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Heterogeneity of Agricultural Land Use Systems and Poverty in Sub-Saharan Africa: Relationship and Evidence from Rural Nigeria

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Abstract

Several factors influencing rural-poverty in sub-Saharan-Africa, for all the factors, agricultural-land access/management and "culture of poverty" are quite dominant in literature. This study examines socio-cultural/economic factors influencing poverty and establishes linkages of heterogeneity of land-use systems. Farm-level cost–route surveys of cross-sectional national-data of 800 respondents were used for analysis. Data were analyzed by descriptive-statistics, trans-logarithmic model, and poverty-measures. Descriptive statistics depict land-ownership structure, farmer's socio-cultural practices, and exploits of government intervention programs influenced agricultural-poverty. Trans-logarithmic coefficients results of short-run sustainability-index (SRSI), land-policy intervention variables and household-sizes are dominance factors. Also, SRSI indicated 0.69, suggesting that 69% of the farmers made unsustainable use of agricultural-land. Moreover, 92% of extremely poor respondents with large household-sizes (61.2%) seek their agricultural-land ownership by rentage, while those with land-titled documents constitute 78.6% of the non-poor. Public-policy interventions must take into account formalization of land-property rights in order to facilitate its transferability and boosting investment.

Keywords

Diverse, agrarian terrestrial custom schemes, deprivation snare, short-run sustainability index, rural Nigeria.

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Introduction

Efforts by African governments and international benefactors in the last decades to eradicate rural poverty have not translated to the desired results (Dillon and Barrett, 2017). Africa has profited from unparalleled growth but a sizeable part of its population (especially those in rural areas) remains trapped in economic poverty (Bandeira and Sumpsi, 2009; McCullough, 2015). These articles identified 55% of sub-Saharan Africa's (SSA) population estimated to be in poverty lived in rural areas and derived livelihood from agriculture. Hence, high numbers of Africans living in poverty were established. This concern calls for attention of governments, international donors, and researchers toward development strategies that are "pro-poor". There are several documented factors influencing rural poverty, such as inadequate access to productive resources, poor infrastructural-developments, and poor/no access to credit, among others (Nkonya et al., 2008). For all factors considered influencing poverty in the literature, agricultural land management and "farmer's sociocultural/economic factors" are quite dominant (Cervantes-Godoy and Dewbre, 2010, Deininger et al., 2017; Kansiine et al., 2018).

Heterogeneity of agricultural land use systems refers to conditions in which land is held, used, and transacted especially for agricultural purposes. Heterogeneity of land use systems and agricultural activities in Africa has gone through a complete cycle (Abdelhak et al., 2012, Chamberlin and Ricker-Gilbert, 2016, Stein and Ghebru, 2016). After being central for decades, land use systems

and policies in Africa have witnessed a pro-market view. In measuring the return to land used for agricultural purposes, it is important to account for the high degree of heterogeneity across rural households. In recent years, programs of access to land have returned high on the agenda of poverty reducing strategies programs of governments, NGOs, and international development agencies with minimum impacts (Sheahan and Barrett, 2014). Poverty-trap has been argued to be "set of factors or events by which poverty, once begun, is expected to continue unless there is outside intervention" (Hardin, 1968; Deininger et al., 2015, Davis et al., 2017). Literature has indicated that access to land can alleviate rural poverty by offering households a fruitful and relatively dependable way to make an income (FAO, 2015; Garner and Campos, 2014).

Though this article is not exclusive, there are various appraisals of factors influencing poverty and inequality that have been published (Gowing and Palmer, 2009; Gerber et al., 2014; Barbier and Hochard, 2016a). There is evidence of more of substantial frontier of knowledge on the causality of land access and inequality in Africa (Harder, 1968; Barbier and Hochard, 2016b). This contribution, however, diverges from these previous studies in that the article uses land use systems as major indicator of poverty and the influence of socio-cultural factors. This paper contends that significant discussions of land use and poverty must be grounded within the context of prevailing farmland fragmentations and socio-cultural factors. However, few studies have provided scant information of this causality (Gollin, 2014; Hollinger and Staatz, 2015).

Several factors influencing rural poverty in sub-Saharan Africa, for all the factors, agricultural-land access/management and "culture of poverty" are quite dominant in the literature. Hence, the main aim of this is to examine socio-cultural/economic factors influencing poverty trap and to establish linkages of heterogeneity of land use systems. It is known that sustainable land use management and resource use efficiency enhances agricultural productivity. Consequently the assumptions of the model guiding sustainable land use management and resource use efficiency were stated to examine factors influencing unsustainable land use management and resource use inefficiency.

Theoretical Considerations of Land Use System in Nigeria and Historical Evidence

Land use for agriculture in developing economies has been a source of developmental concerns (Stein and Ghebru 2016). In most communities in Nigeria, land is regarded as a revered institution bestowed to mankind (the living and coming generations) by God for use. Land use systems have been a bone of contention in many countries because of the inequities in access that defined usage either for productive or nonproductive activities. The theoretical framework in which this study is conceptualized is New Institutional Economics (NIE) and Access Theory (AT). NIE describes access and usage that different people have to land and also challenges associated with the access (Bandeira and Sumpsi, 2009). Past works argued that those with influence and resources have easier access to land, and people with power can influence access to land. But for the poor with little or no power, access to land can be difficult. The NIE approach holds that the performance of an economy depends on institutions (Sjaastad and Bromley, 1999; Bomuhangi et al., 2011; Udoekanem et al., 2014). Hence, this paper explored NIE and its related property rights theory to comprehend the formation of land use functioning among the constituted structure, and obstacles in land-programs operation. AT highlights that access to resources influences bunch of privileges and property. AT deduces the direction between access to land use and poverty (Feder and Feeny, 1991).

Land ownership system in pre-colonial Nigeria was communal. Land is owned by communities and families in trust for all the family members, of which, many are dead, few are living, and countless numbers' yet unborn (Umeh 1973). However, the State still plays a role in providing framework necessary to regulate land tenure arrangements. The Land and Native Rights Act, enacted in 1916, vested the colonial Governor all rights over all native lands in Northern Nigeria. The Native Land Acquisition Act 1917 had since been the advent of the federal system of government in Nigeria. The Native Land Acquisition Act 1917 was replaced by the Native Land Acquisition Law of 1952 in the Western and Mid-Western states and Aliens Law of 1956 in Eastern states (Ijere 1974). The land acts of 1952 and 1956 allowed occupancy of a right to use land to the exclusion of all other persons except the Governor. Land rights are granted for a maximum holding period of 99 years, subject to the payment of ground rent fixed (Mabogunje 2002).

Literature contended that the customary land tenancy in Northern Nigeria experienced early

interferences by the invasions of Fulani jihadists that manipulated customary old fashioned land tenure to their advantage. Moreover, during the reign of the British colonialist Lord Luggard in 1903, the Lands and Native Rights Ordinances was initiated, which was later modified in 1916 (Famoriyo and Adegboye, 1975). The 1916 Ordinance was also revised and substantially modernized in the Land Tenure Law of 1962. The 1962 Land Tenure Law affirmed that all lands in northern Nigeria as "native lands" and thus bestowed its control and management in the Minister (afterward Commissioner). However, in Southern Nigeria land tenure is controlled by customary law (Oshio 1990). Land is alleged as an "ancestral trust" for the advantage of people and future generations. Land is regarded as mutual for the benefits of all. Land in eastern Nigeria (the Igbos) is venerate and is considered as an earth goddesses. Past study argued that in the southeastern states of Nigeria access to land is governed by both statutory and customary laws (Chukwuma and Asogwa 2017). Customary laws emerge from unwritten social rules derived from shared community values and traditions (Opata and Asogwa 2017). Statutory laws confer on its holder's authority/right to make use of communal lands (Famoriyo, 1976).

The Land Use Act of 1978 was enacted to nationalize land ownership in Nigeria as well as to facilitate effective state control of the use and development of land. Before this Act of 1978, access to commercial farmlands was very difficult. This Act has improved a significant access to commercial farmlands. Currently, 23.1% of households in Nigeria owned titled land and 5% for commercial farmlands (Umeh, 1973). Excessive bureaucracy has made land registration in Nigeria very prohibitive. Countries like Rwanda, Ghana, and Botswana take fewer days to register property titles on land. Land is vested in the state's governor to be held in trust and administered for the use and common benefits of all Nigerians (Fabiyi and Idowu, 1993). This Land Use Act of 1978 make clearer provisions for the indigenous land tenure system and hence used as heterogeneity of land use systems, ownership structure, farm production/productivity and commodity crops found in each region as expressed in Figure 1.

Nolte and Sipangule (2010) noted that there has been an increased interest in agricultural land-use policy in Africa's rural areas. The study deduced that about 45% of the agricultural investments have been taken over by the foreign investments particularly medium-scale farmers. Hence, this interest in agricultural land further increases land pressure and land use competition between commercial interests, local livelihoods and ecosystem services and thus enhances poverty among the locals. Hence, land-use policy needs to focus on raising smallholder agricultural productivity. In the same vein, Nkonya et al. (2016) revealed that Sub-Saharan Africa (SSA) has experienced the most severe land degradation in the world. Hence, there is dire need to design a number of policies and strategies to address land degradation and to enhance agricultural productivity. Results indicated that about 23% of the conversion of grassland to cropland and deforestation are the major factors driving land use/cover change (LUCC) thus facilitating poverty among local farmers. Econometric analysis showed that intervention helped access to productive inputs including land degradation threats. Hence, improvement of government effectiveness on land use policy can reduces cost of land degradation and cropland expansion. These opportunities should be exploited effectively as they lead to win-win outcomes-reducing poverty and achieving sustainable land management.

Moreover, poverty reduction and sustainable land management are two objectives that most African countries strive to achieve simultaneously. In designing policies to achieve these objectives concurrently a clear understanding of their linkage is crucial. Deininger et al. (2015) in their analysis opined that better understand this linkage is sustainable land management and effectiveness of resource use. Results revealed that poverty indicators give credence to the land degradation–poverty trap, although some indicators showed negative association with land degradation. These results suggest that certain poverty reduction strategies being implemented through agricultural modernization in Africa can achieve triumph outcomes and simultaneously increasing productivity, reducing poverty, and reducing land degradation.

Examining the heterogeneity of land use, Land Use System in Nigeria and its Historical Evidence can give an insight on how sustainable land use and management of land being engaged over the decades. It is known that sustainable land use management and resource use efficiency enhances agricultural productivity. What is unknown is that agricultural-land access/management and "culture of poverty" influences rural poverty. Also, can land

use policy provide policy guidance to government to influence land-use sustainability and resource use efficiency among small farmers evidence from rural Nigeria? This is the rationale of this study.

Materials and methods

Area of study

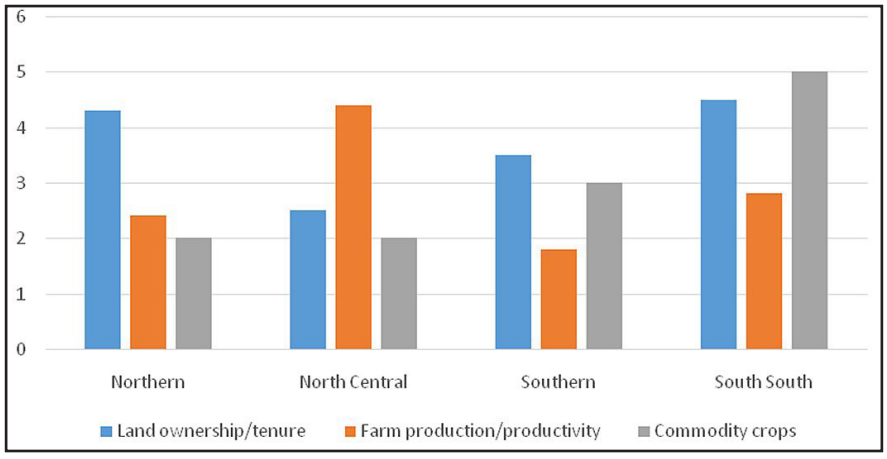
Nigeria comprises of a geographical area of 923,768 square kilometers with a projected population of 180 million (2016 estimate) people (Figure 2). Nigeria lies exclusively within the tropics along the Gulf of Guinea on the western coast of Africa. The country has a favorably diversified agro ecological condition, which makes it possible for the production of a wide range of agricultural products. Less than 50% of the country's cultivable agricultural land is under cultivation. Even then, smallholder and traditional farmers who use rudimentary production techniques, with resultant low yields, cultivate most of these lands. The country is divided into four major regions used as a base of analysis for this study (Table 1).

Method of data collection

Both primary and secondary data were used. A cross-sectional data from 1200 farmers were collected through farm level rigorous cost route surveys, out of which 880 (73.33% response rate) data found useful. The 320 unused data contained incomplete data, questionnaire lost in transit and data that cannot properly be transcribed. However, the secondary data were obtained from the records of various Agricultural Developments Projects (ADPs), Land records department of various Federal and State Ministries respectively. Data collected include: socio-cultural/economic, agronomic, land use data, environmental, prices on input and output data among others. Cross-sectional data on socioeconomic and environmental attributes of the respondents were collected. Farmers were specifically asked to respond to questions on patterns of change in land use and its influence on their agricultural production.

Sampling techniques and procedures

The survey was distributed using Multistage sampling. This techniques was adopted to divide the country into clusters (four regions: Core North, North central, Southern part and South-south) and from each cluster (region) two States were randomly selected and everyone within the chosen cluster is sampled. Secondly, two locations in each state were identified through secondary sources information about the data on heterogeneity of land-use systems and high intensity of farming operations. In addition, poverty status as provided by secondary sources too inspired the choice of these locations. Thirdly, selection of the farm-households from sixteen identified communities/ towns. Each town produced a representative data of maximum 75 and minimum 55. Hence, 55 data were used across board to provide for uniformity. This give 220 per region and 880 overall (Table 2). Also, assistance of competent scientists/researchers were sought for in the identification of certain land use system, degradation parameters and indices among others.



Source: adapted from the revised livelihoods zone map and descriptions for nigeria a report of the famine early warning systems network (fews net) september 2018

Figure 1: Structure of land ownership and major agricultural produce in regions of Nigeria.

Source: Agriculture in Nigeria - Wikipedia

Figure 2: Map of Nigeria.

s/n	Region and Law/Land Use Systems	States	Major Agricultural Activities	Vegetation
1	Northern region/ Primitive and Customary Law	Bauchi, Borno, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara	Cotton, Groundnut, Sorghum, Millet, Maize and Wheat Locust Bean trees (*Parkiafilicoidea*), Tamarind tree (*Tamarindusindica*), and Mango (*Mangiferaindica*).	Low average annual rainfall of 657.3 mm and prolonged dry season (6–9 months)
2	Northcentral region/ Hegemony and Customary	Abuja, Adamawa, Benue, Gombe, Kaduna, Kogi, Kwara, Nassarawa, Niger, Plateau, and Taraba	Grazing livestock such as cattle, goats, horses, sheep, camels, and donkeys. Maize, Cassava, Yam, and Rice	This zone experiences lower rainfall, shorter rainy season and longer dry period
3	Southern region/ Communal and Statutory	Abia, Anambra, Ebonyi, Edo, Ekiti, Enugu, Ogun, Ondo, Osun, and Oyo	Staple crops like, yam, cassava, cocoyam, sweet potatoes, melon, groundnut, rice maize and Oil Palm, (*Elaeisguineensis*), Cocoa (*Theobroma cacao*), Rubber (*Heveabrasiliensis*) banana/Plantain (*Musa spp.*), Cotton and Cola nut (*Cola nitida*). Cowpeas and Beans as well as a number of fruits. A number of timber trees such as the African Mahogany, the scented Sapele wood (*Entandrophragmacylindricum*), and Iroko (*Chlorophoraexcelsa*)	Prolonged rainy season, resulting in high annual rainfall above 2000 mm.
4	South-South region/ Hegemony, Customary and Statutory System	Akwa Ibom, Bayelsa, Cross Rivers, and Delta, Lagos, and Rivers	Oil-Palm, Cocoa, Cassava, Maize, Yam. Various Palm and Fibre plants such as R*aphiaspp*., *Raphiavinifera*, the Wine Palm and *Raphiahookeri*, the Roof-mat Palm.	Prolonged rainy season and lagoons overflow banks in the wet season (8–9 months). Thus longer rains, has led to badly leached soils and severe erosion

Sources: [i] http://soilsnigeria.net; [ii] Oyenuga, V. A. (1967). Agriculture in Nigeria. Food and Agriculture Organization of the United Nations. FAO, Rome, Italy. 308 p.; [iii] Materials from http://www.fao.org; [iv] Sowunmi, F. A. and Akintola, J. O. (2010) Effect of Climatic Variability on Maize Production in Nigeria. Research Journal of Environmental and Earth Sciences , Vol. 2, No. 1, pp. 19–30.

Table 1. Region and land use laws/systems in Nigeria.

Region	State	Local Government/Towns	Questionnaire Distributed	Questionnaire Used
Northern	Kano	Makoda	75	55
		Kura	75	55
	Jigawa	Guri	75	55
		Gumel	75	55
Northcentral	Adamawa	Maiga	75	55
		Mchika	75	55
	Kogi	Yagba east	75	55
		Okene	75	55
Southern	Abia	Abia South	75	55
		Ohafia	75	55
	Ondo	Akoko South	75	55
		Owo	75	55
	Cross rivers	Yakurr	75	55
		Odukpani	75	55
	Rivers	Port-harcourt	75	55
		Ahoda west	75	55
Total			1200	880

Source: Field Survey (2018).

Table 2: Distribution of sampled respondents in the study area.

Method of data analysis

The analytical tools employed in this study are developed to analyze the data in order to fulfill the scope of the paper. Therefore, a combination of analytical tools like descriptive statistics, and econometric procedures were used.

Model estimation and interpretation

Multiple regression model adopted was based on the fulfillment of the assumptions of the functional forms and data availability. This model was used to measure the indices of sustainable land use and management. Consider the production function of

$$Y = h\,(X, L, V, M, \beta)\exp(U_i - V_i) \qquad (1)$$

where

Y = Output of crops consumed

X = Vector of physical inputs and indigenous status measured

L = Land quality variable measured as a dummy variable

V = Vector of land use variables measured as index

M = Vector of land management practices assumed to have an impact on land quality measured by ranking number and dummy.

U_i = Components of error terms

V_i = Misspecification of the model.

$h\,(.)$ = Suitable function to be adopted for the study.

$i = 1, 2, \ldots, n$

The parameters of Equation (1) and the density function of U_i and V_i will be estimated by maximizing the log-likelihood function, given as

$$Lhf = \frac{n}{2} Lh\left(\frac{2}{\pi}\right) - Kn\sigma + \sum_{i=1}^{n} Lh - F\left[\left(\frac{-\epsilon\lambda}{\sigma}\right)\right] - \frac{1}{2}\sigma^{-2}\sum_{i=1}^{n} \in i^2 \qquad (2)$$

where

Lhf = log-likelihood function

Lh = Log-likelihood

K = constant

n = number of observations (880 farming households)

σ = standard deviation error term

λ = $\sigma / \sigma x$

F = Standard distribution

$\in i$ = component error term

π = 3.145

Basic assumptions of the estimation procedure of the model adopted

The validity of the model adopted was built on the following assumptions and taking a cue from past studies (Aigner et al, 1997; Hassan et al., 2012). These assumptions were used as the conceptual constructs that guide the model adopted for this study:

1. A farmer essentially practices a disparate type of land use management depending on biophysical factors every cropping season.
2. Farmers are confronted with even climatic factors and similar soil type.
3. Farmer practices can either enhance productivity of the soil or depreciate it.
4. A farm-specific land use management index was captured from the result of prevailing environmental indicators
5. Agronomic procedures used have clear carryover consequence on the soil and in the estimated frontier.
6. Farm-specific output level is mutually regulated by input use and agronomic procedure.

The theoretical framework routing most land use management measures and adopted by this study are adapted from past study (Liu, 2006). Past studies have indicated that the estimates of the trans-logarithmic model may be unacceptable because of the defilement of symmetry settings of intense sample values to the additions of the second-order terms, particularly in small samples (Kalirajan and Shand, 1986, Shanmugam and Lakshmanasamy, 2001, Mahesh and Meenakshi, 2006). Hence, this problem is somewhat resolved in this study with the use of large sample size (N = 880) and with enhanced degree of freedom (Hassan et al., 2012). Thus, by means of a stepwise selection approach and consideration of likely interaction relationships between land use attribute and management practices, the model was constructed. Consequently, a full trans-logarithmic specification of land quality use and management practices interaction on farm output was embraced.

$$LUM = a_0 + \sum_{i=1}^{n} a_i \, In \, X_{ij} + \frac{1}{2}\sum_{i-1}^{n}\sum_{j=1}^{n} b_{ij}\left(InX_{ij}X_{ij}\right) + \sum_{j=1}^{n} M_j L_{ij} + \sum_{i=1}^{n} L_i \, In \, Mij + \sum_{i=1}^{n} b_{ij} \, (In \, X_{ij})^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} h_{ij}\left(InX_{ij} Inb_{ij}\right) + \sum_{h=1}^{p} e_i \, In \, L_{ij} + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} h_{ij} \, (InX_{ij} \, InM_{ij}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} h_{ij} \, (In \, X_{ij} InM_{ij}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} L_{ij}\left(L_i L_{ij}\right) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} V_{ij}\left(InM_i L_{ij}\right) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} hij \, \left(InM_{ij} \, InL_{ij}\right) + V_i + U_i \quad (3)$$

where

LUM = Land use and management practices on farm output.

i = 1,2, …, 880, j = 1,2, …, p which are physical inputs.

X, L, V and M are as earlier described in Equation (1)

a_0 = parameters of intercepts.

a_i = parameters of physical inputs and indigenous status

b_{ij} = parameters for interactions across the ith and the jth physical inputs

L_{ij} = parameters for dummy variables on land resources quality.

M_j = parameters for land management variables

M_{ij} = parameters for interactions between land management variables and land use variables

h_{ij} = parameters for interactions between the ith physical inputs and land use variables.

X_{ij} = parameters for interactions among land use variables.

V_{ij} = parameters for interactions between the physical inputs and land management variables.

L_iL_{ij} = parameters for interactions between land-use dummy variables and land resource quality.

$M_{ij}L_{ij}$ = parameters for interactions between land management variables and land use resource quality.

$X_{ij}M_{ij}$ is the convectional input that is usually well thought out in the transformation process, but L,V and M are conditioning variables

whose additions into the model is to capture the consequences of land use and management procedures on the outputs from farm.

U_i = components of error terms

V_i = misspecification of the model.

But L,V and M are conditioning variables whose additions into the model is to capture the consequences of land use and management procedures on the outputs from farm.

Measurement of Short-Run Sustainability Index (SRSI)

This comprises of 2-step methodology, firstly, valuation of the farm-specific index of sustainable land use and management (FSM). Secondly summing up the index and the farm-specific inefficiency index (SII) give SRSI. FSM was assessed in Equation (3) with reverence to all the agronomic practices (i.e., land use and management practices) which were assessed at different level of input use and resource quality. Hence, this is stated as

$$FSM = \sum_{i=1}^{n} L_i + \sum_{i=1}^{n} \epsilon_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} S_{ij} + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} h_{ij}(InX_{ij}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} V \quad (4)$$

All symbols/notations are earlier defined in Equation (3) and SII assesses the land use and management index.

Past studies have indicated that if the value of FSM is zero, then land use and management practices do not alter land quality, but, if it is positive, there has been enhancement in the use and management of the land. Also, if the value turns out negative, then land use and management practices have unfavorable consequences on the land resources (Hassan et al, 2012). This study stated that summation of the index of sustainable land use and management results to SRSI and this is stated as

$$SRSI = 1 - [(X_i P)(X_{ij} P)^{-1}] + \sum_{i=1}^{n} d_i + \sum_{i=1}^{n} \epsilon_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} S_{ij} + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} h_{ij}(InX_{ij}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{p} V_i \quad (5)$$

All symbols/notations are earlier defined in Equation (3).

Literature have indicated that if SRSI is positive, it shows that the production process methods in terms of input use, land use, and management the farmers adopted is sustainable, but if SRSI is negative, then the production process not sustainable [Pravitasari et al, 2018]. This study used SRSI to reflect the status of the land use and management and its relationship to poverty.

Estimation technique

Past studies argued that relationship between land use management and poverty is complex (Kumbhakar et al., 2007; L'eopold and Van-Keilegom, 2014). Evidence from these studies suggested that the estimation technique to use is likelihood maximum estimation (LME). This method has been found to have the advantage of not imposing any particular functional form to the correlation between the explained and the explanatory variables. Therefore, this study adopts LME as estimation technique. This technique helped to understand the shape of the relationship between land use and poverty.

Estimating the poverty component

In this paper, poverty is quantified by comparing households to a set of poverty threshold (that is a minimum amount of income needed to cover basic needs, that is access to quality food, water, shelter, education, healthcare and clothing) (Aigner et al., 1997). Hence, households whose income falls under this threshold are considered poor. Consequently, the study generated welfare composite index (WCI) as proxy for household wealth which was used as threshold to determine poverty. The study proposes a single composite index, H, which composed of a household I in form of:

$$H_i = \sum_{k=1}^{k} Y_j I_{ij} \quad (6)$$

Where I_{ij} is a primary indicator for household and $J(j = 1\ldots k)$ for household $i(I = 1\ldots n)$, and Y_i is the weight of the indicator I_{ij} to be estimated. Many different methods have been used to estimate Y_j. In this study multiple correspondence analyses (MCA) was used, taking a cue from past study (Aigner et al., 1997). This method is particularly suitable for the data generated in this study. This includes a set of binary variables representing the different modalities of primary indicators. Each primary indicator Iij can take J modalities, thus H_i is the composite index for household iand can be rewritten as

$$H_i = \sum_{k=1}^{k} 1 \sum_{nk=1}^{nk} W_{nk}^{h}/P \quad (7)$$

where P is the number of primary indicators; nk is the number of indicators k modalities; I is the weight attributed to nk modalities; and a binary variable equal to 1 when household i has modality nk and 0, otherwise

$$W_{jk}^{k} = \frac{Score}{eigenvalue\ for\ axis\ a}$$

Of the modality obtained from MCA. The WCI, I for a household i, is simply the average of the weight of the binary variables. Hence, the weight was attributed to each composite index I A to give a normalized score.

This poverty status of a household is represented by a binary variable (indicator function) that takes the value of one/two if the household is identified as poor and zero otherwise (Ballon and Apablaza, 2012). To capture the poverty and status of respondents, the study employed the use of Foster, Greer and Thorbecke (FGT) (1984). Past study argued that this method has proven to be ideal in determining poverty status. FGT measures are defined by

$$FGT_{\alpha} = \frac{1}{n}\sum_{j=1}^{k} I_y(Z - Yi\}^{\alpha} \quad (8)$$

where Z = poverty line, Y_i = indicator function, n is the size of the population, and α a non-negative parameter. When $\alpha = 0$, i.e $FGT_{\alpha} = 0$, it simply means that the proportion of the poor in the population usually referred to as headcount (HC) or poverty incidence (PI). When $\alpha = 1$, that is $FGT_{\alpha} = 1$, this outcome represents the average poverty gap, this expresses the WCI outcome explaining the level of income necessary for an individual to be able to reach the poverty threshold. When $\alpha = 2$, that is $FGT_{\alpha} = 2$, this reveals the distribution of poverty amongst the poor and places greater weight on those furthest from the poverty line. Past study argued that when this outcome occurs it is signified the severity of the poverty situation (Simar and Wilson, 2007).

Consequently, the study used land access, SRSI, socio-cultural/economic variables, and environmental factors as indicators of poverty among the respondents. This approach helped to explain how land access and sustainable land management practices have influenced the poor and non-poor categories (Racine, 1997). The study presumed that the probability of being in a particular poverty category is determined by an underlying response of variable of land access and SRSI which depicts the true economic status of an individual. In the case of binary poverty status (i.e., being poor or non-poor), let the underlying response variable be defined by the regression relationship

$$Y^{\alpha} = \sum X_i^j \ \beta + \mu_i \quad (9)$$

The interest of this study is Equation (9) and thus, the likelihood function for the Equation (9) is written as

$$L = \Pi_{yi=1} \ [F(-\sum X_i^i \beta_i)\ ][1\text{-F}\ (\ -\sum X_i^i) \quad (10)$$

Where L is the likelihood function that captures the poverty incidence, when this incidence is 1 household is poor and 0 non-poor. This outcome is then used here as a dependent variable. Equation (9) was estimated using Maximum likelihood estimation (MLE) technique as adopted by the study of Ziegelmann (2002).

Results and discussion

Land ownership structures, characteristics of households, and production constructs across different poverty statuses.

Many characteristics concerning rural households in Nigeria can be drawn from Table 3. Table 3 shows poverty status of respondents in the study areas, where 66.4% were categorized poor, out of which 23.2% were extremely poor. Moreover, 92% of those in the category of extremely poor respondents seek their agricultural land ownership structure by rentage, while farmlands with titled documents constitute 78.6% of the non-poor (Table 3). However, the poor category (39.5%) households depend mainly on agricultural livelihoods, whereas, for non-poor, 26.7% augment farm income with nonfarm income (Table 3). In contrast, the poorer have less education, higher families, greater dependency (children and old members), and are more attached to communal and family land.

Table 3 also revealed majority derived livelihood from farming while income received from agricultural production is somewhat insignificant. The non-poor category involved more in nonfarm livelihood and possesses moderate farm size. Moreover, farming households with less than 2 ha of agricultural land are poorer (30.1%) and on family/communal land. This result displays the direct and indirect effects of access to land

as it influenced poverty status. Evidence from Table 3 indicated that government policy intervention program on land use for agricultural purposes constitutes 8.8% but focus more on farmers that uses government land (57.2%) for farming purposes. Likewise, NGO local intervention (36.9%) had more emphasis on family/communal land (28.6%). Whereas, government and NGO (local and international) intervention (6.3%) focuses more on households that owned land titled (3.0%) (Table 3).

Literature on access to land and rural poverty revealed a decisive links. Past study deduce that government intervention/programs should be able to select only those households with practically zero opportunity costs (Ali et al., 2015). This study contended that an average subsidy of one daily 360 Naira (1US$) per capita would influenced majority of the land-poor farmers to a reasonable living (Table 3). The disparities in productivity between poor and non-poor farmers discerned in Table 3 was influenced either by access to productive incentives or capital. The study argued that non-poor farmers have access to productive inputs and augment farm income with nonfarm income. Whereas poor farmers have limited or no access to productive inputs/capital and engaged primarily in agriculture as evidenced by past studies [Jayne et al, 2014]. Hence, results presented on Table 3 and discussed are consistent with other studies in rural areas of SSA (Herrera, 2000; Ali et al., 2015; Kansinne et al., 2018).

Particulars	Extremely Poor *	Poor	Not Poor	Total
Number of households (proportion of total %)	205 (23.2)	380 (43.2)	295 (33.6)	880 (100)
Region				
Northern (core) (%)	51 (23.2)	85 (38.6)	84 (38.2)	220 (25.0)
North central (%)	59 (26.8)	94 (42.7)	67 (30.5)	220 (25.0)
Southern (%)	48 (21.8)	116 (52.7)	56 (25.5)	220 (25.0)
South-south (%)	47 (21.4)	85 (38.6)	88 (40.0)	220 (25.0)
Land Ownership Structure				
Rented (%)	103 (92.0)	7 (6.3)	2 (1.7)	112 (12.7)
Ownership of land with Titled documents (%)	4 (4.5)	15 (16.9)	70 (78.6)	89 (10.1)
Ownership of land with NO Titled documents (%)	23 (14.6)	38 (24.2)	96 (61.2)	157 (17.8)
Family land (%)	52 (24.3)	136 (63.6)	26 (12.1)	214 (24.3)
Communal land (%)	19 (9.0)	170 (80.9)	21 (10)	210 (23.9)
Government land (%)	4 (4.1)	14 (14.3)	80 (81.6)	98 (11.2)
Household Characteristics				
Sex				
Male Head	95	168	135	398
Female Head	110	212	160	482
Marital Status				
Single	12	23	23	28
Married	180	338	249	767
Separated	3	9	12	24
Widowed	10	10	11	31
Household Members				
(1–4)	1	5	4	10
(5–8)	125	318	287	731
(9–12)	66	48	4	118
(13–30)	13	8	0	21

* For illustrative purposes extreme poverty line is set at N360. 00 (US$1) per capita and day of total monetary income. Poverty line is set at 720.00 (US$2). * For each household member 1 = foundation 2 = primary 3 = basic 4 = diversified 5 = university 6 = postgraduate.

Source: Field survey 2016–2018

Table 3. Land ownership structures, characteristics of households, and production constructs across different poverty statuses.

Particulars	Extremely Poor *	Poor	Not Poor	Total
Age in Years				
(15–25)	2	5	2	9
(26–45)	63	137	104	304
(46–60)	134	228	179	541
(61–100)	6	10	10	26
Indigenous head	166	370	275	811
Dwelling Structure				
Rented	116	53	26	195
Family house	36	179	60	275
Owned + Titled Doc.	15	42	137	194
Owned No Titled Doc.	38	106	72	216
Production Characteristics				
Farm Size (Acres)				
(0.5– 2.0)	202	63	7	272
(2.1–3.5)	3	313	254	570
(3.51–5.0)	0	4	29	33
(5.1–10.0)	0	0	5	5
Farming Experience				
(years) (1–5)	13	34	18	65
(6–10)	36	66	58	160
(11–15)	23	52	27	102
(16–100)	133	228	192	553
Farm-specific Resource use Index				
(0.000–0.01)	1	6	8	15
(0.011–0.25)	149	42	8	197
(0.26–0.50)	49	240	7	274
(0.51–1.00)	6	92	274	372
Short-Run Sustainability Index				
(−1.93–0.01)	174	42	0	216
(0.011–0.99)	28	315	16	359
(1.0–2.50)	3	23	215	241
(2.51–6.0)	0	0	64	64
Livelihood:				
Agriculture only	186	209	60	455
Agriculture + Non agriculture	19	171	235	325
Welfare Indicator				
(30,000–65,000)	127	21	0	148
(65,001–90,000)	75	212	11	298
(90,001–125,000)	3	140	76	219
(125,001–1,000,000)	0	7	208	215

* For illustrative purposes extreme poverty line is set at N360. 00 (US$1) per capita and day of total monetary income. Poverty line is set at 720.00 (US$2). * For each household member 1 = foundation 2 = primary 3 = basic 4 = diversified 5 = university 6 = postgraduate.

Source: Field survey 2016–2018

Table 3. Land ownership structures, characteristics of households, and production constructs across different poverty statuses.

Result of analysis of the model adopted

The trans-logarithmic specification model was estimated using Maximum Likelihood Estimation (MLE) method, and the Diagnosis Statistics (Quasi-function coefficient = 0.870, Ln (likelihood) 135; 601 Sigma-square δ^2 = 0.762* (0.041); Gamma (Y) = 0.9026 * (028); Mu (μ) -1.621 * Asterisk indicate significance * 1%, ** 5% *** 10% variance ratio $\gamma = \frac{\delta u^2}{\{\delta u^2 + \delta v^2\}} = 9$) results generated revealed a large estimate of sigma-square which is statistically significant and different from zero. The Diagnosis Statistics analysis and outcome indicated a good fit for the model and thus specified the correctness of the distributional assumptions of the composite error term. In addition, the variance ratio had a high estimate of 91.04%, signifying that systematic effects that are unexplained by the production function are the leading sources of random errors. In other words, the existence of technical inefficiency among the sample of farm explains 91% variation in the output level on land use systems. The coefficients generated from Equation (3) were then used to interpret the elasticities of output with respect to the inputs. These results were generated from the outputs of the likelihood parameter estimates of Equation (3). Hence, these production elasticities are computed and hereby presented in the table below.

Table 4 revealed the sum of the elasticities of output with respect to the physical inputs and the indigenous status that generates estimated scale elasticity; hence, this indicates the presence of short-run decreasing return to scale (SRD). Past study has indicated that SRD depict a case in which each additional unit of output yield smaller increase in product than in the previous unit (Hassan et al., 2012). These production elasticities computed are of interest in explaining the interactions and the variability in farmer's farm outputs. The estimated elasticities of the set of variables and output with respect to the conditioning variables are of particular interest to the computation of short-run sustainability index (SRSI). Hence, the interaction between land use variable and management variable generated a coefficient of joint action index of 0.417, which is statistically significant at p = 0.05 and is positively related to output level. This result indicated that management employed on land use influenced farm output. This finding is supported by past study (Kansiine et al., 2018).

