1}, q_{t+1}) = min_\theta(\theta\colon [x_{t+1}, q_{t+1}/\theta] \in T^t)$$

If the technology used in period *t* is taken as a reference point then the Malmquist index of a singular company for the period changes from *t* and *t+1* can be denoted as

$$m_o^t(x_{t+1}, q_{t+1}, x_t, q_t) = \frac{d_o^t(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)}$$

The subscript *o* indicates that it is an output oriented MPI, $d_o^t(q_{t+1}, x_{t+1})$ is the previously mentioned distance of technologies between the observed point *t+1* and the reference point t, q_t and $q_{t+1}$are *M* by one vectors illustrating output at the specific period, while x_t and x_{t+1} are their corresponding *K* by one input vectors.

Similarly this equation could be composed if period *t+1* would have been taken as the technology's point of reference.

$$m_o^{t+1}(x_t, q_t, x_{t+1}, q_{t+1}) = \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_t, x_t)}$$

The interpretation of these indexes is plain and simple, if *m* takes a value above one it implies positive development of the index and thus of the particular company between both periods, while a value equal to one indicates no growth and a value below one clearly states a decrease in productivity relative to the initial period.

However, while this measure only holds for a one input/output situation and when there is Hicks neutrality assumed, different results may be calculated if multiple inputs and outputs are implemented (Fare *et al* 1998). Thus the Malmquist productivity index is conventionally calculated as a geometric mean of these indices (Fare *et al* 1994):

$$m_o(x_t, q_t, x_{t+1}, q_{t+1}) = \left[\frac{d_o^t(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)} \cdot \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_t, x_t)}\right]^{1/2}$$

In order to make the formula more intuitive here the decomposition as suggested by Fare *et al* (1994) can be applied:

$$m_o(x_t, q_t, x_{t+1}, q_{t+1}) = \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)}\left[\frac{d_o^t(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_{t+1}, x_{t+1})} \cdot \frac{d_o^t(q_t, x_t)}{d_o^{t+1}(q_t, x_t)}\right]^{1/2}$$

The multiplication within the brackets measures the change in technology (TECH), namely how the company's technology changes (graphically: whether the frontier is shifting over time).

$$Technical\ change: \left[\frac{d_o^t(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_{t+1}, x_{t+1})} \cdot \frac{d_o^t(q_t, x_t)}{d_o^{t+1}(q_t, x_t)}\right]^{1/2}$$

The division outside of the brackets measures the change in technical efficiency (EFFCH) between the specified periods, namely how the efficiency of the company's usage of its technologies has changed between the periods (graphically: whether the company's efficiency is closing in on the efficiency frontier. i.e. the "catching up effect).

$$Efficiency\ change: \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)}$$

The interpretation is identical to the one mentioned previously in the single input/output situation – if it is above one, then relative to the previous period the company is experiencing growth, and regress if it is below it. Both Technical and Efficiency change are calculated against a technology benchmark, which is always the most efficient DMU from the analysed data set

$$\frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)} = \frac{d_{ov}^{t+1}(q_{t+1}, x_{t+1})}{d_{ov}^t(q_t, x_t)} \cdot \left[\frac{\frac{d_{ov}^{t+1}(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_{t+1}, x_{t+1})}}{\frac{d_{ov}^{t+1}(q_t, x_t)}{d_o^{t+1}(q_t, x_t)}} \cdot \frac{\frac{d_{ov}^t(q_{t+1}, x_{t+1})}{d_o^t(q_{t+1}, x_{t+1})}}{\frac{d_{ov}^t(q_t, x_t)}{d_o^t(q_t, x_t)}} \right]^{\frac{1}{2}}$$

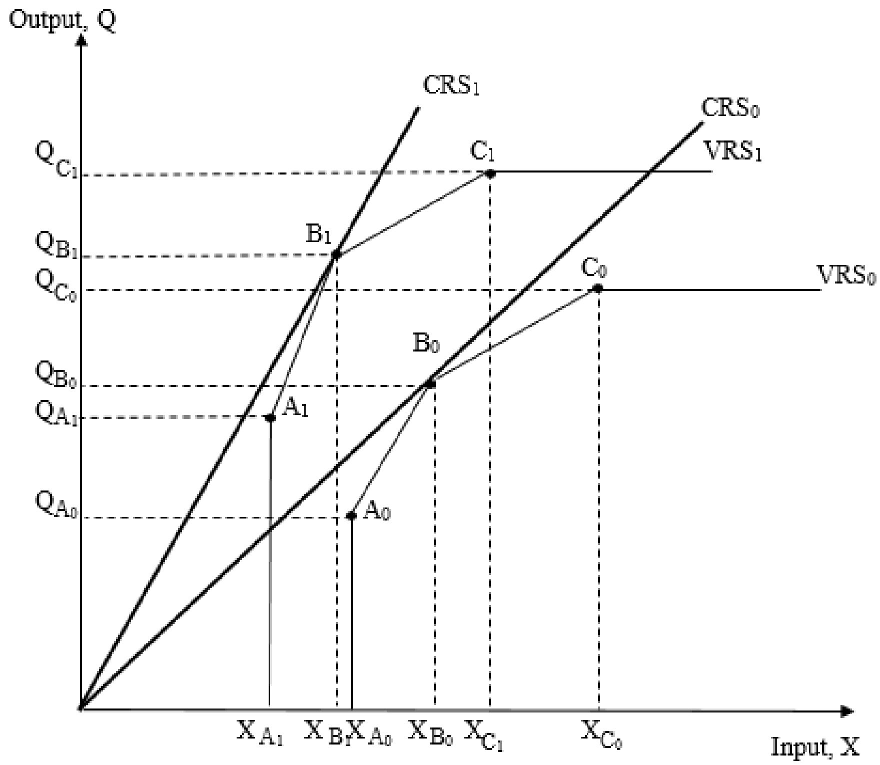
Because of the VRS assumption, Efficiency change can be further decomposed into Pure efficiency change (PECH) and Scale efficiency change (SECH); $EFFCH = PECH \cdot SECH$. Scale efficiency shows the effects on efficiency caused by changes of total used input value. If SECH is above a value of 1, a company in the given period of time has managed to attract more resources than the most efficient DMU in the sample (in absolute terms). Through the assumption of increasing returns to scale, a company with a SECH value of above 1 can utilize the existing amount of resources more efficiently, thus, closing the gap with the most efficient frontier. Pure efficiency shows the effects on efficiency caused by natural improvements of input utilization. If PECH takes a value above 1, a DMU in the given period of time has managed to extract more positive effects of utilizing the same set on inputs than the most efficient DMU in the chosen sample.

$$Pure\ efficiency\ change = \frac{d_{ov}^{t+1}(q_{t+1}, x_{t+1})}{d_{ov}^t(q_t, x_t)}$$

$$Scale\ efficiency\ change = \left[\frac{\frac{d_{ov}^{t+1}(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_{t+1}, x_{t+1})}}{\frac{d_{ov}^{t+1}(q_t, x_t)}{d_o^{t+1}(q_t, x_t)}} \cdot \frac{\frac{d_{ov}^t(q_{t+1}, x_{t+1})}{d_o^t(q_{t+1}, x_{t+1})}}{\frac{d_{ov}^t(q_t, x_t)}{d_o^t(q_t, x_t)}} \right]^{\frac{1}{2}}$$

A graphical representation of a single input/output DMU productivity under both CRS and VRS assumptions can be seen in figure 1.

Figure 1CRS and VRS productivity frontiers. Source: the authors



If it is assumed that the operations are executed having CRS the frontiers are exhibited as straight lines (CRS_0& CRS_1). However, if VRS are assumed then the frontier dents, as it goes through the DMUs. Points $A_{0,1}$, $B_{0,1}$and $C_{0,1}$are the most efficient DMUs from the particular sample and are chosen arbitrarily in order to better illustrate the Malmquist index. Additionally, points B_0 and B_1 are located on both the CRS and VRS frontiers indicating that this unique DMU is efficient on both assumptions and exhibits EFFCH and PECH of a value of one.

The shift of both frontiers (CRS_0 and VRS_0) takes place when the most efficient DMUs experience increasing (above a value of one) TECH values, indicating more efficient practices being applied by the DMUs and more efficient usage of their inputs. All the remaining DMUs in the sample, apart from the ones on the productivity frontiers, are located somewhere below their respective frontiers based on their productivity values.

4.2. Welch t-test

The Welch to-sample t-test is an adaption of the student's t-test and is used to check the hypothesis that two groups have equal means with the alternative hypothesis being that the means are unequal. The Welch t-test requires the sample mean, variance and size in order to calculate the necessary values and compare the distribution of both groups. Assumption wise Welch's t-test in comparison to student's t-test relaxes the homoscedasticity assumption (McDonald, 2014).

Similarly to the Malmquist total factor productivity index the Welch t-test will also be computed with the help of the statistical data analysis program STATA.

4.3. Optimal division of the EAFRD Funding

The previous description of Malmquist indexes and their calculations suggests that these indices can be improved by either having more accessible inputs or by combining these inputs more efficiently to attain higher output levels. With the help of Irina Pilvere, the current rector of Latvia University of Agriculture and previous director of the RSS, the EAFRD funding for the period of 2007 – 2013 was divided, based on its sub-sections' respective objectives:

Table 2EAFRD funds' division by input groups. Source: Irina Pilvere

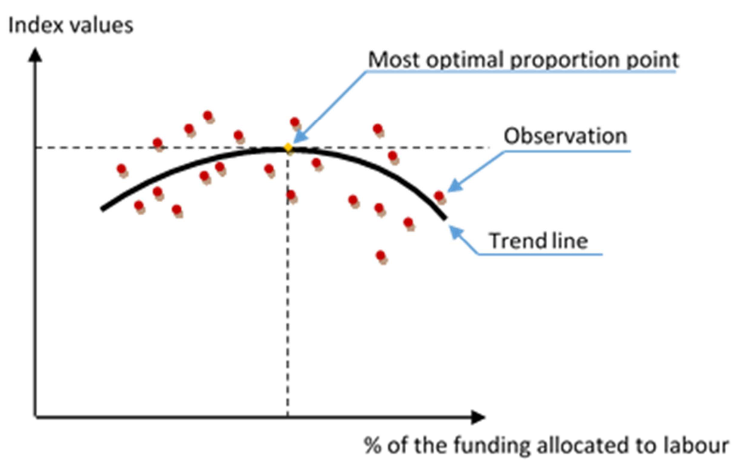
EAFRD Funding groups			
Farm* rejuvenation and support	**Stimulation of more productive and accessible…(input)**		
	Labour	**Land**	**Machinery, tractors**
Support for new farmers (L112)	Support for business creation and development (including diversified activities not directly related to agriculture) (L312)	Infrastructure for agriculture and forestry development/ adaption(L125)	Modernization of agricultural holdings (L121)
Support for semi-subsistence farm restructuring(L141)	Basic services for the economy and population (L321)		Improvement of agricultural product value added (L123)
	Provision of work and skill development for the local population in rural areas (L431)		Fostering the competitiveness of the local development strategy implementation(L411)
	Provision of work and skill development for the local population in rural areas (L431)		Economy diversification and improvement of life quality in rural areas(L413)

** Also contributes to improvements in the decision making of input usage*

The proportions of the allocated funding groups for each county were calculated and applied in the following analysis.

According to Becker (2012), there is no linear interaction between the allocated EU SF and improvements in the economy. The author also argues that after a certain point in the allocated funding amounts there is a decrease in the marginal effect on productivity. For this reason, the acquired counties' MPIs will be plotted against different EAFRD funding group proportions from the total allocated amount for the particular county. Afterwards, second order polynomial trend lines were introduced to analyse the relationship between both axes. Given the formulas of created trend lines', the global maximum points were calculated, indicating the approximate proportions of each funding group that would maximize the MPI value. An example of such an approach can be seen in figure 2.

Figure 2Graphical representation of MTFPI index value depiction against proportions of allocated funding. Source: the authors



By calculating these trend lines' global maximums of the EAFRD subgroup divisions, it was possible to identify the most optimal way of proportions that the funding should be distributed in order to efficiently stimulate the recipient county's/region's growth and thus produce greater return on investment. Afterwards, the distributed funding proportions in the period of 2007 – 2013 were compared with the calculated optimal funding proportions on a county level.