Computation of Short-Run Sustainability Index (SRSI)

Computation of SRSI takes a 2-step methodology, firstly, valuation of farm-specific index of sustainable land use and management (FSM) using Equation (4). Secondly, summing the index with the farm-specific inefficiency index (SII) using Equation (5) will give SRSI. The distribution of the indices is presented in Table 3. The distribution of farms based on FSM indicates that 46% (mean values = 0.458) of the farmers adopted land use and management practices. Hence, 54% of them adopted practices that improved land quality. Further analysis revealed that 16% of the lower group adopted sustainable land management practices while a higher median were found mostly on non-poor group (Table 3). However, FSM projected in this study may be limited because pertinent management practices that enhanced land quality have not been built-in in the analysis. Hence, within the context of the assumptions used for analysis, the indices used to a large extent captured the effect of land use management practices for farming purposes.

Moreover, the farm-specific index of short-run sustainability is a product of indices of farm-specific inefficiency index (SII) and farm-specific index of sustainable land use and management (*FSM*) (Pravitasari et al, 2018). The distribution of SRSI is presented in Table 3. The results of these analyses revealed that 69% (mean value of 0.6895) of the farmers made unsustainable use of agricultural land coupled with practices of resource use inefficiency. Thirty-one percent

Set of Variables	Estimated Value	Remark
Physical input and indigenous status	0.4102	SR-Decreasing Return to Scale
Land use and management	0.0712	SR-Decreasing Return to Scale
Interaction terms	0.149	SR-Decreasing Return to Scale
Overall	0.417	SR-Decreasing Return to Scale

Source: Computed from Maximum Likelihood Estimation (MLE) of Equation (3)

Table 4. Distribution of production elasticities among the variables.

of farmers improved their land productively, as indicated by the net balance of the resource use inefficiency and agricultural land and management. Hence, only 31% of the farmers undertook sustainable production process. Further analysis clearly shows that the majority (76%) of the non-poor practices sustainable land-use (Table 3). The assumption that both the *FSM* and SII are influenced by different factors, such as socio-cultural/economic and environmental, holds here. Moreover, the trend of the relationship between these indices was examined using a simple linear correlation coefficient (r). The result revealed that $r = 0.207$, that is the null hypothesis of no correlation amid the two indices in the farms was consented at $\alpha = 0.05$ level. Hence, each of the indices influences sustainability index differently and at diverse magnitude.

The study used SRSI as a measure of sustainability of agricultural land use and resource use efficiency which is a policy indicator. Hence, a positive SRSI indicated that farmers adopted land use and management practices. Land use policy can be effective for those categories of farmers that made unsustainable land use as reflected in the negative SRSI. Hence, land use policy will provide policy guidance to government to support these categories of people on how to improve land-use sustainability and resource use efficiency.

SRSI were thus used as independent variables in Equation (12) below.

$$y = x\beta + \mu \quad (12)$$

where Y is the vector $n \times 1$, X is a matrix $n \times k$, $\hat{\beta}$ = is a vector k x 1 and u is a vector n x 1

$$yi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots . + \beta_{16} X_{16} + \mu_i \quad (12)$$

Yi is the poverty status of respondents

β_0 - β_{16} are the coefficients of the independent variables

X_1 - X_{16} set of the independent variable

μ_i is the random error (unexplained variation)

Equation (13) will be estimated with ordinary least square (OLS) method expressed below.

$$S = \sum_{i=1}^{n} \acute{v}i^2 = \sum_{i=1}^{n} \{ y_i - \hat{\beta}_0 - \hat{\beta}_1 Xi_1 - \hat{\beta}_2 X_{2i} - \hat{\beta}_3 X_{3i} - \hat{\beta}_{16} X_{16i} \} \quad (13)$$

where S is the least square method of estimation

Yi is the poverty status of respondents

β_0 - β_{16} are the coefficients of the independent variables

X_1 - X_{16} set of the independent variable

μ_i is the random error (unexplained variation)

Independent variables used in Equation (13) and their definitions

The study presented 16 independent variables and were hypothesized to influence the dependent variable. From these 16 variables, 10 were continuous and six were discrete. Selection of these independent variables was logically taken from the review of past research and published literature related to the scope of the study (Gerber et al., 2014). Independents variables are Age (years) (X_1), Indigenous (X_2), Farm year (X_3), Marital Status (X_4), Dependent (X_5), Productive adult (X_6), Education of head (years) (X_7), Primary occupation (X_8), Mode of Dwelling (X_9), Land ownership structure (X_{10}), Farm efficiency index (X_{11}), Land-intervention policy index (X_{12}), SRSI (X_{13}), Household income (X_{14}), Household size (X_{15}), Farm size (X_{16}).

Multiple regression (Equation (12) analysis was conducted to investigate factors influencing the poverty status of respondents via a maximum likelihood estimation technique. The estimated results of the model predict the possibility of the poverty status households' ($R^2 = 0.89$). This suggests that 89% of the explanatory variables explained the dependent variables, while the remaining 11% remained unexplained. Based on the estimated results, nine variables were found to significantly influence poverty status: farm year, dependent-ratio, education-year, farm-efficiency index, land policy intervention variables, SRSI, income, household size, and farm size. The significant positive signs of education year, farm efficiency index, and SRSI, income, and farm size variables can be explained from the perspective of access to productive factors and land quality. Also, fairly literate farmers tended to have more investment opportunities, leading to stronger potential need to enhanced prosperity and also not to fall into poverty. However, the significant but negative coefficients such as farm year, dependent ratio, land-policy intervention variables and household sizes enhance poverty (Table 5). This finding is buttressed by past study (Barbier and Hochard, 2016b).

Variable		Coefficients	Standard Error	t Stat	p-Value
	Intercept	0.965469	0.11253	8.57905	4.4×10^{6}
Age	X_1	0.001736	0.00127	1.36142	0.17373
Indigene	X_2	0.031466	0.03591	0.87623	0.38114
Farm year	X_3	−0.00229	0.00116	−1.96805	0.04938
Marital	X_4	0.014238	0.02009	0.70844	0.47886
Depende	X_5	−0.00911	0.005393	−1.68943	0.091498
Proadult	X_6	0.001395	0.006063	0.230137	0.81804
eduyear	X_7	0.003513	0.00179	1.962812	0.049989
pryoccup	X_8	0.001377	0.007315	0.188295	0.85069
dwelling	X_9	0.006869	0.009693	0.70868	0.478715
landown	X_{10}	0.008216	0.007338	1.119766	0.263125
farmeffin	X_{11}	0.767577	0.052079	14.73863	5.09×10^{-44}
landpol	X_{12}	−0.03664	0.004604	−7.95845	5.47×10^{-44}
srsi	X_{13}	0.189421	0.015478	12.23849	7.16×10^{-32}
income	X_{14}	1.63×10^{-6}	2.3×10^{-7}	7.08658	2.86×10^{-12}
hhsize	X_{15}	−0.03014	0.005225	−5.7681	1.12×10^{-08}
farmsize	X_{16}	0.275053	0.016439	16.73203	1.22×10^{-54}

Diagnostic Statistics
$R = 0.93$, $R^2 = 0.89$, Adjusted $R^2 = 0.82$, Standard deviation = 0.27, No. samples = 880
Source: Multiple regression results (Computer printout).

Table 5: Multiple regression outputs.

Multiple regression results revealed that the significant but negative coefficients of farm year, dependent ratio, land policy intervention variables, and household size enhance agricultural poverty. Large household size tends to influenced high consumption agricultural-outputs and lower income generation. This unexpected result of decreasing returns to land policy intervention could be influenced by poor category of farmers who were exploited (productive factors were diverted by the operators of the prog.) and uses family/communal lands for farming operations. These findings are consistent with other studies in rural areas of SSA (Nkonya, et al, 2008). Households with more children tend to have lower per capita consumption but the presence of elderly members does not have a statistically significant effect. The negative and significant coefficient on the number of working-age adults in a household indicated a widespread underemployment; hence, these issues are important for households' ability to perpetuate poverty.

Examining these variables further using cross-tab analysis revealed that households with large numbers (61.2%) have no formal/primary education and thus poor (41.2%) out of which 14.7% are extremely poor. Moreover, local government intervention programs have focused more on farmers (45.7%) that used family/communal land for agricultural purposes. However, farmers that acquired government land and with titled farmland documents attracted more (28.0%) of NGO (local and international) intervention program. Relating these findings with poverty status, non-poor accessed more (33.5%) of government and NGO intervention program. Linking these outcomes to region, northern region attracts more (23.0%) of local government intervention program, while the southern accessed more (13.3%) of NGO (local and international) intervention program. These findings indicated that government intervention programs focus more on those categories of farmers that acquired government land and has titled documents on agricultural land as evidenced by the past study (McCullough 2015).

The causal association between access to land, location, and other assets evidence the existence of "poverty". This is done to find proof that being a farmer and live in rural areas with fewer economic assets is poor. Evidence from the descriptive and cross-tabulation analyses revealed that being a farmer is directly and causally related to having more household members, less education, and poorer access to productive inputs/factors. Also, the analysis indicated that the sum of direct and indirect links amid the same variables, affirming the links in the longer term, thus, specifying more sign of path dependency (Park et al, 2008).

Policy implication

The study examined heterogeneity of land use systems and its influence on poverty among small farmers in Nigeria. The study improved upon the existing literature by estimating socio-cultural factors influencing poverty path dependency among farming households, taking into account the role of land use management and analyzing the resulting impacts on poverty. The descriptive analysis depicts that land ownership structure, socio-cultural practices of the farmers, and exploit of government intervention programs influenced agricultural poverty. Although no evidence was found for a land-size poverty among households in Nigeria, some communities may be trapped (by location and endowments), but such a "geographic" poverty trap is distinct (an issue beyond the scope of this study). The study finding on path dependence in land holding/land use has important implications for the study of poverty dynamics. Hence, the heterogeneity of land use systems is significant in this case. Past studies have argued that persistent unsustainable land practices reduces the productivity of agricultural systems, on which many rural poor depend, thus trapping them in subsistence-level poverty (Barbier and Hochard, 2016a). Thus, our findings suggest a critical need to ensure more rural people imbibed sustainable land practices. This could be accomplished through a rural development strategy that invests more on rural infrastructures like feeder road, market, and agricultural land quality.

The trans-logarithmic model used here revealed the coefficients that were generated from the likelihood parameter estimation technique. This outcome helped to compute the production elasticities that explained the interactions and the variability in farmer's farm outputs and short-run sustainability index (SRSI). SRSI results revealed that 69% of the farmers made unsustainable use of agricultural land coupled with practices of resource use inefficiency. Moreover, the coefficients of SRSI, land policy intervention variables, and household sizes enhance poverty. Cross-tab analysis also revealed the dominance of these coefficients on farmer's poverty status, hence, emphasizing the need to review land policy intervention and benefits given to small farmers. Analysis of the land ownership structures and it influence on different indicators of income and land-size stratification revealed extraordinary differences in productivity between the poor and non-poor farmers. This evidence must be due to degree of access to productive inputs or capital by farmers. Consequently, government needed to improve on the channel of distributions of timely productive inputs to small-scale farmers

Evidence from the descriptive and cross-tabulation analyses revealed that being a farmer is directly and causally related to having more household members, less education, and poor access to productive inputs/factors. This implies that possible short term benefits from gaining access to land quality and optimized large household size for labor can however be a way out of poverty, though these benefits can be negative in the long term if sustainable practices are not imbibed. Agricultural land use system and intervention agencies particularly NGOs international like IITA (IITA is International institute of Tropical Agriculture located in Oyo State, Southwest, Nigeria.) enhances access to productive inputs which thus influenced non-poor status in the southern part of Nigeria. While large household sizes, land ownership structures and over reliance on government policies and intervention-program are more dominant in the Northern region. The study observed that some socio-cultural practices termed as "culture of poverty" (a set of beliefs, values, and skills that are socially generated and individually held belief) such as polygamous (ancient customs of marrying more wives and have more children by man using them for labor to work on the farm), betrothal (that is handling of widow to the next of kin/younger brother and children to be cater for), and firstborn to care/trains the siblings influences poverty. This norm is an additional burden which the man cannot reject because it is the custom. Hence, there is a need to revisit this culture of poverty and agricultural productivity, probably learnt from experience of Dutch agricultural development.

Conclusion

Land ownership inequality and landlessness are still a major source of conflict in terms of race relations and economic injustices in Nigeria. Sound land policies can facilitate growth in agricultural productivity via secure land tenure, which enhances opportunities for investment as evidenced in this study. For example, land reforms in China in 1978 dismantled collective farming and conferred land rights to households, unleashing a period of prolonged growth in agricultural productivity that transformed rural China (Calhoun and Wasserstrom, 2003; Herston, 2008; Huang, 2008). In Africa, recent massive land certification

program in Ethiopia and Rwanda have been associated with significant increases in investment in the agricultural sector. Thus, this study suggested that public policy interventions to reduce this long term poverty in the agricultural sector would have to take into account formalization of land property rights in order to facilitate its transferability.

Moreover, the issue of farm-land fragmentations and poverty has gone through a complete cycle as evidenced in this study. This thus limits the research for appropriate land use and agricultural policy and can be a focus of further research. Some of the issues might include (a) examining institutional arrangements for inspiring the development of land markets and fascinating greater long-term land investments; (b) recognizing specific educational skills and investments that make for a mobile labor force that eases structural transformation; and (c) finding the cost-effective public investments to encourage passage into relatively sparingly populated areas in a manner that is helpful of rural productivity growth. Though many of these are not new enquiries, the need to put emphasis on them is given new importance in the face of the empirical evidence presented in this study regarding the variances in access to land within the smallholder sectors in many African countries and the hitches of fostering other possibilities to encourage rural income growth.

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E-working: Country Versus Culture Dimension

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Abstract

Globalisation and increasing digitisation mean that companies must increasingly orientate themselves internationally in order to become (more) competitive or to remain competitive. Promoting e-working can revitalise rural development. The issue involved is always interaction between people from different cultures, between people who, according to their cultural backgrounds, feel, think and act differently. When cultural diversity and differences are taken into account, greater creativity, more diverse ideas and faster problem solving are achieved. The cultural dimensions, according to Geert Hofstede, offer a comprehensive model for capturing the various expressions of intercultural values. This paper examines the motives for applying e-working in selected European countries in 2018 according to Hofstede's six dimensions of national culture. Twenty-eight countries from the Eurostat database were analysed (Finland and the Netherlands were excluded, and software detected them in the e-working variable as outliers). Correlation with e-working is statistically significant at PDI (power distance index - negative: the lower the PDI index, the higher the proportion of e-working) and IVR index (indulgence versus restraint - positive: the higher the IVR index, the higher the proportion of e-working).

Keywords

E-working, country versus culture, Hofstede, six dimensions of national culture.

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Introduction

How people live, work, communicate and spend their money has changed dramatically over the centuries. Rural territories face significant challenges in a globalised world as the jobs available in traditional rural sectors are decreasing (Vitola and Baltina, 2013). Consequently, the global rural population is decreasing (WorldBank, 2018). Young, educated and qualified people are the first to leave because of the lack of challenging jobs in the rural areas (Vitola and Baltina, 2013). E-working is on an uneven, upward trend. The number of e-workers is generally increasing (IWG, 2019; Vilhelmson and Thulin, 2016) thanks to technology development and in particular high-speed broadband (Beňo, 2018a; Messenger and Gschwind, 2016), which facilitates much nine to five work to be performed remotely or away from the office. Further factors that drive e-working are long commuting times, the rise of gig-economy employment opportunities, work-life-balance demands and the spread of Covid-19. Generally, e-working makes employees happy, and satisfied employees are usually more productive (Beno and Hvorecky, 2021). In particular, two main factors are responsible: 1) the availability of digital connectivity and 2) the proportion of workers employed in industries and occupations that are amenable to remote work. Recent research reports reveal that rural countries face more challenges in building a remote workforce because they suffer from high rates of unemployment and have fewer educated workers (Gallardo and Florida, 2020).

But different working cultures also lead to different expansions of e-working. Some cultural aspects that play a role here are social behaviour (independence/teamwork), communication, interaction and openness towards new methods and models. It is generally held that people working in Nordic countries are socially more independent and have functional interaction. In Finland, flexible work has been part of the working culture for more than two decades. It is a way of working that meshes well with the deeply rooted culture of trust, equality and pragmatism in the country. In Scandinavia, there are relatively flat organisations, low hierarchies and pragmatism, which are important features for possible flexibility

(Savage, 2019). The UK is more progressive, as far as new working methods are concerned, compared to other countries. Bettina von Stamm of the London Business School states that the key to successful remote working is self-confidence, delegated authority and autonomy that are supported by the British style of management (BBC, 2000). Managers in France still give importance to the size and position of the office. There is a kind of social-space contract, which means that promotion is related to the space (Soyez, 2019). Going to work is a generalised symbol of status in the Eastern European environment. Another factor that has to be taken into account is whether the current culture of the organisation supports e-working.

Culture is a complex and broad set of relationships, values, attitudes, practices, behaviours and beliefs that bind a specific group of people. Hofstede himself provides equivocal definitions: "A collective programming of the mind which distinguishes one group from another" (Hofstede 1980); "Mental programming ... patterns of thinking and feeling and potential acting" (Hofstede, 1991). Culture is not something that is simply gained; it is a slow process of growing into a society (Alony and Jones, 2007). Research by Brennan et al. (2009) illustrates the links between local culture and community development. For example, the idea of a good work-life balance is ingrained in Finnish culture. The rural residences, to which city dwellers regularly uproot themselves to enjoy the Nordic countryside, are embedded in Finnish life (Bishop, 2020).

Geert Hofstede is one of the leading academics on culture (Søndergaard, 1994; Kirkman et al., 2006; Merkin et al., 2014; Dimitrov, 2014). Based on his analysis of the dataset, he initially distinguished four (power distance, collectivism versus individualism, femininity versus masculinity, uncertainty avoidance), later five (including long-term orientation versus short-term orientation) and finally even six (indulgence versus restraint) dimensions of cultural orientation that are different for various national cultures (Hofstede, 1980, 1991; Hofstede et al., 2010).

The main goal of this paper was to examine motives as they apply to e-working within selected European countries in 2018 and in terms of Hofstede's six dimensions of national culture. Correlations were used to find answers to the following research questions: Does diversity of national cultures affect the scope of e-working agreements? What causes a higher level of e-working in selected countries? Are there significant correlations between percentages and numbers of e-workers for PDI (power distance), IDV (collectivism versus individualism), MAS (femininity versus masculinity), UAI (uncertainty avoidance), LTOWVS (short-term/long-term orientation) and IVR (indulgence versus restraint)?

The following section briefly outlines the methodology used in this research. The third section provides an account of the e-working concept. The fourth section gives a short overview of results and closes with a discussion. The last section gives the conclusions.

Materials and methods

The descriptive statistics method was used to analyse and describe the basic features of the data in developing results and drawing conclusions, and the information processed in Table 1 was identified and summarised.

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR	e-working
Austria	11	55	79	70	60	63	10
Belgium	65	75	54	94	82	57	6.6
Bulgaria	70	30	40	85	69	16	0.3
Croatia	73	33	40	80	58	33	1.4
Czech Republic	57	58	57	74	70	29	4
Denmark	18	74	16	23	35	70	7.6
Estonia	40	60	30	60	82	16	7.6
Finland	33	63	26	59	38	57	13.3
France	68	71	43	86	63	48	6.6
Germany	35	67	66	65	83	40	5
Great Britain	35	89	66	35	51	69	4.4
Greece	60	35	57	112	45	50	2

Source: Author's own compilation (based on Eurostat, 2019 and Hofstede, 2015).

Table 1: Hofstede's dimension indexes and e-working percentage of selected countries (to be continued).

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR	e-working
Hungary	46	80	88	82	58	31	2.3
Italy	50	76	70	75	61	30	3.6
Ireland	28	70	68	35	24	65	6.2
Latvia	44	70	9	63	69	13	2.9
Lithuania	42	60	19	65	82	16	2.5
Luxembourg	40	60	50	70	64	56	11
Malta	56	59	47	96	47	66	5.8
The Netherlands	38	80	14	53	67	68	14
Norway	31	69	8	50	35	55	5.5
Poland	68	60	64	93	38	29	4.6
Portugal	63	27	31	104	28	33	6.1
Romania	90	30	42	90	52	20	0.4
Slovakia	104	52	110	51	77	28	3.6
Slovenia	71	27	19	88	49	48	6.9
Spain	57	51	42	86	48	44	4.3
Sweden	31	71	5	29	53	78	5

Source: Author's own compilation (based on Eurostat, 2019 and Hofstede, 2015).

Table 1: Hofstede's dimension indexes and e-working percentage of selected countries (continuation).

To determine the existence of dependency between e-working and individual dimensions, Pearson's correlation coefficient was applied. Three different types of correlation can be categorised, namely positive correlation, the other variable also has a tendency to increase; negative correlation, the other variable has a tendency to decrease and no correlation, the other variable does not tend to increase or decrease. Before it was applied, the normality of the data was verified by the Shapiro-Wilk test and fulfilment of the second condition, linear relation, using the regression analysis.

Using correlations, answers were sought for the research questions: Does diversity of national cultures influence the scope of e-working agreements? What causes a higher level of e-working in selected countries? Are there significant correlations between percentages and numbers of e-workers for PDI (power distance), IDV (collectivism versus individualism), MAS (femininity versus masculinity), UAI (uncertainty avoidance), LTOWVS (short-term/long-term orientation) and IVR (indulgence versus restraint)?

The meaning of e-working

"Flexible working arrangements" or "e-working" are replacing a range of different terms, such as "teleworking", "telecommuting", "networking", "digital nomad" and "flexi space", which seek to describe the ways in which new information and communication technologies have made it possible for information-processing work to be carried out at a distance (Bates et al., 2002). The classic definition of teleworking is outdated (Beno, 2018b). Currently, there is no international statistical definition.

Basically, e-work means the utilisation of ICT (Information and Communication Technology) rather than commuting to work (Beňo and Ferenčíková, 2019). Also, e-work is a method of working using ICT in which the work is not bound to any particular location. Traditionally this has been understood as working remotely from the office, usually from home, whether full-time or for a part of the working week (WDC, 2017). E-working is where employees work at home full-time/part-time, on a hybrid basis or at a different place or virtually. This kind of work involves logging into a work computer remotely (using a virtual private network, e.g. Cisco, Barracuda), sending and receiving email, data and files remotely and developing ideas, products and services, as well as learning remotely and performing other remote business activities. To conclude, e-working is a practical approach to accomplish business objectives. This kind of work allows organisations in the private and public sectors to operate remotely, while employees are absent from their physical workspaces.

The father of e-working is considered to be Jack Nilles (Beno, 2018b). ICT plays an essential role in the spread of work and e-working. The Dunn (2009a, 2009b) and Frempong (2009) studies used

telework as an example of what can be achieved by mobile phone technology innovations. A similar study is by Plauché and Prabaker (2006) on a speech-driven agricultural query system. Though not mobile technology based, it showed how queries can be sent to remote systems, hence proving that it is possible to innovate by using telephones for remote-related actions even with low-literacy levels. ICT allow us to connect not only physically but also virtually. Thus ICT can serve as an important tool to overcome the distance in rural areas and to take full advantage of its resources and further possibilities. The Covid-19 pandemic creates an e-working tipping point. E-working helped to sustain economic activity. Millions of people around the world must now work from home. Obviously, there is no consensus in economics literature about the impact on productivity while working remotely. Beno and Hvorecky (2021) indicate that a workforce that does not feel comfortable with e-work tends to be less productive. Managers face an increasing need for solutions to maximise online technologies to support employee satisfaction.

Computer and communications technology may make it possible for more jobs to be performed remotely (Olson, 1983). Through various technological advancements, e-working facilitates a flexible workplace in which the workforce has options about the structure of its work time (Pearce, 2009). In a remote work environment, various primary instruments (from emailing to face-to-face meetings and video conferences) are used (Kirkman and Mathieu, 2005; Mihhailova et al., 2009). Emailing is viewed as an analytic task approach. Additionally, desktop video-conferencing, collaborative software and Internet/intranet systems evolved into fundamental infrastructure for the modern workplace environment (Becke et al., 2001). Karpova et al. (2009) suggested that synchronous media such as videoconferencing are suitable for stating problems and giving crucial decisions, whereas others such as collaborative document management tools (e.g. Google Docs) are more suited to tasks such as information flow and the organising of tasks across the team. Conference tools (such as instant messaging, audio-/videoconferencing) aid e-workers' collabration and the exchange of ideas and information in person (Karoui et al., 2010). Connectivity, IT infrastructure and communcation tools were identified as the most important aids for remote work (PWC, 2020). To improve communication within the team (on-site or remote), the utilisation of online collaboration tools should be considered (Ye, 2012). The effectiveness of a collaboration tool relies on whether the tool is relevant to the stage of collaboration (Kalika and Jawadi, 2008). Furthermore, computer-mediated communcation has become mainstream in work life (Derks and Bakker, 2010).

Being away from the office in a hybrid setting that means a change of place, country and approach with employees working entirely in a cubicle and/or remotely or in a comfortable setting (at home, or mobile) has benefits (saving time and money, flexibility and autonomy, productivity, less commuting, fewer distractions, work-life-balance and many others) and limitations (difficulty in separating home and work life, domestic distractions and interruptions, feelings of isolation and loneliness, workaholism, etc.). E-working has the following positive and negative impacts: economic, environmental, personal and social - the so-called triple-win option (Beňo, 2021a) for employers, employees and society (Beňo and Ferenčíková, 2019).

Brette and Moriset (2009) emphasise that today's economy is subject to a tension between centrifugal and centripetal forces, the outcome of which is uncertain. As e-working continues to accelerate, there are a number of likely implications, challenges and opportunities that arise in the Covid-19 crisis. We are of the opinion that e-working has created new opportunities for rural development, as stated in a recent study on housing (Beno, 2021b). According to the latest data, interest in rural areas and small towns increased during the coronavirus outbreak (Redfin, 2020). Further, e-working can reverse the rural brain drain (Sisson, 2019). The digital economy offers home-based micro-businesses in rural areas many advantages, but stubborn social, economic and territorial digital divides continue to create challenges for this sector of the rural economy (Philip and Williams, 2019). As mentioned before, there are potential direct and indirect benefits and risks. However, the paradox of e-working is that it includes the implication of investment in ICT, which tends to be located in large urban centres. This can prove challenging for rural communities that are struggling with declining populations and rising unemployment. E-working has been seen as a potential solution for rural development, but it remains a privileged urban and suburban phenomenon. This is confirmed by Davies's (2021) statement that for some rural areas and populations, the urban-rural digital divide persists as a barrier to participation in ICT-supported remote working.

Results and discussion

A very effective method for analysis of relations between dimensions and e-working is multiple regression. The quality of the model is high, and the determination index takes the values close to 1, as seen in Table 2.

Model Summary				
Model	**R**	R Square[b]	Adjusted R Square	Std. Error of the Estimate
1	**.932**[a]	.869	.830	2.273

Note: a... Predictors: ivr, pdi, mas, ltowvs, uai, idv
b.. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.
Source: Author's own compilation.

Table 2: Model summary.

The overall test of the model is also very significant ($p < 0.05$), see Table 3.

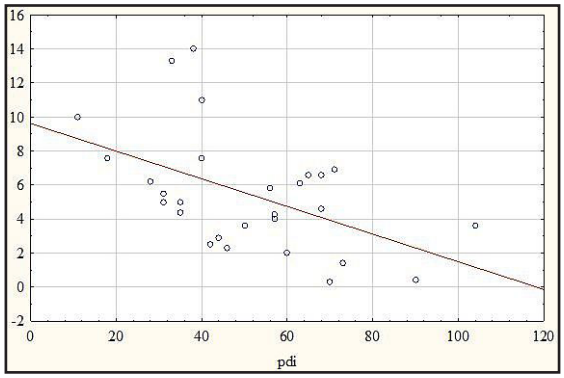
ANOVA[a,b]					
Model	Sum of Squares	df	Mean Square	F	**Sig.**
1 Regression	684.549	6	114.092	22.083	**.000**[c]
Residual	103.331	20	5.167		
Total	787.880[d]	26			

Note: a... Dependent variable: e-working
b... Linear regression through the origin
c... Predictors: ivr, pdi, mas, ltowvs, uai, idv
d... This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
Source: Author's own compilation

Table 3: ANOVA.

The results of the tests of individual indicators are presented in Table 4, which shows the dependency of measurement between e-working and selected dimensions. The correlation with e-working is statistically significant at the **PDI** and **IVR** indices. With the PDI index, the correlation is negative, i.e. the lower the PDI index, the higher the proportion of e-working. With the IVR index, the correlation is positive, i.e. the higher the IVE index, the higher the proportion of e-working.

The analysis results imply (correlation coefficient **– 0.439 PDI**) that countries with low power (distance) have a higher proportion of e-working. This indicates that if the extent of power in the national culture is higher, the proportion of e-working drops, as can be seen in Figure 1, where the downward trend can be seen when PDI increases.



Source: Author's own compilation

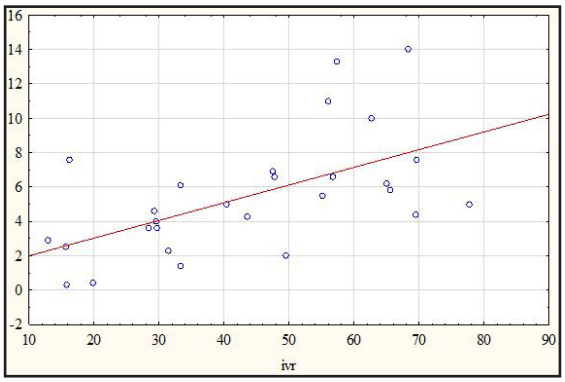
Figure 1: Scatterplot of e-working against PDI.

Correlation coefficient **0.696 IVR** (see Figure 2) indicates positive dependency between e-working and the importance of happiness, and the control over life, thus Work-Life balance.

Coefficients[a,b]								
Model		Unstandardised Coefficients		Standardised Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	**pdi**	**-.043**	**.027**	**-.439**	**-1.591**	**.127**	.086	11.590
	idv	-.005	.031	-.057	-.170	.867	.058	17.324
	mas	.002	.019	.017	.092	.928	.192	5.198
	uai	.021	.022	.291	.986	.336	.075	13.296
	ltowvs	.040	.029	.428	1.343	.194	.065	15.451
	ivr	**.083**	**.026**	**.696**	**3.138**	**.005**	.133	7.506

Note: a... Dependent variable: e-working %
b... Linear regression through the origin
Source: Author's own compilation

Table 4: Coefficients.

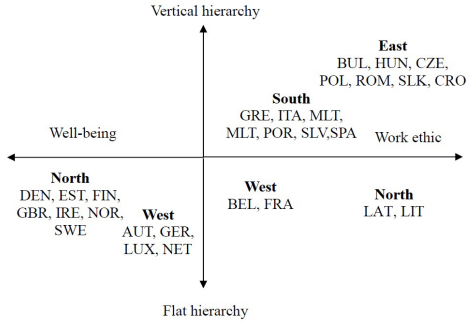


Source: Author's own compilation

Figure 2: Scatterplot of e-working against IVR.

Countries with a high value for individual property (high IVR value) allow their population to meet their basic needs and demands without obstacles (valuing of leisure time, friends, family). On the contrary, with a low index, the degree of dominance increases; people suppress their needs, and complying with strict social standards (leisure time, friends) is of less importance. In simple terms, a high IVR means a higher proportion of e-working, a lower IVR means a low proportion of e-working.

The diversity of cultures in Eastern and Western Europe is a much analysed topic. There are several complex descriptive cultural models (Hofstede, 1980, 1993; Trompenaars, 1993) and theories of cultural standards (Thomas, 1993) that describe intercultural differences between the East and West of Europe in an economic context. Based on the results of correlation, the author tried to summarise the relative positions of world cultures of the countries divided according to cardinal directions (E, W, N and S), together with cultural dimensions. This was done in two graphs of intersection axes that form quadrants. The author located the names so that their dimensional coordinates were taken into account. Figure 3 shows the intersection of the dimensions of flat and vertical hierarchies versus well-being and work ethic.



Source: Author's own compilation

Figure 3: Authority versus WLB.

It is interesting to note how countries can rework their work space according to the values of hierarchy and by behaviour, cooperation and mobility. When determining the distance between employees and managers in or outside the office, it can be seen how in Austria hierarchy operates in the same space as employees where the input space of cooperation and the probability of the director moving into such space are accessible. This model would change completely when the working trends of the V4 countries are monitored. The collaborative spaces should then be located prudently so that cooperation is strengthened. In the end, it seems that the current trend focuses on workers' flexibility. It should be noted that e-working is still of great potential in Austria where mobility seems to be accepted. On the contrary, in the V4 countries employees are expected to behave seriously when performing work.

Another feature that influences different proportions of e-working among the monitored countries is well-being, which is also related to the ecological factor. It is generally known that Austria is a pioneer in environmental protection compared to the V4 countries.

This analysis also implies that countries with Germanic languages (Austria, Germany, Great Britain, Ireland, the Netherlands, Sweden, Denmark, Norway, but not Malta, (index 56)) have low indices with a high proportion of e-working compared to countries with Romance languages (France, Portugal, Spain, Italy, Romania) that have medium to high indices, and therefore a medium to low proportion of e-working. Then come countries with mixed Germanic-Romance languages – Belgium, with a higher index and a lower proportion of e-working, and Luxembourg, with a lower index and a high proportion of e-working. The countries with Slavic languages, namely West Slavic (Czech Republic, Slovakia, Poland) and South Slavic (Croatia, Slovenia and Bulgaria) have high indices and thus a lower proportion of e-working. These are followed by the countries with Finno-Ugric languages (Hungary and Estonia) with medium values, where Hungary has a lower proportion of e-working compared to Estonia, due to the technological advancement of the country.

Another possible factor that influences the proportion of e-working in a country is climate (climate change), because a warm climate could encourage more lethargy than temperate and cold climates. Therefore productivity also decreases, and vice versa (Muszynski and Berry, n.d.; Thorpe, 2020). This is connected with the division of economy. People in lower latitudes are more

dedicated to agricultural or other manual activities than in higher latitudes, where there is less affinity between humans and nature.

As mentioned, the ecological factor together with well-being plays an important role in countries when compared with the proportion of e-working. The basic types of European social model, namely Anglo-Saxon –indicated as liberal (Ireland, Great Britain), continental – indicated as conservative (Germany, France, Austria, Belgium, Luxembourg), Nordic – indicated as social-democratic (Denmark, Finland, Sweden, the Netherlands) and Mediterranean – indicated as a combination of three models (Greece, Italy, Spain, Portugal), can be considered the next factor influencing a higher proportion of this form of work. In connection with EU enlargement, the central (V4) state types – closer to the continental type - and the East European (Baltic) type - where the features of a liberal model prevail - are developed (Alber and Gilbert, 2010; Sapir, 2006).

In key texts by Toffler (1984) and Handy (1984), it is assumed that work from home would be a phenomenon of the future. It seems, however, that their prognosis was far from the reality, as far as its implementation is concerned. Development has not met the expectations globally, nor regionally, as in the case of the countries studied. The V4 countries are actually behind the average of utilisation of this form of work. Theoretically, a large number of persons at many workplaces could basically be allowed to be e-working. In the 1980s, Olson and Primps (1984) suggested that more than 50 % of office work could be done from home, and Steinle (1988) argued that two thirds of job positions could be suitable for e-working for certain persons and employers. Will rural areas necessarily become "remnants of the past inhabited by non-talented losers only" or "will the opportunities provided by the ICT and the changes in the content of occupational duties provide the rural inhabitants an opportunity to be involved in the knowledge economy, which is traditionally linked to metropolitan areas, distantly?" (Nuur and Laestadius 2009; Adamsone et al., 2013). But Covid-19 changed everything. The future of work is suddenly here. Today's office is global and virtual. This pandemic creates an e-working tipping point. Millions of people around the world must now work from home.

However, the Covid-19 outbreak has undermined the way of work with travel restrictions, limitation of the size of meetings, social contacts and self-isolation of workers after return from affected regions. The coronavirus led to the urgent need for the implementation of e-working, increase of digitising, investments in new technologies, more flexibility not only at work, better quality virtual meetings and discussions on business ethics because the demand for e-working would increase in the long term, even after this pandemic. Will Covid-19 change the way we work? Such progress will occur only if societies are able to execute the required complex labour policies, particularly in the period after the pandemic. There are still work activities and tasks that are best suited for personal interaction, and also some workers simply prefer this. However, it will be disappointing if employers and managers do not continue with this change in the workplace after the crisis ends. Covid-19 prompted the largest e-working experiment ever; it has accelerated the future of work and will influence the way we think of work in the years to come. The worst thing society can do would be to ignore what has been learned about the workforce and how workers like to function.

Peters and den Dulk (2003) assumed that the willingness to implement remote work could differ depending on the culture and could be connected with the avoidance of power and ambiguities, which are two cultural dimensions identified by Hofstede as influencing working behaviour. The author agrees with these views on the distribution of power within society and the implementation of e-working, but, based on the findings of this paper, the second dimension is the IVR (Indulgence Versus Restraint) dimension that evaluates the freedom with which people can meet their basic needs and desires for the enjoyment of life.

Conclusion

The level of e-working is hard to measure, partly because of limited official statistics and because the practice is sometimes carried out at the discretion of local management in the absence of company policy. Furthermore, there is no international statistical definition, often no official e-working policy, and it is a widespread practice operated by employers, usually as part of flexible work policies. However, it is also clear that e-working is a growing phenomenon largely driven by technological change, work demands, the wish to decrease commuting time and the need to maintain WLB and halt the spread of Covid-19. To realise the benefits on a wider scale, to the individual, the employer, the economy and society as a whole, some actions can

be undertaken to support a greater take-up of e-working.

Cultural differences are a big challenge in the work process globally. People all work differently, and professional expectations as well as cultural values have a significant impact on how workspaces are designed. This analysis dealt with e-working related to cultural values. The overall analysis implies that cultural differences should be taken into account in the implementation of e-working. It should be emphasised that other factors such as tolerance, population density and technological skills must also be considered. In addition to this assessment, it was confirmed that the most important values were separation of private and professional lives (WLB), well-being and the way individuals cooperate on the basis of the importance of hierarchy.

Twenty-eight different cultures with six dimensions were studied in relation to e-working. It is clear that hierarchy is considered culturally less important, and it can be argued that cooperation and support of e-working and well-being are the optimum solution.

According to the World Economic Forum's 2018 report on global competitiveness, the flattest hierarchy in the world, in terms of the index of its willingness to delegate authority, is Denmark. It is followed by Sweden, Norway in 3rd place, Finland in 4th place and the Netherlands 6th. In Austria, hierarchy is also important (19th place) compared to the V4 countries – Czech Republic (27), Slovakia (59), Poland (84) and Hungary in 88th place (Schwab, 2018).

People in all the studied cultures could work in different ecosystems: in the office, outside the office, virtually or manually, and in other locations. This applies particularly in Nordic and Western countries, where work can be in a different position compared to other monitored cultures that clearly create boundaries between office hours and personal time. In countries where the culture of management is based on control rather than on trust, e.g. France, Spain, Italy, Greece and in the former Eastern Bloc, it seems more logical to manage employees' productivity in offices. This is an interesting finding when one realises that Spain is the fifth most cooperative space per inhabitant and France is the 9th (Coop, 2016). Trust leads to cooperation, which means countries that have management based on trust are more willing to attract cooperation, e.g. Norway, Finland, Great Britain, Sweden, Luxembourg, Germany, Denmark, Estonia and Belgium (Coop, 2016).

The results of a happy community with an evaluation of happiness (evaluation of life, positive and negative influence in 2016 – 2018) that also has a great influence on the proportion of e-working are interesting too. Finland is ranked top, Denmark in 2nd place, the Netherlands 5th, Norway 6th, Sweden 7th and Austria 10th. The V4 countries are: Czech Republic 20th, Slovakia in 38th place, Poland 40th and Hungary in 62nd place (Helliwell et al., 2019). An assessment of OECD countries in terms of WLB (how much do you work?, how much do you play?) has confirmed the results of this analysis: The Nordic countries where e-working has more support have higher values. An interesting finding was that countries such as Italy (9.4%), Spain (8.8%), Lithuania (8.3%), Hungary (8.0%), Slovakia (7.9%) and the Czech Republic (7.6%) with their lower proportion of e-working show higher values of WLB interest. Austria and Poland have an equal value of 6.8% (OECD, n.d.). This implies that these countries are not making use of the basic information on the advantages of this form of work, from an educational sphere to a practical sphere. The hierarchy of organisations, which is connected with trust within the society and subsequent cooperation, needs to be adjusted. Population ageing, climate change, pandemics, the generation gap and attributes in life will also have a significant impact on the development. Therefore rural development policies that support e-working could be helpful to sustain highly skilled employees outside urban and suburban areas and increase economic, social and cultural activities. Salemink et al. (2015) highlight that rural communities are most in need of improved digital connectivity to compensate for their remoteness. Gallup Poll discovered that many urban residents would like to make a move to rural America: 27% said a rural area would be their ideal community, while only 12% responded that they prefer a big city. The remaining 39% would choose a town, a small city or a suburb of a small city (Newport, 2018).

To achieve sustainability, rural development requires e-working models that are designed in and for local needs. If we want to work successfully with people from other cultures, we have to consider the specifics of the different cultures and develop a shared understanding of the common task and of working together. There is no one-size-fits-all model that can be used always and everywhere. Every case and every team constellation is unique and must be treated as such.

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Modifiable Areal Unit Problem (MAUP): Analysis of Agriculture of the State of Paraná-Brazil

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Abstract

The way the researcher groups his research data will influence the result of his work. In the literature, this phenomenon is treated as a Problem of the Modifiable Areal Unit. The objective of this article was to analyze the three spatial levels by Municipalities, Regional Centers and Mesoregions using the following data: gross domestic product, effective agricultural production, grain production and gross value of agricultural production for the state of Paraná-Brazil in the period since 2012 until 2015. The methodological procedure studied data from the Paranaense Institute for Economic and Social Development of the above-named variables collected on the website of the Paranaense Institute for Economic and Social Development of the 399 municipalities, 23 regional centers and 10 mesoregions. The results found show the presence of the Modifiable Areal Unit Problem, presenting different results for each level of grouping. The study revealed the problem of the modifiable areal unit is a relevant occurrence and it should be disregarded by researchers who work with clusters of spatial data in their studies. The results found allow a better understanding of the scale effect and demonstrate the efficiency of spatial analysis in socioeconomic data.

Keywords

Aggregation, agribusiness, autocorrelation, scale effect, spatial process, decision making

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Introduction

Following the development of science, new challenges are imposed on researchers, once new problems arise, consequently, new resolutions are proposed, according to Kupriyanova et al. (2019). Surveys work with different spatial boundaries for the analysis of the most varied themes, in which the relationship between time and space is analyzed, the size of the clusters changes and the phenomenon entitled Modifiable Areal Unit Problem (MAUP) can present different results according to the spatial boundaries are changed. Observation and evaluation of the effects of the Modifiable Areal Unit Problem become a relevant issue in the modeling, because if the appropriate levels of geographic scale and zone configuration are not defined and identified; statistical models based on spatial data can induce the misleading conclusions.

Thus, considering the same population under study, the spatial definition of its borders affects the results will be obtained. The estimations obtained within a system of area units are directly related to different ways in which they can be grouped and consequently different results can be obtained by simply alteration of the boundaries established (Janelle et al., 2004; Wei et al., 2017; Duque et al., 2018; Didier and Louvet, 2019).

Some studies, already carried out, realized the importance of MAUP in spatial data (Lee et al., 2015; Cabrera-Barona et al., 2018; Pietrzak, 2019). Investigating the effect of MAUP aims to study various sizes of spatial resolutions that can lead researchers to determine the most appropriate scale to be used for analysis purposes, Wei et al. (2017) report that the effects of MAUP can be completed through statistical results.

Chaves et al. (2018) report that the problem modifiable areal unit can alter the support of soybean cultivation, inform that is not possible to cultivate soybean and other crops in the same environment simultaneously, highlight that MAUP is related to two specific problems, namely:

the scale effect and zoning effect, economically this result may compromise the planning of soybean productivity.

Lee et al. (2018) in their studies found that the problem of the modifiable areal unit has a clear and evident scale effect for the uncertainties surrounding its relations with spatial autocorrelation, identified in their experiments with simulation, that in an initial level, autocorrelation spatial plays an important role in the nature and extent of the effects of MAUP.

According to the United Nations Program for Sustainable Development - UNDP (2020) suggest that researchers should work with disaggregated data in economic analyzes according to the 2030 Agenda that addresses the Sustainable Development Goals (SDGs).

Salmivaara (2015), Santo et al. (2015), Cabrera-Barona et al. (2016) and Burdziej (2019) studied and evaluated the scale effect (MAUP) at different levels of spatial units. Recent studies consider the scale effect in decision-making (Xu et al., 2018; Tunson et al., 2019).

Anselin (2018) presents Geary's global univariate index (c) and Geary's local (c_i) to study the spatial autocorrelation of quantitative characteristics considering the location of the data. Spatial regression models, such as spatial autoregressive (SAR), conditional autoregressive (CAR) and geographically weighted spatial model (GWR), are established to study the relationship of an interested variable to its covariables and considering the location of the data and from your close neighbors. (Anselin and Bel, 2013; Araújo et al., 2014; Meyappan et al., 2014; Javi et al., 2015; Zou and Wu, 2017). The SAR and CAR models are considered global models; their results are valid for the entire study area, whereas the GWR explores local variations and estimates the regression coefficients at the local level. The spatial regression methods allow taking into account the dependence between the sample elements collected in regions considering the location of the data (Lesage, 2015; Duan et al., 2015).

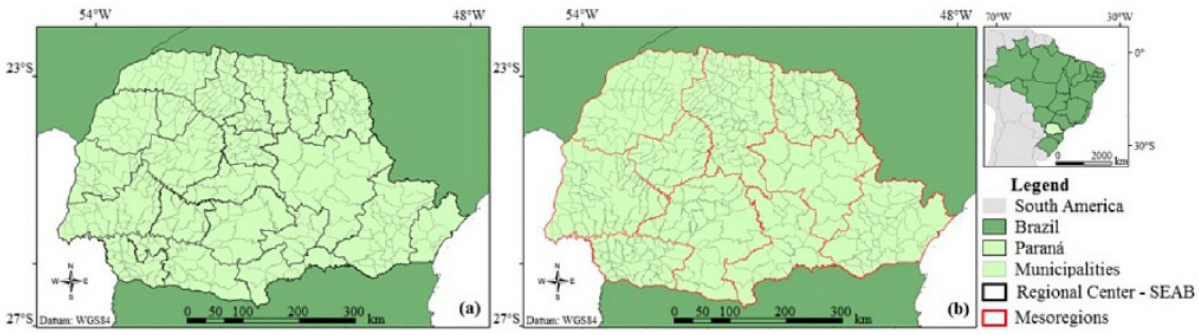
This article presents a study of MAUP from a database of the gross domestic product, effective of agricultural production, total grain production and gross value of agricultural production, obtained through the Paranaense Institute of Economic and Social Development (IPARDES) in the years 2012 to 2015. The analysis focused on three levels: Municipalities, Regional Centers and Mesoregions. The objective of this study was to analyze the MAUP, in the state of Paraná-Brazil, using different spatial resolutions and to show the extent to which the different scale effects can directly reflect in the decision making of regional analyzes of public and private institutions in the agribusiness economics.

Materials and methods

The study area comprises 399 municipalities, 23 regional development centers (Figure 1a) and 10 mesoregions (Figure 1b) in the state of Paraná. Socioeconomic data from the years 2012 to 2015 and the variables were used: gross domestic product [R$], effective agricultural production [quantity/unit], gross value of agricultural production [R$], Total grain production (soybeans, corn 1st harvest, corn 2nd harvests, and wheat) [t].

For the analysis of spatial autocorrelation, the hypothesis test was used by means of the $Z(c)$ pseudo-significance statistic (Almeida, 2012).

Exploratory Spatial Data Analysis was applied to this database to identify its global spatial associations and clusters. Then, the spatial regression models SAR, CAR and GWR were



Source: Adapted from SEAB-DERAL (2015)

Figure 1: Delimitation of study area (Figure 1a and Figure 1b).

applied to verify which model best explains the gross value of agricultural production (V_{pb}). For the analysis of spatial autocorrelation, the global Geary index (c) (Equation 1) was used, which allows the assessment of global autocorrelation.

The Geary global index (c) assumes the spatial autocorrelation depends on the distance between two or more observations, assumes the values between 0 and 2 (ANSELIN, 2018), and if $c = 0$, it indicates direct positive spatial autocorrelation; if $c = 1$, it indicates absence of autocorrelation and if $c > 1$, it indicates negative spatial autocorrelation (Anselin, 2018).

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

on what,

n: number of spatial units (areas);

x_i and x_j: values of attribute X considered in regions i and j;

$\bar{x}$: average value of attribute X in the studied region;

w_{ij}: element of the normalized neighborhood matrix, corresponding to the spatial weights 0 and 1, being 0 for areas i and j that do not border between themselves and 1 for areas i and j that border between each other. In this work, the Queen Contiguity criteria (Anselin, 2018) was used.

Considering the following hypothesis test H_0: There is no association between the observed value in a region and the observed value in nearby regions, c values are close to 1; versus H_1: There is an association between nearby regions, c values are close to 0. In order to verify the significance of the global Geary index (c), if there is no association between the value observed in a region and the value observed in nearby regions, it is done through the pseudo-significance statistic $Z(c)$ (Equation 2) (Anselin, 2018).

$$Z(c) = \frac{[c - E(c)]}{Sd(c)}, \quad (2)$$

where, $E(c)$ is the expected value of the Geary global index (c); $Sd(c)$ is the standard deviation of Geary's global index (c). About H_0, the $Z(c)$ statistic has a standard normal distribution with mean 0 and variance 1 (Almeida, 2012).

Geary's local autocorrelation index (c_i) (Equation 3), which measures the degree of spatial correlation at each specific location (Anselin, 2018). The local statistic c_i is an indicator of spatial association called LISA because it satisfies two requirements, namely: the ability for each observation to signal statistically significant spatial clusters, and the property that the sum of c_i for all regions is proportional to the indicator of global spatial autocorrelation c by Geary (Anselin, 2018).

$$c_i = \sum_{j=1}^{n} w_{ij}\,(x_i - x_j)^2, \quad (3)$$

The linear spatial models SAR, CAR and GWR estimated by maximum likelihood for gross value of agricultural production (V_{pb}) as a function of the total quantity of bovine production (*QTbovine*), total quantity of pig production (*QTpig*), total quantity of production of poultry (*QTpoultry*) and total amount of grain production (*Totgrain*) are presented in Equations (4), (5) and (6), respectively:

$$\widehat{V_{pb}} = \widehat{\beta_0} + \widehat{\beta_l} QTbovine + \widehat{\beta_2} QTpig + \widehat{\beta_3}\, QTpoultry + \widehat{\beta_4}\, Totgrain + \hat{\rho}\, \mathbb{W}V_{bp}, \quad (4)$$

$$\widehat{V_{pb}} = \widehat{\beta_0} + \widehat{\beta_l} QTbovine + \widehat{\beta_2} QTpig + \widehat{\beta_3}\, QTpoultry + \widehat{\beta_4}\, Totgrain + \hat{\lambda}\, W_{\varepsilon}, \quad (5)$$

$$\widehat{V_{pb}} = \widehat{\beta_0}(u_i, v_i) + \widehat{\beta_l}(u_i, v_i) QTbovine + \widehat{\beta_2}(u_i, v_i) QTpig + \widehat{\beta_3}(u_i, v_i) QTpoultry + \widehat{\beta_4}(u_i, v_i) Totgrain, \quad (6)$$

$\hat{\beta}_y$: estimated parameters of each model (SAR, CAR and GWR), y = 0,…, 4;

WV_{pb}: expresses the weighted spatial dependence with weight allocation of the spatial neighborhood;

$\hat{\rho}$: estimated autoregressive spatial coefficient;

$\hat{\lambda}$: estimated autoregressive coefficient;

W_{ε}: error component with spatial effects,

$(u_i,\ v_i)$: denotes the coordinates of the centroid of the i-th area, i = 1, ..., 399;

$\widehat{\beta_y}(u_i, v_i), y = 0, \ldots, 4$: realization of the continuous function $\widehat{\beta_y}(u, v)$ on the ketoid of the i-th area, i = 1,…, 399 (Fotheringhan et al., 2002).

Lopes et al. (2014) employed, in the comparison of the SAR, CAR and GWR models, the highest value of maximum likelihood logarithm (MLL), which represents the best fit to the observed data. The Akaike Information Criterion (AIC) and the Baysian Criterion (BIC) were also used in this study, considering the best model is which has the lowest value of AIC and BIC (SPRING, 2003).

The data analysis was performed with the aid of free software R (R Core Team, 2018). The following packages were used: GISTools, Spdep, Spgwr, Rgeos and Nortest.

Results and discussion

On Table 1, they are presented Geary global spatial autocorrelation indexes (*c*) and Z(*c*) significance tests, for Gross Domestic Product (GDP), bovine production, Pig production, Poultry production, Production of milk, Gross value of agricultural production, Grain production for the municipalities belong to Paraná state (Brazil).

It is possible to check in the 2012's GDP, Geary's global spatial autocorrelation index was not significant, realized the absence of spatial autocorrelation.This result is justified according as inform IBGE (2012) this period there were climatic problems such as the drought in the first half, affecting crops and the retraction of factory production in the state of Paraná-Brazil. For 2013, 2014 and 2015, there are some significant positive spatial autocorrelation of the GDP.

There was a significant positive spatial autocorrelation for all variables studied. This behavior shows that in the Paraná state, there are municipalities with high and /or low livestock production, total grain production and gross value of agricultural production surrounded by municipalities that have similar characteristics, with the mean spatial autocorrelation being $\overline{c} = 0.5016$. (Table 1).

Economically it is observed through the results found, specifically for the production of milk and production of poultry, values close to zero, which implies that municipalities economically with high and or low production of these commodities are surrounded by neighbors also with high and or low productions, this information is economically very necessary and important because it allows showing the reality of the economic and agricultural scenario of these locations, thus highlighting their productive and economic potential.

With this information, it is possible to develop public policies in municipalities with disparate results and in municipalities with low productivity detect problems and improve production. The information can thus subsidize state agricultural policies in the municipalities with the greatest difficulties, in the case of milk there is a very high contingent of family farmers.The global Geary index (*c*) for each year studied by the Regional Centers (Table 2) indicated positive spatial autocorrelation of 5% significance for the production of bovine, pig and poultry, and gross value of agricultural production.

However, in the product gross domestic product and in the total production of grains (soybeans, corn 1st and 2nd harvest and wheat) there were no significant spatial autocorrelation because the indices were close to one, presenting the data are randomly distributed over the analyzed years.

From this point, the presence of the problem of the modifiable areal unit (MAUP) begins to be perceived in which by changing the spatial level of area, different statistical results are obtained (Table 2). Jiawei et al., (2020) comment that the spatial scale is also a major concern in the research on grain production and so, as you highlight Chen (2018),when choosing analytical units to quantify regional economic structure for a specific study, future research should pay attention to scale-related problems.

Comparing the spatial level of the regional centers and the spatial level of the municipalities, through Geary's global analysis (*c*) the results show the presence of a MAUP effect in the Gross Domestic Product and in the Total grain production, as it is possible to check in the Tables (1) and (2).

Variables	2012	2013	2014	2015
GDP	0.928^{Ns}	0.794*	0.790*	0.827*
Bovine production	0.525*	0.522*	0.510*	0.509*
Pig production	0.421*	0.421*	0.402*	0.412*
Poultry production	0.590*	0.592*	0.629*	0.613*
Milk Production	0.397*	0.395*	0.369*	0.361*
Gross value of agricultural production	.	0.668*	0.621*	0.674*
Grain production	0.408*	0.410*	0.403*	0.456*

Note: Ns - not significant values; * statistically significant at the level of 5% probability; . - absence of information in the official database.

Source: own calculations

Table 1: Global Geary Index (*c*) of gross domestic product (GDP), actual agricultural production (bovine, pig, poultry, milk), gross value of agricultural production and total grain production (soybeans, corn 1st and 2nd harvest) and wheat) since 2012 until 2015 of the three hundred and ninety-nine municipalities in Paraná-Brazil.

Variables	2012	2013	2014	2015
GDP	0.900^{Ns}	0.920^{Ns}	0.895^{Ns}	0.954^{Ns}
Bovine production	0.514*	0.515*	0.541*	0.536*
Pig production	0.557*	0.557*	0.560*	0.572*
Poultry production	0.610*	0.611*	0.561*	0.548*
Milk Production	0.418*	0.415*	0.405*	0.391*
Gross value of agricultural production	.	0.751*	0.683*	0.701*
Grain production	0.850^{Ns}	0.868^{Ns}	0.900^{Ns}	0.861^{Ns}

Note: Ns - not significant values; * statistically significant at the level of 5% probability; . - absence of information in the official database.
Source: own calculations

Table 2: Global Geary Index (*c*) of gross domestic product (GDP), effective agricultural production (bovine, pig, poultry, milk), gross value of agricultural production and total grain production (soybeans, corn 1st and 2nd harvest) and wheat) from the years 2012 to 2015 of the twenty-three regional centers of SEAB-Paraná-Brazil.

Therefore, it shows the problem of the modifiable areal unit can reflect negatively on the decision-making process of public and private agencies (Table 2).

In the Table 3, the global index of Geary (*c*) by Mesoregions belonging to Paraná state demonstrates the presence of MAUP, because all indexes c presented values close to 1, a value indicative of a random spatial pattern, a fact corroborated by the test of pseudo-significance Z(*c*), which indicates absence of significant spatial autocorrelation.

In the analysis of Geary's global autocorrelation (*c*) for the Mesoregions of Paraná, Table (3) shows a high effect of the Modified Areal Unit Problem (MAUP) in all studied variables, it means that the statistical results found were quite different from those found in municipalities and regional centers. All values of the Geary index (*c*) which were close to 1 characterized absence of spatial autocorrelation.

This spatial behavior shows how serious the Modifiable Area Unit Problem (size of the spatial resolution) is, considering the same study population. Comparing the three studied spatial levels (municipalities, regional centers and mesoregions) (Table 1, Table 2 and Table 3), it is required the decision-making process must respect to the different results found and the decision should be made cautiously, in the sense order to better understand the different results of the spatial levels analyzed associated with the real study scenario. Considering the same population of studies, the different scales tested must be consistently evaluated, begin that many studies point to the use of disaggregated data. It is suggested non-generalization of the facts, it means, they all share a similar characteristic.

The Modified Areal Unit Problem in the three verified spatial levels had a relevant presence, mainly in the regional centers and mesoregions when compared to municipalities, evidences of it were the values analyzed in the mesoregions where were not significant for any variable studied (Table 3).

These results showed the importance of the MAUP study in the decision-making process and it suggests how necessary is consider the possibility of individual differences between the analyzed variables and the individual difference cannot be generalized, which is corroborated by Burdziej (2019).

Geary's local autocorrelation indexes (c_i) are presented using the LISA Cluster Map for poultry production from 2013 to 2015 by municipality, in Figure 2. The result shows spatial grouping of points in the studied regions, namely: West, Southwest, Central South and part of the North Central region, suggesting significant positive spatial autocorrelation, having regions with high or low production of birds surrounded by regions with similar characteristics (dark red color and pink color in Figure 2).

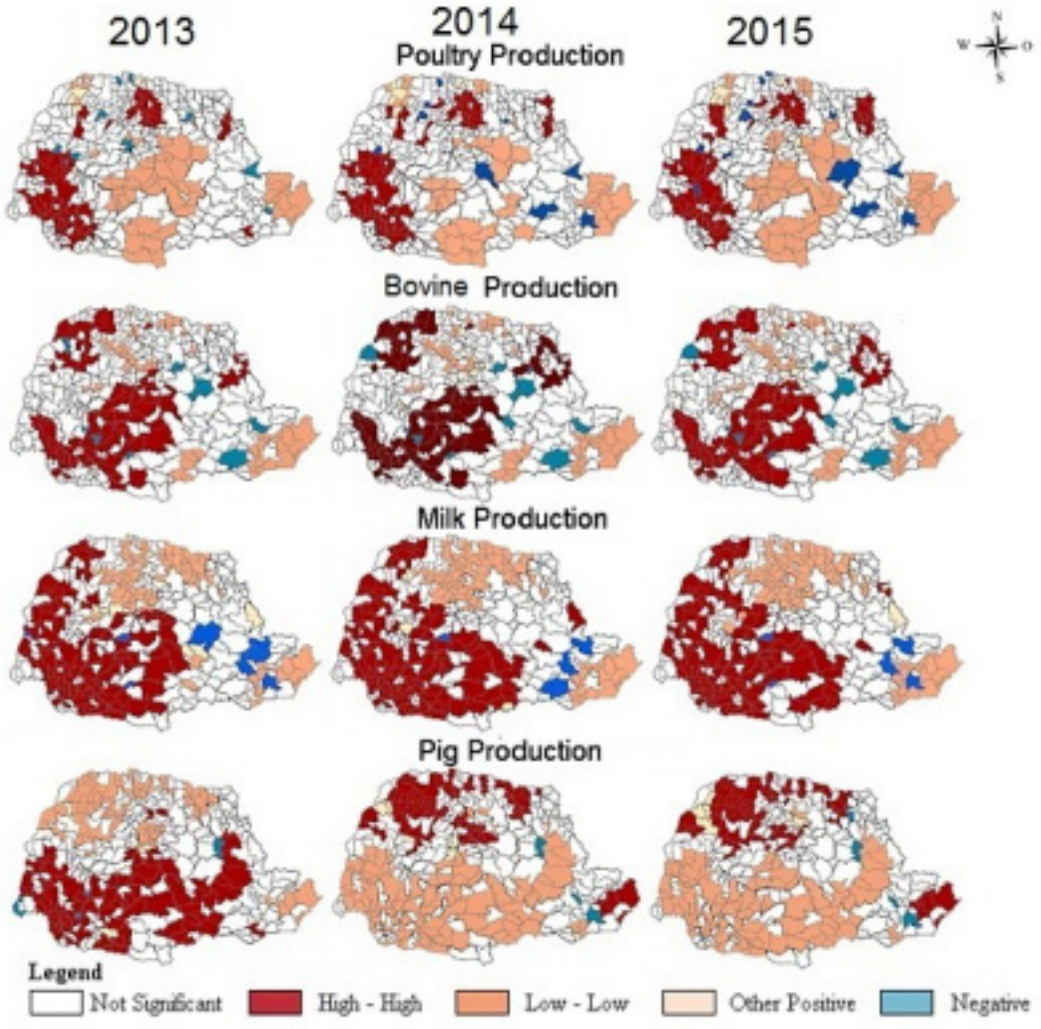
It was also observed the presence of negative spatial autocorrelation during 2013, 2014 and 2015; it suggests regions with high and/or low poultry production surrounded by neighbors with similar characteristics and regions with low poultry production, surrounded by regions with high poultry production, in the light blue color of Figure 2.

It is observed the Modifiable Areal Unit Problem (MAUP) is very visible when comparing the Municipal Map (Figure 2) to the Regional Centers Map (Figure3), there is a significant

Variables	2012	2013	2014	2015
GDP	1.160^{Ns}	1.159^{Ns}	1.128^{Ns}	1.211^{Ns}
Bovine production	0.943^{Ns}	0.943 Ns	1.002^{Ns}	0.995^{Ns}
Pig production	0.959^{Ns}	0.959 Ns	0.977^{Ns}	1.028^{Ns}
Poultry production	0.759^{Ns}	0.759 Ns	0.794Ns	0.802^{Ns}
Milk Production	0.702^{Ns}	0.702Ns	0.755 Ns	0.759^{Ns}
Gross value of agricultural production	.	1.234 Ns	1.181 Ns	1.216^{Ns}
Grain production	1.142^{Ns}	1.151^{Ns}	1.165^{Ns}	1.118^{Ns}

Note: Ns - not significant values; * statistically significant at the level of 5% probability; . - absence of information in the official database.
Source: own calculations

Table 3: Global Geary Index (*c*) of gross domestic product (GDP), effective agricultural production (bovine, pig, poultry, milk), gross value of agricultural production and total grain production (soybeans, corn 1st and 2nd harvest) and wheat) from the years 2012 to 2015 of the twenty-three regional centers of SEAB-Paraná-Brazil.



Source: own research

Figure 2: LISA Cluster Map maps, related to poultry production, bovine, milk and pig by municipalities for the years 2013 to 2015.

difference between them. This results corroborates with the results obtained by Zen et al., (2019), who accessed the sensitivity to the MAUP, by calculating global statistics over there grid displacements.

Through Geary's local autocorrelation index (c_i), it is observed, in the bovine production from 2013 to 2015 (Figure 2), spatial patterns of clusters occur. In which, it is present positive spatial

autocorrelation and negative spatial autocorrelation, it means, the producing regions are similar to each other and they are close to each other, as well as regions distant from each other, allowing the identification of significant clusters (5%) shown in Figure 2, light pink.

In the 399 municipalities of Paraná state, it was observed clusters of municipalities with high bovine production surrounded by neighbors with similar characteristics (dark red color in Figure 2). The pattern of spatial concentration was observed most frequently in the municipalities of Guarapuava, Pitanga, Laranjeira do Sul, Catanduvas, Boa Vista de Aparecida, Guaraniaçu and Umuarama. Municipalities with significant negative spatial autocorrelation were observed, it means, municipalities with high bovine production surrounded by municipalities with low bovine production (light blue color in Figure 2) and municipalities with low cattle production surrounded by neighbors with high bovine production, this behavior signals spatial outliers, showing low spatial interaction between the municipalities.

Between 2014 and 2015, it was observed that there was a greater spatial concentration of data showing similar characteristics (High-High) in the municipalities of Guarapuava, Laranjeira do Sul, Loanda, Altonia, Três Barras, Catanduvas, Campo Bonito, Umuarama, Altamira do Paraná and Quedas do Iguaçu. This behavior may be related to the incentive in the use of confinement technique, which allows greater control over production costs.

The adoption of the bovine confinement system allows greater gains in production and signals that it is a profitable and viable livestock activity (Barbieri; Carvalho and Sabbag, 2016). This technique allows to concentrate more animals per area and consequently to have a larger scale reducing costs, besides obtaining bigger gains when providing more concentrated food without generating the movement of the animal generating greater added value to the product at the time of commercialization, allowing greater gains to the producers.

Regions that are not prone to agricultural cultivation due to steep topographic conditions, relief demographics, among others, which do not favor the planting of agricultural crops, are destined for other activities such as bovine raising. Cultivation techniques, no-till techniques are restricted in these environments.

Considering milk production, in most of the municipalities, there was a greater frequency of significant positive spatial autocorrelation, represented by the colors dark red and pink in Figure 2, with a predominance of regions with high milk production, surrounded by neighbors also with high milk production, mainly in the West, Southwest and Center South regions.

Regions with significant negative spatial autocorrelation were also observed, mainly in the Metropolitan Region and Eastern Center, in Figure 2, identified as light blue color. The results demonstrate the pig production, for the years studied presented, in its great majority, positive spatial autocorrelation (Figure 2, in dark red and pink colors), emphasizing on the mesoregions, namely, Centro Oriental, North Central, South Center, West and Northwest.

It is important to note, for the year 2013, there were municipalities with high pig production surrounded by neighbors with this same characteristic, in the West, Center South and part of the Central Eastern region, for 2014 and 2015, these same similarities were observed in parts in the municipalities belonging to the Northwest and North Pioneiro regions. In 2014 and 2015, there was a decrease in pig production in the municipalities (Low-Low) represented in pink. This fact may be related to the high production costs of this herd, which corroborates Embrapa, (2016) who studied the costs of pig production in the main states of Brazil, including Paraná and as a result, he found the variable most influencing the costs of pig production is the cost of labor, this result is relevant, since agricultural production also fluctuates according to the prices practiced in the markets associated with the production costs borne by rural producers, if the price to be paid to the finished final product is not attractive, the tendency is that much producers choose to migrate to other more profitable activities.

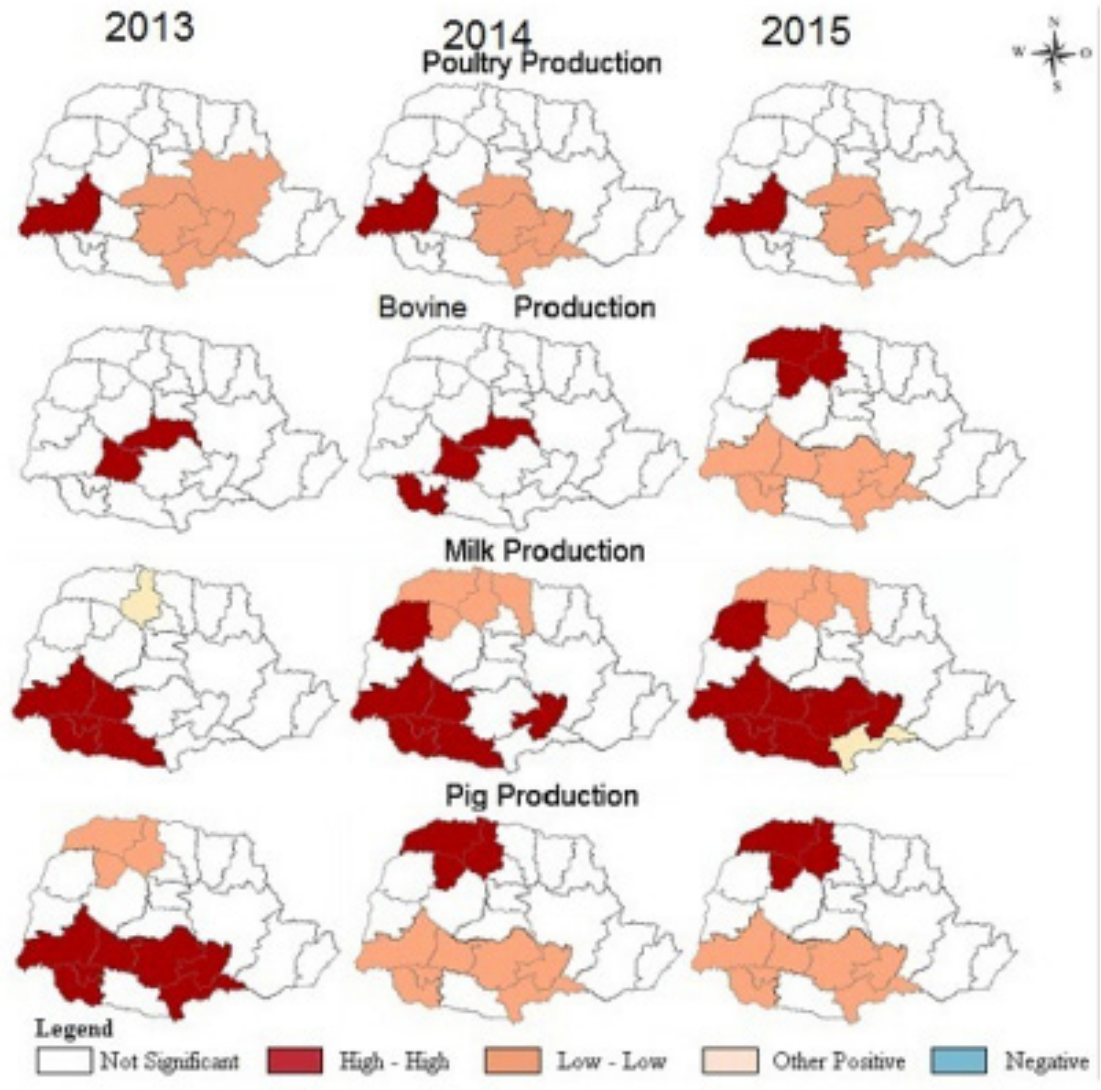
Considering that livestock production is economically demanding, a viable alternative would be to add technologies, investments in labor (technical and professional education) in order to improve good agricultural practices by promoting greater incentives to the activity that requires a lot of experience and planning on the part of rural producers.

The results presented in Figure 3, for poultry production, point out three significant clusters (High-High) just for the regional centers of Cascavel, which differentiates it in great relevance to the map of the municipalities (Figure

2 in the dark red shade). This difference is accentuated when compared to the results of the mesoregions, as shown in Figure 4, for the year 2013, which characterizes the MAUP, in which there was a high-high cluster just for the North Central mesoregion, already for the years 2014 and 2015 there were no clusters with significant results. The statistical results are different. There was the presence of a Low-Low group, mainly in the Regional Centers of Pitanga, Guarapuava, Irati and União da Vitória (Figure 3 in pink).

The MAUP is clearly observed, comparing the maps made from the same database, the results of the significant clusters of the Regional Centers and Mesoregions are quite different from those observed in the municipal map (Figure 3 and Figure 4). The significant cluster agglomeration suggesting positive spatial autocorrelation for bovine production appears in the regional centers of Pitanga, Laranjeira do Sul, Francisco Beltrão, Paranavaí, Maringá and Cianorte (Figure 3 in brown). The regional centers that make up the municipalities of the West region practically disappear in 2013 and 2014 (Figure 3 in white).