5. Results

5.1. Malmquist total factor productivity index's results – county level

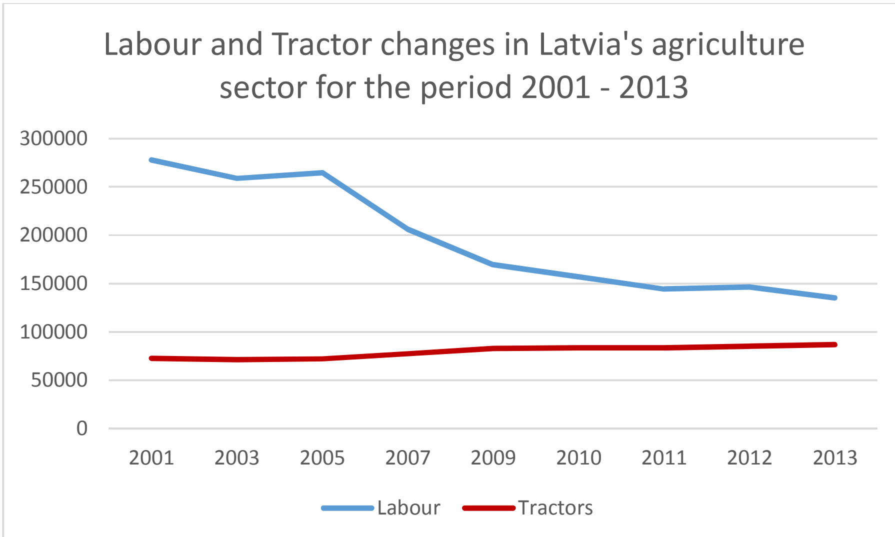
The first part of this study's research was focused on examining the changes in the Malmquist total factor productivity index (MTFPI) development before and after 2007 on a regional level. Since the acquired results are prone to economic and political shocks the MTFPIs were calculated by using a two year period sets rather than measuring them on an annual basis. This safety measure would effectively reduce the risk of having observations containing sudden volatility. Given the MTFPI's development, as well as development of both sub-indexes, Malmquist index efficiency change (EFFCH) and Malmquist technological change (TECH), geometric means were calculated for 2-years periods before and after EU Structural funds were allocated. The resulting indices can be seen in table 3. For a more graphical representation of the efficiency changes after the EU SF acquisition Appendix H and Appendix I should be consulted.

Table 3Malmquist total factor productivity index and sub-index results. Source: Authors' calculations

	2001 - 2007					2007 - 2013				
DMU	MTFPI	MEFCH	MTECH	MPECH	MSECH	MTFPI	MEFCH	MTECH	MPECH	MSECH
Kurzeme	0.8052	0.98165	0.8202	1	0.98165	0.9106	1.02707	0.88663	1	1.02707
Latgale	0.9026	1.02374	0.88165	0.99416	1.02976	0.9894	0.99226	0.99708	0.97858	1.01398
Vidzeme	0.755	0.90085	0.83803	0.78181	1.15227	0.8936	1.08465	0.82386	1.24678	0.86996
Riga	0.8937	1.04019	0.85919	1	1.04019	0.9053	0.98531	0.91884	1	0.98531
Zemgale	0.8509	1	0.85091	1	1	0.8866	1	0.88663	1	1

When comparing MTFPI changes before and after EU SF absorption, there has been a clear improvement in all regions of Latvia. In the period 2001-2007 all five regions of Latvia experienced a severe decrease of total factor productivity, mainly caused by technological regress in the country. As it can be seen in figure 2, the total amount of people employed in the agriculture sector started a steady decline from 2005, which can be easily attributed to the fact that throughout the last 15 years there has been a significant emigration of people. The negative effects of labour becoming relatively scarce were not fully compensated by the increase of total amount of used tractors (figure 3), leading to new equilibrium conditions, in which it was no longer possible to produce the same value of output with the old input combinations. This forced the country's total production possibility frontier to shift downward. The region of Kurzeme experienced these effects the most witnessing an average drop of 18% per a two year period, from the perspective of technologies.

Figure 3Development of Labour and Tractors in Latvia's agriculture sector from 2001 to 2013. Source: STSA & CSB



After 2007 the number of registered tractors continued to increase steadily, while the number of labour continued to diminish, repeatedly leading to the country's technological regress. Despite that, with a relatively decreasing fall in the labour factor, technological regress was slowed (in Kurzeme, from an average drop of 18% to 12% per 2-years period).This could indicate that it is reasonable to expect that in the near future technological regress could be reversed into technological progress.

It was determined that the comparison of each region's efficiency change (EFFCH) would most clearly represent their development, as each region is affected by similar factors that shift the production frontier. As mentioned previously, EFFCHis further decomposed into two sub-indexes and shows whether a region is closing or widening the gap between its production capabilities and the most efficient, country's, production frontier. As it can be seen in the obtained results (table 3), the values of EFFCH for Zemgale are equal to 1 in both periods, which indicates that Zemgale is the region with the highest absolute efficiency (PECH equals to 1) and with the highest total amount of output (SECH equals to 1). For these reasons Zemgale is used as a benchmark against which all other regions' efficiency changes are measured. In the period 2001-2007, Kurzeme, Zemgale and Rīga had a PECH index value of 1, indicating that these were the three regions, through which the efficient production possibility frontier was drawn. As these values remained the same also in the following period, it is clear that these three regions did not experience any changes in their learning effects of more efficient usage of existing production resources. For Rīga and Kurzeme, the main driving-force of changes in efficiency (EFFCH) were changes in scale efficiency (SECH). From the obtained results, during the period of 2001-2007 Pierīga had an average SECH=1.04019, meaning that in this time period its output increased by 4.019% faster than in Zemgale. After the transfers of the EU SF had started in 2007, Pierīga experienced a drop in its average SECH value over the whole period. The new SECH value was located at 0.98531, meaning that in this period of time its output increased by 1.469% slower than in Zemgale on a 2-year's period basis. This is a negative effect on the reduction of disparities between Zemgale and Pierīga, as after the EU SF acquisition the gap in efficiencies between both regions has been widening. Contrary to Pierīga, the period after EU SF acquisition had reduced disparities between Zemgale and Kurzeme in terms of efficiency (EFFCH from 0.98165 before EU SF to 1.02707 after EU SF).

Latgale and Vidzeme are the only two regions that are not part of the country's most efficient production frontier. Latgale, which has a PECH value below 1 in both periods, has shown a negative development in its learning curve, suggesting that farms of this region have not managed to find a way how to use the existing production resources – land, tractors and labour – in better proportions to improve the value of produced output. On the other hand, Latgale has managed to faster increase the total value of produced output when compared to Zemgale, by 2.976% in 2001-2007 and 1.1398% in 2007-2013. This positive effect completely offsets the negative effects caused by negative learning improvements, allowing farms in Latgale to raise their technical efficiency (EFFCH) improvement to a level very close to farms in Zemgale (in 2007-2013 EFFCH=0.99226). Vidzeme is the region with the highest growth of efficiency (EFFCH) in the period after the EU SF acquisition, indicating the presence of the strongest "catching-up" effects. Although the average scale efficiency improvement in Vidzeme has been significantly lower than in Zemgale (SECH=0.86996), farms in Vidzeme have managed to tremendously benefit from learning effects, exhibiting efficient utilization of existing resources. Because of positive learning effects, Vidzeme has experienced a growth in efficiency of 24.678% per a 2-year's period when compared to Zemgale. It is worth mentioning that in the period before the EU SF acquisition Vidzeme was heavily falling behind other regions in terms of total efficiency growth and having positive learning effects. This could potentially indicate of strong positive effects on reduction of disparities created by the EU SF acquisition.

5.2. Malmquist total factor productivity index's results – regional level

For a more detailed analysis on both regional and country level, the situation in the agricultural sector productivity was examined on a county level. Once again Malmquist total index productivity (TFPCH), efficiency change (EFFCH) and technological change (TECH) were obtained for each county, with the slight change of taking annual data on the basis of one year, and geometric average values were calculated for the period of 2009-2013 (Appendix A& Appendix B).Similarly as before the comparison of each region's efficiency change (EFFCH) was used to represent the respective region's development, as each region is affected by similar factors that shift the production frontier.

Guiding by the work of Špička and Machek (2015), similar characteristics were applied to define two unique groups, where the counties would be divided based on the changes in their efficiency in the period of 2009 – 2013.Afterwards Welch's T-test was used to search for significant differences between regions with positive efficiency development and those with negative. In the first part of the Welch's T-test analysis it was tested whether the relationship between farms' produced output and efficiency changes is of any significance. Afterwards, in the same manner the relationship between efficiency change and usage of different amounts of inputs was investigated.

Table 4 shows the mean values of produced output per farm in those counties, where EFFCH is below 1 (group A), and in those counties, where EFFCH is above or equal to 1 (group B). As it can be seen, counties with higher amounts of total output became more efficient only in Zemgale, showing that increase of output of those farms, which are representing this region, would give a high probability of increased efficiency. Contrary to Zemgale, the situation in Latgale is quite the opposite – throughout the last four years farms producing lower-value outputs have been the ones boosting the efficiency improvement in the whole region. In the other three regions differences of groups A and B in the values of produced output per farm have not been statistically significant.

If the cumulative changes of output per farm in the period of 2009-2013 are compared, it can be seen that farms with the highest growth have been those that have an EFFCH value below 1. As this result is statistically significant in all five regions, it is safe to say that on a county level farms with diminishing efficiency are the ones with the highest proportional development in output. This indicates of the existence of an average output per farm value, after which efficiency is no longer improving and negative effects of PECH over-weight the positive effects of SECH.

Table 4Differences between regions with positive (Group B) and negative (Group A) geometric average EFFCH development from the output value per farm perspective for the period 2009 - 2013

Indicator	Region	Group A (EFFCH<1) mean	Group B (EFFCH>=1) mean	Combined	H0 (μ1 – μ2)	T-statistic	P-value	Significance
Value of output per farm	Kurzeme	4290	4771	4432	μ2 – μ1>0	-0.2778	0.6047	
	Zemgale	6042	13117	7531	μ2 – μ1>0	-1.7713	0.9236	*
	Pierīga	3518	2782	3135	μ1 – μ2>0	0.5193	0.6951	
	Vidzeme	3074	2284	2580	μ1 – μ2>0	0.8579	0.7984	
	Latgale	2106	1522	1587	μ1 – μ2>0	1.4111	0.8971	*
Cumulative change, value of output per farm in the period of 2009-2013	Kurzeme	49.58%	24.20%	42.12%	μ1 – μ2>0	4.4111	0.9998	***
	Zemgale	45.47%	22.75%	40.68%	μ1 – μ2>0	3.4509	0.9985	***
	Pierīga	90.50%	10.76%	49.04%	μ1 – μ2>0	3.8277	0.9989	***
	Vidzeme	52.78%	11.47%	26.96%	μ1 – μ2>0	5.1065	1	***
	Latgale	92%	41.25%	46.89%	μ1 – μ2>0	4.8929	0.9934	***

Description of statistical significance: * (α = 0.1), ** (α= 0.05), *** (α= 0.01)

5.3. Utilized tractors per farm – the perspective of efficiency

Table 5 shows the mean differences of tractors per farm in counties with EFFCH being below 1 (group A) and EFFCH above or equal to 1 (group B). Generally, no statistically significant relationship between the amount of used tractors and efficiency improvement has been identified, as Pierīga is the only region, which has significant differences in group A and group B means. For Pierīga, the counties with the highest usage of tractors per farm have been the ones experiencing negative effect on total efficiency, suggesting that higher amounts of available tractors leads the farmers of Pierīga into an inefficient choice of inputs, putting too much weight on the usage of tractors.

The means of cumulative changes of used tractors per farm for groups A and B are statistically insignificant as well, with an exception of Latgale. In Latgale, farms with the lowest growth of total number of tractors are the ones having efficiency improvements, indicating that having more production resources does not automatically transfer into production of higher efficiency.

Table 5Differences between regions with positive (Group B) and negative (Group A) geometric average EFFCH development from the utilized tractors per farm perspective for the period 2009 - 2013

Indicator	Region	Group A (EFFCH<1) mean	Group B (EFFCH>=1) mean	Combined	H0 (μ1 – μ2)	T-statistic	P-value	Significance
Used tractors per farm	Kurzeme	1.222511	1.19715	1.22	μ1 – μ2>0	0.1614	0.563	
	Zemgale	1.1564	0.98	1.12	μ2 – μ1>0	1.1895	0.8637	
	Pierīga	1.5618	1.1363	1.345	μ2 – μ1>0	1.4852	0.9205	*
	Vidzeme	1.2337	1.0579	1.1238	μ2 – μ1>0	1.0719	0.8455	
	Latgale	0.7323	0.78105	0.7756	μ1 – μ2>0	-0.6332	0.7226	
Cumulative change, used tractors per farm in the period of 2009-2013	Kurzeme	23.42%	26.80%	24.41%	μ1 – μ2>0	-0.9918	0.8319	
	Zemgale	29.00%	27.50%	28.68%	μ2 – μ1>0	0.3411	0.6274	
	Pierīga	22.50%	24.69%	23.64%	μ2 – μ1>0	-0.4136	0.6581	
	Vidzeme	29.33%	25.80%	27.13%	μ2 – μ1>0	1.0099	0.8387	
	Latgale	47.00%	35.13%	36.44%	μ1 – μ2>0	2.4712	0.9659	**

Description of statistical significance: * (α = 0.1), ** (α= 0.05), *** (α= 0.01)

5.4. Cultivated land per farm – the perspective of efficiency

Table 6 shows the mean differences of cultivated land per farm in counties with EFFCH below 1 (group A) and EFFCH above or equal to 1. As it can be seen in Pierīga, Vidzeme and Latgale farms operating less efficiently are significantly larger than those that have improvements in efficiency. In terms of efficiency smallest farms are catching up the largest ones, marking the presence of diminishing disparities in efficiency between different sized farms.