The same fact occurs in the mesoregions (Figure 4). On the other hand, in 2015, the regional center of Cascavel, Toledo, Guarapuava and União da Vitoria presented a cluster (Low-Low), and their



Source: own research

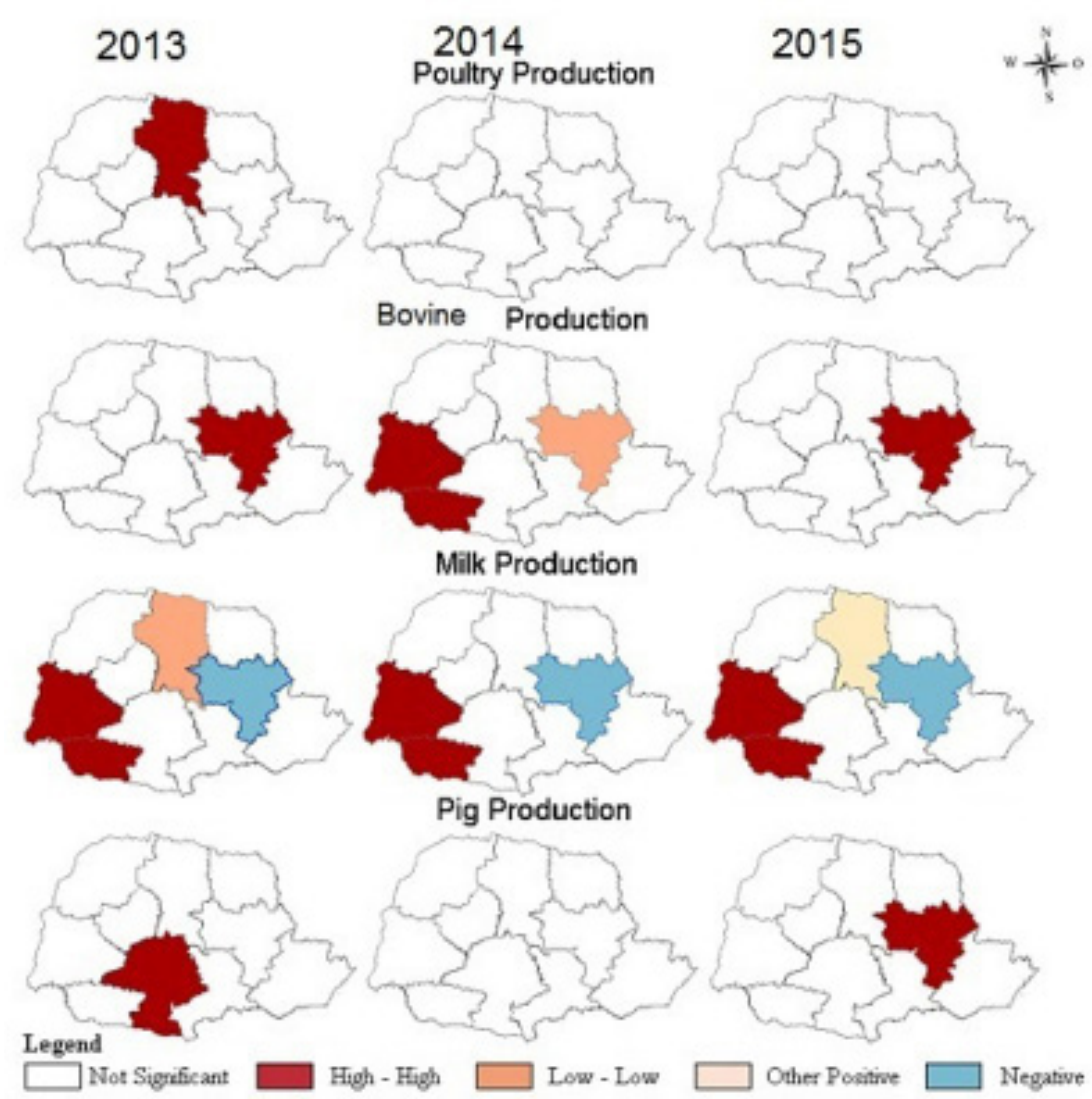
Figure 3: LISA Cluster Map maps, relative to the production of poultry, bovine, milk and pig by Regional Centers for the years 2013 to 2015.

municipalities were not identified on the municipal map, suggesting the difference between these maps. For milk production, the result also shows the presence of MAUP, demonstrating significant differences between maps of municipalities and maps of regional centers, Roces-Díaz et al. (2018) comment that when analyzing spatial data in different scales, they found different results between the levels studied, concluded that the use of spatial data in different resolutions, the results found showed significant differences.

The result points to significant clusters, suggesting positive spatial autocorrelation (High-High) just for the regional centers of: Cascavel, Laranjeira do Sul, Francisco Beltrão, Dois Vizinhos, Pato Branco, Irati and Umuarama. Toledo regional center (major producer milk from Western Paraná) simply disappeared from the map (Figure 3).

Therefore, as it appears in the municipal data, it is necessary to have coherence and consideration when analyzing the data by regional centers. The MAUP is clearly visible in these presented results. The group considering different spatial resolutions can generate complications in decision-making process, which in fact shows it in this analysis. For the production of pigs in 2013, significant clusters (High-High) were observed in the following regional centers: Toledo, Cascavel, Dois Vizinhos, Laranjeira and Guarapuava (Figure 3 in dark red). In 2014 and 2015, there were significant regional clusters in these same regions (Low-Low), which is very different from the municipal map and map by mesoregion (Figure 3), once other regions had this characteristic.

The results found make sense, because there was a slowdown in pig production in 2014 and 2015 due



Source: own research

Figure 4: LISA Cluster Map maps, relative to the production of poultry, bovine, milk and pig by Mesoregions for the years 2013 to 2015.

to the high production costs (EMBRAPA, 2016). It was observed constant productions in these periods. The results presented in Figure 4 demonstrate the MAUP to the production of poultry, bovine, milk and pig. Comparing the maps made through the three levels of differentiated spatial resolutions, the results of the significant clusters of the Mesoregions are different from those observed in the maps of the Municipalities and maps of the Regional Centers (Figure 4).

The municipality agglomeration in the West Mesoregion practically disappeared to the effective production of poultry and pig production in 2014 and 2015 in the state of Paraná (Figure 4), which suggests how worrying the problems were, which can occur mistaken decision-making process, when analyzed through the same study population considering a single level of analyzed spatial resolution.

For each year (2013, 2014 and 2015), SAR, CAR and GWR models of the gross value of agricultural production (V_{pb}) were built in relation to livestock production and total grain production for each year, considering the existence of spatial autocorrelation. The results to the municipalities in the state of Paraná are presented in Tables 4, 5 and 6.

The SAR, CAR and GWR forecast models for the gross value of agricultural production (V_{pb}) considering the explanatory variables: total amount of bovine production (*QTbovine*), total amount of pig production (*QTpig*), total amount of poultry production (*QTpoultry*) and total amount of grain production (*Totgrain*) for the year 2013, are shown in Table 4.

All the estimated parameters $\widehat{\beta}'s$ are observed in all models are positive, which implies a directly proportional influence of the herds of the livestock production and total grain production in 2013.

The result indicated the response variable: the SAR autoregressive model at R^2 = 77.32% explained gross value of agricultural production (V_{pb}) in 2013 (coefficient of determination). The Maximum logarithm value of the likelihood function - 160.670. The other indexes point to a model adjusted with the addition of spatial dependence on the response variable $\hat{\rho}$ = 0.45283. The results inherent to the application of the CAR model to estimate the gross value of agricultural production (V_{pb}) to 2013 explains R^2 = 77.8%, presenting a significant autoregressive coefficient λ (Lambda) (0.490*), showing that spatial autocorrelation attributed to the error was significant at the 5% level of significance (Table 4).

Table 4 also shows the estimated GWR model for the gross value of agricultural production (V_{pb}) with a determination coefficient R^2 = 83.3%. It shows that there was, through the analysis of the GWR model, the best fit, considering the SAR and CAR models, once it presented the highest MLL value and the lowest values for AIC and BIC. Therefore, the local GWR model was the best explanation to the gross value of agricultural production (V_{pb}) for the year 2013.

Table 5 shows the results of the SAR, CAR and GWR models of the gross value of agricultural production (V_{pb}) in 2014 for the municipalities. In all models, the estimated parameter $\widehat{\beta}_2$ is negative, which implies an inversely proportional effect of the total quantity of pigs (*QTpig*) in the gross value of agricultural production (V_{pb}) for the year 2014, in the years 2014 to 2015 there was retraction in the production of pig, which may be related to the high production costs in this activity (IBGE, 2016).

The results also showed, for 2014, the best model, which explains the estimate of the gross value of agricultural production (V_{pb}), was the GWR model. As it is a local model, it attributed a significant improvement to the spatial regression process in the studied region (Table 5).

In 2015, it was observed, similarly to previous years, the GWR model was the best explanation to the gross value of agricultural production (V_{pb}) as a function of cattle production, pig production, poultry production and total grain production of the 399 municipalities of Paraná (Table 6).

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	2.734	0.043	0.081	0.452	0.076	0.452*	-	- 160.670	0.774	343.340	387.163
CAR	4.32	0.053	0.080	0.451	0.074	-	0.490*	- 165.013	0.778	344.026	371.913
GWR	4.55	0.042	0.093	0.430	0.067	-	-	**0.310**	**0.833**	**322.957**	**311.735**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 4: Statistical results of the SAR, CAR and GWR models for the gross value of agricultural production in 2013 for municipalities.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	10.970	0.0097	-2.461	0.287	0.065	0.451*	-	-195.165	0.773	412.329	456.153
CAR	17.259	0.0901	-2.825	0.283	0.064	-	0.492*	-199.548	0.768	413.095	440.983
GWR	18.109	0.073	-3.580	0.262	0.057	-	-	**0.340**	**0.831**	**354.374**	**343.152**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 5: Statistical results of the SAR, CAR and GWR model for the gross value of agricultural production in 2014 for municipalities.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	6.627	0.138	-2.369	0.381	0.062	0.400*	-	-243.147	0.793	508.295	552.118
CAR	7.710	0.118	-2.862	0.373	0.064	-	0.469*	-252.732	0.783	519.464	547.351
GWR	7.744	0.025	0.341	-0.036	0.089	-	-	**0.393**	**0.840**	**400.421**	**393.021**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 6: Statistical results of the SAR, CAR and GWR model for the gross value of agricultural production in 2015 for municipalities.

In similar way of studies based on municipal database, the SAR, CAR and GWR models to Regional Centers of the state of Paraná-Brazil were studied.

It is observed according to the results presented in Tables 7 to 9 that the parameters $\hat{\rho}$, $\hat{\lambda}$ of the SAR and CAR models are not significant. The geographically weighted spatial regression model (GWR) was the best representation of the gross value of agricultural production (V_{pb}) in the three years 2013 to 2015. Therefore, the result shows the SAR and CAR models of the gross value of agricultural production (V_{pb}) is associated to the study unit that are the municipalities.

Whereas just in the regional centers and mesoregions, the GWR model is significantly related to production of bovine, pigs, poultry and grains. In this sense, the MAUP effect is observed in the database of regional centers and mesoregions. This result corroborates the results obtained by Jonatan and Brewer (2017), who, in their findings, verified that the aggregated data are sensitive to MAUP, and the levels of aggregation, sizes and zones, affect the validity and reliability of the results. Their findings suggest that researchers need to choose the most appropriate scale for specific problems analyzes.

It is evident the presence of MAUP (Table 7, Table 8 and Table 9) in the analysis of the spatial level by regional centers. MAUP is also observed in the mesoregions for the models (SAR and CAR), once the parameters related to the spatial level were not significant in any studied year. Considering the GWR model, it was possible to adjust a model for the gross value of agricultural production (V_{pb}) for the studied years, this fact is justified because the estimation of the parameters takes into account the spatial information, Table 10, Table 11 and Table 12.

In accordance with Table 11 and Table 12, it was observed the SAR and CAR models were also not significant, showing the spatial structure is not being incorporated into the model, which resulted in a multivariate regression model, with a significant degree of explanation for the studied variables. Indeed, this fact confirms the scale effect, characterizing the presence of MAUP in the studied mesoregions.

Therefore, the MAUP is visible in the study, considering the comparative analysis of the SAR, CAR and GWR models. The GWR model was the one that explained the variable response gross value of agricultural production.

In the analysis of these models, it was clear the presence of MAUP in the comparison among the results based upon municipal, regional center and mesoregions databases.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	11.150	-0.039	0.393	0.137	-0.045	-0.341^{Ns}	-	2.797	0.829	16.405	28.895
CAR	5.450	-0.022	0.316	0.313	-0.021	-	0.030^{Ns}	0.181	0.785	13.636	21.584
GWR	5.485	-0.022	0.316	0.310	-0.022	-	-	**0.234**	**0.795**	**24.392**	**13.170**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 7: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2013.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	37.323	-0.042	-11.486	0.033	-0.040	-0.537^{Ns}	-	7.605	0.90	6.788	19.278
CAR	25.106	-0.013	-9.817	0.106	-0.027	-	-0.164^{Ns}	4.768	0.873	4.462	12.410
GWR	25.013	-0.013	-9.851	0.111	-0.022	-	-	**0.193**	**0.877**	**20.563**	**9.341**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 8: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2014.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	25.03	-0.05	-12.76	0.18	-0.05	-0.39^{Ns}	-	1.56	0.88	18.87	31.36
CAR	17.58	-0.03	-11.39	0.23	-0.03	-	0.05^{Ns}	-1.92	0.84	17.85	25.80
GWR	5.485	-0.022	0.316	0.310	-0.022	-	-	**0.234**	**0.795**	**24.392**	**13.170**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 9: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2013.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	13.34	-0.007	0.30	0.497	-0.11	-0.47Ns	-	8.44	0.94	5.10	8.43
CAR	8.73	-0.04	0.26	0.549	-0.21	-	-1.39^{Ns}	4.04	0.86	5.90	8.02
GWR	5.91	0.02	0.37	0.053	-0.06	-	-	**0.16**	**0.86**	**14.20**	**2.98**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 10: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2013.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	13.01	0.19	-6.837	-0.35	0.23	-0.17^{Ns}	-	14.24	0.93	-6.48	-3.15
CAR	25.64	-0.01	-8.22	0.10	-0.11	-	-1.49^{Ns}	8.52	0.91	-3.04	-0.93
GWR	25.76	0.03	-10.64	0.01	-0.04	-	-	**0.12**	**0.85**	**12.08**	**0.86**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 11: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2013.

Statistics	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\rho}$	$\hat{\lambda}$	MLL	R^2	AIC	BIC
SAR	16.83	0.09	-9.91	0.07	-0.03	-0.18^{Ns}	-	10.48	0.94	1.02	4.35
CAR	17.69	0.03	-13.36	0.11	0.01	-	0.47^{Ns}	3.06	0.89	7.87	9.98
GWR	17.10	0.04	-12.06	0.06	0.00	-	-	**0.17**	**0.88**	**14.80**	**3.58**

Note: * significant probability level of 5 %; $\hat{\rho}$, $\hat{\lambda}$ auto-regressive coefficients; MLL: maximum likelihood logarithm ratio; R^2 adjusted coefficient of determination; AIC: Akaike information criterion; BIC: Bayesian information criterion; bold: best adjusted model.

Source: own calculations

Table 12: Statistical results of the SAR, CAR and GWR model of the gross value of agricultural production by regional centers in 2013.

Conclusion

The result indicates Geary's global and local spatial association indicators were more intense when analyzing municipalities in detriment of regional centers and mesoregions.

There were variations among municipalities, regional centers and mesoregions in the gross value of agricultural production from 2013 to 2015 and the effects of the effective agricultural production varied strongly in the universe of regions in the study. It shows there is a difference in the gross value of agricultural production related to the number of agricultural production according to their location.

The geographically weighted spatial regression model (GWR) was the best representation of the gross value of agricultural production (V_{pb}) in the three analyzed years, this evidence is all comparisons made.

The SAR and CAR models were highly sensitive when using different spatial resolutions, demonstrating their instability.

The GWR model remained stable with the changes in the different spatial resolutions analyzed, and its use in studies involving Spatial Area Statistics is more prudent.

A general recommendation is to work using different levels of spatial analysis and compare their results, whenever possible. Maintaining, throughout a research, a single territorial delimitation of the object of study, it may not be ideal for decision-making process.

Therefore, the resources for analyzing spatial data and spatial regression models, which we have only a snapshot of what can be analyzed, act in the direction of providing a more accurate picture of such dynamics. The use of these techniques does not provides just a new visualization resources, but also new regional performance indicators that presuppose the use of georeferenced databases, this situation may allow regional researchers to consider spatial aspects in their empirical analyzes.

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The Dynamics of the Social Network of Urban Farmers in Subak Sembung Denpasar

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Abstract

A reduction in the number of farmers, urbanization, limited land, poverty, environmental changes, uncertainty of production results and limited access to resources are still being serious problems and have a direct effect on farmers' income. Facing that conditions, in order to survive, social networks are one of the adaptation strategies implemented by the farmers. This research aimed to examine the social phenomena of urban farmers in Subak Sembung, Denpasar City and to try to find the rational actions conducted by the farmers in dealing with economic problems that occurred. This research was conducted in March - October 2020. The location of Subak Sembung was chosen because Subak Sembung is a subak that still exists in Denpasar City. The total samples were 20% of the total population, which is 40 people. This research used qualitative and quantitative approaches. The qualitative method in this research was using a case study, while the quantitative method used a survey. The research results showed that social, economic and environmental changes that occurred caused urban farmers to adapt. The adaptation pattern that was implemented was to apply a survival strategy and a double income pattern. The economic condition of urban farmers in Denpasar City was very good. The social network that was formed is a social network to fellow farmers, farmers to management subak, and farm shops. Action rationalism was performed in the context of improving the economy, working relations, and preserving culture.

Keywords

Social network, urban farmers, water-control systems (Subak).

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Introduction

The decrease of farmers, urbanization, limited land, poverty, environmental changes, uncertainty of production results and limited access to resources are still serious problems and have a direct effect on farmers' income. Facing that conditions, many farmers have implemented various strategies to survive in the midst of the rapid development of other sectors in the Denpasar City. Social networks are one of the adaptation strategies implemented by the farmers.

The research results by Risman et al. (2019) stated that the social network strategy was a survival strategy conducted by establishing relations both formally and with the social environment, for example borrowing money from retainer, friends, family, and even seaweed barter. This strategy was used to solve the socio-economic problems of seaweed farmers, whether it was education problems, resistance in working, or income. Furthermore, Gandi et al. (2017) stated that the actors involved in the social network of the agricultural bonded system included farmers, wholesaler, traders and the government. Those four actors were tied together with trust as their asset. Social networks focused on social relations or objective patterns of bonds that connected members.

The urban farmers in Denpasar City in performing their lives have guidelines that were used to legitimize their actions to interpret their relations patterns with nature. These guidelines were passed down from one generation to the next and at a later stage became the forerunner of their growing culture. The adaptation process is one part of the process of cultural evolution. Meanwhile, cultural evolution is a sequence of human efforts to adapt or respond to changes in the physical

and social environment that occurred temporally.

Facing that conditions, the farmers in Denpasar City need to perform adaptation strategies for their survival. In facing economic problems, farmers must take advantage of various strategies, one of them is the social network strategy. This method was an adaptation strategy performed by farmers in Denpasar City for their survival. Furthermore, according to Lestari (2017) stated the general factors that affect adaptability, were: education, income and health. There were several specific factors that affect adaptive capacity, which were the level of vulnerability, institutional, knowledge and technology. It was reinforced by research by Sumaryanto (2012) which stated that adaptation capacity affected the level of vulnerability through two line, which were directly and indirectly. The indirect line was through a mechanism of potential impact reduction, while the direct line included the step of coping strategies in resolving problems related to the perceived vulnerability.

The innovation of this research was to find the function of social networks not only as a social relation, but also to find out the economic motives in it. So that, in the end social networks can help farmers to access resources more easily both in the agricultural and non-agricultural sectors. Another innovation in this research was that the research on farmer adaptation strategies had been done a lot, but it did not discuss more specifically about social networks as a rational action for farmers.

This research aimed to examine the social phenomena of urban farmers in Denpasar City and try to find out the rational actions taken by farmers in dealing with economic problems that occurred. In detail, the aimed of this research were (1) to analyze the adaptation patterns performed by farmer households in dealing with changes of the land usage (2) to analyze the economic conditions that occurred in urban farmers in Denpasar City (3) to analyze the formation of social networks of urban farmers in Denpasar City (4) to analyze the rationality of action in networked urban farmers in Denpasar city.

Materials and methods

This research was conducted at the end of March 2020 to October 2020. The city of Denpasar was chosen because it is the capital of Bali Province (Bali Province is the main tourist destination in Indonesia) where most of the population work in the tourism and commercial sectors. Uniquely, in Denpasar, there is still an urban farming population. The population of urban farmers that can be found in Denpasar City is in Subak Sembung. Subak Sembung is one of the surviving subaks in the midst of Denpasar City. In addition, the Subak Sembung area still has 115 hectares' area which administratively includes Peguyangan Village, North Denpasar Sub-district. The population in this research were 200 farmers who manage/members of the Subak Sembung Denpasar City. The number of samples was 20% of the total population or about 40 people.

In this research, data were collected through observation and interviews. The observation technique that used was direct observation, to observe or watch directly, hear, and feel the object of the problem that occurred in Subak Sembung. Researchers as the data collectors participated and were involved in activities that were the source of observations. While engaged in activities, researchers can watch, feel, listen to various things that were directly related to the data to be collected. Through this way, researchers believed to watch and observe by themselves how the Social Networking system that occurred in Subak Sembung. The interview technique that used was structured interviews, which is interviews with distantardization. Where researchers had prepared questions that will be asked to all respondents. Question and answer procedures, style, and wording in questions had also been arranged. This technique was used to obtain direct data from informants.

The aim one, two, three and four were analyzed by qualitative analysis. Qualitative analysis based on the opinions and ideas of the people that being studied, and seeing as closely as possible the target of the study, which was farmers in Subak Sembung, Denpasar City. The quantitative data collected in this research will be used to support qualitative analysis. Before being analyzed, all the data obtained was checked to minimize the possibility of errors or follow the following procedure (1) editing, which is the process of examining data for possible errors (2) coding, which is classifying respondents' answers with certain codes (3) tabulation, which is the arrangement of data into tables.

Results and discussion

The adaptation pattern that performed by the farmer households in facing the changes of land usages

The results showed that 35% of farmer' family members work outside the agricultural sector, such

as in the service and tourism sector, 27.5% stated that there were some members of farm families who worked outside the agricultural sector, and 37.5% members of farmer families who worked in agricultural sector (Table 1).

No	Adaptation pattern	Number of people
1	All family member work outside of farming sector.	
	· Yes	15
	· No	14
	· A few	11
	Total	40
2	The wives also earn outside the agricultural sector	
	· Yes	9
	· No	31
	Total	40
3	Family members mobilized to help farming	
	· Yes	25
	· No	15
	Total	40
4	Head of the Family did various jobs to earn additional income	
	· Yes	17
	· No	23
	Total	40
5	Performing product diversification pattern according to the market needs	
	· Yes	33
	· No	7
	Total	40
6	Performing the last alternative which was leaving agriculture.	
	· Yes	-
	· No	40
	Total	40

Source: processed from the primary data, 2020

Table 1: The adaptation that performed by the farmer households in facing the changes of land usage.

In order to adapt to urban conditions, farmers in Subak Sembung applied a survival strategy and a double income pattern. The patterns of survival strategies that performed by Subak Sembung farmers were 1) family members were mobilized to help farming (62%), 2) the head of the family did a variety of jobs to earn additional income (42%), and 3) performed a product diversification pattern that match to the market needs (82%).

The research result by Li and Hu (2014) stated that in order to survive in limited land, farmers tried to use these three main survival strategies, which were competitive differentiation, cooperation and product diversification. Furthermore, Christopher and Helena (2018) showed that Ileje migrants adopted a survival strategy, which was the intensification of non-traditional commercial crops such as corn, rice, millet and banana. The research results by Sheil and Graykowski (2012) added that small and medium farms can be commercially competitive by using a survival adaptation strategy through a collaboration between farmers and cooperatives.

Besides the survival strategy, the strategy used by the farmers in Subak Sembung also used a double income pattern strategy. It can be seen more clearly in table 1, which were 1) several family members working outside the agricultural sector (27.5%), 2) all family members working outside the agricultural sector (37.5%), 3) the wives earn outside the agricultural sector (22%), and 4) the head of the family did various jobs to get additional income (42%).

The research results of Sumarti (2007) stated that the double income strategy of households as an attempt to improve the economic welfare of farmers in various lining of smallholder plantations, needs to be placed in a local multilevel (multiple level) framework, both at the farm household level and at the local community and government level. A different opinion was expressed by Abdurrahim (2014) that the double income strategy “formed” through the development of MPA-COREMAP (Alternative Livelihood - Coral Reef Rehabilitation and Management Project) did not going as expected. After only three years of development, only 9 pokmas (community groups) out of 19 pokmas still survive and continue the MPA development program. Providing financial capital in the form of a revolving fund; physical capital in the form of production tools and infrastructure; and human capital through various trainings was not enough to build a sustainable livelihood system. Social capital in the form of trusts, networks, and institutions that can drive community’ activities sustainably, relatively non-existent.

The good news was that all respondents do not have desire to stop being a farmer because farming can still provide additional income for the family, farmers do not have skill in other fields, farming is a hobby and the land that currently available is still productive to cultivate.

Economic condition happening to the urban farmer in Denpasar City

The The economic condition of farmers in Subak Sembung indicated that 95% of respondents own motorbikes and 82.5% own cars. Thus, if it

was seen from the availability of transportation facilities, the farmers in Subak Sembung can be said to be in prosperous category (Table 2). If it was seen generally, the economic conditions of farmers in Subak Sembung were not in the poor category, according to Isdijoso et al., (2016) the criteria for measuring poverty according to the BKKBN, the BPS poverty measurement criteria on PSE05 and the BPS poverty measurement criteria on PPLS 2008. In line with research by Sa'diyah and Fitrie (2012) which stated that vehicle ownership, most of them also already have a motorbike, but here the motorbikes' function not only as the family transportation but were also used to earn additional income, for example motorcycle taxis, selling vegetables.

No	Economic Condition	Number of People
1	Have Motorbike	
	· Yes	37
	· No	3
	Total	40
2	Have Car	
	· Yes	33
	· No	7
	Total	40
3	Source of Farming Capital	
	· Own capital	38
	· Capital from caretaker	2
	Total	40
4	Have ever owed money from wholesaler or farm shops	
	· Yes	5
	· No	35
	Total	40

Source: processed from the primary data, 2020

Table 2: Economic condition happening to the urban farmers in Denpasar City.

The research results also showed that 95% of the respondents had source of farming capital came from their own capital and 87% of respondents stated that they never owed money to wholesaler or agricultural shops. In other words, farmers in Subak Sembung had been able to be economically independent to performed their business (Table 2).

Emery (2015) research results that independence had the effect of covering the structural dependency faced by farmers (such as dependence on creditors). Further strengthened by the results of research by Sucitayasa et al., (2018) the management of vegetable cultivation that performed by farmers in Denpasar City was still traditional. The independence level of farmers in managing vegetable farming in Denpasar City on the capital/ finance, production, and marketing aspects was evenly in the medium category. Further research by Djuliansah et al., (2020) found different results for soybean farmers in Pancatengah Sub-district which were still unable to perform soybean farming independently without government assistance. This was due to the absence of selling assurance and price guarantees as well as fear of crop failure. As a result of their inability to resolve pests and soybean plants diseases.

The establishment of urban farmers' social network in Denpasar City

According to Parasmo and Utami (2017) social networks in a community showed the type of social relations that was bound on the basis of kinship identity, race, ethnicity, friendship, proximity or on the basis of certain interests and showed a social relation that occurred, so that it showed more on the process than form. Furthermore, Ramirez (2013) described each type of social network had impacts on technology diffusion differently, because the relation between individuals that involved in technology occurred in diverse social contexts. The collaboration of individuals with technology can occur in three social settings: kinship (family), landlord-tenant relations (occupation), and affiliation (social association).

The social network pattern of urban farmers in Subak Sembung was a relations to fellow farmers, which were: 1) a relation of interest (borrowed a tractor and work equipment), 2) a relation of giving (gave/asked for seeds to other farmers), 3) a relation of feelings (gathered after work with other farmers in the fields to exchange information), 4) economic motivation (bought other farmers' garden products for personal consumption, discussed and seek information on grain prices, offered to help other farmers), and 5) non-economic motivation (tractor rental information).

The relations between farmers and management Subak, which were: 1) power relations (coordination with Kelian Subak/the chairman of Subak, determination of rice planting period, and the distribution of water), 2) character of open relations (subak member meetings and mutual cooperation), and 3) economic motivation (seeds availability and subsidized fertilizers). The relations between farmers and agricultural shops, which were 1) the character of open relations (established good relations) and 2) economic motivation (price information, fertilizer buying, and medicines). The relations between farmers and wholesaler, which was economic motivation (interaction

with wholesaler occurred based on the highest supply or according to agreement). In detail, the knot of urban farmers' social network in Subak Sembung can be seen in Figure 1.

The pattern knot of social network in each case will be different, all will be influenced by the characteristics and real conditions of each research location. The research results by Sukmana and Sari (2017), stated that the social network knot formed in the practice of hidden prostitution in the Songgoriti tourist area, Batu City, involved various stakeholders, which were: government officials, the Villa Supo association, PSK service users, villagers who own villas, motorcycle taxi drivers (tour-guide), owners of karaoke and billiards places, commercial sex workers (CSWs), and the local community. These stakeholders created a mutually supportive and beneficial network chain, especially economically. Furthermore, the research results of Maanana et al., (2015), described three types of social networks that was built between farmers and sellers of sweet orange, Kisar, which were trust, cooperation, and social exchange. This collaboration developed trust between farmers and sellers who determine the price of the sweet orange, Kisar. Finally, there was a sense of mutual help, honesty and a harmonious relation between farmers and sellers.

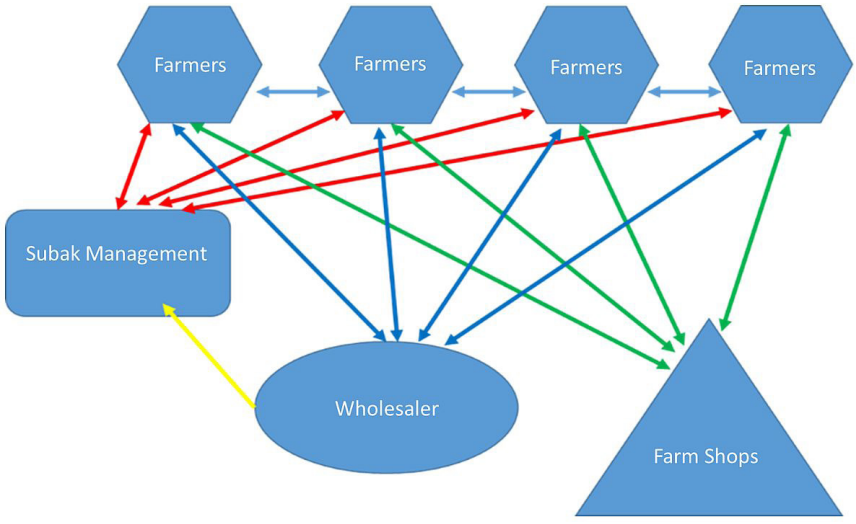
The rationality of actions in networking urban farmers in Denpasar City

According to Hidayat (2016) stated that the rationality of an idea or action was always associated with the suitability, accuracy, or acceptability of the idea or action with mutually agreed norms. Furthermore, Isfandiar (2015) stated that rationality and common sense (idea) were the key methods used to analyze data in a systematic observation. In economics, sociology and political science, a decision or situation was often called rational, if it was aimed at optimization in pursuing a goal.

Basically, a social network was a rationality of action in the form of social relations which were in it points/knots that connected to other points/knots. Previously, it had been explained that the actors who play a role in the social network of farmers in Subak Sembung had various relations (interests, presents, feelings, economic motivation, non-economic motivation, power and the character of open relations).

The rationalism of the actions taken by the Subak Sembung farmers in improving the economy were 1) family members working outside the agricultural sector, 2) mobilizing family members to help businesses, 3) family heads doing various kinds of work to increase income, 4) performing a pattern of product diversification in accordance with market needs, 5) looking for information on the grain price and wholesaler, and 6) looking for information on the availability of subsidized seeds and fertilizers.

Besides the rationalism of action in the economic field, farmers in Subak Sembung also took action rationalism in working relations and conserving culture. The action rationalism in the work relations performed by Subak Sembung farmers was 1) borrowed farming equipment from fellow farmers, 2) got/asked for seeds from other farmers, and 3) while resting in the fields, farmers gathered with other farmers to exchange farming



Source: own processing

Figure 1: The knot of urban farmers' social network in Subak Sembung.

information. Action rationalism in conserving culture was also performed by Subak Sembung farmers, which were 1) coordinated with subak kelian/subak chairman about determining the rice planting period and water distribution, 2) subak members' meeting, 3) mutual cooperation, and 4) coordinated in performing ceremonial activities.

In line with research result by Adriani (2015) which stated that social rationality was performed by farmers by diversifying jobs. Most of the farmers in the research area developed other farming businesses besides rice, which were soybean and long bean farming. This was the impact of economic rationality, which was performed to overcome low farm income and overplus of working time for farmer families. Furthermore, the research results of Mutiar et al., (2018), described the rational instrumental actions of fishermen in relation to fishing marketing. These actions were actions that lead to the interests to be achieved. That is, they did the action without being noticed by the boss. The strategy of "cheating on the baskets" was a phenomenon that occurred among the small fishermen of Karangsong.

Conclusion

The change of social, economic, and environmental that occurred cause urban farmers to adapt. The adaptation pattern that performed was to apply a survival strategy and a double income pattern. The economic condition of urban farmers in Denpasar City was very good. The social network that formed was a social network to fellow farmers, farmers to subak wholesaler management, and agricultural shops. In addition, there was a one-way social network between wholesaler to subak management. Action rationalism was performed in the context of improving the economy, working relations, and conserving culture.

The thing that became an important concern was the social network pattern that occurred in Subak Sembung, which was between farmers and wholesaler. Most of the farmers sell their products to wholesaler, wholesaler had a strategic position in connecting farmers with buyers in order to achieve economic goals for both parties. The relations between farmers and wholesaler produced mutually beneficial economic exchanges. Wholesaler did not have the role of creditor/owner of capital and this can be said to be a positive side.

The policy implication that can be performed by both the Denpasar City government and the Bali Provincial Government was to create a joint forum between farmers and wholesaler, which can be in the form of cooperatives or other institutions. With the existence of this forum, it can be used as a work ecosystem that can create more beneficial results for both parties. This forum is also expected to act as legality to receive material assistance and assistance with knowledge and training, so that in the end it can improve the welfare of both parties.

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The Evaluation of Agricultural Land Use Sustainability in the Post-Socialist Camp Countries: Methodological and Practical Aspects

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Abstract

An effective implementation of the sustainable use of agricultural land program is impossible without reliable results of the current state of the problem. In this sense, the correct selection of indicators and methods for determining the level of stability is important. The authors proposes the definition of the agricultural land use sustainability integral indicator based on three methodological approaches: the construction of the indicators system, each of them reflects some aspects of the land use sustainability at the macro level (according to the specific issues); the construction of the integral indicator for comparing the countries' land use sustainability. According to the given methods it has been proved that agricultural land use in the countries of the post-socialist camp has a positive dynamics, but the sustainability indicators for all indicators have not achieved yet. This study was supported in part by the Erasmus SUPPA program – Jean Monnet Associations Application No 611556-EPP-1-2019-1-UA-EPPJMO-SUPPA.

Keywords

Sustainability, land use, method, methodology, approaches, criteria, formulas.

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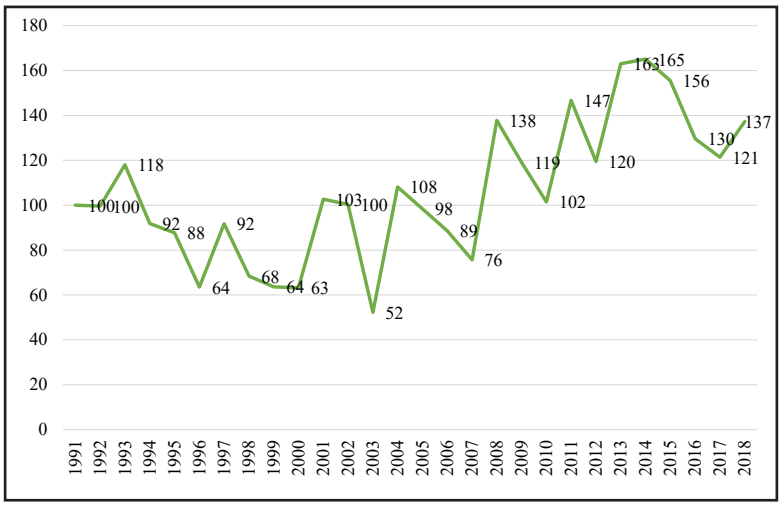
Introduction

In the former Soviet Union, among the 15 republics the Ukraine was "the breadbasket" of the state: the best black soil; a high standard of culture, deep roots and traditions of the grain growing; a hardworking nation. In the "Treatise on taxes and contributions" Petty says that labor is the father of wealth, and land is the mother (Petty, 1769). It is hard to disagree with the prominent economist's opinion. So, are the Ukrainians really rich and well fed?

There are different points of view on the fact what kind of the country's development should be in general and agricultural land use in particular. All of them have their right to exist, but there is a problem – what is the ultimate goal of their implementation? For example, the draft of the State Target Program of the agricultural sector for the period to 2020 provides the following effect as the expected result and the effectiveness of the Program: the increase in the volume of gross agricultural production in all categories of farms (2016). And the Ukrainians remember the 30-es years of the last century and what price they paid for the imperial ambitions of the Soviet Union. During that period, Stalin also aimed to increase the production volumes and export potential. We can assess the situation from the perspective of modernity: the volumes of the grain production in the country during 2013-2018 were the highest in the last twenty-five years (Figure 1), the wheat export from Ukraine during the last six years increased by 42%, and the real incomes of the population decreased by 44% (Figure 2).

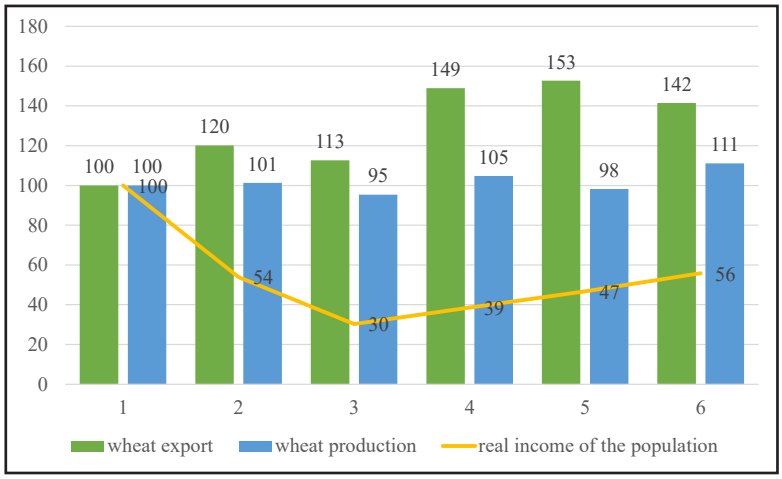
Of course, it does not mean that you need to produce or sell less – you need to properly define the purpose and objectively evaluate the outcomes. Who needs a high economic performance if it does not give any social effect and worsens the ecological situation?

In our opinion, such effects as the increase of the production volumes and that of the export potential are not the sustainable development goals,



Source: developed by the author based on State Statistics Service of Ukraine (2018)

Figure 1: The indices of grain and leguminous crops production volumes in Ukraine, %.



Source: developed by the author based on State Statistics Service of Ukraine (2018)

Figure 2: The indicators of the real income of the population, production volumes and wheat export in Ukraine, % .

these and/or other positions may be the objectives for sustainability. We are convinced that sustainability of the agricultural land use can decide for at least two global world problems for the Ukrainians – food security and poverty reduction in rural areas.

This is why it is necessary to change priorities and determine the following: what indicators are really important and, based on the results, develop and implement the development program.

There are several approaches to the construction of the sustainability assessment indicators system. From the analysts' point of view, the most convenient way for decision-making is to determine a unified integral indicator, but according to the methodology, it is difficult to develop such kind of an indicator.

Thus, the methodology proposed by scientists (Kotykova et al., 2019) for assessing the sustainability of agricultural land use development at the macro level using the integral indicator is recognized as imperfect: the results of the evaluation will have different interpretations depending on the objective factors, which may ultimately influence the outcome both positively and negatively.

The same conclusion can be drawn from the results of "Global human appropriation of net primary production doubled in the 20th century" research, the authors of which note that "The rise in efficiency is overwhelmingly due to increased crop yields, albeit frequently associated with substantial ecological costs, such as fossil energy inputs, soil degradation,

and biodiversity loss. If humans can maintain the past trend lines in efficiency gains, we estimate that HANPP might only grow to 27-29% by 2050, but providing large amounts of bioenergy could increase global HANPP to 44%. This result calls for caution in refocusing the energy economy on land-based resources and for strategies that foster the continuation of increases in land-use efficiency without excessively increasing ecological costs of intensification" (Krausmann et al., 2013).

So an objective assessment can only be achieved if all significant influencing factors are included into analysis' system in their interconnection and interdependence.

The development of agricultural land use is largely determined by the population's diet, natural and climatic conditions.

This thesis is confirmed by the results of the research by Lacirignola et al. (Lacirignola et al., 2014) "Immediate action is required in the Mediterranean to address environmental degradation that is mainly driven by consumption patterns. Increasing stress on biological and social systems is put by unsustainable consumption patterns. Food consumption patterns are important drivers ofenvironment degradation. The objective of this review paper is to explore natural resources-food nexus in the Mediterranean region by highlighting the environmental footprints of the current consumption and production patterns. Secondary data from different sources such as FAOSTAT, the World Bank, Water Footprint Network (WFN), and Global Footprint Network were used to analyze the situation in 21 Mediterranean countries".

Therefore, in addition to the traditional indicators of land use efficiency, it is necessary to study environmental losses, pollution, health and population's living standard because of agricultural activity and diet.

The impact of natural and climatic conditions upon the level of agricultural land use is a poorly predicted and uncontrolled process. Inter-Governmental Panel on Climate Change has shown that the earth temperature has increased by 0.74 degrees C between 1906 and 2005 due to increase in anthropogenic emissions of greenhouse gases. By the end of this century, temperature increase is likely to be 1.8-4.0 degrees C. This would lead to more frequent hot extremes, floods, droughts, cyclones and gradual recession of glaciers, which in turn would result in greater instability in food production (Aggarwal, 2008).

The abovementioned risks can be monitored through the "emergency" block.

Some scientists suggest the usage of intensive technologies of land use in the context of issue of planet's population increase and in terms of sufficient food provision.

Lal (2000) indicates that: "Enhancing food production would necessitate adoption ofland saving technologies through agricultural intensification on prime agricultural land, conversion of marginal lands to other appropriate land uses, and restoration of degraded lands and ecosystems. Soil-specific technologies for agricultural intensification will have to be developed, fine-tuned, and adopted. These technologies will address the issue of (i) enhancing soil structure, (ii) increasing nutrient use efficiency through integrated nutrient management and strengthening nutrient recycling mechanisms, (iii) conserving soil and water through residue management and adoption ofconservation tillage, (iv) improving water use efficiency through development and adoption of efficient methods of water harvesting, recycling and irrigation, and (v) increasing cropping intensity".

So, on the one hand, it is about increasing the level of land use intensity, and on the other, the authors emphasize the need to improve such technologies in order to protect soil, water and other natural resources. The same opinion is held by Chartres and Noble (2015) "Given the current pressures on natural resources, this will have to be achieved by some form of agricultural intensification that causes less environmental impact. Therefore, it is not just intensification of agriculture, but 'sustainable intensification' that must be at the forefront of the paradigm shift".

Therefore, the level of land use intensity and technological level are important indicators while studying the sustainability of agricultural land use.

Despite the high level of economic efficiency resulting from land use intensification, we cannot consider such an approach as an acceptable one at this stage of society's development. "On the negative side, intensification of agriculture in many parts of the world has resulted in salinization of irrigated lands in the drier regions and the loss of forest vegetation in the humid tropics" (Juo and Wilding, 2001).

Taking into account the conclusions of Lal (2015) about the fact that "Soil degradation, characterized

by decline in quality and decrease in ecosystem goods and services, is a major constraint to achieving the required increase in agricultural production", it is reasonable to include indicators, which depict structural shifts, to the group of sustainability indicators of agricultural land use.

We also support the position of Tscharntke et al. (Tscharntke et al., 2012), who states "Under the current scenario of rapid human population increase, achieving efficient and productive agricultural land use while conserving biodiversity is a global challenge". The assessment of these factors' impact can be determined through indicators reflecting the protection of ecosystem functions and biological diversity.

Therefore, the study of monitoring the sustainability of agricultural land use, understanding the concept proposed by the UN as a sustainable development, is conducted by a narrow circle of scientists (Marada et al., 2012; Smith and McDonald, 1998). At the same time research is concentrated mainly in one of the areas: economic (Hreshchuk, 2019; Jansen, 2005), environmental (Turcekova et al., 2015; Gutierrez et al., 2017), social (Huaranca et al., 2019; Obando, 2018; Taylor, 2001). And even these studies are mostly limited by the experience of individual regions without comparisons with the results of agrarian reforms and agricultural policies of other countries, which significantly narrows the possibilities of using their positive practices.

In recent years studies assessing the impact of the level of agricultural land use on the state of food security have become especially relevant.

Integrated and systematic studies in terms of monitoring the sustainability of agricultural land use in Ukraine and the post-socialist countries have not been conducted. In addition it should be noted that there are differences in the indicators paid attention to in the EU and Ukraine, which does not allow for comparisons. This necessitated this study.

The hypothesis of our study is that there are significant differences in the achieved level of sustainability of agricultural land use in the EU Member States.

The purpose of our study is to identify a relevant set of indicators to assess the level of sustainability of agricultural land use development and the changes that happened in post-socialist camp's EU Member States for the period of 2005-2013.

Materials and methods

So, due to the international experience and the national research on this issue, in our opinion, it is advisable to use the methodological approaches:

- the construction of the indicators system, each of them reflects some aspects of the land use sustainability at the macro level (according to the specific issues);
- the construction of the integral indicator for comparing the countries' land use sustainability.

The first approach to the construction of indicators of sustainability is based on the construction of a system of indicators that can reflect some aspects of sustainability – environmental, economic, social and others. Compared to the integral indicators of sustainability, this approach is more widely spread. However, as it was already noted, there is no universally accepted and well-reasoned integral indicator for evaluating the effectiveness of the transition to sustainability in the world. In this context, the emphasis is on the construction of the system of indicators. It is advisable to have a limited number of indicators that are closely connected with the development of the macroeconomic policy priorities system. For example, the system of 100-150 indicators is hardly suitable for people who make decisions in the executive and legislative power structures. For this purpose the selection of the most important indicators for a particular purpose is made. Almost all international organizations and most countries followed this way in the development of "core indicators".

The use of the basic list of indicators is a necessary condition for the initial phase of creating a national system of indicators of sustainability. It should be kept in mind that indicators do not always answer the question of stability or instability of the processes. The answer to this question can be received only after the correct interpretation of the results.

There are two groups of indicators: gross natural and specific indicators. The first group of indicators is characterized by the natural or "specific-natural" expression, the second one is characterized by the "natural-cost" expression. The gross indicators are better suited for the analysis

of the current environmental situation, the degree of its favorability for humans and the environment, the level and magnitude of effects on nature, the harm to health, and others. These indicators are easy to apply for limited areas, the regional analysis. On the other hand, the specific indicators of the nature capacity, the specific contaminants are more suited for the assessment of the structural and technological trends, the changes in the economic structure. They are also useful for the forecasting of the economic development, the changes of the actions for the environment and the changes of the environmental situation for the future. As the experience of our country in the 1990-s shows, analyzing one environmental problem the indicators may have the opposite dynamics (eg, the gross water pollution decreased, but specific pollution increased).

It is necessary to determinate of the indicators system of the agricultural land use sustainability that reflects the situation at the macro level in the best way.

The construction of the integral indicator to compare the countries' land use sustainability:

- the measurement of the partial (individual) indicators in one dimension (in a single scale) in relative values – the so-called method of indicators coagulation;
- the selection of partial indicators, which have the homogeneous effect (positive or negative) of increasing the numeric value;
- weighting (scoring) of the importance of each component.

For the adequate evaluation of the agricultural land use sustainability to compare the countries and to rank them in order to reduce their total capacity it is necessary:

- to prove the assessment criteria (they should be information available, simple or calculations, the numberof them should be not many, but they have as much s possible to describe the development of the land use);
- to develop a methodology for calculating the integrated indicators that sorting by different methods do not significantly affect the position in the ranking. In addition, it should be quite simple and clear, but partial indicators obtained in the calculation of integral indicators should not be just relative coefficients but still have economic content.

The information base for the research consisted of legislations, regulatory acts and program documents of the governmental authorities of Ukraine and the United States, official materials of the Cabinet of Ministers of Ukraine, methodological and statistical data of the National Statistical Office of the Russian Federation as well as data of respective bodies and establishments of other countries, scientific information from Internet (the results of the international organizations and the FAO's researches), and the results of the author's own studies.

The sustainability of the agricultural land use analysis is performed by the author's method in Ukraine and in the countries of the post-socialist camp, which are now the countries of the EU. This approach is applied for three reasons:

- firstly, a comparative analysis is always more objective;
- secondly, for comparison the former socialist countries were chosen, as they had similar to Ukraine economic, political and social problems after the collapse of the USSR;
- thirdly, the study group is only current EU members, as Ukraine is also seeking the membership in the European Union.

The following abbreviations are used in tables and figures (according to NANPP):

Lithuania – LT, Bulgaria – BG, Czech Republic – CZ, Poland – PL, Croatia – HR, Slovakia – SK, Estonia – EE, Latvia – LV, Romania – RO, Ukraine – UA, Slovenia – SI.

The system of indicators and criteria's approaches to the agricultural land use sustainability assessment are provided in Figure 3.

The economic methods and calculation methods are given below.

Methodology and methods of calculating the basic indicators of the agricultural land use sustainability proposed for the use at the macro level (according to the specific problems)

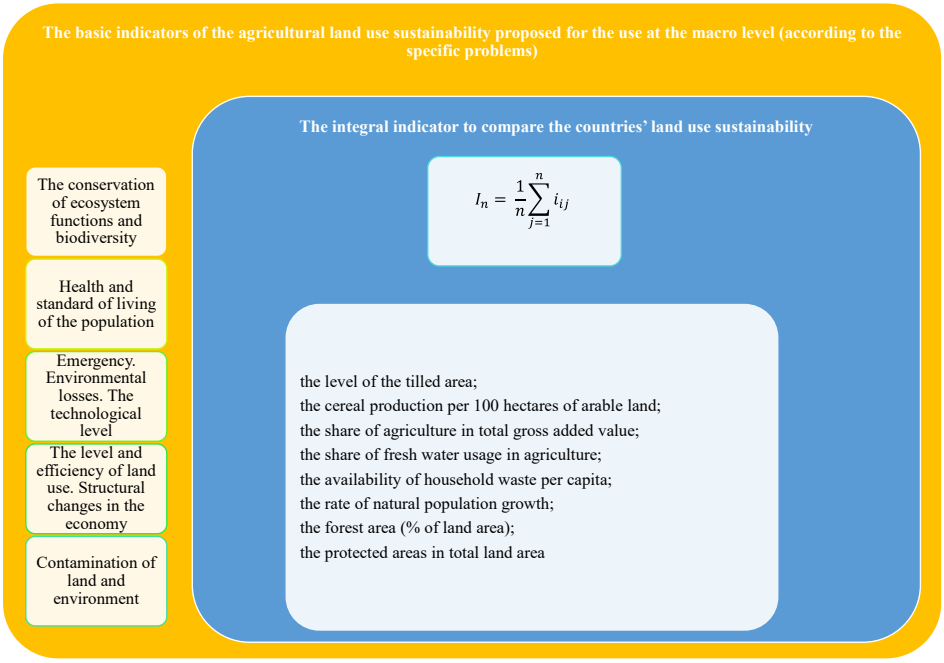
We have developed an appropriate system based on the following fundamental methodological approaches:

1) the indicators of sustainability must meet the following basic criteria: to combine environmental, social and economic aspects; to be clear and have unambiguous interpretation for those who make decisions; to have a quantitative expression; to be

based on the existing system of the national statistics and not to require significant investments to gather information and calculations; to be representative for the interregional comparisons; to be able to assess in the time dynamics; to have a limited number;

2) the classification of the indicators is carried out according to the specific issues. The indicators are constructed in the way to give a quantitative description of the selected issues, based only on the state statistics database.

A very "compressed" system of the basic indicators of the agricultural land use sustainability at the macro level is developed on the basis of the defined criteria. This system is recommended for the macroeconomic government programs and national action plans (Table 1).



Note: I_n – the integral indicator to compare the countries' agricultural land use stability; n – the number of indicators (partial criteria).
Source: own work

Figure 3: The methodological approaches to the agricultural land use sustainability assessment.

Problems	Indicators
The level and efficiency of the land use	1.1. The degree of the land resources development, %
	1.2. The level of the tilled area, %
	1.3. The yield of grain, centners per 1 ha
	1.4. Cereal production per 100 hectares of arable land, tons
	1.5. Gross agricultural output per 100 hectares of agricultural land, thousands of units of national currency
	1.6. The area of arable land per 100 persons of the population, ha
Structural changes in the economy	2.1. The share of agriculture in total gross added value, %
	2.2. The share of urban population in country's total population, %
Environmental losses	3.1. The share of fresh water usage in agriculture, %
Emergency	4.1. Number of fires
	4.2. The area of forest land traversed by fires, ha
Contamination of land and environment	5.1. The flow of sulfur oxide into the atmosphere per capita, kg
	5.2. The availability of household waste per capita, kg

Source: own work

Table 1: The basic indicators of the agricultural land use sustainability proposed for the use at the macro level (to be continued).

Problems	Indicators
The technological level	6.1. The adding of the mineral fertilizers per 1 ha of arable land, kg
Health and standard of living of the population	7.1. The rate of natural population growth
	7.2. Gross agricultural output per capita, national currency units
	7.3. The index of income concentration (Gini coefficient), %
	7.4. The employment rate of the population, %
	7.5. The average annual per capita consumption:
	7.5.1. Calories, kilocalories
	7.5.2 Proteins, g
	7.5.3 Fats, g
The conservation of ecosystem functions and biodiversity	8.1. The area of the forest fund, thous. ha
	8.2. The forest area (% of land area), %
	8.3. The area of the protected areas, thous. ha
	8.4. The protected areas in total land area, %

Source: own work

Table 1: The basic indicators of the agricultural land use sustainability proposed for the use at the macro level (continuation).

The economic content of the indicators (calculation methodology) used in this study is described in Annex 1.

Methodology and methods of calculating the integral indicator to compare the countries' land use sustainability

The partial set of criteria, in our point of view, should include the following parameters:

- the level of the tilled area;
- the cereal production per 100 hectares of arable land;
- the share of agriculture in total gross added value;
- the share of fresh water usage in agriculture;
- the availability of household waste per capita;
- the rate of natural population growth;
- the forest area (% of land area);
- the protected areas in total land area.

For the integral indicator only those baseline indicators from each block were chosen the impact of which was considered as decisive and that is why weighting factors wern't set for them because they equal in actual impact. The selected indicators reflect all blocks of basic indicators of sustainability of agricultural land use, proposed for use at the macro level. Exceptions are blocks 4 and 6. Indicators of block 4 are not included for a number of reasons: first, the block lacks partial indicators that can be comparable and commensurate with other indicators; secondly, the forest cover of the territory is directly related to the indicators of Unit 4, and this indicator is included in the list of partial indicators of the integrated index for assessing the sustainability of agricultural land use. Application of mineral fertilizers per 1 ha of arable land (indicator 6 of block) was not included in the list of partial indicators in determining the integral index for assessing the sustainability of agricultural land use, as this indicator is representative only in dynamics and compared to regulatory data, which have significant differences for different soils and production technologies: it is not possible to establish a single base for all countries to calculate the rating.

The formula of the agricultural land use sustainability assessment is the following:

$$I_i = \frac{1}{n}\sum_{j=1}^{n} i_{ij}, \quad (1)$$

where I_n – the integral indicator to compare the countries' agricultural land use stability; n – the number of indicators (partial criteria).

The calculation of partial criteria (indices) is made by the formula:

- for the *j-s* criteria, the quantitative growth of which positively affects the level of the country's development:

$$i_{ij} = \frac{f_{ij}}{\max_i f_j}, \quad (2)$$

- for the *j-s* criteria, the quantitative growth of which negatively affects the level of the country's development:

$$i_{ij} = \frac{\min_i f_j}{f_{ij}}, \quad (3)$$

where i_{ij} – the partial index of the i rural area (district) development for the certain period; f_{ij} – the value of the j partial indicator (criterion) for the i country; maxi f_j – the maximum value of the j partial indicator for all i countries; mini f_j – the minimum value of the j partial indicator for all i countries.

Results and discussion

1. The agricultural land use sustainability assessment according to the system of indicators, each of them reflects some aspects of the land use sustainability at the macro level (according to the specific problems)

The system of indicators is based on the structure of "problems-indicators", but, unlike the international structures of indicators, environmental, economic and social problems, which should reflect indicators are given in the "problems". 26 basic ecological and economic indicators and their modifications, quantitative importance and dynamics are given in Table 2.

For the agriculture in Ukraine compared to other countries of the post-socialist camp the high degree of the development of the land resources and the inadequate (on this background) reduction of the agriculture share in the total gross added value is extremely important. Moreover, the volume of the gross agricultural output per 100 hectares of farmland (in the national currency) increases.

The grain yield indicator shows the efficiency (more precisely, inefficiency) of this approach. Ukraine ranks the sixth place according to this indicator. However, in Ukraine there is the highest rate of grain production per 100 hectares of arable land.

Indicators	BG	LV	LT	PL	RO	SK	SI	HR	CZ	EE	UA
The first block. The level and efficiency of the land use											
1.1. The degree of the land resources development, %	48	28	45	52	62	40	25	22	55	21	61
	46	30	46	47	60	40	24	23	55	23	69
1.2. The level of the tilled area, %	29	18	30	40	39	29	9	16	42	14	51
	32	19	37	35	38	29	9	16	41	15	54
1.3. The yield of grain, centners per 1 ha	33.7	28.0	28.9	32.2	33.1	44.7	59.4	55.8	46.9	26.7	26.0
	44.2	33.6	36.2	37.7	38.4	44.7	45.9	54.4	52.1	30.9	39.9
1.4. Cereal production per 100 hectares of arable land, tons	110	62	72	72	82	116	80	69	129	45	123
	147	122	125	86	83	121	80	114	149	65	194
1.5. Gross agricultural output per 100 hectares of agricultural land, thousands of units of national currency	113	33	231	330	374	…	…	…	2970	969	250
	121	64	209	535	539	163	534	1761	2588	101	681
1.6. The area of arable land per 100 persons of the population, ha	41	50	58	32	42	26	9	20	31	42	67
	48	59	79	28	44	26	8	21	30	48	78
The second block. Structural changes in the economy											
2.1. The share of agriculture in total gross added value, %*	10.9	4.1	6.2	5.1	14.3	3.9	2.6	…	3.3	4.2	10.9
	5.4	4.9	4.0	3.6	7.5	3.2	2.6	4.7	2.1	3.6	9.9
2.2. The share of urban population in country's total population, %	70.6	68.0	67.5	61.5	53.2	55.6	50.5	56.4	73.6	68.7	67.9
	73.3	66.6	66.6	60.6	54.2	53.9	49.8	58.4	73.1	67.7	69
The third block. Environmental losses											
3.1. The share of fresh water usage in agriculture, %	19.0	13.0	7.0	16.2	23.2	1.8	1.3	…	2.6	0.2	2.4
	16.0	13.0	3.0	10.0	17.0	3.0	0.0	1.0	2.0	1.8	1.5
The fourth block. Emergency											
4.1. Number of fires	241	365	301	12803	64	287	73	147	636	65	4223
	408	422	123	4883	116	233	75	137	…	15	1113
4.2. The area of forest land traversed by fires, ha	1458	120	51	7387	162	524	280	3135	227	87	2300
	3314	217	25	1289	421	270	66	1999	…	79	400

Note: * the data about the countries (except LV, LT and CZ) are given for 2003 and 2011; ** the data about LV, LT and RO are given for 2000 and 2008; *** the Quinta coefficient of funds value is given for Ukraine; **** the numerator contains the data for 2011

Source: developed by the author according to the State Statistics Service of Ukraine (2018); Federal State Statistics Service of Russian Federation (2015); National Statistical Committee of the Republic of Belarus (2015); Word data Center (2019)

Table 2: The agricultural land use sustainability assessment by the indicators proposed for use at the macro level (2005/2013). (to be continued).

Indicators	BG	LV	LT	PL	RO	SK	SI	HR	CZ	EE	UA
The fifth block. Contamination of land and environment											
5.1. The flow of sulfur oxide into the atmosphere per capita, kg**	113.9	5.0	12.0	33.2	…	16.5	…	…	21.4	55.9	24.8
	108.8	1.2	10.0	22.1	25.8	10.8	…	6.3	15.0	30.6	31.2
5.2. The availability of household waste per capita, kg	588	320	387	319	383	273	494	336	289	433	…
	432	312	433	297	272	304	414	404	307	293	260
The sixth block. The technological level											
6.1. The adding of the mineral fertilizers per 1 ha of arable land, kg	74	68	98	162	51	81	330	295	90	61	18
	136	100	84	202	56	112	267	235	127	83	46
The seventh block. Health and standard of living of the population											
7.1. The rate of natural population growth	-5.4	-4.9	-3.9	-0.1	-1.9	0.2	-0.3	-2.1	-0.5	-2.2	-7.6
	-5.2	-4.0	-3.9	-0.5	-3.5	0.5	0.8	-2.4	-0.2	-1.3	-3.5
7.2. Gross agricultural output per capita, national currency units	488	166	1336	1088	1654	…	…	…	8898	…	2016
	586	380	1648	1526	2369	421	437	3674	7762	482	7419
7.3. The index of income concentration (Gini coefficient), %***	29.2	33.6	31.9	34.1	31.0	25.8	28.4	…	25.4	37.2	3.6
	34.3	36.0	32.6	32.8	27.3	26.6	24.9	33.6	26.4	32.7	3.4
7.4. The employment rate of the population, %	55.8	62.1	62.9	52.8	57.6	57.7	66.0	55.0	64.8	64.8	65.4
	59.5	65.0	63.7	60.0	59.7	59.9	63.3	52.5	67.7	68.5	67.4
7.5. The average annual per capita consumption****:											
7.5.1. Calories, kilocalories	2723	3149	3464	3371	3424	2841	3090	2979	3318	3171	2916
	2877	3293	3463	3485	3363	2902	3173	3052	3292	3214	2969
7.5.2. Proteins, g	78	86	120	99	109	74	99	78	99	92	86
	84	97	124	102	105	74	99	82	91	96	90
7.5.3. Fats, g	96	118	101	113	105	101	118	107	128	93	90
	92	127	103	121	105	107	119	110	139	88	100
The eighth block. The conservation of ecosystem functions and biodiversity											
8.1. The area of the forest fund, thous. ha	3652	3056	2176	9192	6628	1929	1308	2135	2648	2366	10556
	3845	3468	2284	9435	6951	1940	1271	2491	2667	2456	10624
8.2. The forest area, %	33.6	49.1	34.7	30.0	28.8	40.1	64.9	44.4	34.3	55.8	17.5
	35.4	55.8	36.4	30.8	30.2	40.3	63.1	44.5	34.5	57.9	17.6
8.3. The area of the protected areas, thous. ha	10234	12182	2945	68579	18826	…	…	4540	11785	15496	1057
	41617	13181	11542	112295	46796	17664	11232	9090	17426	16289	1576
8.4. The protected areas in total land area, %	8.7	16.2	4.4	21.3	7.8	…	…	5.2	15.1	22.1	1.8
	35.4	17.6	17.3	34.8	19.2	36.1	54.9	10.3	22.4	23.2	2.6

Note: * the data about the countries (except LV, LT and CZ) are given for 2003 and 2011; ** the data about LV, LT and RO are given for 2000 and 2008; *** the Quinta coefficient of funds value is given for Ukraine; **** the numerator contains the data for 2011

Source: developed by the author according to the State Statistics Service of Ukraine (2018); Federal State Statistics Service of Russian Federation (2015); National Statistical Committee of the Republic of Belarus (2015); Word data Center (2019)

Table 2: The agricultural land use sustainability assessment by the indicators proposed for use at the macro level (2005/2013). (Continuation).

The change of the land provision indicator (the area of arable land per 100 persons of the population) is marked by the positive dynamics in Ukraine. However, comparing this indicator to the level of arable territory, which is the highest value in Ukraine, it is obvious that the positive trend is provided by the increasing of the arable land area with the decreasing of the population.

The global issues are reflected in the indicators of ecosystem functions saving and the conservation of biodiversity and the protection of land (the indicators are the following: the area of the forest fund and the protected areas, the forest area, the share of the protected areas in the total area).

According to the natural indicators of the given block of indicators, Ukraine ranks the first places among the post-socialist countries, but according to the relative indicators, it ranks the last places. Ukraine has the largest area of the forest fund and the lowest level of the forest cover; the share of the protected areas is less than 3 %, while in other countries it ranges from 10 to 55 %. Moreover, the area of the arable land in the post-socialist countries is in times less than the area

of the protected areas, and in Ukraine – on the contrary.

The problem of the low technological level of production and the connected with it accidents and disasters, leading to environmental pollution is an extremely difficult problem for solving for the post-socialist camp countries (the indicators are the following: the share of the costs of fresh water in agriculture, the number of fires, the area of forest land traversed by fires, mineral fertilizers per 1 ha of arable land).

The problem of the economic evaluation of the pollution impact on the state of the soil is extremely relevant, as the European and Ukrainian studies showed. It is necessary for the executive and legislative bodies of power to pay more attention to the protection of land resources (the indicators are the following: the flow of sulfur dioxide into the atmosphere per capita; the availability of household waste per capita).

Among the post-socialist countries Ukraine ranks the eighth place according to the share of costs of fresh water in agriculture, but at the same time it ranks the second place according to the number of forest fires and the flow of sulfur dioxide into the atmosphere per capita, the fourth place according to the area of forest lands traversed by fires, and the last place according to the level of mineral fertilization.

Because of the environmental pollution and the decrease of the agriculture efficiency the problem of health and the living standards of population in Ukraine is identified (the indicators are the following: the rate of natural population growth, gross agricultural output per capita, the index of income concentration, the employment rate of the population, the average annual per capita consumption of calories, proteins and fats).

Ukraine compared to the post-socialist countries occupies the top positions according to the received gross agricultural output per capita (the second place), the level of employment (the third place) and the level of average calorie consumption (within the norms). However, the death rate in Ukraine exceeds the birth rate and fat consumption exceeds the protein consumption.

In turn, the changes in these indicators affect the structural changes in the ratio of rural and urban population: in Ukraine urbanization increases, while in Latvia, Lithuania, Poland, Slovakia, Slovenia and the Czech Republic the dynamics of the increasing of the proportion of rural population is positive.

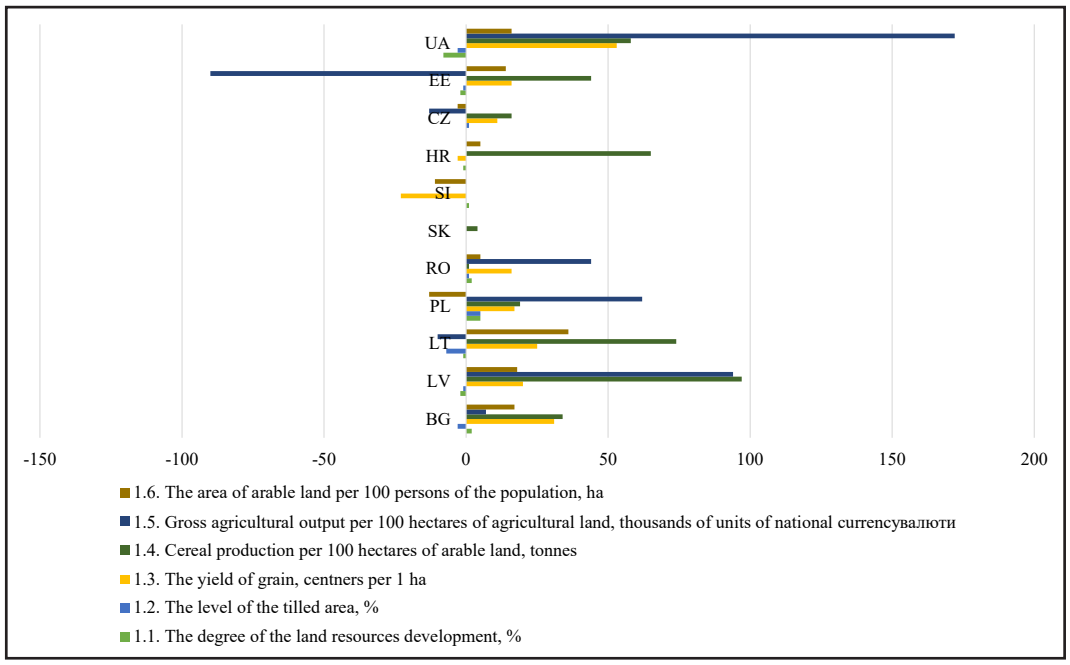
According to the obtained data, the agricultural land use in Ukraine, as well as in the other post-socialist countries, has a positive dynamics by the majority of indicators, but has not reached the sustainability indicators yet. According to the six indicators in Ukraine, Latvia, Lithuania, Slovenia, Croatia and Estonia the negative dynamics of development is set. Poland and Slovakia have better results (the first one has 4 indicators with negative value growth and the second one has 5 indicators with negative value growth). Bulgaria and the Czech Republic have worse results (the first one has 8 indicators with negative value growth and the second one has 9 indicators with negative value growth). However, only 3 out of 25 indicators (cereal production per 100 hectares of arable land, the area of pro in the total area) set a positive trend for all the countries.

In the context of the separate blocks of indicators, different trends are set.

As for the block "The level and efficiency of the land use" the most indicators with negative growth rate are set for Latvia and Estonia (Figure 4). Ukraine together with Latvia, Slovenia, Croatia and the Czech Republic is in the group of countries in which the negative deviation of growth rates is determined by two indicators. The least negative deviations in the growth rates indicators for this block are set in Bulgaria (1 indicator) and Slovakia (there is no any negative deviation).

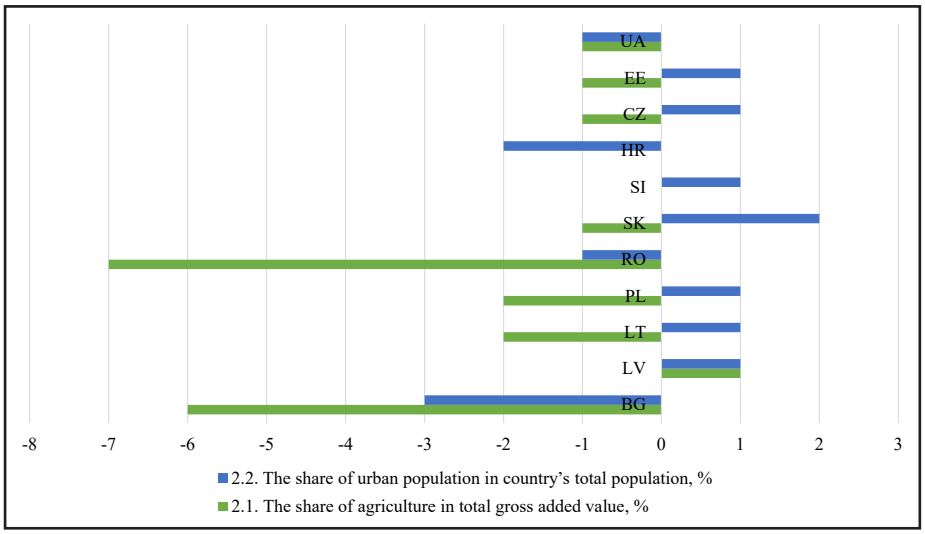
For such countries as Latvia, Lithuania, Croatia, Estonia and Ukraine, the problematic issue is the pace of dynamics of the development of the land resources and arable areas. The common thing for these countries is the positive dynamics of grain production per 100 hectares of arable land, though, the yield of grain in Slovenia and Croatia in dynamics decreased.

According to the block "Structural changes" only Latvia and Slovenia have positive dynamics of the indicators (Figure 5). The negative rate of the share of agriculture in total gross added value is set in 8 countries (Latvia and Slovenia are the exceptions), and most of all is in Romania and Bulgaria. The accelerated pace of urbanization can be seen in 4 countries (Bulgaria, Romania, Croatia and Ukraine).



Source: developed by the author

Figure 4: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the block "The level and efficiency of the land use".