From the perspective of cumulative changes, in two regions – Latgale and Vidzeme – average amounts of cultivated land per farm have been growing more rapidly in those counties, which operational efficiency has decreased in the given period of time. Similarly to the previous division, farms with a larger growth of used input resources are the ones that are becoming more inefficient. This confirms the fact that there is inefficient usage of inputs by those farms, which have better access to particular resources.

Table 6Differences between regions with positive (Group B) and negative (Group A) geometric average EFFCH development from the cultivated land per farm perspective for the period 2009 - 2013

Indicator	Region	Group A (EFFCH<1) mean	Group B (EFFCH>=1) mean	Combined	H0 (μ1 – μ2)	T-statistic	P-value	Significance
Cultivated land per farm	Kurzeme	30.20	32.86	30.98	μ2 – μ1>0	-0.9352	0.8171	
	Zemgale	30.81	31.72	31	μ2 – μ1>0	-0.2944	0.6135	
	Pierīga	28.57	23.23	25.8	μ1 – μ2>0	2.0171	0.9727	**
	Vidzeme	32.66	29.55	30.71	μ1 – μ2>0	1.3541	0.9012	*
	Latgale	26.73	24.1	24.39	μ1 – μ2>0	1.6452	0.9378	*
Cumulative change. Cultivated land per farm in the period of 2009-2013	Kurzeme	14.75%	18.20%	15.77%	μ2 – μ1>0	-1.1414	0.8649	
	Zemgale	22.00%	20.50%	21.69%	μ1 – μ2>0	0.5844	0.7066	
	Pierīga	16.00%	16.54%	16.28%	μ2 – μ1>0	-0.1063	0.5416	
	Vidzeme	24.11%	17.13%	19.75%	μ1 – μ2>0	2.3769	0.9828	**
	Latgale	28.00%	23.75%	24.22%	μ1 – μ2>0	2.6169	0.9889	***

Description of statistical significance: * (α = 0.1), ** (α= 0.05), *** (α= 0.01)

The first part of Welch T-test analysis suggests that in Pierīga, Vidzeme and Latgale counties that have farms with lower sizes and farms that are utilizing smaller amounts of inputs are the ones with positive total efficiency development (EFFCH above 1). This would imply that disparities between different counties in terms of efficiency are decreasing; however, it seems that it is not initiated by smarter usage of existing resources, as proportionally the most inefficient counties are the ones with the highest increase of generated output or used inputs. For Kurzeme and Zemgale, there are no significant differences between the total usage of inputs and efficiency improvement for the farms representing each of the regions. At the same time, in Zemgale farms producing larger values of output are the ones with efficiency improvement. As these farms are also with the highest cumulative increase of output, the authors can conclude that in this region SECH is the factor determining presence of growing efficiency.

In the second part of Welch T-test analysis the relationship between efficiency changes and the choice of used inputs' combinations tested whether there is a significant relationship. Through these tests absolute values of efficiency were compared between two groups of counties – those with negative efficiency improvement (Group A) and those with positive efficiency improvement (Group B) in the period of 2009-2013.

5.5. Produced output per tractor and employee – the perspective of efficiency

Table 7 represents the means of absolute efficiencies of operated tractors and employees for groups A (EFFCH below 1) and B (EFFCH above or equal to 1). Except for Zemgale, Latgale is the only region, which has statistically significant differences in any of the two indicators. In Latgale the value of output per employee is significantly smaller in those counties, where efficiency in the past 4 years has been improving. This indicates that counties with lower level of employee utilization are becoming more efficient and, in terms of efficiency, are catching up to the most developed counties. Quite the opposite result can be seen in Zemgale, where counties with the highest produced output values per both employee and tractor are rising in efficiency. For this reason, in terms of efficiency, the disparities between different counties of Zemgale are widening.

Similarly to the farms of the largest sizes and usage of inputs, cumulative changes of produced output both value per employee and tractor are significantly higher in those counties, which have experienced a negative development of efficiency; these results are significant in each of the 5 regions, thus, describing the overall situation in the country. The improvement of produced output value per given input in regions with negative efficiency development can be explained by the contrasting availability of resources. As described earlier, counties with positive total efficiency change have experienced a relative decline of available resources in comparison to those of negative efficiency change, thus, resulting in higher growth of produced output per one unit of tractor or employee. As a result, these counties have learned new ways how to optimize the usage of existing resources, stimulating pure efficiency improvement (PECH). At the same time, due to relative reduction of usage of inputs as well as produced output, these counties are having a negative effect from scale efficiency changes (SECH).

Table 7Differences between regions with positive (Group B) and negative (Group A) geometric average EFFCH development from the output value per employee and tractor perspective for the period 2009 - 2013

Indicator	Region	Group A (EFFCH<1) mean	Group B (EFFCH>=1) mean	Combined	H0 (μ1 – μ2)	T-statistic	P-value	Significance
Value of ouput per employee	Kurzeme	2442	2621	2495	μ2 – μ1>0	-0.2027	0.5771	
	Zemgale	4218	8495	5119	μ2 – μ1>0	-1.7654	0.9226	*
	Pierīga	1898	1505	1694	μ1 – μ2>0	0.5883	0.7184	
	Vidzeme	2171	1623	1829	μ1 – μ2>0	0.9365	0.8192	
	Latgale	1327	932	976	μ1 – μ2>0	1.5638	0.9077	*
Value of output per tractor	Kurzeme	4090	4197	4121	μ2 – μ1>0	-0.0682	0.5263	
	Zemgale	5377	15066	7417	μ2 – μ1>0	-2.0793	0.9413	*
	Pierīga	2918	2747	2829	μ1 – μ2>0	0.1293	0.5508	
	Vidzeme	2471	2139	2264	μ1 – μ2>0	0.497	0.688	
	Latgale	2993	2008	2111	μ1 – μ2>0	1.229	0.8405	
Cumulative change, Value of ouput per employee in the period of 2009-2013	Kurzeme	49.42%	19.20%	40.24%	μ1 – μ2>0	5.3076	1	***
	Zemgale	69.60%	37.50%	62.84%	μ1 – μ2>0	3.5464	0.9989	***
	Pierīga	72.58%	6.46%	38.20%	μ1 – μ2>0	3.273	0.997	***
	Vidzeme	51.78%	12.87%	27.46%	μ1 – μ2>0	5.5003	1	***
	Latgale	97.50%	44.25%	50.17%	μ1 – μ2>0	4.9878	0.9903	***
Cumulative change, Value of output per tractor in the period of 2009-2013	Kurzeme	21.42%	-2.20%	14.47%	μ1 – μ2>0	5.3891	0.9999	***
	Zemgale	12.47%	-3.75%	9.05%	μ1 – μ2>0	3.6236	0.9991	***
	Pierīga	55.42%	-10.00%	21.40%	μ1 – μ2>0	3.972	0.9992	***
	Vidzeme	18.22%	-11.33%	-0.25%	μ1 – μ2>0	5.0164	1	***
	Latgale	30.00%	4.75%	7.56%	μ1 – μ2>0	5.8267	1	***

Description of statistical significance: * (α = 0.1), ** (α= 0.05), *** (α= 0.01)

5.6. Utilized tractors per employee – the perspective of efficiency

Table 8 shows the means of modernization levels for counties of group A (EFFCH below 1) and group B (EFFCH above or equal to 1). As there is no significant difference in modernization between counties that have become more efficient and those that have lost their efficiency, it seems that there is no correlation between having more tractors per employee and having higher total efficiency. This finding confirms the applied theory of the Malmquist total factor productivity, as each input is given an equal weight when calculating Malmquist indexes. Because of the applied theory, if an output remains constant and the level of tractors increase by the same proportion as the level of labour decreases, the overall level of efficiency will not change.

Table 8Differences between regions with positive (Group B) and negative (Group A) geometric average EFFCH development from the tractors per employee perspective for the period 2009 - 2013

Indicator	Region	Group A (EFFCH<1) mean	Group B (EFFCH>=1) mean	Combined	H0 (μ1 – μ2)	T-statistic	P-value	Significance
Tractors per employee	Kurzeme	0.7064	0.6934	0.7	μ1 – μ2>0	0.234	0.5908	
	Zemgale	0.8462	0.6727	0.8097	μ1 – μ2>0	1.2697	0.8708	
	Pierīga	0.8584	0.6587	0.7686	μ1 – μ2>0	1.1213	0.8603	
	Vidzeme	0.9097	0.7843	0.8313	μ1 – μ2>0	1.0425	0.8389	
	Latgale	0.4608	0.4884	0.4853	μ2 – μ1>0	-0.5936	0.7123	
Cumulative change, tractors per employee in the period of 2009-2013	Kurzeme	23.92%	21.20%	23.12%	μ1 – μ2>0	0.4028	0.6539	
	Zemgale	50.20%	42.75%	48.63%	μ1 – μ2>0	1.5752	0.9299	*
	Pierīga	10.50%	20.00%	15.44%	μ2 – μ1>0	-1.4649	0.9196	*
	Vidzeme	28.56%	27.73%	28.04%	μ1 – μ2>0	0.2131	0.5834	
	Latgale	51.50%	38.25%	39.72%	μ1 – μ2>0	2.5553	0.9607	**

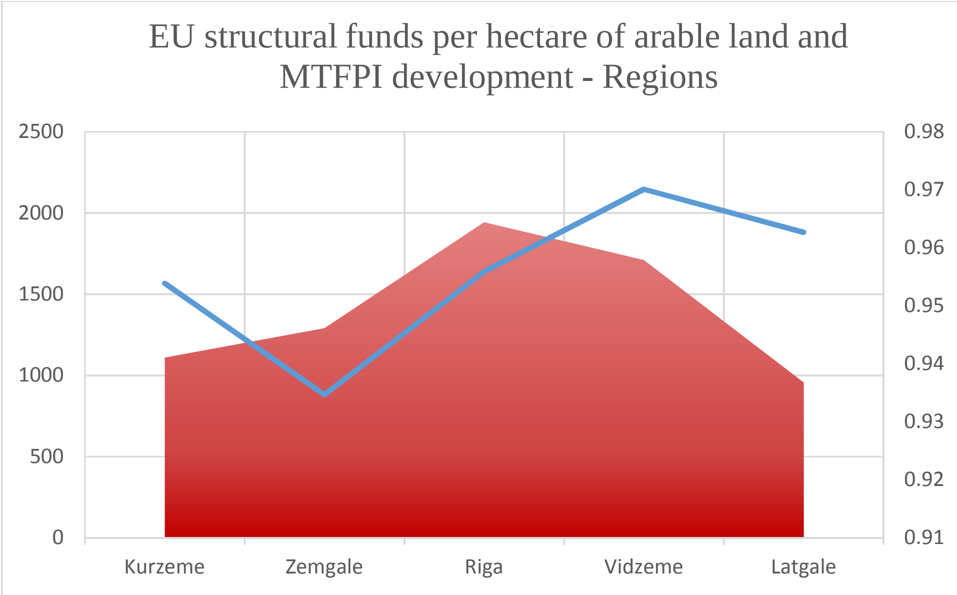
Description of statistical significance: * ($\alpha = 0.1$), ** ($\alpha = 0.05$), *** ($\alpha = 0.01$)

The second part of Welch T-test suggests that in most of the regions efficiency improvement of counties cannot be explained by significant increase in the improvement of utilization of any particular production resource (tractors or labour), meaning that counties with an EFFCH value above 1 have managed to improve the utilization of both of these resources simultaneously. In terms of efficiency, there is no observed decrease of disparities between the counties of different absolute efficiency levels. Even further, counties with the highest levels of produced value per employee (or tractor) have continued to increase their utilization levels more dynamically than those counties with lower levels of produced value per value of input. On top of that, in Zemgale the disparities, in terms of efficiency, between counties with different levels of input utilization have grown, indicating that in this region SECH effects outweigh the effects from PECH.