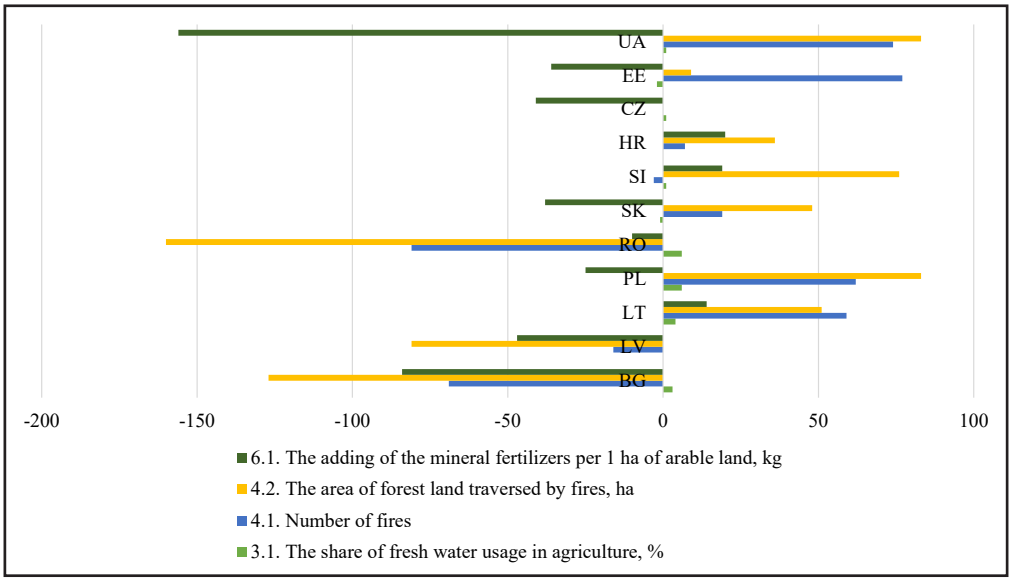


Source: developed by the author

Figure 5: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the block "Structural changes in the economy".

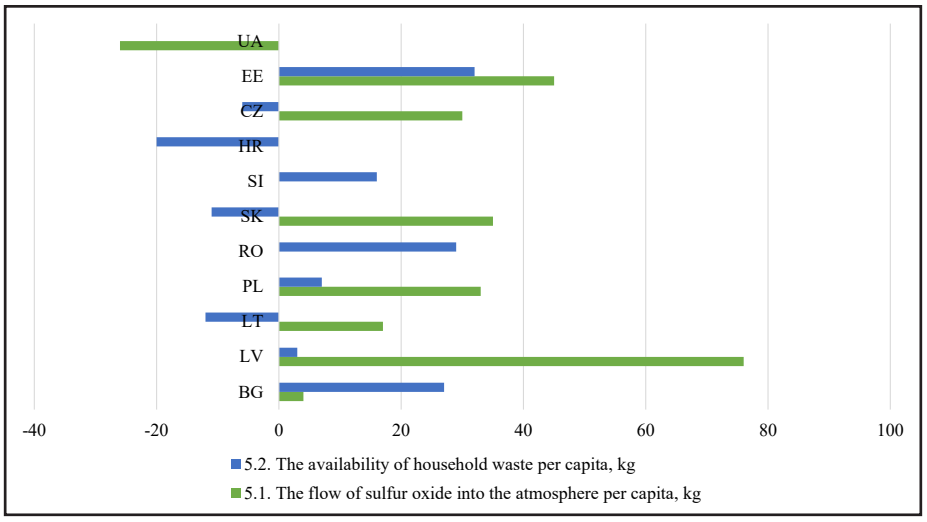
According to the block "Environmental losses", "Emergency" and "The technological level" the negative growth rates can be seen in all indicators, but most of all it is connected with the adding of the mineral fertilizers (Bulgaria, Latvia, Poland, Romania, Slovakia, the Czech Republic, Estonia and Ukraine) (Figure 6). On the other hand, such changes can be regarded as positive, contributing to the greening of production, as the growth rates of crops yield for most of these countries are positive. It should be noted that Bulgaria, Latvia and Romania have a very high growth rate of the number of fires and the area of forest land traversed by fires.

According to the block "Environmental pollution", Ukraine should be mentioned as the only country among the surveyed countries, which increased the flow of sulfur into the atmosphere per capita while reducing its number (Figure 7).



Source: developed by the author

Figure 6: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the blocks "Environmental losses", "Emergency" and "The technological level".



Source: developed by the author

Figure 7: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the block "Contamination of land and environment".

According to the block "Health and the living standards of the population", Ukraine is the only country which has the positive growth in all indicators (Figure 8). Another six countries (Latvia, Lithuania, Poland, Slovakia, Slovenia and Estonia) have negative trends only for one of the identified indicators. The highest growth rates of the negative values are set by the indicator of income inequality – in Bulgaria, Latvia, Lithuania, Romania and Croatia.

The top trends according to the studied indicators are set by the indicators of the block "The conservation of ecosystem functions and biodiversity» (Figure 9). Only in Slovenia the negative growth rates of the area of the forest funds and the forest area are found. However, the largest growth rates of the protected areas are set in Bulgaria and Lithuania.

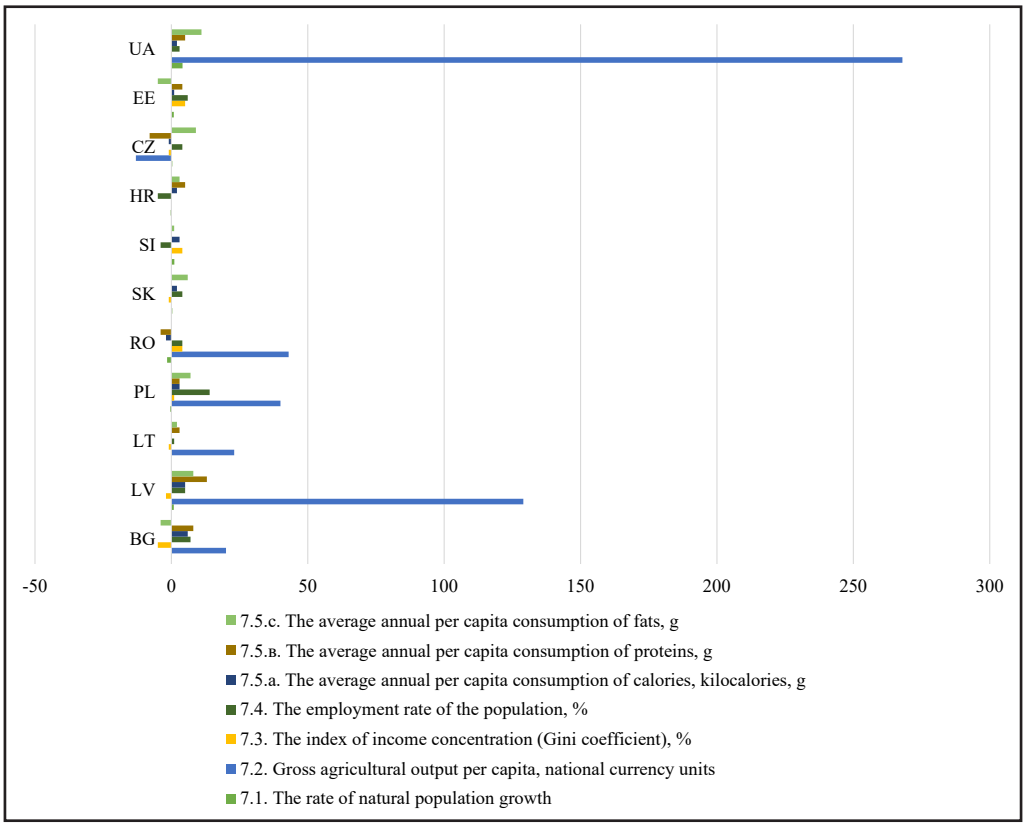


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Figure 8: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the blocks "Health and standard of living of the population".

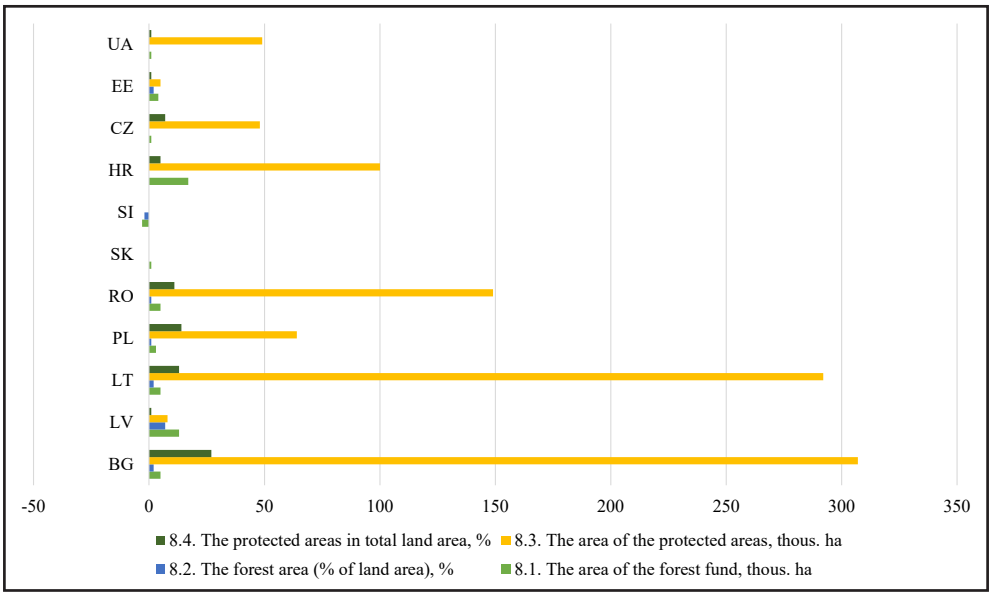

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Figure 9: The assessment of the dynamics of indicators of the agricultural land use sustainability according to the indicators of the block "The conservation of ecosystem functions and biodiversity".

Most indicators the dimension of which is allowed, we correlated with the data for 2005. As for some indicators because of the lack of the data the comparison was held for other periods:

- the share of agriculture in total gross added value – the data about the countries (except Latvia, Lithuania and the Czech Republic) are taken for 2003 and 2011;

- the flow of sulfur oxide into the atmosphere per capita – the data about Latvia, Lithuania and Romania are taken for 2000 and 2008;
- the average annual per capita consumption – the data for 2011 are given in the numerator. According to the index of income concentration (Gini coefficient) – the Quinta coefficient of funds value is given for Ukraine, which is calculated according to the methodology for assessing the living standards and incomes of the population of Ukraine according to the official statistics.

2. Calculating the integral indicator to compare the countries' land use sustainability

According to the calculations in 2005, Estonia, the Czech Republic and Latvia got the first three places in the ranking (Figure 10).

Estonia had the highest share indices by two of the eight indicators: the share of the fresh water usage in agriculture and the share of the protected areas in the total area.

In the Czech Republic the value of three partial indicators exceeded 0.7: cereal production per 100 hectares of arable land; the availability of household wastes per capita; the level of employment.

In Latvia the value of three partial indicators exceeded 0.7: the availability of household wastes per capita; the level of employment; the forest area; the share of the protected areas in the total area.

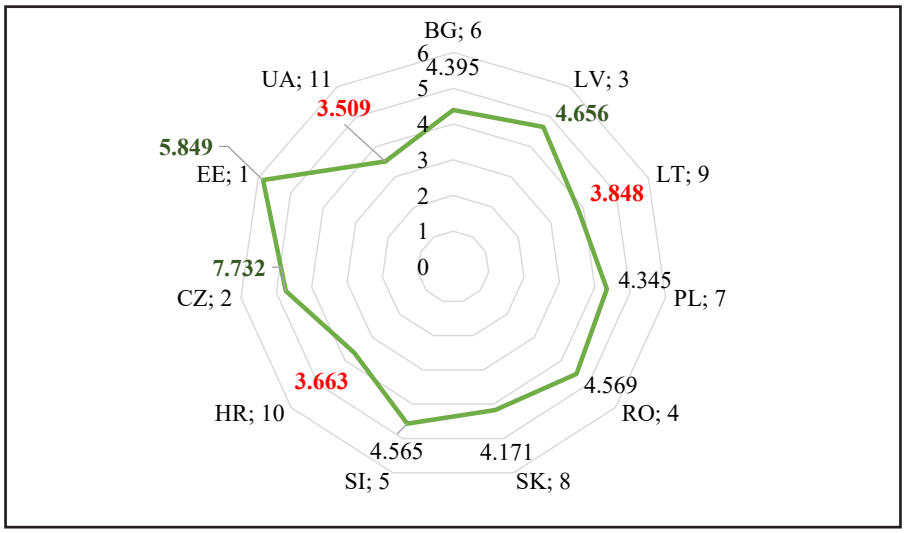
Ukraine, Croatia and Lithuania got the last three places in the ranking. The main reason for such low indicators, common to these countries, is the low share of the protected areas in the total area. In addition, Ukraine and Lithuania have the high level of the share of the fresh water usage in agriculture.

Overall, the gap between the highest and lowest generalized indicator of the agricultural land use sustainability assessment in 2005 was 2.34 units (the value of the highest indicator exceeds the value of the lowest one by 1.7 times).

During the ten years the ranking table changed for all surveyed countries except Bulgaria. Five countries fell by ranking, including: Poland – by 1 position; Lithuania and Estonia – by 2 positions; the Czech Republic – by 5 positions; Romania – by 6 positions. Five countries increased by rating, including: Latvia and Croatia - by 1 position; Slovakia – by 3 positions; Slovenia – by 4 positions; Ukraine – by 7 positions.

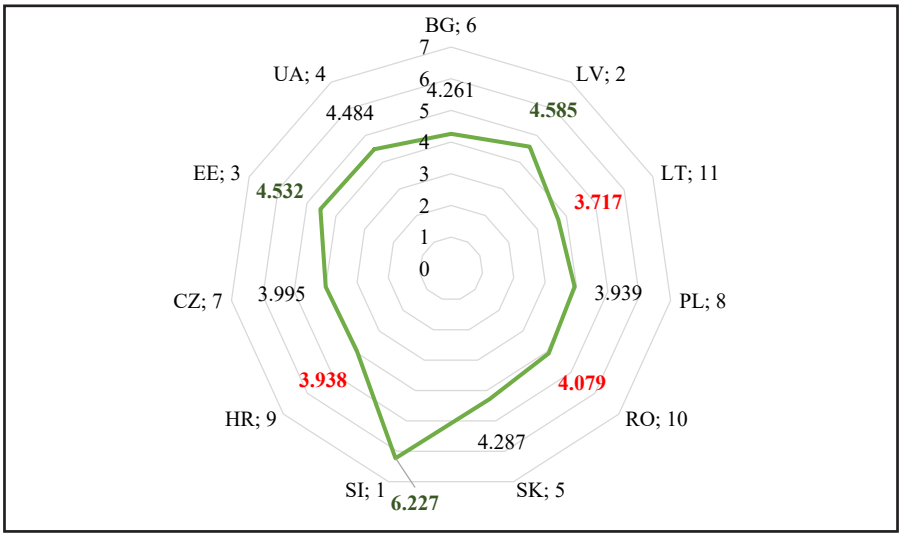
In 2013, Estonia and Latvia retained its primacy in the ranking, and Slovenia got into the top three instead of the Czech Republic (Figure 11).

The distribution of places among these countries according to the partial indicators also changed. For example, Slovenia had the highest share indicators in four out of eight indicators: the level of the tilled area; the forest area; the share of the protected areas in the total area and the share of the fresh water usage



Source: developed by the author

Figure 10: The rating of the post-socialist countries according to the agricultural land use sustainability assessment in 2005.



Source: developed by the author

Figure 11: The rating of the post-socialist countries according to the agricultural land use sustainability assessment in 2013.

in agriculture, in which there was a significant increase (of 0.761 units).

In Estonia and Latvia according to the three partial indicators their value exceeded 0.7: the availability of the household wastes per capita; the level of employment and the forest areas.

Croatia, Lithuania and Romania took the last three places in the ranking instead of Ukraine. In Romania in 2013 compared to 2005 the value of five out of eight partial indicators decreased (cereal production per 100 hectares of arable land, the share of the fresh water usage in agriculture, the level of employment, the share of the protected areas in the total area, the share of agriculture in the total gross added value). In Ukraine during this period the values of four indicators significantly improved (cereal production per 100 hectares of arable land, the share of agriculture in total gross added value, the forest area, the availability of the household wastes per capita).

The main reason for such poor indicators, common for these countries, also changed. If in 2003 it was a low proportion of the protected areas in the total area, in 2013 it was a high proportion of the fresh water usage in agriculture. Besides, Lithuania and Romania had a high level of the tilled area.

Overall, the gap between the highest and lowest general indicator of the agricultural land use sustainability assessment in 2013 was 2.51 units (the value of the highest indicator exceeds the value of the lowest indicator by 1.7 times).

Similar approaches to assessing the sustainability of agricultural land use, based on a system of indicators describing the economic, social and environmental results of land use, have been introduced by Marada et al. (2012) and Smith and McDonald (1998).

Marada et al. (2012) presents the importance and possibilities for assessing the sustainability of farming on arable land. The methodology SAGROS was developed at the Mendel University in Brno to provide tool for these assessments in the Czech conditions. It covers environmental as well as economic and social dimension of sustainability using set of 21 main and 32 partial indicators. Final result is presented by overview of normalised values in radial graph to make identification of week points of farm management easier. Unfortunately, this method was used to assess particular agricultural enterprise in the period 2009-2011. At the same time, the study confirms the representativeness of the assessment of the sustainability of agricultural land use according to our proposed method at the macro level, which has already been tested at the micro level.

Smith and McDonald (1998) review the current state of knowledge in defining sustainable agriculture within the broader sphere of sustainable development. They conclude that agricultural sustainability encompasses biophysical, economic and social factors operating at the field, farm, watershed, regional and national scales.

The immediate challenge is to determine what are sustainable agricultural uses before they are implemented – at the planning stage. The final section outlines a framework within which current land evaluation, environmental impact and strategic environmental assessment approaches to land use planning may be extended, and argues that these approaches must include, from the beginning, sustainability criteria.

For the first time, a comprehensive study assessing the level of sustainability of agricultural land use in the countries of the post-socialist camp, which are full members of the EU, as well as Ukraine, was published in 1999. Countries reports on the current environmental situation in agriculture were presented at the Central and Eastern European Sustainable Agriculture Network seminar (FAO, 1999). This document best reflects the objectives of our study in terms of content and list of countries studied. All reports have the same structure, which simplifies their comparative assessment, and are built on the principle of identified problems, which corresponds to the first methodological approach of our study. On the other hand, the reports are more descriptive, which makes it impossible to compare them quantitatively by measuring the indicators according to the second methodological approach proposed in our study. At the same time, the conclusions declared in the report are in full agreement with the conclusions of our study, in particular, obtained by the first methodological approach.

The next similar study was conducted in 2005, the results of which were published Agriculture and environment in EU-15 – the IRENA indicator report (EEA, 2005). The project covered 15 EU Member States in 2002 and aimed to develop a system of agri-environmental indicators to monitor progress towards integrating environmental concerns into the CAP. The report covers the period from 1990 to 2000 on 42 indicators. The evaluation was performed for each indicator on a score system from 0 to 2, which generally gave a result in the range from 6 to 19 points: 13 indicators are in the range of 15 points and above, which characterizes them as positive; 28 indicators are in the range from 8 to 14 points and are characterized as potentially positive; only 1 low potential indicator (ground water levels – IRENA 31). Thus, this study is more consistent with the first methodological approach proposed by us in the article. However, the conclusions of the report are not detailed for specific countries, and the recommendations are general for all countries studied, so they can not be compared with the results obtained in our study, although the list of indicators is significant in number.

The latest report on a large-scale study of the sustainability of agricultural land use on identified issues in EU member states was published in 2014 (Keenleyside et al., 2014). Unlike previous documents, this study focuses on assessing the results achieved through the implementation of the Common Agricultural Policy. This fact-finding study provides recommendations for future EU policy on the development of High Nature Value farmland. All the digital information in the study is given in aggregate for the 27 EU member states in 2014, so it is impossible to compare the results of the report with the research of the article, but the main recommendations of the report are consistent with the conclusions of the article in the economic block.

Further research focuses mainly on the ecological component of agricultural land use. This approach may be due to the fact that social issues related to land use are not as critical for EU member states as for Ukraine. In particular, a report was published in 2014 that includes aspects of data on the various relationships between agriculture and the environment (Elbersen et al., 2014). The report describes data gaps in the field of ecologically valuable pastures and lands, provides examples of best practices in agricultural land use and practical recommendations for optimal design and management of coastal buffer zones. The conclusions of the report coincide with the conclusions of the study in terms of proposals for solving environmental problems, which is explained by the purpose of the report. However, the proposals and recommendations presented in the report are mostly generalized without country detail.

A number of other reports were published before 2014, but the conclusions cannot be compared with those obtained in the article, as the reports either covered a narrow range of research problems or considered a set of problems in the context of a single country or 2-3 countries.

After 2014, no studies similar in content and coverage to countries were conducted.

Summarizing the above, in general, for all studied countries, the following three criteria for sustainable land development in the long-term perspective could be identified.

First, for land resources, their number or ability

to produce biomass must, at least, not decrease over time, that is to ensure a simple mode of reproduction. This means preserving the area of the most valuable agricultural land or – in the case of reducing their area – maintaining (increasing) the level of agricultural production, forage potential of land for farm animals, etc.

Secondly, it is necessary to develop and implement systems of low-waste and resource-saving technologies, which will significantly reduce their workload per person or unit of area.

Third, pollution of land resources (both total and by type) in the future should not exceed its current level, it is necessary to predict the possibility of minimizing pollution of socially and economically acceptable level (unrealistic to expect "zero" pollution).

This approach to determining the main criteria is based on the fact that land belongs to the category of inexhaustible renewable resources. Thus changes in economy of land resources should be based on methodological principles of modern resource science:

1) inexhaustible resources do not exist. On the Earth in relation to human activity there is an inviolable law of exhaustion of all natural resources. Even sources of cosmic energy – solar radiation and gravitational (tidal) energy can be limited in time due to changes in their quality on Earth under the influence of anthropogenic actions;
2) exhaustibility of land resources depends on the level of their renewable. The amount of land extraction that exceeds the amount of their self-restoration, in fact, puts these resources in the category of non-renewable. Excess of extraction over recovery, even short-term, is dangerous not so much by reduction of stocks of resources, how many disturbance of natural regulatory mechanisms of recovery;
3) no research or economic activity can be qualified as the reproduction of land resources. As a rule, it is only a matter of expanding the front of their operation. In the best and very special case man can only partially restore the previously impaired ability of natural mechanisms to recover;
4) large-scale exploitation of land resources on the scale of the evolution of the biosphere on Earth can be maintained only for a relatively short time, limited by the impending global environmental crisis;
5) the laws of nature exclude ownership of ecosphere resources, including land. Resources should not belong to individuals, groups of people or states. They belong to all mankind as a whole, including all future generations of people. Therefore, the ownership of land resources established by human laws is always relative and can never be complete. Land ownership, which harms nature and through it man, must be excluded;
6) land resources used by man must be reproduced, restored both quantitatively and qualitatively. This means the qualitative characteristics of the soil. Expecting natural recovery in conditions of violation of the environmental regulatory function of the biosphere in most cases are not justified;

The implementation of these principles essentially means the application of a high biosphere environmental tax on land resources, which will ultimately lead to an increase in the cost of the entire resource base of the economy and, accordingly: general quantitative restrictions on the extraction of agricultural land resources; the need for fuller use of useful components from raw materials; stimulation of all means and technologies that allow to reduce the volume of land resources in the process of production and consumption; the need to find technologies for agricultural production that would replace the use of land resources with new, cheaper and highly environmental.

All these criteria must be taken into account in the process of developing the concept of sustainable development. Taking into account certain criteria will preserve the environment for future generations and will not worsen the ecological conditions of their habitat.

Conclusion

The generalization of the foreign and domestic methodological experience to develop the sustainability indicators sets the following trends:

- the increase of the number of indicators used to assess sustainability necessitates their classification. The totality of the indicators characterizing the relations in the "society-

nature" system is proposed to attribute to the ecological and economic indicators. The indicators of the balance type that show the ratio between "the reserves of the natural capital" and the degree of its use, taking into account compensation measures, are recommended to attribute to the indicators of sustainability;

- the value of the component-wise indicators (with a total increase in their number) is kept at the regional level, and the role of the integral indicators, including the assessment of the natural resources and human potential, increases. As part of the regional programs of ecological and economic development the component-wise indicators are used that can be transferred to the integral indicators using integrated environmental and economic accounts.

The expediency is proved and methodological approaches for the agricultural land use stability assessment has been made up: the construction of the system of indicators, each of which reflects some aspects of the land use sustainability at the macro level; the construction of the integral indicator to compare the countries' land use sustainability.

According to the given methods it has been proved that agricultural land use in the countries of the post-socialist camp has a positive dynamics, but the sustainability indicators for all indicators have not achieved yet.

It has been defined that Estonia, Latvia and Slovenia got the first three places; and Croatia, Lithuania and Romania got the last places in the ranking of sustainability of the agricultural land use for the countries of the post-socialist camp. To solve the problems in the field of the agricultural land use, Lithuania, Bulgaria, the Czech Republic, Poland, Slovakia, Latvia, Romania and Ukraine should focus on the issues of the land resources use; Poland, Slovenia, Estonia, Romania should concentrate on the issues of the efficiency of the land use; Lithuania, the Czech Republic, Poland, Croatia, Slovakia, Slovenia, Estonia and Latvia should centre on the issues of the improvement of the system of the structural changes in the economy; all countries, except for Slovenia, should focus on the issues of reducing the environmental losses; Lithuania and Estonia should be concentrated about the issues of the reduction of the environmental pollution; Croatia should stick to the issues of raising the level of employment; Lithuania, the Czech Republic, Croatia, Estonia, Latvia, Romania and Ukraine should pay attention to the issues of the preservation of ecosystem functions and biodiversity.

The obtained results should be used in the future in the construction of national and regional models of optimal use of agricultural land on the example of the study Ongsomwang and Lamchuen (2015).

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Declaration of interest statement

The data that support the findings of this study are openly available in State Statistics Service of Ukraine at http://www.ukrstat.gov.ua, in Federal State Statistics Service of Russian Federation at http://www.gks.ru, in National Statistical Committee of the Republic of Belarus at http://www.belstat.gov.by, in Word data Center at http://wdc.org.ua.

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The Internet of Things - the Nearest Future of Viticulture

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Abstract

It is recognized that viticulture and wine sector in general successfully combines traditions and innovations. The Internet of Things technology has already found its way to the vineyards as a prospective innovation. The innovations in wine industry are discussed in the publications, however, IoT not so often falls within the focus.

In order to show the production and consumption trends in viticulture we rely mostly on the data accumulated by the International Organization of Vine and Wine. Some analytical materials of Food and Agriculture Organization of the United Nations were also relevant for this study. The information about implementation of Internet of Things is quite fragmentated by now and was collected from different sources.

At least two drivers of Internet of Things in viticulture could be mentioned. The first is the climate change and the need to respond to its challenges by wine growers. Technology helps to detect the changes and suggest the best and timely solutions. The second reason why the IoT has prospective in wine sector follows from the characteristics of wine and its consumption trends. There are quite a few strategic decisions to be taken by wine producer and consumers related to wine. These strategic decisions need to be based on a precise data accumulation and processing. The Internet of things is relevant for the decisions of storage, sales, ratings, and collectibles. The range of end-users of the data processing is wide enough in the wine sector.

The Internet of Things is already reality of viticulture and it has prospective to develop further. This paper argues that viticulture is a readily open for the IoT and there is a field for IoT implementation in there.

Keywords

Internet of Things, IoT, wine, consumption, viticulture, smart agriculture, internet of grape, smart vineyard, law and technology.

JEL Classification Q160, N50, L66, L86, E21

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Introduction

Recently the concept of "smart agriculture" became the core idea of the innovations in the contemporary agricultural sector (OECD-FAO, 2020). The vitiviniculture is among the first where new digital technologies are successfully implemented. The digitalization comes to the vineyards and makes them more efficient, more productive and improves control over the processing (OECD, 2019).

Quite an important part of the viticulture digitalization is the implementation of the Internet of Things (IoT) technologies. Collecting data from things then accumulating the data via internet, analyzing it and even suggesting the correct decision – that is the essence of the internet of things. The IoT in viticulture supports the decision making on irrigation, fertilization, harvesting etc. The new technology allows the optimal mapping of vineyards as well as quick reactions to the changing circumstances and ambient conditions. Technologies in general and the IoT in particular open the new opportunities for the winegrowers and become more and more popular. There is even a new term "internet of grape" sometimes used in the publications (Rossanez et al, 2018).

Innovations and modern technologies related to the wine sector are popular topics of international academic research. There are already a few studies devoted just to the bibiliography in this field (Seccia, 2019, Glänzel and Veugelers, 2006). Comparative studies of innovations in wine sector of different countries constitute a bulk of publications (Cusmano et al., 2010).

The publications focusing on the wine sector usually characterize the viticulture and wine making as an industry where traditions and innovations constitute a successful combination or a synergy (Stupino et al., 2019; Vrontis et al., 2016).

In the studies on innovations management the contemporary innovations are usually classified into internal, external, and mixed (Schilling M. 2020, Shashkova and Kudryashova, 2020). This classification is successfully applied to the viticulture and wine sector (Vrontis et al., 2016). IoT in the wine sector was also in the focus of social sciences studies (Spadoni et al., 2019, Bencini et al., 2010).

However, the IoT technology in vitiviniculture did not attract much attention of academics. This paper is filling this gap referring to the already existing cases and showing the prospective of IoT implementation in viticulture. The purpose of this paper is to demonstrate the potential of IoT for the viticulture.

Materials and methods

Two important international organizations are dealing with the viticulture around the world and accumulate the data about the wine production, wine consumption and vitiviniculture. These two organizations are The Food and Agriculture Organization of the United Nations (FAO) and the International Organization of Wine and Vines (OIV).

The Food and Agriculture Organization was found as a specialized agency of the United Nations mainly focused on the food security. The FAO has 194 member states and works in more than 130 countries worldwide[1]. Usually, viticulture forms a part of agriculture. It was not the case in some countries. Due to the focus on the general issues of agriculture and food security the data of FAO refers to grape not dividing it to the table grape and wine grape. Therefore, not all the conclusions and data are relevant for this study.

More relevant information can be found in the data and documents of another international organization - the International Organization of Vine and Wine. OIV is an intergovernmental organization with a focus on vines, wine, wine-based beverages, table grapes, raisins and other vine-based products. By 2018 the OIV the representatives of 48 counties already took part in its work[2].

In this research we shall rely mostly on the data of the OIV and on certain conclusions of FAO specifically referring to winemaking.

This research paper endeavors to present the viticulture as a field where IoT can be readily implemented and disseminate in the nearest future. The following hypotheses could be drafted for this research paper:

Hypothesis 1: There is a need for the IoT in viticulture. The drivers for IoT implementation in viticulture could be identified in the contemporary changing world;

Hypothesis 2: Due to the objective need for IoT in viticulture there should be an evidence for that and examples of successful applications. Based on these examples we can assert that there is a prospective for IoT implementation and market for this technology.

The combination of empirical and theoretical methods is employed in this research. The issue of this study shall be placed in a broader context. The first hypothesis requires to give a reason why the IoT is needed in the viticulture. Characteristics of wine and certain consumption trends are relevant for carrying out this task.

Design of this research required to find examples of the implemented technologies around the world. This task was successfully performed and the cases from different parts of the world are presented in this research. The aim of the paper is to collect and analyze the information about the IoT projects and show the drivers of the new technologies implementation in viticulture and agriculture. Most of the literature in the field do not focus specifically on the IoT in viticulture. This paper fills in this gap.

Results and discussion

Driving factors for the IoT development in viticulture

There are a few drivers for implementation of the IoT technologies in viticulture and the list

[1] http://www.fao.org/about/en/ (Accessed 12 May 2021)

[2] https://www.oiv.int/en/the-international-organisation-of-vine-and-wine/member-states-and-observers (Accessed 12 May 2021)

of them could be extensive and never closed. Some of these drivers are shared with other sectors of agriculture and others are specific for the viticulture. The list of factors includes both natural and social factors. In this research we focus on two factors which seemed to us the most important this time and relevant for IoT technologies.

The first factor to be mentioned here is the climate change. It is the natural factor relevant for agriculture in general, but still having peculiarities specific for viticulture.

Only zones roughly between the 30th and 50th latitudes are suitable for wine growing. These zones were quite stable for a long time and traditions were established within these territories of viticulture. Besides the link to territory within the general limits of winegrowing area viticulture is strongly tied to the place and its characteristics which is well expressed in the concept of terroir - unique interplay of natural (soil, climate etc.) and cultural (traditions, wine makers practices etc.) factors inherent to a limited area (Vaudour, 2002).

Many agricultural products are sensitive to the change of climatic factors (OECD-FAO, 2020). However, wine is special because of a limited zone of quality winemaking and the concept of terroir. The climate change moves limits of this traditional zones and force wine makers to look for new solutions. At the same time the historically established terroirs are distorted(Tomasi, 2013).

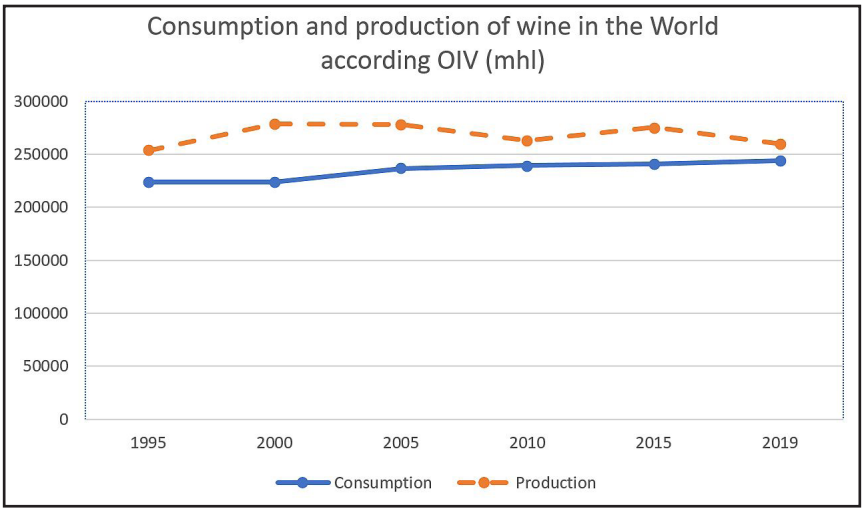
Improving technological support for decision-making related to the vineyards helps to find solutions of how to keep the historical terroir. The IoT accumulating and allowing to analyze the data of the vineyards precisely shows the climate changes and allows timely decision making on the wine variety and the farm management.

The second driver of the technological changes in viticulture is the nature of wine as a product. The quality of wine and the traceability of its production are very important for consumers (Bencini et al., 2010; Casetti and Kudryashova, 2021) .

Demand for wine is quite steady as well as production quantities according to the data of OIV collected since 1995 (Figure 1).

According to OIV the vineyard surface area and consumption of wine is stable or grows poorly (OIV, 2019)

However, the market is very competitive (OIV, 2019), and consumers are obsessed by quality of wine and those factors which impact the price (processing, traceability, fame of vineyards etc.). Innovations has been identified as the key success factor for the increasingly competitive wine industry (Hira and Swartz, 2014). The prices of wine unlike the other agricultural products varies from year to year (Pitt, 2017). The wine prices can change enormously from year depending on the weather conditions. Other peculiarity related to the variation of price is that the weather conditions are relevant for the longevity of wines. The storability is an important quality of fine wines and the value of wine is preserved with years or even grow dramatically. The variation of prices



Source: Based on the data of OIV https://www.oiv.int/en/statistiques/recherche

Figure 1: Consumption and production of wine in the world according to OIV (mhl).

forces the wine makers to take both strategical decisions requiring massive of data and take more interim decisions.

Wine sector in general is quite steady, but recently there are some changes in consumption patterns. Globalization and regional integration processes has brought the culture of wine consumption to the countries where it was not a traditional earlier.

The OIV declares that wine is being consumed more and more in the countries with a large, young population. The data of OIV shows that the consumption of wine in Europe where it is traditional is slightly decreased meanwhile consumption of wine in Asia slightly increased (Figure 2).

Besides the general trends in consumption patterns the mass tourism comes into play. The international hotel business and the tourist flow from western world expanded the demand for wine in the regions where wine was not consumed due to traditional, religious, and cultural factors.

Examples of IoT implementation in viticulture

The IoT technology falls within the external or mixed innovations. It is not an invention of vineyards and wine makers. IoT is usually developed by the computer and technology industry. However, development of IoT for viticulture is not possible without participation of wine industry. The knowledge of viticulture resides in the vineyards. There are already the pilot projects of implementations of IoT in the specific vineyards as well as the projects realized in cooperation with wine science, winemakers and the technological company.

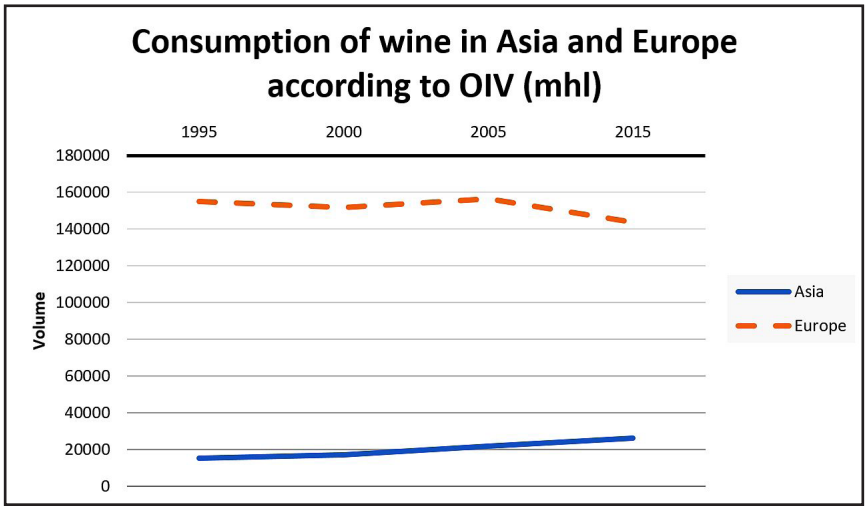
Here we demonstrate the examples of implementation of IoT in viticulture as an evidence that the IoT is not a distant future in this sector. There are already a few companies involved in research and development of the IoT technologies intended for wineries.

The Tracovino is a project which is already commercialized and available for sale on the market. The project carried out by Ericsson, Intel, MyOmega System Technologies and Telenor Connexion. Each company provided a certain component for the project. This project was implemented on four wineries in Germany. The Tracovino system put together platform, sensors, networks and smartphones. Various information about the soil PH, moisture, nutrient components, information about the climate and weather conditions (temperature, humidity, solar radiation, enlightment etc.). The system is energy efficient and solar-powered. As a product for winemakers Tracovino is a package of sensors, controllers, services[3]. By 2015 a few winemakers were already connected to Tracovino: Knebel, Clemens, Franzen. Haart[4].

The EU Integrated project "GoodFood" should be mentioned here. Although it is nearly, but not exactly IoT project according to the opinion of its authors. In this project the "Ambient Intelligence" technologies was deployed in a few pilot sites.

[3] Tracovino: In vino IoT https://www.wespeakiot.com/tracovino-in-vino-iot/

[4] Ericsson Connected Vineyards https://www.ericsson.com/4a21f3/assets/local/news/2015/12/iot-connected-vineyards.pdf



Source: Based on the data of OIV https://www.oiv.int/en/statistiques/recherche

Table 2: Consumption of wine in Asia and Europe according to OIV (the data is available only up to 2016).

Ambient Intelligence (AmI) was designed to get simple data from smart sensors, fusing and mining data allowing the user to have a reliable and detailed information of changes in the environment in order to let the user control the site and make decisions wherever in the world. AmI is the concept very close to IoT but the AmI is not a self-controlled system. A few of the pilot sites were organized in Italy. One of the pilot sites was deployed in 2005 in the Montepaldi farm, Chianty Tuscany Italy. This pilot site is owned by the University of Florence. Another was deployed in 2007 in the Chanti Classico area, monitoring the variations in "terroir". The AMI technology in the GoodFood project proved to be reliable and able to provide detailed data representation to the final users. (Bencini et al., 2010)

There is an example of pilot IoT project in the viticulture coming from the United States. Salt Creek Vineyard based in Massachusetts implemented the IoT for detecting weather parameters and soil parameters. The Salt Creek Vineyard manage several fields with completely different microclimates therefore the wineries must be cared for differently. The project relies on the technologies and equipment provided by Dell and INEX IoT Impact Labs with their partners[5].

Recently a very advanced and sophisticated digital technology product was announced in Australia. And this project is the outcome of the joint efforts of different sectors of economy and government. The Australian project VitiVisor is a one of the most advanced in terms of digitalization of vitiviniculture. The VitiVisor platform is designed to collect data from the vineyards by means of sensors and cameras generating the massive of data (Savage, 2020). The collected data is stored and analyzed by and artificial intelligence. Based on the analysis the VitiVisor offers advice on the irrigation, pruning, fertilizers, fungicide application etc. The IoT helps to aggregate together different technologies and scientific knowledge: the engineering, agriculture economics, water technologies, artificial intelligence, robotics, remote sensing The VitiVisor is a digital platform developed by the University of Adelaide in cooperation with the non-commercial organizations from the wine sector. The project is supported by the wine industry and regions of Australia. The platform shall be open for access to all the winegrowers in Australia. This kind of projects became possible only due to teamwork of research (academic), policy (government) and industry and synergia of their intentions and interests (Hira and Aylward, 2013).

[5] https://www.iotworldtoday.com/2016/12/07/11-innovative-iot-use-cases/

Discussion

"Datafication and digitization" have recently increased the volume and coverage of agricultural data and mentioned cases demonstrate it. Combined with the progress in communication development and processing capacity these data technology developments pushed the farm management to a new level. Large streams of data and increase of the analyzing capacity enabled to establish dependencies and make predictions informing and serving the day to day decision-making process. Still the contemporary data processing technologies have not been used to its full potential to date (OECD, 2019, Shashkova and Verlaine, 2020). IoT is one of the most relevant contemporary technologies for agriculture and in particular viticulture.

At least two drivers for the implementation of IoT in viticulture could be mentioned. The possible climate change is one of them. The zone for production of wine is quite limited therefore the viticulture is very sensitive to the moves of these limits. IoT technology collecting data helps to preserve the historical zone serving the decision taking. The IoT allows to understand better the traditional terroirs collecting more precise data about the microclimate (Tomasi et al., 2013). In the future if the climate will really change it will help to preserve the historical terroirs.

The IoT helps not only to take better decisions on the vineyards within the traditional winegrowing zones, IoT technology allow to make the attempts to broaden the traditional wine making zones. More data and data processing technologies are needed for setting vineyards in a non-traditional location. The precise data on the microclimate conditions allows to find spaces eligible for wine growing outside the traditional wine regions and closer to the main tourism directions. Good illustration here is the concept of New Latitude Wines. New Latitude wines are produced of wine grape grown outside the traditional wine growing band. For example, the experimental wineries developed by the Chinese wine company Changyu in Thailand produces red and white table wines well under 18 degree of north latitude. In order to carry out this project sensors were placed in different arears of Thailand to find territorial spots eligible for vineyards in Thailand (Robinson, 2015). The touristic infrastructure needs much wine more convenient and cheap comparing to the imported wines.

Another driver for IoT implementation is the special interest to the quality of wine and traceability of its production. Special feature of wine is its storability and the price variation depending on the weather conditions in a specific year. Due to the specific characteristics of wine the wine producer has to take more strategic decisions than other farmers. There are certain concepts of special years which are better than others. For example, the wine maker decides to keep the wine for more years – like the colheita port wine. The winemaker decides on the longevity of wine. Therefore, there is a demand for more precise and extensive data.

Wine is a special product in terms of the information required by consumer as well. Even the labelling of wine is thoroughly regulated and contain the information about the country, region, estate or property where the grape for the specific wine comes from. And consumer wants to know even more about wine: how they store and process it, and how they use it. (Pitt L. 2017) Various ratings, opinions of experts etc. are surrounding wine. The stakeholders around wine industry like auctioneers, sommeliers, restaurants, wine collectors, wine experts and reviewers etc. become the end-users of the information and predictions on the basis of the IoT. Not only the winemakers need it as precise as possible.

For the viticulture IoT is the contemporary reality rather than the future. There are already commercial projects in this field and we have demonstrated a few of them coming from different parts of the world. The examples show that IoT is already in use for a few years and there are no signs that the participants want to stop them.

The experts of the FAO noted that the quality of wine is not good enough in many territories due to the lack of awareness of the modern viticulture practices (FAO UN, 2010) The same could be said about the IoT technology in viticulture. It was not so easy to bring together these examples. To certain extent even this article contributes to the modernization of viticulture giving the information about the IoT in viticulture.

Conclusion

The viticulture is the sector of agriculture where the implementation of IoT is mostly expected. There are two factors which can facilitate the implementation. First is the climate change which has particular impact on viticulture. Second factor refer to specific characteristics of wine. These factors in the future relevant for proper assessment of the market for IoT technologies in viticulture and further prospects of growth.

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Cloud Computing in Agricultural Enterprises in Slovakia

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Abstract

We are currently making great strides in the field of ICTs, which is associated with the availability of other larger volumes of information any species. There are problems with their analysis, storage, as well as security in companies. The aim of the paper was to focus on the agricultural sector in terms of innovation. In the presented article we deal with the issue of cloud computing and its use in management in agricultural enterprises in Slovakia. We characterize cloud computing, its advantages and disadvantages, as well as the current use of this service by agricultural entreprises in Slovakia. We used the method of questionnaire survey and personal interview to investigate the above problems. We also focused on the study of cloud computing and related issues from available foreign sources. The results show that agricultural enterprises in Slovakia use cloud computing services less with comparing to the countries of EU.

Keywords

Agriculture enterprise, cloud computing, information.

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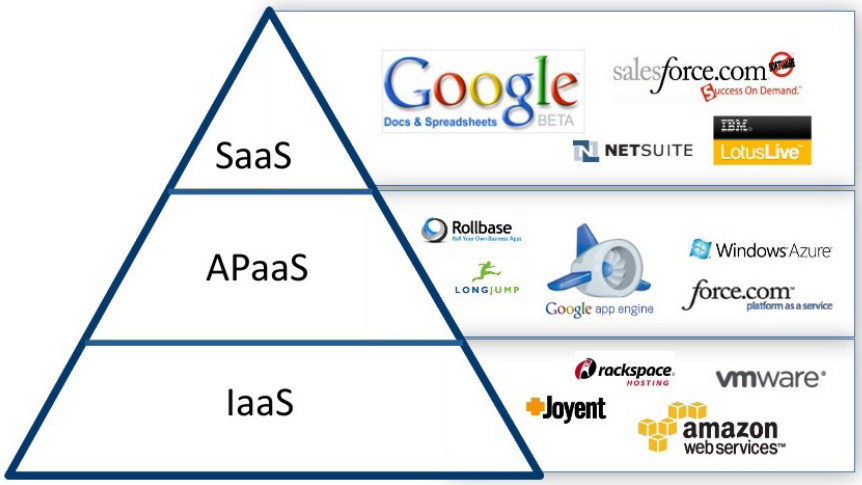
Introduction

The development of ICT in business increases the dependence of enterprises on their use and managers must pay an necessary attention of this. ICT penetration also influences agricultural enterprises (Szabo et al., 2017). Their development influences economic environment and ranks among factors of business prosperity and competitiveness. Nowadays, it is not possible to manage enterprises and take professional decisions without information and using of ICT (Bolek et al., 2018). Some professionals consider cloud computing to be a significant advance in the area of development of computing technology over the last decade (Rajaraman, 2014). It is a new generation of information technology that integrates grid and cluster computing, virtualization, distributed processing, and computing (Sui and Sui, 2018). Cloud computing is a model that provides convenient network access to shared configurable computing resources on demand, which can be quickly provided and released with minimal effort in the area of management or interact from the service provider (Mell and Grance, 2011). The goal of cloud computing is to deliver applications over the Internet using hardware and software existing in data centers that provide these services in a transparent manner without the user needing to know the details of the underlying software and hardware. It offers cost-effective development of scalable web applications on a highly available fault-tolerant infrastructure (Wazzan and Fayoumi, 2012). Cloud computing is used for efficient data processing to make better decisions. It is an affordable, scalable and highly available platform technology (Tan, 2016). Many companies are interested in moving from their old system to a cloud computing system, with a view to minimizing the cost of using computing resources (Amanatullah et al., 2013). Cloud computing is a way to integrate a state-of-the-art background computing infrastructure to provide computing services to a large number of users (Goraya and Harjinder, 2015).

Choosing the right service model is a crucial success factor for a business. Therefore, it is necessary to understand what each model involves, what responsibility the cloud service provider as well as the consumer himself has. There are 3 cloud service models: Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS) (Figure 1).

SaaS is the provider's applications that run in a cloud infrastructure, and these applications are accessible



Source: Gartner (in Schalk 2010)

Figure 1: Examples of cloud computing services in single modules.

to the consumer from various client devices either through a web browser or through a programming interface. The provider manages the entire infrastructure, networks, servers, operating systems, storage, as well as the applications themselves. The consumer has the option to configure only some user-specific application parameters. PaaS provides the ability to deploy consumer-created applications to the cloud infrastructure. With PaaS, the provider also manages the cloud infrastructure. However, in addition to the possibility of setting the application parameters, the consumer also has control ver the entire application. With IaaS, the consumer also does not manage the cloud infrastructure, but has control over the operating systems, storage and deployed applications. Limited control over selected network components is also possible (Mell and Grance, 2011). Data as a Service (DaaS) is less talked about compared to the above layers, as many vendors currently offer cloud services in one or all of these layers. Given that people in the research field are interested in using the cloud, there is great interest in the availability of data as a service, especially for geographic data. It is thus the provision of valuable data as a service over the Internet on the basis of payment for its use (Patil et al., 2012).

Cloud computing includes three types of deployment models: public cloud, private cloud, and hybrid cloud. The public cloud offers services to every consumer over the Internet, which means that the cloud infrastructure is owned by a specific organization that sells services to the public. Private cloud offers services to selected customers, which means that the cloud infrastructure is owned by one organization, which manages it itself. The hybrid cloud is a combination of public and private cloud; offers services from both public and private sources (Wazzan and Fayoumi, 2012). Many companies are implementing private clouds on their premises due to distrust of data security. With a private cloud, an enterprise can design, develop, and implement a customized cloud service and have complete control over data and other security issues, which is not possible in a public cloud (Wang, Rashid and Chuang, 2011).

Hori, Kawashima and Yamazaki (2010) report the following benefits of cloud computing:

- lower start-up costs,
- unrestricted allocation of resources on request,
- maintenance and updates are performed in the background,
- easy and rapid development, including cooperation with other cloud systems,
- more opportunities for the development of global services.

Patel and Patel (2013) include to the benefits of cloud computing its easy service management (there are no worries about procuring of licences, hardware, data center operations), scalability (easy extensibility of the service with new users), device and location independence (the way of accessing to the cloud can be your computer, someone else's computer, smart phone or solar powered touch pad). Abdalla and Varol (2019) also see certain issues with cloud storage services, such as control, security, support, performance and vendor blocking.

Cloud computing plays an important role

in the agricultural sector. With the introduction of the latest technologies, management is very simple. Cloud computing facilitates the storage, management, access and dissemination of agricultural information quickly and at low cost (Goraya and Harjinder, 2015). In the modern era of cloud computing technology, it is very useful to centralize an agricultural database (soil, weather, research, crops, farmers, agricultural marketing, fertilizer and pesticide information) in the cloud (Choudhary, Jadoun and Mandoriya, 2016). Cloud computing enables farms to provide all necessary services at affordable costs (Patil et al., 2012).

With the growing use of mobile devices and the development of wireless technologies, cloud computing has become a widely used model for providing services over the Internet (Alqahtani and Arishi, 2020). Mobile cloud computing is currently the primary element of research direction in mobile applications (Hao et al., 2018). Mobile cloud computing offers several benefits to the agricultural sector. Without worrying about investing in hardware and software, farmers can send their requests for specific data via cloud services using their mobile phones and internet connection. The cloud service provider processes these requests and sends back the results to clients (Athmaja and Hanumanthappa, 2016). The integration of cloud computing into the mobile environment also provides other benefits, such as longer battery life or lower processing load (Alonso-Monsalve, Garcia-Carballeira and Calderon, 2018). Involving cloud computing in the agricultural sector results in efficiently higher production, cost control, performance monitoring, and the like (Nanami and Gonen, 2020).

Mobile cloud computing is also important in the field of accounting processing. There are many applications that create invoices, track income and expenses, generate financial statements and other.

Materials and methods

The main goal of this article is to present the results of research in the field of cloud computing, specifically its use in agricultural enterprises in Slovakia. We specify the main goal in more detail into sub-goals, which are:

1. clarification of cloud computing issues,
2. finding out the measure of use of cloud computing in agricultural enterprises in Slovakia,
3. introducing the advantages and disadvantages of using cloud computing based on the answers of respondents,
4. comparison of selected aspects of the solved problem with EU countries.

Primary data are obtained by the questionnaire method. Due to the scientific research activities of our university (SPU in Nitra) and solved research tasks at the Department of Accounting, we focused on agricultural enterprises. The article presents partial results of the research project VEGA 1/0489/15 "Increasing the effectiveness of managers' decision-making with the support of information systems and accounting" in the period of years 2015-2018 and research activities 2019-2020. We examined the issue of cloud computing in more detail using the questionnaire method. The compiled questionnaire was available online, where we received answers from 73 respondents (enterprises). We used the MS EXCEL spreadsheet processor to evaluate the questionnaire. In addition to the questionnaire, the following methods are also used: analysis, synthesis, selection, comparison, mathematical-statistical and graphical methods. We also used the method of guided interview, where we consulted supplementary questions with managers of selected enterprises. Then, we focused on the study of cloud computing and related issues from available foreign sources.

Results and discussion

Information has long been one of the important factors in increasing the enterpise's competitiveness in the market. That is why it is important for enterprises to pay increased attention to innovations in the field of ICTs, as these are currently the ones that greatly influence theirs market position.

Based on the published questionnaire, we received answers from 73 respondents. According to the number of employees, we speak of small and medium-sized enterprises, where 69.86 % stated the number of employees less than 10; 8.22 % employ 11-50 employees and 21.92 % have a number of employees in the range of 51-250.

We were mainly interested in answers to questions about the use of cloud computing in these enterprises. Based on the obtained answers, we introduce the following results.

Answers od respondents to the question

about the availability of data from the corporate information system differ. 54.79 % of respondents stated that access to data is possible only from individual computers in the enterprise. 19.18% claim that they also have remote access in the enterprise, which also allows them to work from home. 13.70 % of respondents also use external storage (cloud computing) and 17.81 % said "I don't know" (Figure 2).

Businesses that do not use cloud computing services have their own information system with their own database. These enterprises need employees specializing in the care of ICTs which in turn increases labor and personnel costs.

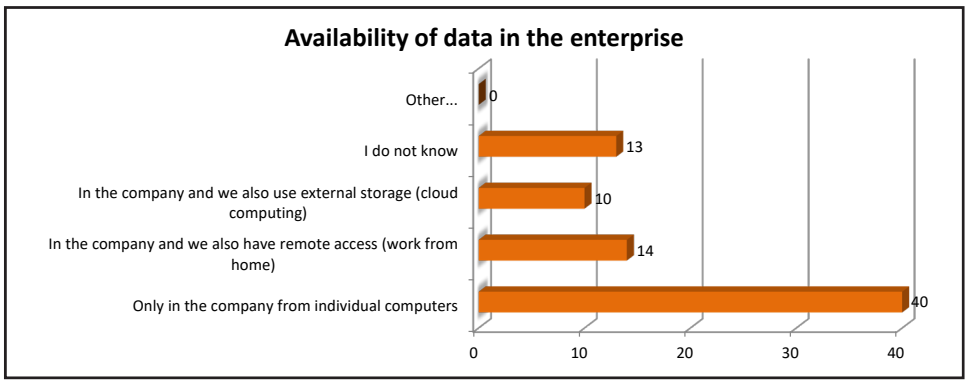
In cloud computing, the enterprise does not own an information system or database, but leases software and data storage from the company that provides these services. Consequently, there are no costs for employees who would take care of ICTs. But there are costs for cloud computing services.

Štětka, M. (2014) states that cloud computing enables small and medium-sized enterprises to become competitive, given its scalability and operating costs. For comparison - their research in the Czech Republic states that only 5 % of IT professionals use cloud services and 10 % plan to move to the cloud in the near future. He also gives figures from the most virtualized market in the world, from Australia, where up to 54 % of entrepreneurs use active cloud computing and 25 % are considering using it.

The situation is different in the environment of Slovak enterprises. 69.86 % of agricultural enterprises use online communication with other entities. It is mainly about online communication, data transfer with the financial administration, health and social insurance company. They are followed by banks, suppliers and customers. 53.42 % of respondents indicated the operation of the company's website (Figure 3).

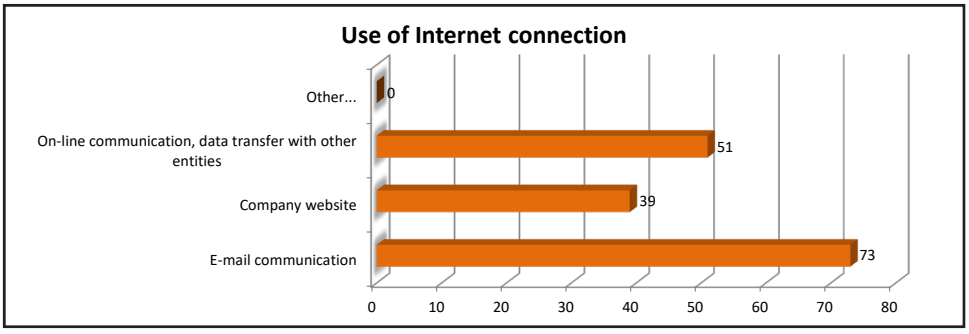
The use of an Internet connection for e-mail communication is a matter of course for all 73 respondents. This is the most common way to use cloud computing over a period of several years. This is also confirmed by Eurostat research for the period 2014, 2016 and 2018, when on average 67 % of EU-28 enterprises also put e-mail communication in the first place (Figure 4).

A more detailed use of cloud computing services by enterprises in individual countries is shown in Figure 5.



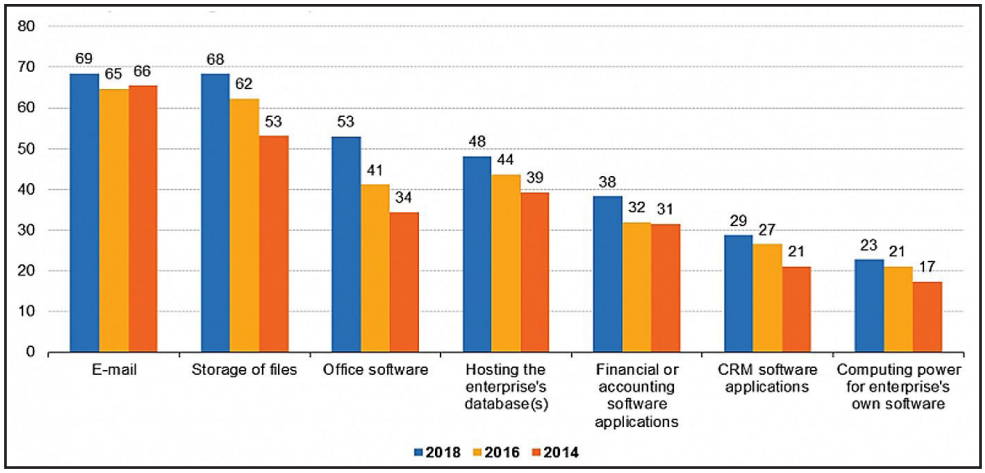
Source: author´s calculations

Figure 2: Question no. 9 Data from your corporate information system is accessible.



Source: author´s calculations

Figure 3: Question no. 7 For what purposes do you use an internet connection in your company?



Source: Eurostat (2020)

Figure 4: Use of cloud computing services in enterprises of EU-28 by purpose – 2014, 2016 and 2018 (% of enterprises using the cloud).

	Use of cloud computing	E-mail	Storage of files	Office software	Hosting the enterprise's database(s)	Financial or accounting software applications	CRM software applications	Computing power for enterprise's own software
	% enterprises	% enterprises using the cloud						
EU-28	26	69	68	53	48	38	29	23
Belgium	40	71	71	59	55	41	40	33
Bulgaria	8	73	64	56	58	28	26	20
Czechia	26	77	64	56	36	33	21	17
Denmark	56	74	69	58	55	52	41	37
Germany	22	48	61	34	33	28	19	19
Estonia	34	68	48	43	26	64	19	9
Ireland	45	78	78	63	52	45	34	22
Greece	13	68	61	48	43	20	22	22
Spain	22	74	73	48	64	32	33	28
France	19	65	77	46	63	32	35	20
Croatia	31	82	65	54	47	44	17	24
Italy	23	82	60	47	46	34	25	13
Cyprus	27	82	66	60	32	31	27	19
Latvia	15	64	41	41	48	46	19	8
Lithuania	23	70	61	39	52	41	27	36
Luxembourg	25	66	73	57	53	29	29	24
Hungary	18	73	59	56	38	35	27	31
Malta	37	81	73	64	42	28	26	23
Netherlands	48	67	72	56	70	59	45	24
Austria	23	58	67	38	30	17	21	20
Poland	11	67	53	51	33	27	23	15
Portugal	25	82	63	52	40	33	26	31
Romania	10	77	60	52	50	50	0	31
Slovenia	26	71	57	57	37	33	20	25
Slovakia	21	83	60	60	39	44	26	25
Finland	65	79	69	65	53	56	37	18
Sweden	57	72	74	53	52	51	31	26
United Kingdom	42	72	77	73	49	45	32	28
Norway	51	78	77	61	65	60	40	32
Montenegro	18	65	50	44	50	41	13	26
Serbia	15	:	:	:	:	:	:	:
Turkey	10	81	73	64	58	65	38	49
Bosnia and Herzegovina	8	73	59	49	64	56	25	37

Source: Eurostat (2020)

Figure 5: Use of cloud computing services in enterprises of EU-28 by purpose per a year 2018.

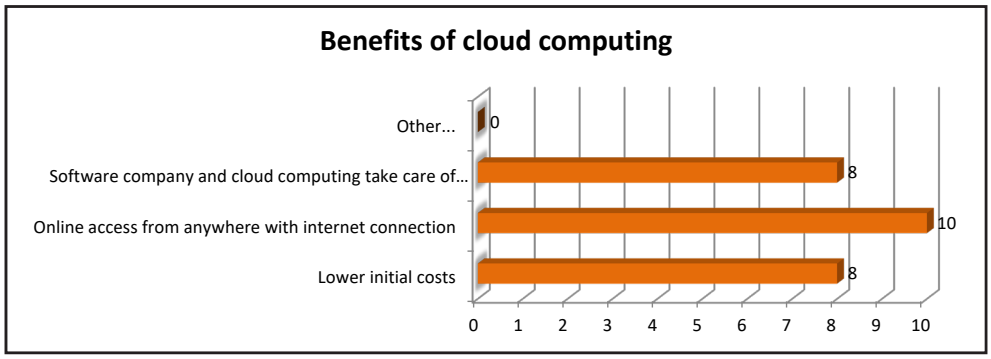
Businesses using cloud computing services cite online access to data from anywhere with an Internet connection as the biggest advantage. We can say that in today's globalized environment, this approach is almost everywhere where an entrepreneur or manager needs it, and the coverage of the Internet connection is constantly expanding to less developed areas. 10.96 % of respondents agree on the other 2 advantages of cloud computing, namely in lower initial costs, as well as in the fact that updates and information security are handled by a company

that provides cloud computing services (Figure 6).

On the contrary, 62.50 % of respondents consider the biggest disadvantage of using cloud services to be the failure of the Internet connection, which will make it impossible to work with the data needed for decision-making and management. Only 37.50 % fear data misuse and 25 % data loss. 6.85 % of respondents also identified increased operating costs as a disadvantage (Figure 7).

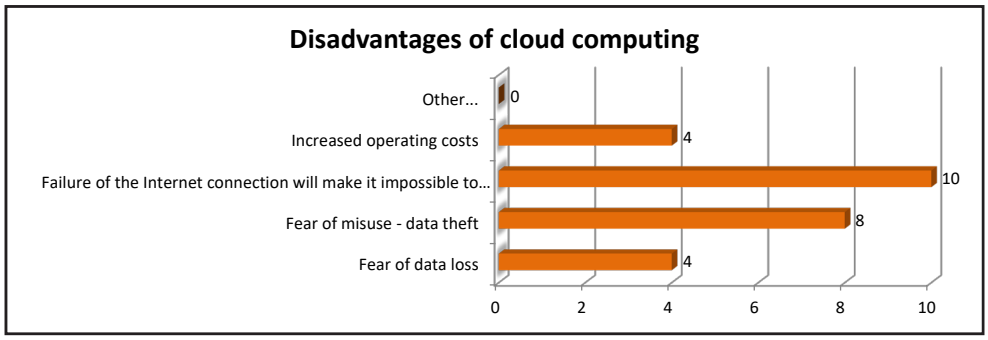
The fact that the loss of the Internet connection is a threat to enterprises using cloud computing is also confirmed by the Gartner company's analysis, which shows that two out of five enterprises are forced to close within five years of experiencing a major IT outage (Štětka, 2014).

In the following figure we can see a comparison of the use of cloud computing services by enterprises in individual EU countries in 2018. The Slovak Republic is almost among the last countries with 21.10 %, which is also confirmed by the results of our research. Finland is the leader in the use of cloud services with 61.30 %. On the contrary, Bulgaria is the worst with 8.30 % (Figure 8).



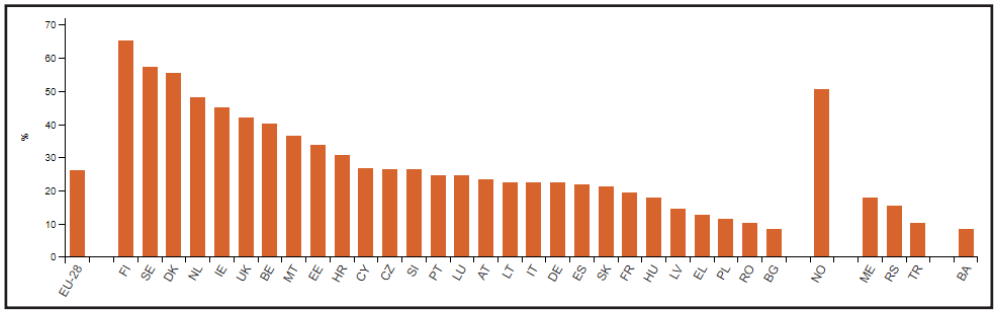
Source: author´s calculations

Figure 6: Question no. 10 - If you use cloud computing, state its benefits.



Source: author´s calculations

Figure 7: Question no. 11 - If you use cloud computing, state its disadvantages



Source: author´s calculations

Figure 8: Use of cloud computing services in the EU-28 per a year 2018 (% of enterprises using the cloud).

Conclusion

In the last decades, ICTs have been developing at a rapid pace. If a company wants to stay in the market, it needs to adapt to these changes. The introduction of ICTs in the area of farm management is a necessity. The requirements for recording and reporting data for the management needs of the managers themselves, as well as for various external entities, are growing. Today, we do not find an agricultural enterprise that does not have its information system handled automatically. The level of either computing technology or implemented software is in single enterprises various.

Based on the research, we came to the conclusion that agricultural enterprises in Slovakia still do not trust cloud computing. Most enterprises have their own information system with their own database. Businesses using cloud computing have cited online access to data as its biggest advantage. On the contrary, they consider the failure of the internet connection to be the biggest disadvantage, which will prevent them from working in the information system.

The SR has large reserves in the use of cloud computing services. Within the EU-28 countries, according to Eurostat, the SR ranks as high as 21 place in the use of cloud computing, where only 21 % of enterprises use these services.

Based on the processed data, we obtained an overview of the state of use of cloud computing in agricultural enterprises in Slovakia. It is important to realize how much this issue needs to be addressed at this time.

The results of the research can be further used in a more detailed analysis of these problems with the application of mathematical and statistical methods. Using the Chi-square test of the square contingency, it is possible to examine the dependence between the qualitative features - the answers of the respondents to the individual questions of the questionnaire.

In our opinion, cloud computing is very promising for the future, which is confirmed by the opinions of foreign authors. The growth of the use of cloud computing services can be achieved by realizing more extensive and massive foreknowledging of managers and business owners about the possibilities of using cloud computing, its advantages and disadvantages. Poor awareness of new possibilities in the field of ICTs especially in the agricultural field, causes the lagging progress of these enterprises, which to a large extent also ultimately affects their competitiveness.

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Consumption and Beef Price Changes on Demand in East Nusa Tenggara, Indonesia

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Abstract

Households consume animal protein after carbohydrate food is fulfilled, moreover animal protein prices are increasing. This study aims to analyze the effect of rising beef prices on demand. The demand system approach uses the Quadratic Almost Ideal Demand System (QUAIDS) model. Estimation of parameters using Iterated non-linear Seemingly Unrelated Regression. The research data use the 2016 National Socio-Economic Survey (Susenas, 2016), amounting to 10,751 households. The results of the study concluded that beef is the third most elastic animal food after fresh fish and chicken meat. Fresh fish in the most elastic among all animal foods with a demand elasticity of 3.31%, followed by chicken, beef, milk powder, and eggs with demand elasticities of 1.55%, 1.62%, 1.29%, and 0.80%, respectively. Beef is a luxury item with an income elasticity of 1.59%, as well as fresh fish, chicken meat, and milk powder. While eggs are normal goods. Although fresh fish is more elastic than beef, beef marginal expenditure share (MES) is higher than fresh fish MES, so that in the long run, the increase in household income tends to increase beef consumption more than fresh fish.

Keywords

Beef prices, animal food demand, elasticity, luxurious good, marginal expenditure share.

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Introduction

To eliminate hunger, achieve food security and proper nutrition, and improve sustainable agriculture is the second objective of Sustainable Development Goals (SDGs). Two indicators in the SDGs objectives that are directly related to nutritional status are the prevalence of energy shortages (prevalence of undernourishment) and the prevalence of populations with moderate or severe food insecurity. The adequacy level of energy and protein consumption can be used as an indicator to look at the nutritional conditions of the community and also the success of the government in integrated food, agriculture, health and socio-economic development (Ariani, 2010). To realize the second goal of the SDGs are food sufficiency, including protein adequacy, is very important (Robert et al., 2005).

Monthly average expenditure per capita (quantity and value) of food items, March 2016 in East Nusa Tenggara (NTT) for fresh fish and shrimp is 1.18 kg (Rp. 22,978), preserved fish and shrimp is 0.57gram (Rp. 2,360), beef is 0.03 kg (Rp. 2,276), chicken meat is 0.19 kg (Rp. 8,814), chicken egg is 2.53 unit (Rp. 5,335), duck egg is 0.01 unit (Rp. 25), sweeted condensed milk are 0.05/397grams (Rp. 522), infant formula is 0.03 kg (Rp. 2,524). Household consumption of animal protein is still below national monthly average expenditure per capita. Monthly average expenditure per capita in Indonesia for fresh fish is 2.99 kg (Rp. 28,969), preserved fish and shrimp is 1.29 gram (Rp. 4,651), beef is 0.03 kg (Rp. 3,791), chicken meat is 0.48 (Rp. 14,239), chicken egg is 8.51 unit (Rp. 11,778), duck egg is 0.36 unit (Rp. 347), sweeted condensed milk are 0.34/397 grams (Rp. 3,156), infant formula is 0.05 kg (Rp. 4,909).

The consumption of animal foods (beef, pork, chicken, and other meat) is much lower than in the United States (Katare et al., 2020).

Indonesian beef consumption is still very low, only 2.56 kg per capita per year compared to other ASEAN countries such as Vietnam 9.9 kg/capita/year, Malaysia and Singapore 15 kg/capita/year, while Germany is 40-45 kg/capita/year and the highest in Brazil reaching 55 kg per capita per year (Central Bureau of Statistics, 2018). Indonesian meat consumption is increasing, but an increase does not follow the increase in domestic production, so it must be imported. Indonesia imports the most massive beef from Brazil and Australia because prices are more competitive (Nendissa et al., 2019), empirically, we find that NTT is one of the biggest beef producing regions in Indonesia. However, during this time, NTT beef production was sent out of the province for household consumption in NTT. So this condition causes the level of meat consumption per capita in NTT below.