5.7. EU SF per hectare of arable land- total factor productivity perspective

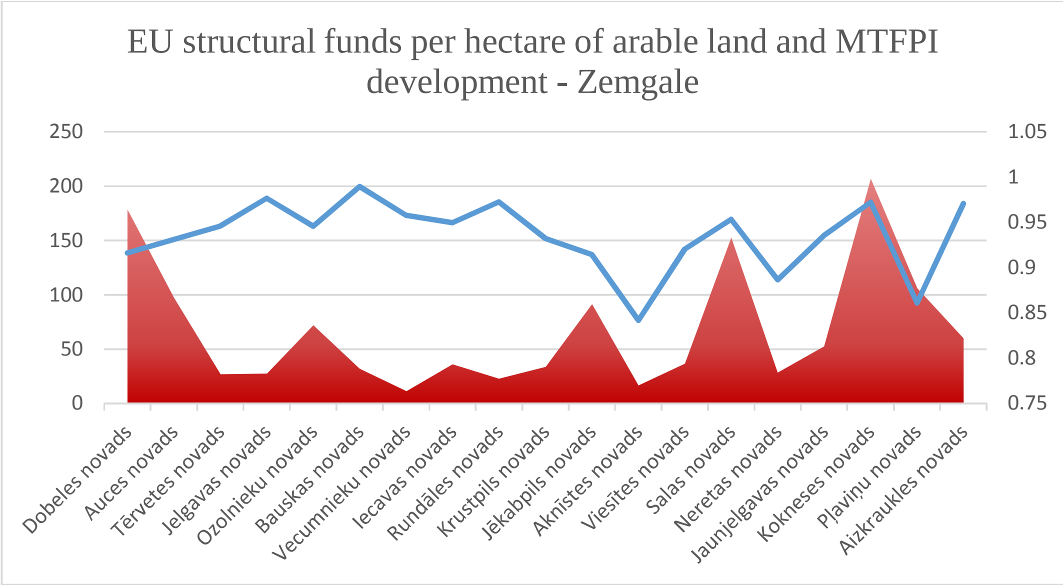
Although there were some similar tendencies graphically, no statistically significant link was identified between the EU structural fund amounts per hectare of used arable land and the MTFPI. Figure 4 illustrates the situation for all five regions of Latvia.

Figure 4Link between EU structural funds' amount and MTFPI for the regions of Latvia for the period 2009 - 2013. Source: Authors' calculations and RSS



The red area indicates the received EU structural funds per hectare of arable land (left hand scale) in the regions of Latvia, while the blue line shows the respective region's MTFPI (right hand scale). Although there is some vague interrelationship observed between the EU structural funds per hectare and the development of the MTFPI, it is in our interest to go into more detail to drawn any kind of conclusions and examine each region subdivided in a similar manner by its corresponding counties. For example, the situation of the region of Zemgale has been illustrated in more detail in figure 5below.

Figure 5Link between EU structural funds' amount per hectare of arable land and MTFPI in Zemgale for the period 2009 - 2013. Source: Authors' calculations, RSS and STSA



In the perfect case scenario the MTFPI line should ascend as the amount of structural funds per hectare in the respective county increases. However, as it can be seen from the graph such cases are very rare and disproportional to the received amounts, indicating very little to no impact from the structural funds on the county's total productivity. The situation for other regions can be examined in Appendix C.

To thoroughly inspect the impact of the EU structural funds every region's counties were divided in two groups, counties experiencing progress in their productivity (MTFPI above or equal to one) and countries experiencing regress (MTFPI below one), and the Welch's t-test was applied to find some linkage between both groups. In the case of EU structural funds per hectare of arable land grouped by the MTFPI there was no statistically significant difference in the means of both groups indicating very little to no effect from the structural funds on the different regions' productivity.

Throughout the whole sample in no region was it identified that the EU structural funds had any statistically significant impact on the development of the MTFPI. The summary of our findings in this group can be found in table 9.

Table 9Differences between regions with positive (Group B) and negative (Group A) geometric average MTFPI development from the EU SF per hectare perspective for the period 2007 - 2013

Region	Unit	Group A mean	Group B mean	Combined	H_0 (μ1 – μ2)	T-statistic	P-value	Sig.
Kurzeme	EUSF[1] /CL[2]	65	67.89	65.34	μ2 – μ1>0	-0.1505	0.5569	
Zemgale		73.74	63.78	67.97	μ1 – μ2>0	0.3715	0.6285	
Pierīga		77.3	78.85	77.8	μ2 – μ1>0	-0.0447	0.5176	
Vidzeme		70.68	74.61	71.31	μ2 – μ1>0	-0.2396	0.5935	
Latgale		54.5	48.61	53.19	μ1 – μ2>0	0.3288	0.6272	

[1] EUSF (European Union Structural Funds) – the amount of received funding for the period 2007 – 2013 expressed in Euros, [2]CL – Cultivated Land in the region expressed in hectares. Description of statistical significance: * (α = 0.1), ** (α= 0.05), *** (α= 0.01)

5.8. The EAFRD funding optimal allocation

As it was previously mentioned in the study by Becker (2012), transfers of more funding does not necessarily translate into greater Malmquist index values, thus, confirming the existence of inefficient allocation possibilities of the EAFRD funding. In order to find the best proportions on how to divide the EAFRD Funding, the funds were grouped (see table 2, section 4) and each group's proportion from the total allocated funding was plotted against the acquired counties' TFPI indices; second order polynomial trend-lines were constructed and local maximums were calculated. The results have been summarized in table 10.

Table 10Summary of EAFRD fund distribution as per type and investment proportion

Type of EAFRD Funds	**Concave/Convex function**	**Local maximum**	**Optimal funding division, % of total**
Farm rejuvenation and support	Concave	25,48%	25,48%
Stimulation of labour	Concave	49,40%	49,40%
Stimulation of tractors	Concave	22,89%	22,89%
Stimulation of land	Convex	None	100 – (25,48 + 49,40 + 22,89) = 2,23%

Having acquired the optimal division proportions it is possible to compare it with the past allocation of funding throughout period of 2007-2013 on the level of regions and on a country level country. It should be noted that the optimal division of the funding stays constant irrespectively of the scale at hand, namely, the same division is applicable to the county level.

Table 11 EAFRD funding proportional allocation for the period of 2007 - 2013 and the optimal suggested allocation. Values above/close to/below the optimal proportion are coloured in red/yellow and green respectively.

Type of EAFRD Funds	Allocation in the period of 2007-2013						Optimal division
	Latvia	Kurzeme	Zemgale	Pierīga	Vidzeme	Latgale	
Farm rejuvenation and support	37,33%↓	34,82%↓	32,09%↓	32,49%↓	44,51%↓	41,89%↓	**25,48%**
Stimulation of labour	34,17%↑	27,88%↑	33,38%↑	37,52%↑	34,62%↑	38,21%↑	**49,40%**
Stimulation of tractors	25,19%↓	32,61%↓	30,62%↓	27,1%↓	17,35%↑	18,50%↑	**22,89%**
Stimulation of land	3,30%↓	4,69%↓	3,91%↓	2,88%↔	3,52%↓	1,41%↑	**2,23%**

As it can be seen from the retrieved results, during the period of 2007-2013 too large proportion of Funding has been attributed to farm rejuvenation and support. On top of that, in Kurzeme, Zemgale and Pierīga past investments in development of machinery and tractors significantly exceed calculated optimal values. The authors' calculation of optimal Funding division suggests that money from previously mentioned groups should be transferred to development of labour. This complements already mentioned argument that scarcity of labour input has become an obstacle for technological progress (TECH) and, thus, prohibits farmers to choose the most effective input combinations.

5.8.1. Support for the results section

Although the results may seem surprising it is complicated to identify the main reasons why the EU structural funds have failed to achieve their intention. Numerous works have been made to analyse the EU structural funds' efficiency and opinions are not unanimous. For instance, Becker (2012) indicates that large amounts of allocated EU structural funds do not signify more growth and that the fund efficiency develops similarly to government revenue on the Laffer curve, where there is one point beyond which the transferred funds' efficiency drops and more funds do not lead to higher growth. It was also argued that the fund transfer system could be improved in several ways i) defining poor performing regions and investing more in human capital and the improvements of the local government ii) limiting transfers under the EU Regional Policy to approximately 1.3 percent of the beneficiary region's GDP. Similarly Becker, Egger and Ehrlich (2013) find that the fund absorption capacity of different income regions is uneven and suggests reallocating funding to human capital to increase this capacity prior any distribution. Ederveen, Groot and Nahuis (2006) argue that while the EU structural funds commonly are not effective, their effectiveness is proven in countries with the appropriate institutions. In their study openness to foreign competition and forthright institutional quality attributes (e.g. low corruption level and high quality indices of institutions) yielded positive statistically significant final results indicating that these characteristics are to be sought when distributing funds. Nonetheless, in a more recent study Cardenete and Delgado (2013) analysed the EU structural fund impact in Andalusia, Spain for the period of 2007 – 2013 and concluded that without the contribution of the funding the region would experience a sharp decrease of 15.5% of GDP, 16% of disposable income and 1.3% of total output in the period. While other works indicate that the structural funds' effectivity depends on other varying factors and the recipients' geographical location (Esposti & Bussoletti, 2008; Gripaos *et al*, 2008).

6. Conclusions

The main findings indicate that there is a complex synergy of numerous factors that contribute to the success of the SF absorption. From other works in the field it was concluded that it is essential to develop the recipient region's absorption capacity, which aligns with this work's findings of the necessity to invest more in human capital and invest in the local government to make the whole process efficient. Similar conclusions were drawn from consulting Irina Pilvere, an industry expert, where the concern was about the poor absorption capacity of different counties in Latvia and the rapidly decreasing working population, which is expected to drop even further by at least 50 percent.

While a direct answer to the research question can be a bit complicated and hard to explain, since within each region each of the 110 counties had differing results, for such purpose were the sub-questions developed. Appendices A and B for the index values both on a regional and county level and Appendices I and J for a graphical representation of the results. While there have been improvements in some county efficiency and productivity levels there was no statistically significant link found that these improvements were attributable to the success of the EU SF.

The first sub-question can be answered from two perspectives: whether there has been reduction of disparities on a county level and whether the EU SF have had a significant effect on this outcome. In the first part of this sub-question, the results show that, in terms of efficiency development, in Pierīga, Vidzeme and Latgale there has been a reduction of disparities as the counties that have farms with lower sizes and that are utilizing smaller amounts of inputs are the ones with positive total efficiency development (EFFCH above 1). Unfortunately, the cumulative differences show that these results are not initiated by more efficient division of total available resources, as proportionally the most inefficient counties are the ones with the highest increase of generated output or used inputs. For Kurzeme and Zemgale, there are no statistically significant differences in the total usage of inputs and efficiency improvement for the counties representing each region. In the second part of this sub-question, the results show that the EU SF, specifically, absorbed funding from EAFRD projects, have not had a statistically significant effect on the calculated MPI, thus, suggesting that the funding division in the period of 2007-2013 has been unsatisfactory.

For the second sub-question a better funding reallocation was identified and proposed as the optimal division, which should be taken into consideration when distributing the next

EU funds for the period of 2014 – 2020.By aggregating the information from a sample of 110 counties it became evident that investments in the farm rejuvenation and support process should be reduced and more funding should be allocated to the retention and development of the local labour force. The proposed optimal division of the total amount of received funding is as follows: The farm rejuvenation and support section needs to experience the biggest cuts and constitute only 25.48% of the total EU funding amount, investments in labour force and its retention should be increased by quite a margin and contribute 49.40%, funding intended to stimulate the acquisition of machinery should be reduced in the majority of regions and comprise 22.89%, and lastly, in the majority of regions transfers to support the stimulation of cultivated land should be reduced to 2.23% of the total EU funding amount.

After consulting with the current rector of Latvia University of Agriculture and previous director of the RSS Ms. Pilvere and the representatives from the CSB, including the Agriculture and Environment Statistics Department Deputy Director Anita Raubena, it was also agreed that the prevailing decision making process in the Ministry of Agriculture is quite bizarre in the sense that very little emphasis is made on statistical support. Ms. Raubena even commented that regional authorities usually contact CSB in need of data on a county level rather than actually supplying it. While this was not the subject of this study, it was deemed noteworthy to mention this aspect as a potential factor, which could prevent effective fund distribution and decision making as a whole.

7. Drawbacks and Limitations

The concept of the Malmquist Productivity Indexes is built on a complicated methodology and contains strict conditions, thus, the model has a few limitations, which might affect the precision of the calculated results. The first set of limitations can be attributed to variables. According to the applied methodology, a comparison of different input bundles and their efficiencies is built on an assumption that all inputs and their absolute values have the same weight. In reality, this assumption is inaccurate – the idea behind the concept of modernization is to switch from labour-intensive activities to activities involving more capital, which results in rapid decrease of one input (labour) and steady increase of another (machinery). In the future studies it would be advisable to analyse accurate proportions of input weights before calculating the Malmquist Indexes.

When evaluating the process of data acquisition, the main drawback seems to be the lock of data for all of the required variables. The calculated approximations for output and labour have made the results more unreliable and imprecise, as MPIs are based on period-on-period differences, which are extra-sensitive for any inaccuracies in the measurements. On top of that, the inexistence of data about fertilizer usage in the agricultural sector led to additional assumption of constant land productivity when approximating the output values, further affecting the precision of the calculated indexes.

The final drawback of the applied Malmquist model is related to impossibility to create a robustness check(s). Although there are different alternative models, which also measure productivity and efficiency of a particular company or industry (see section 2), each of them has its own assumptions and involves different variables and mathematical formulations. Because of that, there is no use of applying another model, retrieving different results and then explaining why this comparison can be questioned and is not completely valid.

Although Malmquist productivity indexes were retrieved in order to analyse the effect of EAFRD Funding, obviously, there are other investment types, which affect the acquired indexes as well. As it was mentioned in the introduction, the agricultural sector directly from the EU receives two types of investments – EAFRD Funding for structural projects and fixed area payments. The second type of investment has not been identified in this Thesis; although these payments are proportionally the same for all counties and regions, the absorption efficiency and capacity differs, thus, influencing the results. Besides other EU funds, there are foreign direct investments (FDI) and loans of local banks that are allocated for development of agricultural sector (see appendix G). Although these sums exceed one billion Euros, their average annual changes in the period of 2007-2013 do not exceed 10%-13%. As MPIs are based on annual changes, in order to have a significant effect on retrieved results these sums should be much more volatile, thus, swinging the effects on index developments.

There is also the problem of spill-over effects. Although some investments are allocated to a specific county or region, they still have some effect on the neighbouring areas as well. According to Irina Pilvere, the strongest spill-over effects can be attributed to those funds that are meant to preserve the local population and improve the living environment quality in rural areas. Although one can argue that the TECH index partly covers the effects that each chosen county has on other neighbouring counties, these results are still imprecise. The TECH index shows the development of productivity for the best performing counties and how it affects other counties, while spill-over effects are based on a county's position and these effects are related to a limited number of counties, not the whole sample.

Besides all of the previously mentioned factors, there are numerous other that might as well affect the precision of the retrieved results. The efficiency of investment's absorption is not only dependent on county's capacity, but also on the existing infrastructure level; the existence of developed road networks as well as closely located distributors of produced goods significantly eases agricultural activities. On top of that, agriculture can be stimulated by political decisions implemented by the administrations of the analysed counties, which could be potentially examined in further studies.

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Appendix

Appendix 1. Malmquist indices on a regional level

Average before EU SF, 2002 - 2007					
DMU	tfpch	effch	techch	pech	sech
Kurzeme	0.80	1.00	0.84	1.00	1.00
Latgale	0.90	1.04	0.89	1.01	1.03
Vidzeme	0.75	0.91	0.85	0.79	1.18
Riga	0.89	1.06	0.87	1.00	1.06
Zemgale	0.86	1.00	0.86	1.00	1.00

Avarage after EU SF, 2007 - 2013					
DMU	tfpch	effch	techch	pech	sech
Kurzeme	0.91	1.03	0.89	1.00	1.03
Latgale	0.99	0.99	1.00	0.98	1.01
Vidzeme	0.89	1.09	0.82	1.27	0.87
Riga	0.90	0.99	0.92	1.00	0.99
Zemgale	0.89	1.00	0.89	1.00	1.00

Appendix 2. Malmquist indices on a county level

Kurzeme		Average MPI in the period of 2007-2013				
DMU		tfpch	effch	techch	pech	sech
Ventspils	novads	0.99	1.02	0.98	1.02	1.00
Kuldīgas	novads	0.96	0.99	0.97	0.99	1.00
Alsungas	novads	1.01	1.04	0.97	1.00	1.04
Skrundas	novads	0.92	0.95	0.97	0.96	1.00
Pāvilostas	novads	0.94	0.96	0.98	0.99	0.97
Nīcas	novads	0.96	0.99	0.97	1.00	0.99
Rucavas	novads	1.01	1.03	0.97	1.06	0.98
Priekules	novads	0.96	0.97	0.99	0.98	0.99
Grobiņas	novads	0.94	0.97	0.97	0.98	0.99
Durbes	novads	0.93	0.94	0.99	0.96	0.98
Aizputes	novads	0.99	1.02	0.97	1.03	0.99
Vainodes	novads	0.94	0.98	0.96	1.02	0.98
Saldus	novads	0.97	1.00	0.97	1.00	1.00
Brocēnu	novads	0.94	0.99	0.95	1.00	0.99
Dundagas	novads	0.96	0.99	0.97	1.04	0.96
Rojas	novads	0.92	0.95	0.97	1.00	0.95
Talsu	novads	0.93	0.96	0.97	0.96	1.00

Zemgale		Average MPI in the period of 2007-2013				
DMU		tfpch	effch	techch	pech	sech
Dobeles	novads	0.92	0.98	0.94	1.00	0.98
Auces	novads	0.93	1.00	0.93	1.00	1.00
Tērvetes	novads	0.95	1.00	0.95	1.00	1.00
Jelgavas	novads	0.98	1.00	0.98	1.00	1.00
Ozolnieku	novads	0.95	0.97	0.98	0.96	1.00
Bauskas	novads	0.99	1.00	0.99	1.00	1.00
Vecumnieku	novads	0.97	1.02	0.95	1.03	0.99
Iecavas	novads	0.95	0.97	0.98	0.97	1.00
Rundāles	novads	0.97	1.00	0.97	1.00	1.00
Krustpils	novads	0.93	0.95	0.98	0.95	1.00
Jēkabpils	novads	0.91	0.96	0.95	0.98	0.98
Aknīstes	novads	0.84	0.90	0.94	0.89	1.01
Viesītes	novads	0.93	0.99	0.93	0.98	1.01
Salas	novads	0.96	0.97	0.98	0.97	1.00
Neretas	novads	0.89	0.95	0.94	0.95	1.00
Jaunjelgavas	novads	0.94	0.96	0.98	0.96	1.00
Kokneses	novads	0.97	1.00	0.98	1.00	1.00
Pļaviņu	novads	0.86	0.89	0.97	0.88	1.01
Aizkraukles	novads	1.03	1.05	0.99	1.00	1.05

Pierīga		Average MPI in the period of 2007-2013				
DMU		tfpch	effch	techch	pech	sech
Tukuma	novads	0.97	1.00	0.97	1.00	1.00
Kandavas	novads	0.96	0.99	0.97	1.00	0.99
Jaunpils	novads	0.98	1.00	0.98	1.00	1.00
Engures	novads	0.92	0.95	0.96	0.95	1.00
Salacgrīvas	novads	0.97	1.01	0.96	1.02	1.00
Alojas	novads	0.96	1.00	0.96	1.00	1.00
Limbažu	novads	0.96	1.00	0.96	1.01	1.00
Krimuldas	novads	0.99	1.03	0.96	1.03	1.00
Ogres	novads	1.06	1.09	0.96	1.11	1.00
Skrīveru	novads	1.03	1.07	0.97	1.00	1.07
Lielvārdes	novads	0.88	0.90	0.97	0.90	1.00
Ķeguma	novads	1.05	1.10	0.96	1.10	1.00
Ikšķiles	novads	1.00	1.04	0.96	1.08	0.97
Babītes	novads	0.80	0.83	0.97	0.76	1.08
Mārupes	novads	1.07	1.11	0.96	1.18	0.94
Olaines	novads	0.92	0.95	0.97	0.94	1.01
Ķekavas	novads	1.04	1.08	0.96	1.08	1.00
Baldones	novads	0.80	0.83	0.96	0.83	1.00
Salaspils	novads	1.06	1.10	0.96	0.98	1.16
Ropažu	novads	0.98	1.02	0.96	1.02	1.00

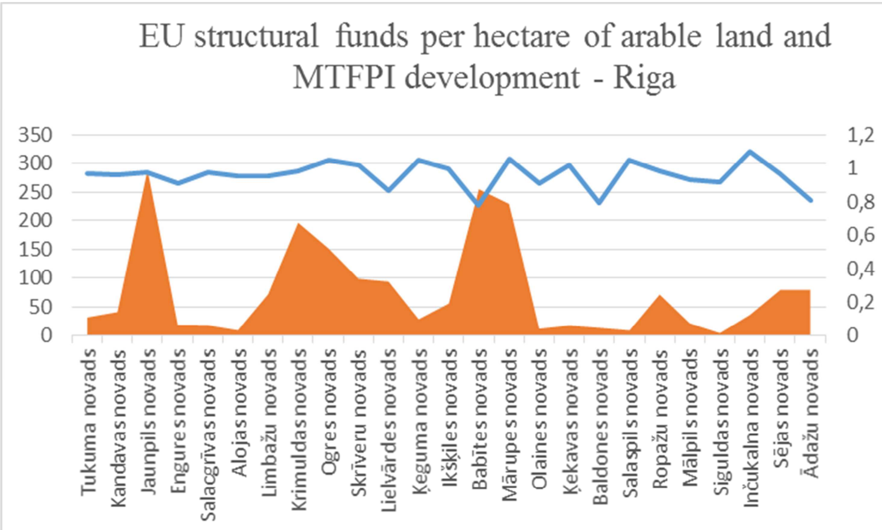
Mālpils	novads	0.95	0.99	0.96	0.99	1.00
Siguldas	novads	0.92	0.96	0.96	0.96	1.00
Inčukalna	novads	1.12	1.16	0.96	1.00	1.16
Sējas	novads	0.98	1.01	0.96	1.01	1.00
Ādažu	novads	0.82	0.85	0.96	0.77	1.12

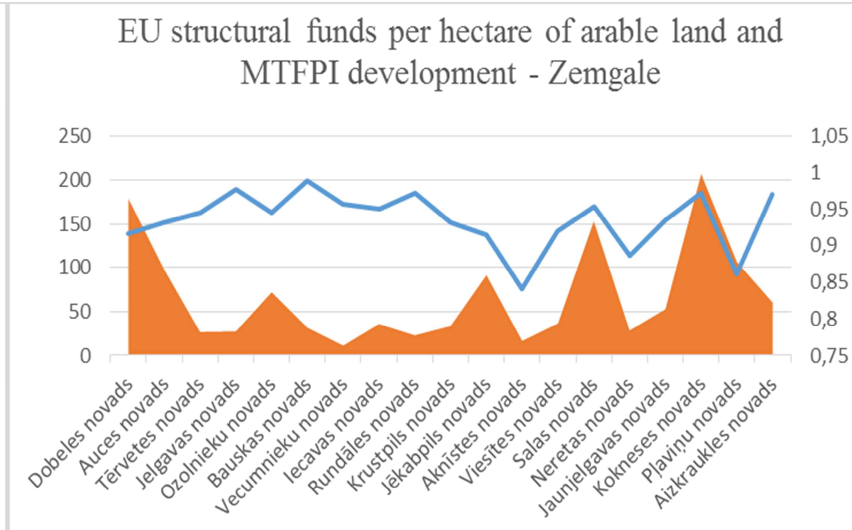
Vidzeme		Average MPI in the period of 2007-2013				
DMU		tfpch	effch	techch	pech	sech
Valkas	novads	0.97	1.04	0.94	1.02	1.02
Strenču	novads	0.90	0.96	0.94	1.00	0.96
Smiltenes	novads	1.01	1.02	1.00	1.02	1.00
Mazsalacas	novads	0.97	1.04	0.94	1.04	0.99
Rūjienas	novads	0.95	1.00	0.96	1.00	1.00
Naukšēnu	novads	0.89	0.96	0.94	0.96	0.99
Burtnieku	novads	0.95	1.03	0.94	1.00	1.03
Kocēnu	novads	0.99	1.06	0.94	1.05	1.01
Beverīnas	novads	0.97	1.00	0.97	1.00	1.00
Cēsu	novads	1.02	1.06	0.98	1.00	1.06
Vecpiebalgas	novads	1.01	1.03	0.98	1.03	1.00
Jaunpiebalgas	novads	1.07	1.14	0.95	1.15	0.99
Raunas	novads	0.96	0.97	1.00	0.98	1.00
Pārgaujas	novads	1.11	1.14	0.98	1.14	1.00
Priekuļu	novads	1.05	1.07	1.00	1.08	0.99
Līgatnes	novads	0.94	1.00	0.94	1.00	1.00
Amatas	novads	1.09	1.19	0.94	1.16	1.01
Alūksnes	novads	0.91	0.96	0.95	0.97	1.00
Apes	novads	0.86	0.92	0.94	0.93	0.99
Madonas	novads	1.00	1.01	1.00	1.00	1.01
Cesvaines	novads	0.97	0.97	1.00	1.00	0.97
Lubānas	novads	0.91	0.98	0.94	0.94	1.10
Ērgļu	novads	1.02	1.08	0.94	1.09	1.00
Gulbenes	novads	0.98	1.01	0.98	1.00	1.01

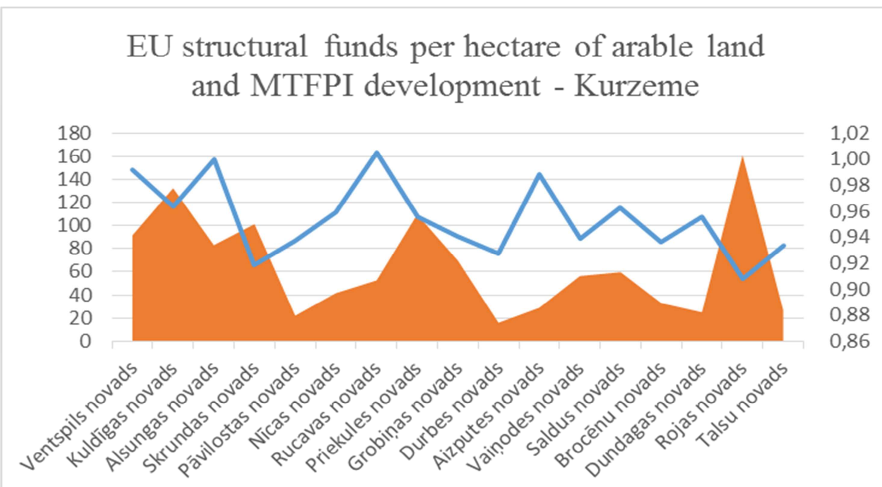
Latgale		Average MPI in the period of 2007-2013				
DMU		tfpch	effch	techch	pech	sech
Riebiņu	novads	0.98	1.06	0.92	1.04	1.02
Preiļu	novads	0.95	1.03	0.92	1.01	1.02
Vārkavas	novads	1.03	1.11	0.92	1.09	1.02
Līvānu	novads	1.03	1.12	0.92	1.09	1.02
Rēzeknes	novads	0.96	1.04	0.92	1.00	1.04
Vīļānu	novads	0.95	1.03	0.92	1.02	1.01
Kārsavas	novads	0.91	0.98	0.93	0.98	1.01
Ciblas	novads	1.01	1.10	0.92	1.09	1.00
Ludzas	novads	0.93	1.01	0.92	1.01	1.01
Zilupes	novads	0.95	1.03	0.93	1.04	0.98

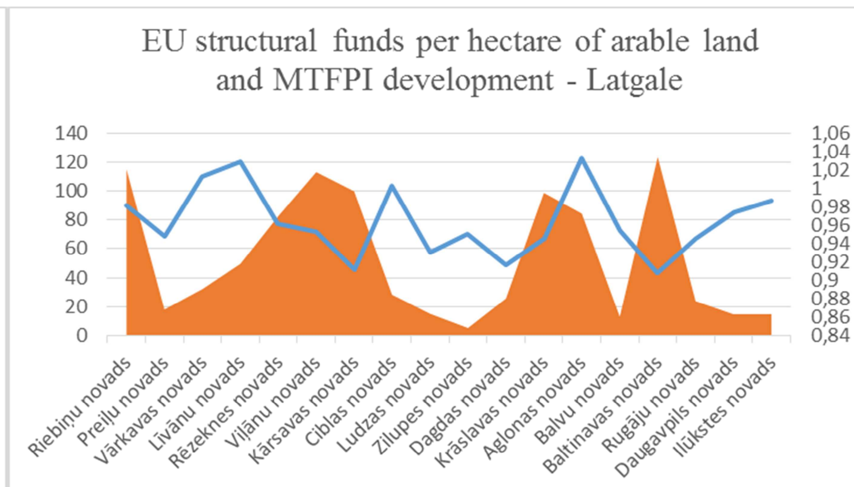
Dagdas	novads	0.92	1.00	0.92	0.97	1.03
Krāslavas	novads	0.95	1.02	0.92	1.00	1.02
Aglonas	novads	1.04	1.12	0.92	1.11	1.01
Balvu	novads	0.95	1.03	0.92	1.01	1.03
Baltinavas	novads	0.91	1.00	0.91	1.00	1.00
Rugāju	novads	0.96	1.04	0.92	1.04	1.01
Daugavpils	novads	0.97	1.05	0.92	1.00	1.05
Ilūkstes	novads	0.99	1.07	0.92	1.03	1.03

Appendix 3. EU SF per hectare of arable land against MTFPI development

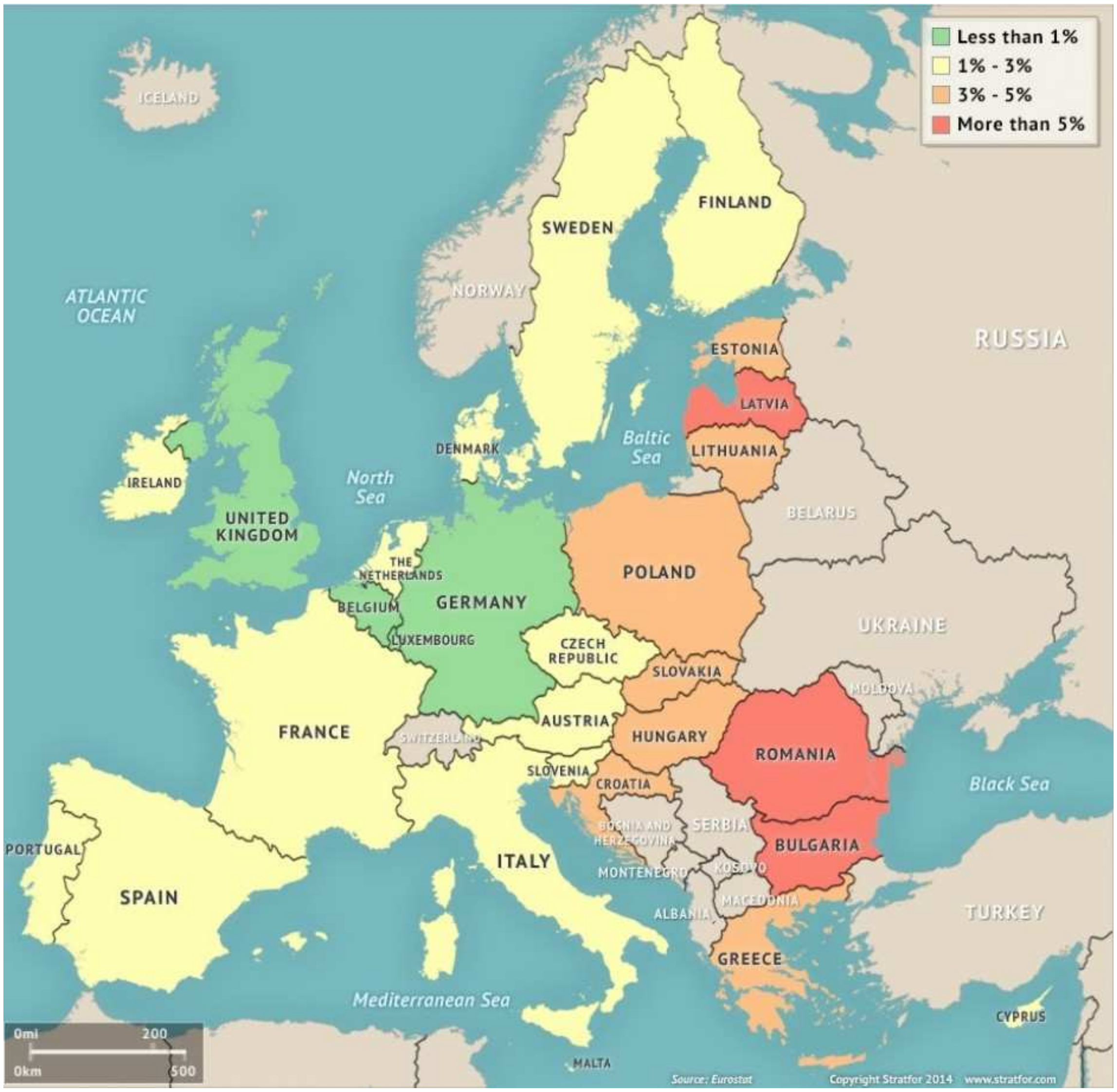






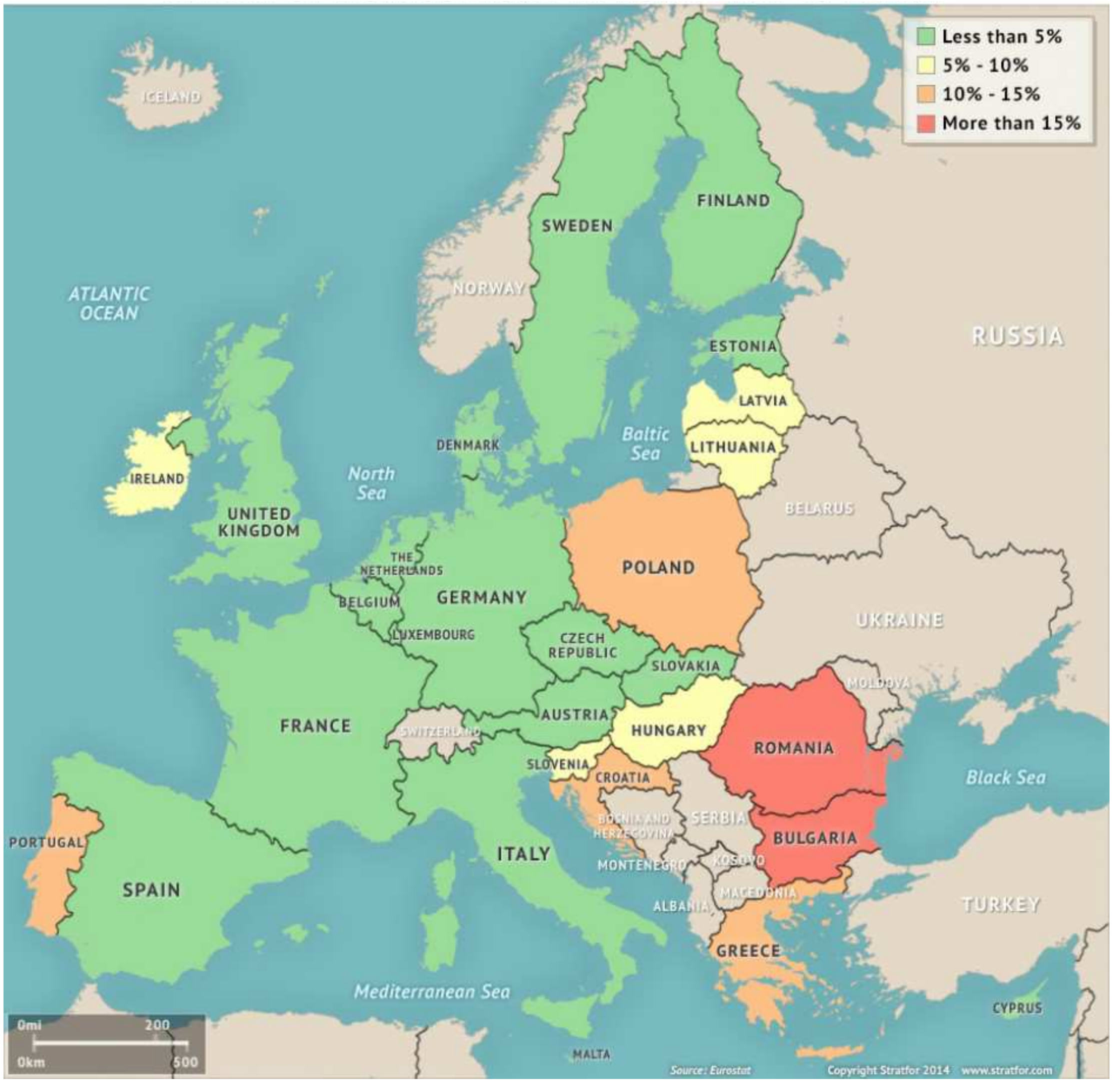


Appendix 4. Share of agriculture in GDP



Source: https://www.stratfor.com/analysis/understanding-eu-common-agricultural-policy

Appendix 5. Share of agriculture in total employment



Source: https://www.stratfor.com/analysis/understanding-eu-common-agricultural-policy

Appendix 6. EAFRD fund list and description

EAFRD Funds:	Purpose of these funds:
L112 – Support for new farmers	Promote the involvement in agriculture in the younger generation by establishing new or taking over existing farms or commercials with the purpose of producing agricultural products;
L121 – Modernization of agricultural holdings	Modernize companies working in the agricultural sectors to improve their economic performance and competitiveness. Eligible activities encompass construction of new manure storage facilities, reconstruction of existing manure storage facilities, purchase of required building materials and purchase of stationary equipment.
L123 - Improvement of agricultural product value added	Boost the processing effectivity of agricultural products, promote the creation of agricultural products with high added value, increase the number of bio farms, integrated farms and processing of those products that are specific for Latvian agro-climatic conditions.
L125 - Infrastructure for agriculture and forestry development and adaption	Improve the infrastructure, which would affect agriculture development, increase forest productivity, improve stand health and the quality of timber, improve agriculture and forestry development. Aid is granted to the reconstruction and renovation of amelioration systems.
L141 - Support for semi-subsistence farm restructuring	Encourage semi-subsistence farm restructuring, promoting development of commercial activities and competitiveness
L312 - Support for business creation and development (including diversification of activities that are not directly attributed to agriculture)	Encourage the development of businesses that are not directly linked to agriculture, thus developing alternative sources and increasing the income levels in rural areas.
L321 - Basic services for the economy and population	Support investments in quality improvement of public infrastructure in rural areas, thus promoting preservation of the local population.
L411 - Fostering the competitiveness of the local development strategy implementation territories	Acquisition and installation of equipment, machinery, information technologies and software; software creation for production and pre-treatment of agricultural production and packaging; various fruit-growing plant acquisition; purchasing and installation of fences.
L413 - Economy diversification and improvement of life quality in rural areas	
L431 - Provision of work and skill development for the Local population in rural areas	Promote effective implementation of the local development strategy by providing work and developing skills of the Local population in rural areas.

Appendix 7. Loans and FDI to entities operating in the agriculture, forestry and fishing sector and their annual changes.

Figure 6 Loans to entities operating in the agriculture, forestry and fishing sector. Source: www.fktk.lv

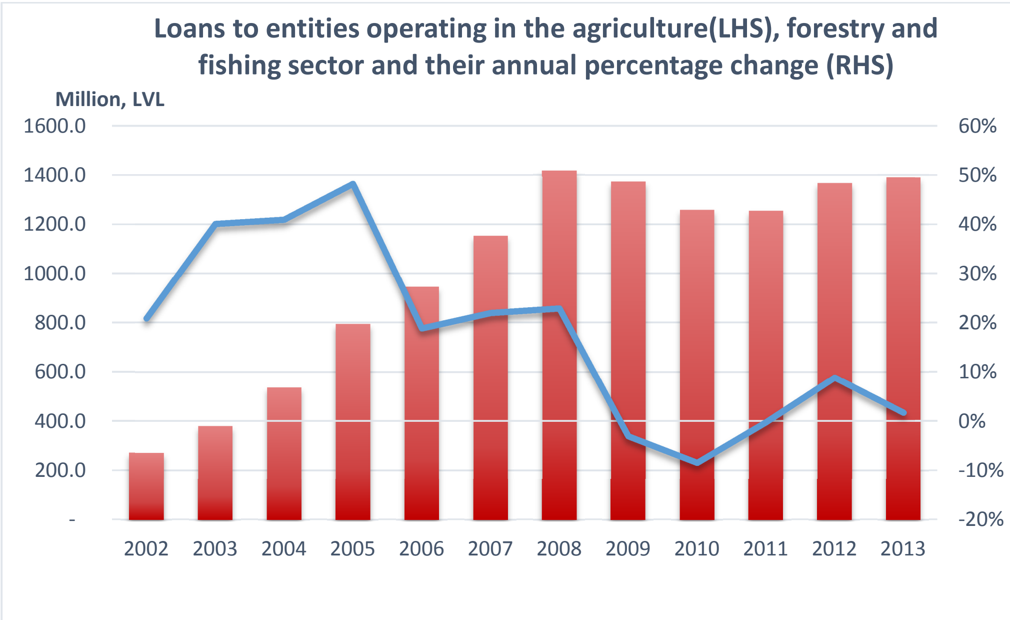
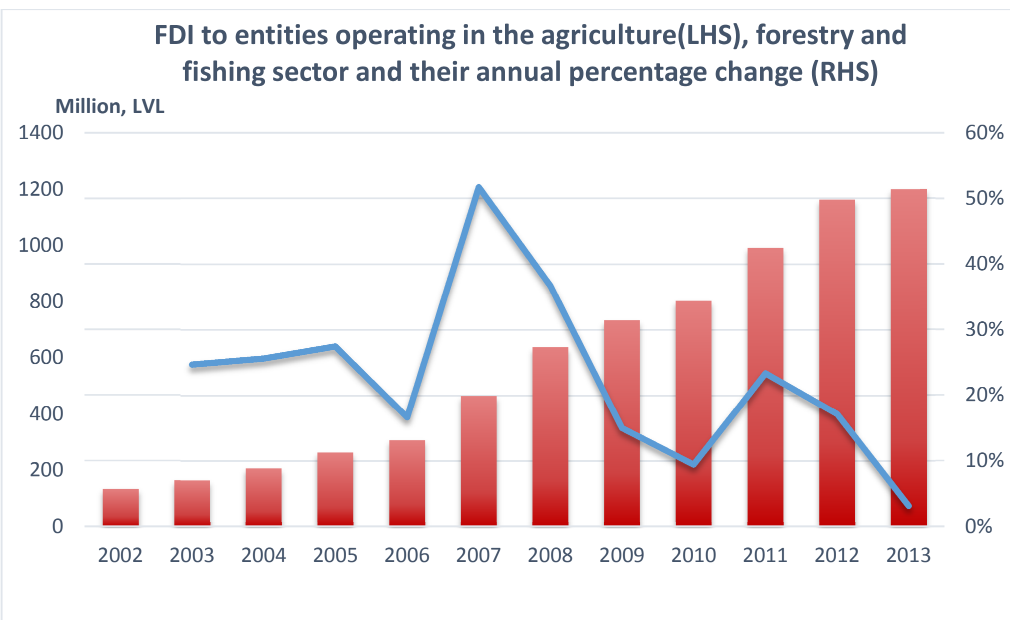
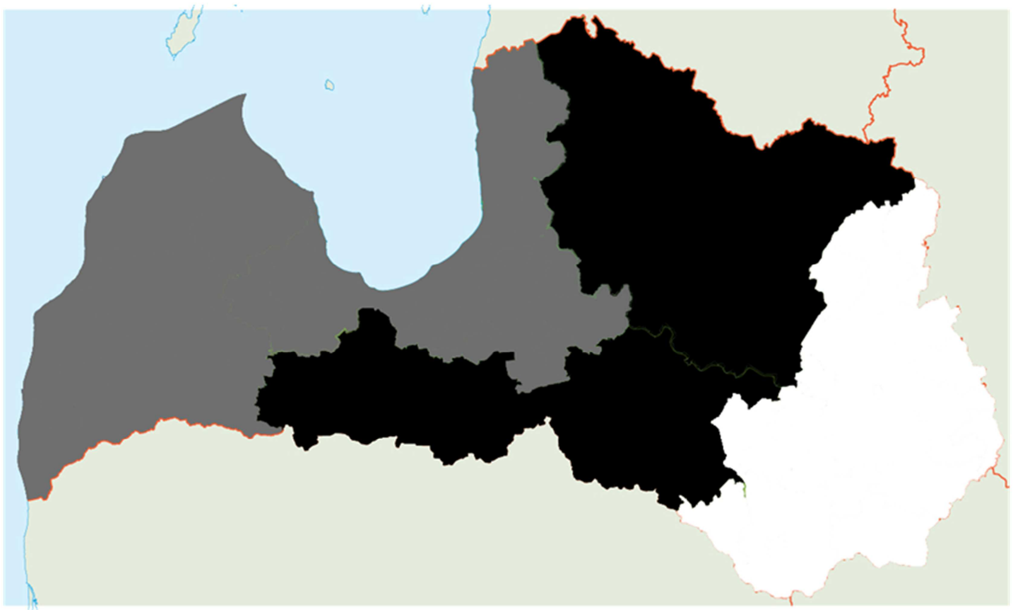


Figure 7 Foreign Direct Investment to entities operating in the agriculture, forestry and fishing sector. Source: www.statdb.bank.lv



Appendix 8. MTFPI graphical illustration on a regional level, 2007 -

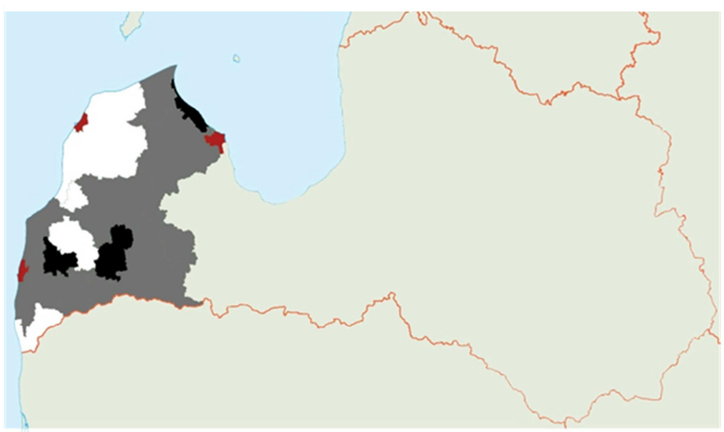
Figure 8 MTFPI graphical illustration on a regional level for the period 2007 - 2013



TFPICH 0.95 – 0.99
TFPICH 0.90 – 0.94
TFPICH 0.85 – 0.89

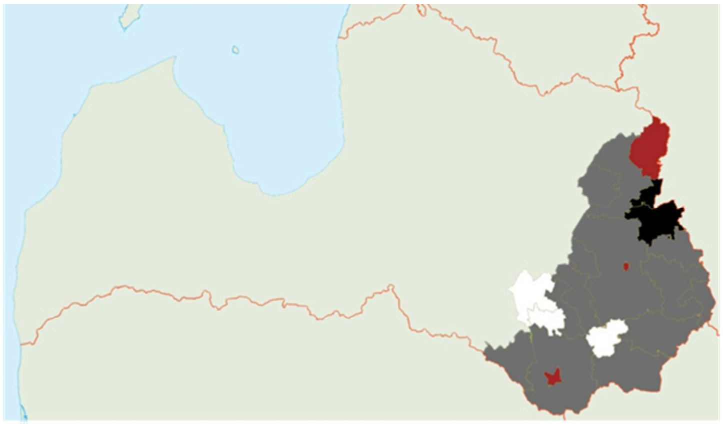
Appendix 9. Effch graphical illustrations of each region's counties, 2007 - 2013

Figure 9 EFFCH graphical illustration of Kurzeme's counties for the period 2007 -2013



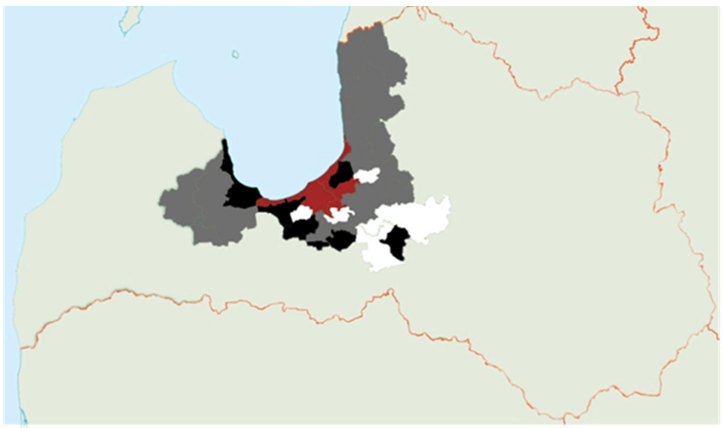
EFFCH 1.00 – 1.05
EFFCH 0.96 – 1.00
EFFCH 0.90 – 0.95
Omitted regions

Figure 11EFFCH graphical illustration of Latgale's counties for the period 2007 -2013



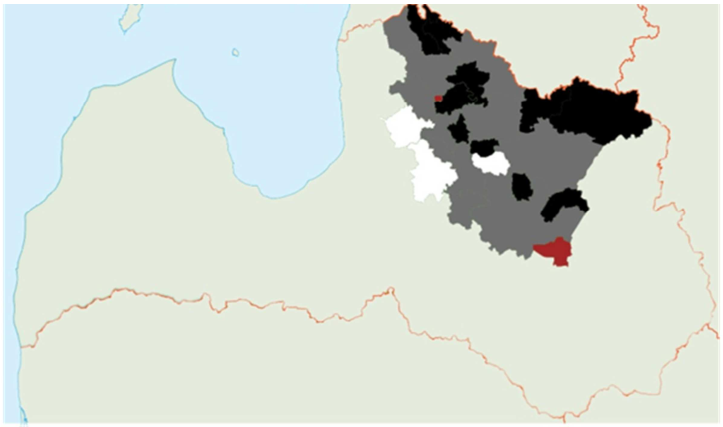
EFFCH 1.11 – 1.20
EFFCH 1.01 – 1.10
EFFCH 0.91 – 1.00
Omitted regions

Figure 10EFFCH graphical illustration of Riga's counties for the period 2007 -2013



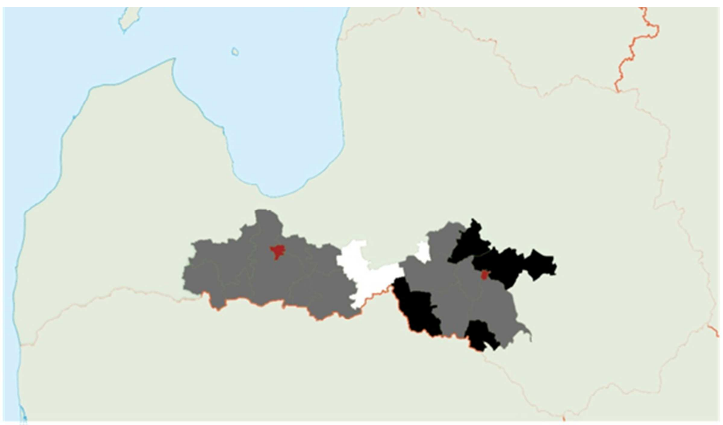
EFFCH 1.06 – 1.20
EFFCH 0.96 – 1.05
EFFCH 0.80 – 0.95
Omitted regions

Figure 13EFFCH graphical illustration of Vidzeme's counties for the period 2007 -2013



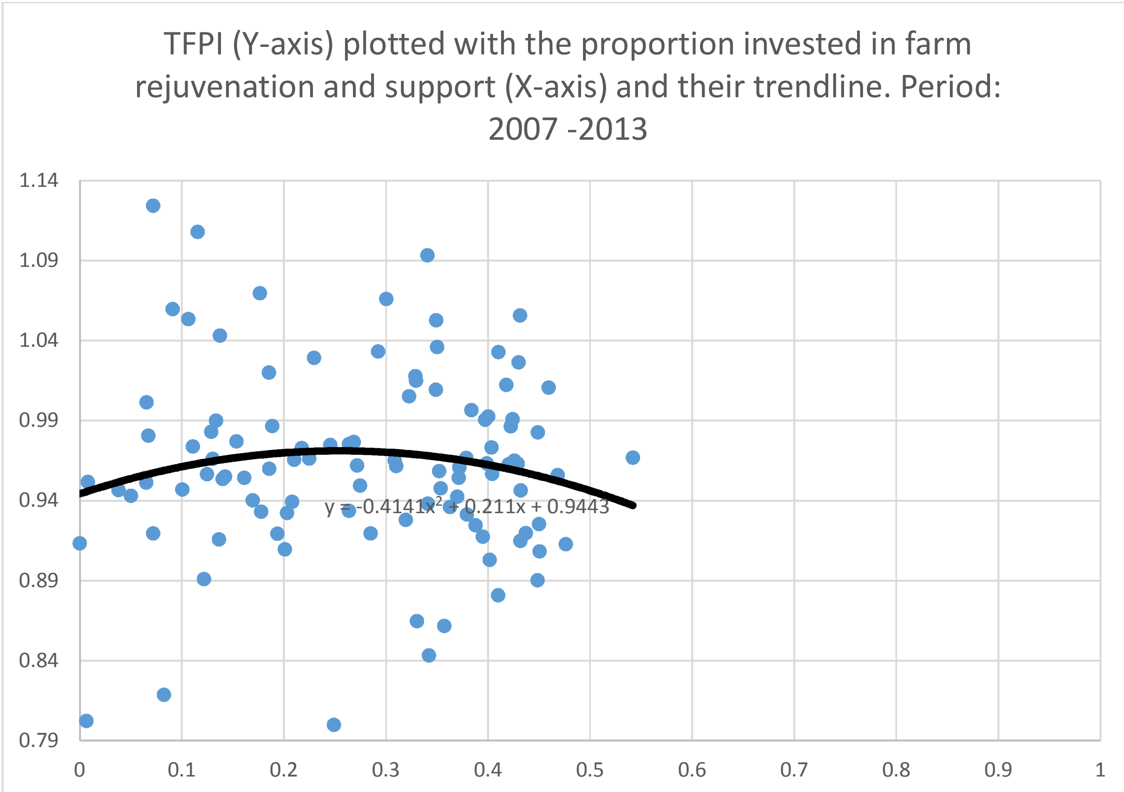
EFFCH 1.11 – 1.20
EFFCH 1.01 – 1.10
EFFCH 0.91 – 1.00
Omitted regions

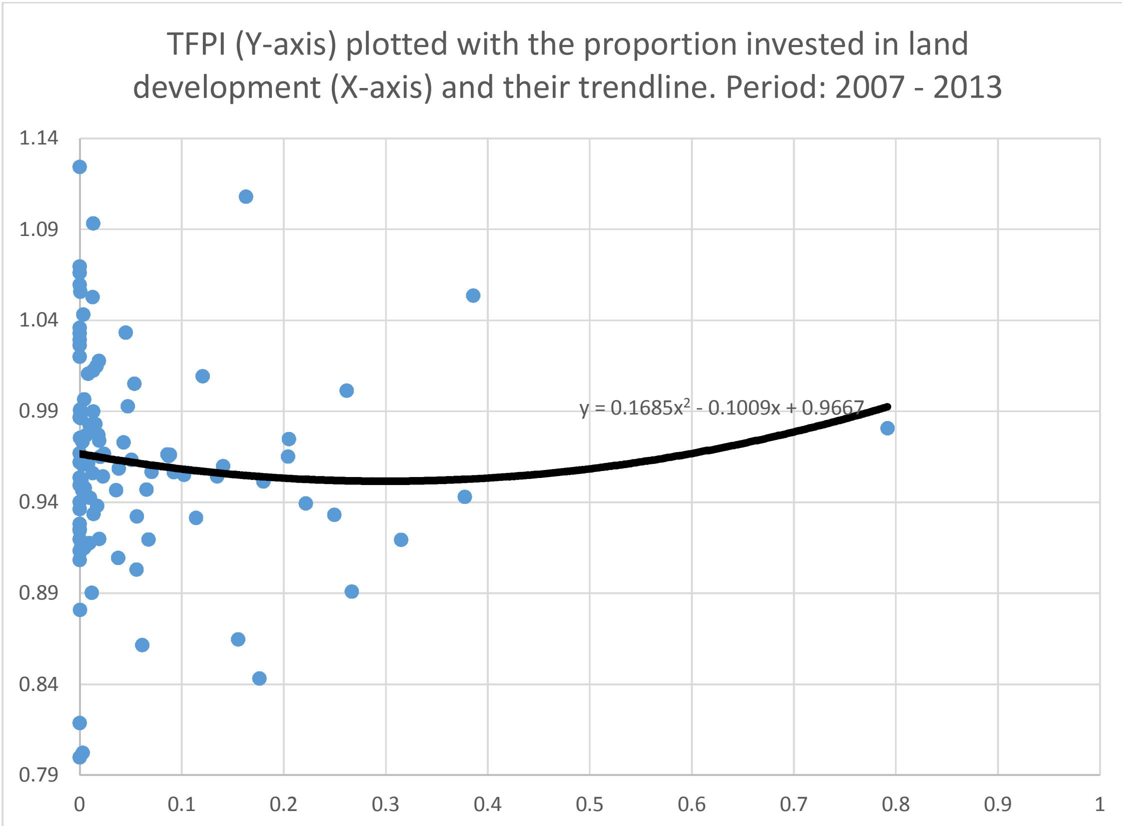
Figure 12EFFCH graphical illustration of Zemgale's counties for the period 2007 -2013

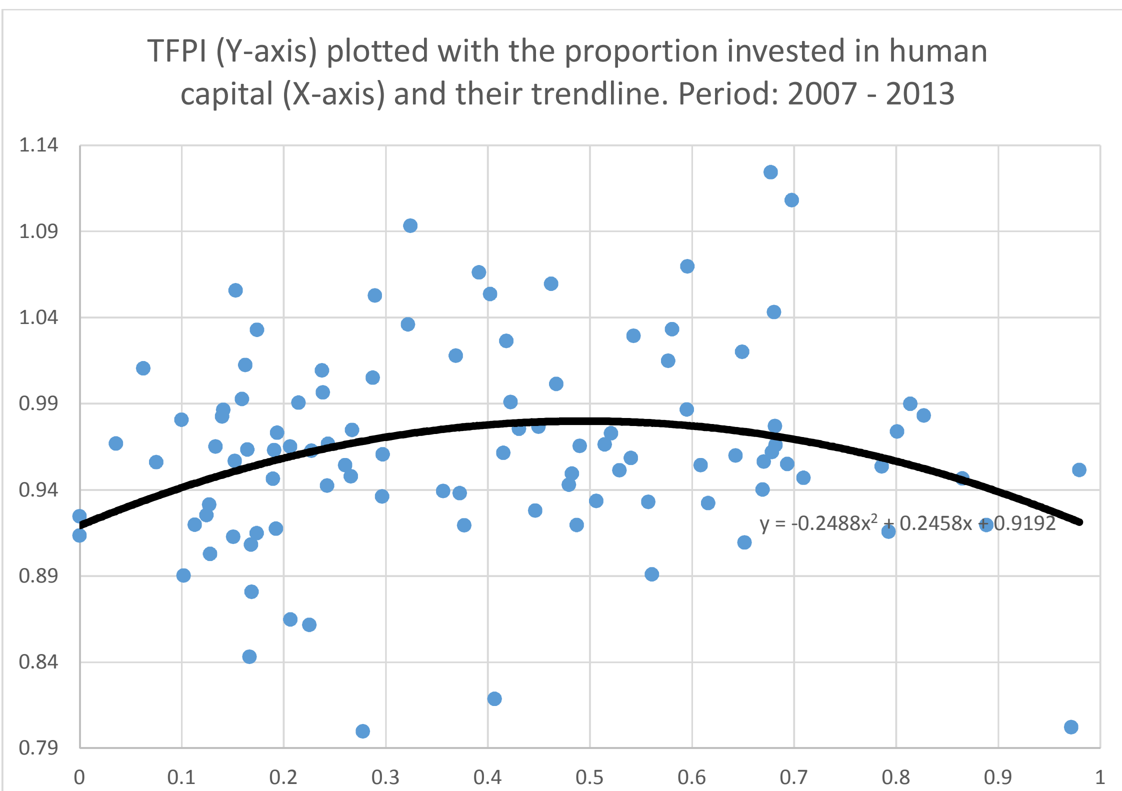


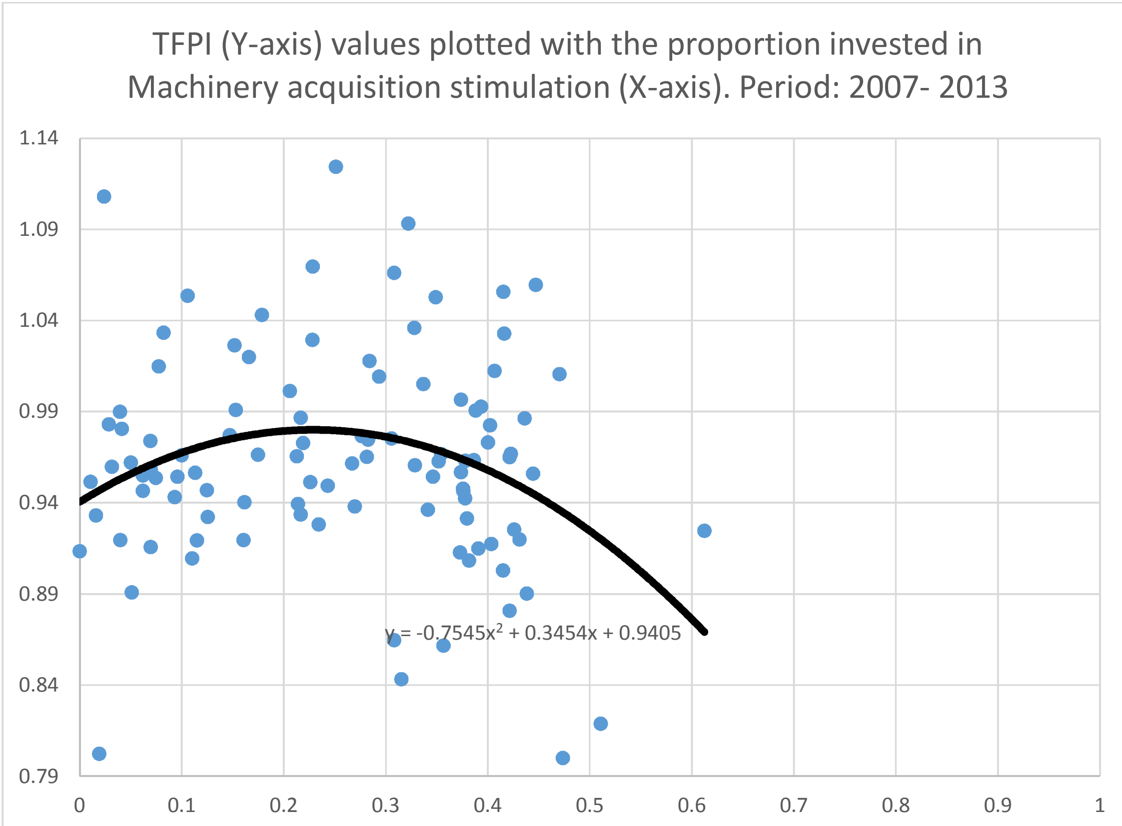
EFFCH 1.00 – 1.05
EFFCH 0.96 – 1.00
EFFCH 0.89 – 0.95
Omitted regions

Appendix 10. TFPI values plotted against different proportions of the EAFRD funding invested in each region's counties in the period of 2007 - 2013




TFPI (Y-axis) plotted with the proportion invested in land development (X-axis) and their trendline. Period: 2007 - 2013
y = 0.1685x² - 0.1009x + 0.9667
1.14
1.09
1.04
0.99
0.94
0.89
0.84
0.79
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


TFPI (Y-axis) plotted with the proportion invested in human capital (X-axis) and their trendline. Period: 2007 - 2013
y = -0.2488x² + 0.2458x + 0.9192
1.14
1.09
1.04
0.99
0.94
0.89
0.84
0.79
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


TFPI (Y-axis) values plotted with the proportion invested in Machinery acquisition stimulation (X-axis). Period: 2007- 2013
1.14
1.09
1.04
0.99
0.94
0.89
0.84
0.79
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
y = -0.7545x² + 0.3454x + 0.9405