Research on food demand systems has been carried out in several country i.e. in Switzerland (Abdulai, 2002), in Semarang-Indonesia (Abdullah et al., 1994), in Ethiopia (Alem, 2011), in Pakistan (Naz et al., 2018). Research on food demand system-special for beef and also food consumption preferences, and food consumption patterns has been carried out in several country i.e. in Indonesia (Hutasuhut et al., 2002), in Nigeria (Ugwumba and Effiong, 2013), in Japan (Mahbubi et al., 2019), in Kenya (Korir et al., 2018), in (Kharisma et al., 2020), in Ethiopia (Tefera et al., 2018; Alem, 2011) (Abegaz et al., 2018), in Germany (Kaliji et al., 2019), and in India (Law et al., 2020). Research on the change in price elasticities in the U.S. beef cattle also has been carriet out (Jeong, 2019) using two budgeting model, also about beef consumption carriet out by Katare et al., (2020), (Andreyeva et al., 2010), (Schroeder et al., 2000). In Eropa has also been done by Roosen et al., (2003), Braschler (1983). Research on beef in East Nusa Tenggara, among others, has been carried out by (Nendissa et al., 2018). This research is about marketing namely, structure, conduct, and performance (SCP). However, research on consumption and changes in beef prices on demand is still rarely found. Therefore this study aims to analyze the effect of price and income changes on-demand at the household level. The demand system approach uses the Quadratic Almost Ideal Demand System (QUAIDS) model with parameter estimation using Iterated Non-linear Seemingly Unrelated Regression (Mittal, 2010). The parameter estimation results are used to calculate the price elasticity itself so that information will be obtained whether the beef is elastic, inelastic, or unitary elastic (Dávila, 2010; Negi, 2018). Cross price elasticities will also be calculated so that it is known whether beef with other animal foods is substitution or complementary. Estimation results of the parameters will also be calculated income elasticity so that it will be known whether beef is a luxury item, normal or inferior (Coelho and Aguiar, 2007, Alderiny and Ahmed, 2019). At the end of the analysis, a marginal expenditure share (MES) will be calculated in five animal food groups, to see the impact of changes in income on demand in the long run (Kumar and Kaur, 2017; Kaur and Kaur, 2020). The results of the study can be used to develop price or income policy scenarios to support the fulfillment of protein consumption, especially in East Nusa Tenggara (ENT).

Materials nad methods

Model Specification: Quadratic Almost Ideal Demand System (QUAIDS)

The most commonly used method in demand analysis in the last two decades is AIDS model developed by (Deaton and Muellbauer, 1980). The AIDS model has a number of some demand properties such as testing for symmetry and homogeneity through linier restriction among the commodities (Banks et al., 1997) generalized the AIDS model by demonstrating that the appropriate form for some consumer preferences is of a quadratic nature contrary to the linier form in the basic AIDS. In addrition, the QUAIDS model maintains the theory consistency and the demand properties of the AIDS model.

The approach of estimating QUAIDS, using the household consumption and expenditure survey. On the basis of selected five commodity animal food groups, which are indexed by i, we estimate a system of demand equations, consisting of total of animal protein consumption expenditure m, expenditure shares w_i and commodity prices p_i.The estimation of our system of demand equations following (Poi, 2012a), using non-linear, Seemingly Unrelated Regression (SUR). Based on the non-parametric analysis of consumer spending patterns, it appears that the Engel curve requires a higher order of logarithm expenditure. The QUAIDS model has almost the same features as AIDS and can capture the curvature of Engel. Therefore, QUAIDS has been chosen as the demand model for estimated empirical strategies. As with the general demand

system model, the AIDS model is determined by the following food budget shares (w_i):

$$w_i = \frac{p_i q_i}{m} , \quad (1)$$

where p_i is price of i, q_i is quantity of i, and m is total expenditure, so demand system:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(\mathbf{p})}\right] , \quad (2)$$

where p_j is price of j and a(p) is index price of total expenditure:

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{k} \alpha_i \ln p_i + \\ + \frac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{k} \gamma_{ij} \ln p_i \ln p_j \quad (3)$$

As well as the AIDS model, the QUAIDS model also needs restrictions to be consistent with utility maximization, i.e.:

Adding up:

$$\sum_{i=1}^{k} \alpha_1 = 1 , \sum_{i=1}^{k} \beta_i = 0, \ \sum_{i=1}^{k} \gamma_{ij} = 0 \quad (4)$$

Homogeneity: $\sum_{j=1}^{k} \gamma_{ij} = 0$, and (5)

Slutsky's symmetry: $\gamma_{ij} = \gamma_{ji}$ (6)

Restriction on demand theory (4), (5) and (6) are imposed during estimation and ensure that notation (3) defines a(p) as a linearly homogeneous function of the individual prices. Further, where notation (4), (5) and (6) hold, notation (2) provides a system of demand function which add up to total expenditure ($\sum w_i = 1$), is homogeny as long as prices and income are zero according to the Slutsky Symmetry theory (Deaton, 1980). So, that the AIDS model can interpreted: as price (p_j) and real expenditure $\left(\frac{m}{\mathrm{a}(\mathbf{p})}\right)$ is not change, so share of expenditure (w_i) is constant (α_i).

A development of the AIDS model, the QUAIDS model was proposed by Banks et. al (1997), namely by adding an element of quadratic logarithm of expenditure. This follows the nature of flexibility the Engel curve share of household expenditure is not linear, and some commodities are staple goods and some commodities are luxury goods (Banks et al., 1997b). The QUAIDS model in budget share is:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(\mathbf{p})}\right] + \\ + \frac{\lambda_i}{b(\mathbf{p})} \left\{\ln \left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 \quad (7)$$

The term equals equation (2) and b(p) is the Cobb-Douglas aggregate price, written as follows:

$$b(\mathbf{p}) = \prod_{j=1}^{k} p_i^{\beta_i} \quad (8)$$

In the consumer demand theory, adding-up conditions are also needed:

$$\sum_{j=1}^{k} \lambda_j = 0 \quad (9)$$

When entering the household socio-demographic variable, based on the expenditure function (cost) as follows:

$$e(\mathbf{p}, \mathbf{z}, u) = m_0(\mathbf{p}, \mathbf{z}, u) \times e^R(\mathbf{p}, u) \quad (10)$$

Where z is a vector of household characteristics, e^R(p,u) is expenditure function, and m_0(p,z,u) scale of the expenditure function that can be obtained from:

$$m_0(\mathbf{p}, \mathbf{z}, u) = \bar{m}_0(\mathbf{z}) \times \phi(\mathbf{p}, \mathbf{z}, u) \quad (11)$$

where m_0 measure the increase in household expenditure as a function of z, and ϕ is a change in the price of goods consumed. So, m_0(z) is:

$$\bar{m}_0(\mathbf{z}) = 1 + \rho' \mathbf{z} \quad (12)$$

where ρ is a vector estimate parameters, ϕ(p,z,u) is a parameter of:

$$\ln \phi(\mathbf{p}, \mathbf{z}, u) = \frac{\prod_{j=1}^{k} p_j^{\beta_i} (\prod_{j=1}^{k} p_j^{\eta_j'} - 1)}{\frac{1}{u} - \sum_{j=1}^{k} \lambda_j \ln p_j} \quad (13)$$

Where η_j describes the column to j of the matrix parameter η. To adhere to consumer demand theory, a further adding-up condition is required, given as

$$\sum_{i=1}^{k} \eta_{rj} = 0$$

for r = 1 ..., s. The estimation of the QUAIDS animal food model in East Nusa Tenggara, Indonesia can be written into the formula:

$$w_i = \alpha_i + \sum_{j=1}^{\mathrm{k}} \lambda_j \ln p_j + \left[\frac{m}{\bar{m}_0(z) a(p)}\right] \\ + \frac{\lambda_i}{b(\mathrm{p}) c(\mathrm{p}, z)} \left\{ln \left[\frac{m}{\bar{m}_0(z) a(\mathrm{p})}\right]\right\}^2 + \varepsilon \quad (14)$$

where

$$c(\mathbf{p}, \mathbf{z}) = \prod_{j=1}^{k} p_j^{\eta_j' z} \quad (15)$$

The parameters generated from the QUAIDS model are used to calculate the own-price elasticity, cross price elasticity of both Hicksian and Marshallian, also expenditure elasticity. Marshallian (uncompensated) price elasticity is:

$$\epsilon_{ij}^u = -\delta_{ij} + \frac{1}{w_i} \left(\gamma_{ij} - \left[\beta_i + \eta_j' z + \frac{2\lambda_i}{b(\mathbf{p})\, c(\mathbf{p}, \mathbf{z})} \ln \left\{\frac{m}{a(\mathbf{p})\, \bar{m}_0(\mathbf{z})}\right\}\right] \right. \\ \left. \times \left(\alpha_j + \sum_l \gamma_{jl} \ln p_l\right) - \frac{(\beta_i + \eta_j' z)\lambda_i}{b(\mathbf{p})\, c(\mathbf{p}, \mathbf{z})} \left[\ln \left\{\frac{m}{a(\mathbf{p})\, \bar{m}_0(\mathbf{z})}\right\}\right]^2 \right) \quad (16)$$

Expenditure (income) elasticity) is:

$$\mu_i = 1 + \frac{1}{w_i}\left[\beta_i + \eta'_j z + \frac{2\lambda_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})} \ln\left\{\frac{m}{a(\mathbf{p})\bar{m}_0(\mathbf{z})}\right\}\right] \quad (17)$$

Hicksian (compensated) elasticity is:

$$\epsilon^c_{ij} = \epsilon^u_{ij} + w_j\mu_i \quad (18)$$

Equation (1) to (6) adopted from Deaton and Muellbauer (1980), and equation (7) to (18) adopted from (Poi, 2012) with reference to Banks et al. (1997). The parameters are estimated by iterated feasible generalized non-linier least which are equivalent to the multivariate normal maximum likelihood estimator for this class of problem via Stata's 14.3 with 'NLSUR' command as suggested by Poi (2012).

Maginal Expenditure Share

Marginal Expenditure Share (MES) is the percentage change in demand for goods due to changes in income in the long run (Ackah and Appleton, 2007). MES is calculated from both own and cross-price Marshallian elasticities, both own and cross-price Hicksian elasticities, and expenditure elasticities. MES is calculated using the following formula:

$$m_i = \eta_i \,.\, w_i \quad (19)$$

where:

ϵ^u_{ii} : Marshallian own-price elasticity

ϵ^u_{ij} : Marshallian cross-price elasticity

ϵ^c_{ii} : Hicksian own-price elasticity

ϵ^c_{ij} : Hicksian cross-price elasticity

η_i : Expenditure elasticity

m_i : Marginal expenditure share

Data

The data used in this research is secondary data, conducted by the Central Bureau of Statistics is in the form of household surveys, called the Susenas (National Socioeconomic Survey) data, March 2016. The data analyzed were socio-demographic data (household region status, total household member (HHsize), household consumption and expenditure, and total expenditure. This study's variables include the variable price of five animal food groups, namely egg price, chicken meat price, beef price, fresh fish price, and powdered milk price. The price variable is approximated by the expenditure of each animal food divided by the amount consumed. Besides price, there is also a consumption variable, namely consumption of the five animal food groups, namely consumption of eggs, chicken meat consumption, consumption of beef, consumption of fresh fish, and consumption of powdered milk.The animal foods observed in this study were eggs (chicken eggs, local chicken eggs, and duck eggs), chicken meat (local chicken meat and chicken meat), beef, fresh fish (fresh fish and shrimp including fish, shrimp, squid, and shellfish) as well as milk powder (milk powder and infant milk). The sample of this research is 10,751 households.

Results and discussion

Factors affecting animal food demand

The results of the QUAIDS analysis obtain parameter. The parameters obtained from the data analysis results are the constant parameter (alpha), the price parameter for the five animal food groups (beta), the income parameter for the five animal food groups (gamma), the income square parameter (lambda), the region status parameter (etha), and the HHsize parameter (rho). Parameter of prices, expenditure (income), the quadrat of income and demographic factors ie, HHsize, and region status (urban or rural) are almost all significant at alpha 1% to 5% (Table 1). All alpha (constant) parameters are significant, except the eggs group parameters are not significant. The price of beef, the price of eggs, and the price of milk powder are very significant (alpha 1%). In comparison, the price of chicken meat and fresh fish is not significant. Animal food prices include the prices of five animal food groups, namely eggs prices, chicken meat prices, beef prices, fresh fish prices, and milk powder prices. Like AIDS, the QUAIDS model also fulfills three restrictions, namely adding-up, homogeneity, and symmetry.

All quadrat expenditures have a very significant effect on animal food demand except fresh fish. The coefficient quadrat income for eggs and fresh fish are positive, while chicken meat, beef, and milk powder are negative. This means that if household income doubles, the demand for eggs and fresh fish increases, while the demand for chicken meat, beef, and milk powder decrease. The negative coefficient sign indicates that goods tend to be fancy. In contrast, positive signs indicate that normal goods tend to be luxurious. So, eggs group and fresh fish are categorized as normal items, whereas chicken meat, beef, and milk powder tend to be luxury goods. Referring to the positive beef quadrat income parameter results, the policy to increase household income is considered very appropriate to increase beef consumption.

Parameter	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Alpha (constant)						
alpha_1	-0.070	0.085	-0.820	0.411	-0.236	0.097
alpha_2	0.631	0.067	9.380	0.000**	0.499	0.763
alpha_3	0.195	0.037	5.280	0.000**	0.122	0.267
alpha_4	0.126	0.023	5.580	0.000**	0.082	0.170
alpha_5	0.118	0.040	2.940	0.003**	0.039	0.197
Beta (price)						
beta_1	0.248	0.064	3.860	0.000**	0.122	0.373
beta_2	-0.055	0.046	-1.180	0.238	-0.146	0.036
beta_3	-0.030	0.013	-2.350	0.019*	-0.055	-0.005
beta_4	-0.005	0.006	-0.800	0.423	-0.018	0.007
beta_5	-0.158	0.015	-10.430	0.000**	-0.188	-0.128
Gamma (expenditure)						
gamma_1_1	0.226	0.045	5.040	0.000**	0.138	0.313
gamma_2_1	-0.184	0.037	-5.020	0.000**	-0.256	-0.112
gamma_3_1	-0.010	0.012	-0.840	0.401	-0.034	0.014
gamma_4_1	0.024	0.007	3.380	0.001**	0.010	0.038
gamma_5_1	-0.055	0.012	-4.730	0.000**	-0.078	-0.032
gamma_2_2	0.127	0.034	3.740	0.000**	0.060	0.193
gamma_3_2	0.005	0.011	0.420	0.672	-0.018	0.027
gamma_4_2	0.007	0.007	1.060	0.289	-0.006	0.020
gamma_5_2	0.046	0.011	4.020	0.000**	0.023	0.068
gamma_3_3	-0.027	0.013	-2.010	0.044*	-0.054	-0.001
gamma_4_3	-0.009	0.006	-1.610	0.107	-0.020	0.002
gamma_5_3	0.042	0.008	4.960	0.000**	0.025	0.058
gamma_4_4	-0.015	0.005	-2.950	0.003**	-0.025	-0.005
gamma_5_4	-0.007	0.006	-1.200	0.230	-0.017	0.004
gamma_5_5	-0.026	0.013	-1.970	0.049*	-0.051	0.000
Lambda (quadrat of expenditure)						
lambda_1	0.013	0.001	17.620	0.000**	0.012	0.014
lambda_2	-0.003	0.001	-3.100	0.002**	-0.006	-0.001
lambda_3	-0.002	0.000	-3.350	0.001**	-0.002	-0.001
lambda_4	0.000	0.000	-0.950	0.344	-0.001	0.000
lambda_5	-0.008	0.001	-11.250	0.000**	-0.009	-0.006
Etha (demography)						
eta_urban_1	-0.240	0.036	-6.590	0.000**	-0.312	-0.169
eta_urban_2	0.118	0.022	5.270	0.000**	0.074	0.161
eta_urban_3	0.031	0.006	5.270	0.000**	0.020	0.043
eta_urban_4	0.005	0.002	1.930	0.054*	0.000	0.009
eta_urban_5	0.087	0.010	8.710	0.000**	0.067	0.107
eta_hhm_tot_1	-0.002	0.001	-3.300	0.001**	-0.003	-0.001
eta_hhm_tot_2	0.002	0.000	4.530	0.000**	0.001	0.003
eta_hhm_tot_3	0.000	0.000	2.030	0.042*	0.000	0.001
eta_hhm_tot_4	0.000	0.000	0.100	0.924	0.000	0.000
eta_hhm_tot_5	0.000	0.000	-0.470	0.638	-0.001	0.001
Rho						
rho_urban	-0.499	0.000	1015.500	0.000**	-0.500	-0.498
rho_hhm_tot	0.000	0.000	1.950	0.052*	0.000	0.000

Note: ** and * indicate significant at the 1% and 5% significance level, respectively
1=eggs, 2=chicken meat, 3=beef, 4=fresh fish, 5=milk powder, hhm=household member (HHsize)

Source: March 2016 Susenas, research findings

Table 1: QUAIDS Parameter estimates of animal food demand.

Etha is a demographic variable parameter that is the settlement type or status of household residence (region) and the HHsize in each animal food. Almost all animal food prices, both in urban and rural prices, are significant to demand. In the HHsize variable, the significant HHsize is in the commodity eggs, chicken meat, and beef, while in fresh fish and powdered milk is not significant. This means that an increase in HH size decreases egg demand (negative coefficient sign). In contrast, an increase in HHsize increases demands chicken meat or beef (positive coefficient sign).

Marshallian (uncompensated) own and cross-price elasticity

The results of the QUAIDS model analysis produce parameters. From these parameters, it is used to calculate price and income elasticities as in equations (16), (17), and (18). Price elasticity includes own and cross-price elasticities, while price elasticity also includes Marshallian (uncompensated) and Hicksian (compensated) price elasticities. Table 2 shows the elasticity own-prices and the elasticity of Marshallian cross-prices. All Marshallian own-price elasticities are negative. This is consistent with the economic theory that rising animal food prices reduce demand. Alternatively, in other words, rising prices for eggs, chicken meat, beef, fresh fish, and milk powder reduce the consumption of animal foods. Households reduce animal food consumption if there is an increase in prices.

The fresh fish group was the most elastic among all animal foods with a demand elasticity of 3.31%, followed by chicken, beef, milk powder, and eggs with demand elasticities of 1.55%, 1.62%, 1.29%, and 0.80%, respectively. An increase in the price of fresh fish by 1% decreases the demand for fresh fish by 3.31%. East Nusa Tenggara is the second-largest beef producer after East Java. This is consistent with the results of the analysis that the elasticity of beef demand is below the elasticity of fresh fish. This means that the effect of rising beef prices is smaller than that of fresh fish because the region is a beef producer so that consumption of beef is far more accessible to households compared to provinces as consumers only.

Table 2 also shows the elasticity of Marshallian cross prices. The cross-price elasticity shows the relationship between animal food and others animal food. If the positive cross-price elasticity indicates a substitution relationship if the negative indicates a complementary relationship. The analysis shows that almost all Marshallian cross-price elasticities are positive, meaning that between animal foods is substitution. An increase in animal food prices increases the demand for other animal foods—fresh fish substitutes all other animal foods except milk powder, which is complementary. An increase in the price of fresh fish 1% increases beef demand by 0.24%, chicken meat by 0.09%, and eggs by 0.05%. Whereas with milk powder, it reduced demand by 0.02%. This study's results are different from studies in America that the elasticity of beef is less than one or so-called inelastic goods (Katare et al., 2020). Indonesia is a developing country, so that price changes have a more significant response than developed countries such as America. The consumption of beef is also higher in America than in Indonesia.

Beef is a substitution with all other animal foods. An increase in beef price by 1% decreases demand for beef and increases the demand for fresh fish by 0.52%, then powdered milk, eggs, and chicken meat, respectively 0.03%, 0.02%, and 0.003%.

Animal food group	Eggs	Chicken meat	Beef	Fresh fish	Milk powder
Eggs	-0.800	0.203	0.016	0.052	0.060
	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)
Chicken meat	-0.168	-1.623	0.003	0.093	0.027
	(0.009)	(0.010)	(0.004)	(0.004)	(0.006)
Beef	-0.270	-0.001	-1.548	0.244	0.099
	(0.018)	(0.020)	(0.021)	(0.013)	(0.017)
Fresh fish	-0.348	0.986	0.515	-3.314	0.007
	(0.037)	(0.039)	(0.025)	(0.033)	(0.033)
Milk powder	-0.330	0.020	0.033	-0.019	-1.292
	(0.009)	(0.010)	(0.006)	(0.006)	(0.011)

Source: March 2016 Susenas, standart errors of means in parentheses

Table 2: Marshallian (uncompensated) own and cross-price elasticity.

The power of substitution is small, so it can be said that animal food in East Nusa Tenggara is a close substitute. This also happens in chicken meat and milk powder, where the substitution power with other animal foods is also very low.

Hicksian (compensated) own and cross-price elasticities

The Hicksian (compensated) price elasticity is price elasticity when there is only the effect of price changes. Table 3 presents the own and cross-elasticity of Hicksian. In East Nusa Tenggara, all own-price elasticities are negative. This is consistent with the economic theory, which states that there is a negative relationship between the price and the quantity of goods demanded. Alternatively, in other words, rising prices reduce animal food consumption. Of the five animal food groups, the most elastic animal food groups are fresh fish, then beef, chicken meat, milk powder, and eggs, with Hicksian own-price elasticities of 3.26%, 1.47%, 1.25%, 1.05%, and 0.54%. Similar to Marshallian own-price elasticity, fresh fish are also the most elastic, but Hicksian own-price elasticity is smaller than Marshallian own-price elasticity. This is because the Hicksian price elasticity only contains a substitution effect. In contrast, the Marshallian price elasticity contains a substitution effect and income effect.

In contrast to the Marshallian cross-price elasticity, that all Hicksian cross-price elasticities are positive in animal food demand caused by the substitution effect alone. It means that the price increase has consequences for changes in the type of animal food consumed by households. Positive cross-price elasticity means an increase in animal food that one increases the demand for other animal foods, often called a substitution relationship. Fresh fish substituted with beef, chicken, eggs, and milk powder with cross elasticity of 0.28%, 0.14%, 0.06%, and 0.02%. A 1% increase in the price of fresh fish increases beef demand by 0.28%. Beef is substituted with fresh fish, powdered milk, chicken, and eggs with Hicksian cross-price elasticities of 0.62%, 0.11%, 0.09%, and 0.06%. The increase in prices accompanied by an increase in income increased demand for fresh fish by 0.05 points (3,260-3,314).

The second most elastic animal food is beef. While the increase in beef prices accompanied by an increase in income increased beef demand by 0.075 points (1,474-1,548). The implication of this research is an animal food price policy is needed, so that prices do not increase. Rising prices cause a decrease in all animal food consumption. This is in-line with the research (Khoiriyah et al., 2019)(Khoiriyah et al., 2020) that beef is very elastic in Indonesia, both in rural households and at various levels of poverty in Indonesia. Field information explains that the price of beef in the region in 2016 reached Rp. 100,000 to Rp. 110,000/kg. But often cattle in the region are sold in the form of not beef but are sold to other provinces namely Jakarta and Kalimantan with an average price of Rp.27,000 to Rp. 32,000 per kg of live weight (Nendissa et al., 2018).

Expenditure elasticity

The demand for goods and services also depends on household income. Expenditure (income) elasticity shows the percentage change in demand as a result of the percentage change in income. The results of the analysis of income elasticity and Marginal Expenditure Share (MES) as in Table 4. Fresh fish is the most elastic among all animal foods, with an income elasticity of 2.16%. A 1% increase in income increases the demand for fresh fish by 2.16%. Chicken meat, milk powder, and beef are also elastic, which are respectively 1.67%, 1.59%, and 1.48%. Because the income elasticity of fresh fish, chicken meat, milk powder, and beef are greater than one, the four

Animal food group	Eggs	Chicken meat	Beef	Fresh fish	Milk powder
Eggs	-0.542	0.308	0.040	0.064	0.131
	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)
Chicken meat	0.749	-1.249	0.087	0.136	0.278
	(0.009)	(0.010)	(0.004)	(0.004)	(0.006)
Beef	0.542	0.330	-1.474	0.282	0.321
	(0.019)	(0.020)	(0.021)	(0.013)	(0.017)
Fresh fish	0.837	1.468	0.623	-3.260	0.331
	(0.036)	(0.040)	(0.025)	(0.033)	(0.033)
Milk powder	0.543	0.376	0.112	0.021	-1.053
	(0.009)	(0.010)	(0.006)	(0.006)	(0.011)

Source: March 2016 Susenas, standart errors of means in parentheses

Table 3: Hickisan (compensated) own and cross-price elasticity.

animal food groups are luxury goods. Whereas eggs are normal goods due to changes in egg demand as a result of an increase in egg prices, changing by less than one ie, 0.47%. This is consistent with research in various countries that beef is also a luxury item (Acar et al. (2016), Aftab et al. (2017), Abegaz et al.(2018), Pangaribowo (2010).

Animal Food Groups	Expenditure Elasticity	Marginal Expenditure Share
Eggs	0.470	0.067
Chicken meat	1.668	0.054
Beef	1.476	0.266
Fresh fish	2.155	0.140
Milk powder	1.589	0.217

Source: Author's calculations from Susenas

Table 4: Expenditure elasticity and marginal expenditure share.

Table 4 also presents Marginal Expenditure Share (MES). MES describes the additional changes in the amount requested as a result of changes in income but in the long run (Anindita et al., 2020; Sa'diyah et al., 2019). MES is important to analyze because it can be used, among other things, to develop price or income policy scenarios to achieve a recommended dietary allowance (RDA) according to the national RDA that is 57 grams/capita/day. MES beef is the biggest. This means that in the long run, households in NTT increase beef consumption if there is an increase in income. Likewise, milk powder, also experienced an increase in demand if there was an increase in income. The highest to lowest order of increasing demand (MES) is the consumption of beef, milk powder, fresh fish, eggs and chicken meat respectively by 0.266%, 0.217%, 0.14%, 0.067%, and 0.054%. Although fresh fish is more elastic than beef. beef MES is bigger than fresh fish MES. This means an increase in income, in the long run encourages households to increase beef consumption more than eating fresh fish.

Conclusion

This paper presents on analyzing the impact of changes in prices, incomes, and demographic factors on animal food demand in East Nusa Tenggara. The demand system approach uses the Quadratic Almost Ideal Demand System (QUAIDS) model using parameters using Iterated non-linear Seemingly Unrelated Regression. The research data uses secondary data collected by the Central Bureau of Statistics for household consumption and expenditure data through the 2016 National Socio-Economic Survey (Susenas). The sample of this study was 10.751 households. The results of the study concluded that the fresh fish group was the most elastic among all animal foods with a demand elasticity of 3.31%, followed by chicken meat, beef, milk powder and eggs with demand elasticities of 1.55%, 1.62%, 1.29%, and 0.80%, respectively. An increase in the price of fresh fish by 1% decreases the demand for fresh fish by 3.31%. Demand for beef is elastic.

Fresh fish is the most elastic of all animal foods, with an income elasticity of 2.16%. A 1% increase in income increases the demand for fresh fish by 2.16%. Chicken meat, milk powder, and beef are also elastic, which are respectively 1.67%, 1.59%, and 1.48%. Four groups of animal food are fresh fish, beef, chicken meat, and milk powder, including luxury goods, while eggs are normal goods. The highest to the lowest order of Marginal Expenditure Share (MES) is the consumption of beef, powdered milk, fresh fish, eggs, and chicken meat with MES, respectively, by 0.266%, 0.217%, 0.14%, 0.067%, and 0.054%. Although fresh fish is more elastic than beef, beef MES is higher than fresh fish MES. This means an increase in income, in the long run, encourages households to add more beef consumption than fresh fish.

East Nusa Tenggara is one of the biggest beef producing regions in Indonesia. Beef production is shipped out of the province rather than for household consumption in the region. This condition causes the level of per capita meat consumption in East Nusa Tenggara below. To increase beef consumption in East Nusa Tenggara, the government needs to provide income policies that can increase household purchasing power for beef. This is reinforced by the results of research beef income elasticity of 1,476 (quite elastic). The increase in household income by 1% increased beef consumption is higher than the increase in beef prices, which is increased by 1.48%. While in the long run, a 1% increase in beef income increases beef consumption by 0.27%. This increase, in the long run, is the biggest among all animal foods in East Nusa Tenggara.

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Demand for Meat in Indonesia: Censored AIDS Model

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Abstract

This study estimates the demand for meat in Indonesian urban households encompassing beef, goat, broiler chicken, and native chicken. We estimate the demand for meat using cross-sectional data from the 2013 Indonesian Socio-Economic Household Survey data, which records food expenditure for a week before the survey. Because of some zero expenditure, the Censored Almost Ideal Demand System (AIDS) using the consistent two-step estimation is applied. The estimated own-price elasticities indicate that all meat products are price-inelastic. Nonetheless, broiler chicken is the most responsive meat product while goat is the least responsive meat product to price changes. All meat products are normal good referring to the estimated income elasticities. However, Native chicken is the most responsive and goat is the most unresponsive to the income change. The estimated cross-price elasticities conclude that broiler chicken and beef are substitute goods. The policy simulation indicates that beef is a meat product that is unresponsive to price and income changes. Native chicken is the most responsive meat product to price and income change, followed by broiler chicken.

Keywords

Demand for meat, censored AIDS, price and income elasticity, urban Indonesia.

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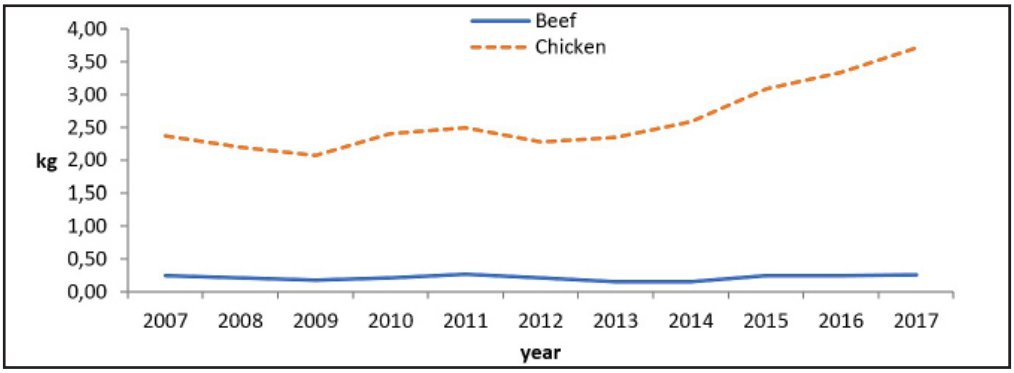
Introduction

The world food crisis starting in 2004 has increased the food price index. Based on the FAO food price index, which consists of the average of five commodity group price indices (meat, dairy, cereals, vegetable oils, and sugar), the food price index increased from 161.4 in 2007 to 201.4 in 2008. It declined in 2009 and 2010, but it experienced a high spike to reach a peak of 229.9 in 2011. The food price index then declined again to 201.8 in 2014 and was 164 in 2015. World meat prices also increased in line with rising world food prices. It was 130.8 in 2007 and then rose to 160.7 in 2008. It declined for the following two years, but then it jumped again in 2011 and reached the highest price in 2014 with the meat price index by 198.3. However, the meat price index declined to 168.1 in 2015. Indonesia has also been experiencing a crisis of meat prices, especially the price of beef. The price of beef has been increasing steadily since 2013. The price of beef was approximately Indonesian Rupiah (IDR) 85,000 per kg in 2013. The price of beef has been above IDR 100,000 since 2014. Similarly, other meat products such as the price of broiler chicken have been increasing. The price of broiler chicken also continued to increase since 2012. The price of broiler chicken was below IDR 20,000 per kg in 2011, but it has reached IDR 25,000 per kg in 2012 and was approximately IDR 27,000 per Kg in 2013 and in 2014[1].

Chicken and beef are two meat products that are commonly consumed by households in Indonesia. Figure 1 presents chicken and beef consumption in Indonesia from 2007-2017. The average chicken consumption was 2.6 k per capita per month from 2007-2017. Chicken consumption was relatively stable in the period 2007-2014 at 2 kg per capita per month. Chicken consumption has started to increase since 2015, with consumption levels above 3 kg per capita per month. Chicken consumption was close to 4 kg per capita per month in 2017. Consumption of beef was stable but it was relatively low. The average beef consumption was 0.21 kg per capita per month. Chicken consumption was higher than beef consumption because chicken is the main dish of meat products in the Indonesian household. Some factors affect

[1] The exchange rate of USD was approximately Indonesian Rupiah (IDR) 11,900 in 2014.



Source: own processing

Figure 1: Consumption of chicken and beef 2007-2017 (kg per capita per month).

low beef consumption in Indonesia. First, it is a lack of domestic production of beef. The capacity of domestic production for beef is only 70% and the rest of them are from import. Another factor is the location of cattle production and distant markets. The length of the production chain to consumers causes high transportation cost, which affects on the high price of beef. Overall, referring to Organization for Economic Co-operation and Development (OECD) data, meat consumption was relatively low in Indonesia with meat consumption by 11.5 kg per capita per year in 2017, comparing to the Philippines (31.6 kg), Malaysia (54.4 kg), Thailand (26.6 kg), and Vietnam (55 kg). Consequently, the average daily consumption of protein per capita was 56.7 grams and barely above minimum protein adequacy (52 grams) in 2016.

Many previous studies have investigated the demand for meat in Southeast Asian countries, which have similar consumer preferences. Hoang (2018) investigated food demand in Vietnam, including pork and other meats and seafood, using the 2010 Vietnam Household survey by applying the two-stage budgeting system (Working lesser-QUAIDS). The estimated price elasticities of demand for pork (-0.844) and other meats and seafood (-0.834) are inelastic but expenditure elasticities of demand for pork (0.956) and other meats and seafood (1.199) are high. By employing the linear Almost Ideal Demand System (LA-AIDS), Lippe et al. (2010) estimated demand for meat as a part of demand food in urban households in Thailand using the 2007 household survey in Bangkok and Chiang Mai. The price elasticity and income elasticity for meat are -0.84 and 0.71. By using Household expenditure survey 2004/2005, Sheng et al., (2008) employed the LA-AIDS model to estimate the complete demand system of food in Malaysia, including meat. They documented that both price and expenditure elasticities for meat are high by -1.1194 and 1.4064, respectively. Sheng et al., (2010) applied the QUAIDS model to estimate the demand for meat in Malaysia consisting of beef, pork, mutton, and Poultry using Household expenditure survey 2004/2005. The price elasticity for beef, pork, mutton, and poultry are -2.4776, -4.4401, -3.9767, -1.1057, respectively while the expenditure elasticities for the associated meat products are 1.8971, 1.1442, 1.1520, and 0.7002, respectively.

Some previous empirical studies have examined the demand for meat in Indonesia such as Jensen and Manrique (1998), Hutasuhut et al. (2002), Widarjono and Rucbha (2016), Faharuddin et al. (2017), Faharuddin et al. (2019) among them. Jensen and Manrique (1998) investigated the demand for food based on income groups in urban areas using the Indonesian National Socio-Economic Survey (SUSENAS) in 1981, 1984, and 1987 by applying the LA-AIDS model. The price elasticity for meat varies from -0.81 to -0.91, while the income elasticity ranges from 0.25 to 0.69. By focusing two provinces consisting of provinces of DKI and West Java, which is about one-fourth of the population, Hutasuhut et al. (2002) using LA-AIDS model examined the demand for meat using household survey data from the 1990, 1993 and 1996 SUSENAS. The meat was grouped to four meat groups encompassing beef group, chicken groups, liver group, and untrimmed bones where the two last groups were not reported due to their relatively small shares in consumption. The beef group is price-inelastic (-0.919) and the chicken group is price-elastic (-1.088). Accordingly, the beef group is income-inelastic goods (0.634) and chicken group is income-elastic goods (1.141).

Widarjono and Rucbha (2016) applying the two-stage budgeting (Working lesser- QUAIDS method) examined food demand in urban areas in Indonesia using data from the 2011 SUSENAS. Because of different consumer preferences across the country, the urban household was separated by Java Island as the main island and outside Java Island. Price elasticities for meat are from -0.552 to -1.001 and from -0.405 to -0.923 for the households in Java and outside Java Island, respectively. The income elasticities for meat are from 0.339 to 0.912 and from 0.353 to 0.624 for household in Java and outside Java. Faharuddin et al. (2017) applying the QUAIDS investigated the demand for food by household location (urban and rural area) using the 2013 SUSENAS. The price elasticities for meat are from -1.180 to -1.220 and expenditure elasticities for meat are from 1.445 to 1.564. Faharuddin et al., (2019) also investigated the demand for food from the 2013 first quarter SUSUNAS using the QUAIDS model. This study separated households into two groups consisting of agricultural households whose main income from agriculture and non-agricultural households. Based on price and income elasticity, meat demand for the agricultural household is more responsive (-1.231 and 1.600) than non-agricultural households (-1.184 and 1.454) to price and income changes.

Previous studies such as Jensen and Manrique (1998), Widarjono and Rucbha (2016) (Faharuddin et al., 2017) and Faharuddin et al., (2019) have estimated the demand for aggregate meat as part of the analysis of food demand in Indonesia. Therefore, the analysis of the demand for meat as aggregate meat does not reflect the demand for various meat products such as beef, chicken, and mutton. To best our knowledge, only a few previous studies have focused on the demand for meat products in Indonesia such as Hutasuhut et al. (2002). This study estimates the demand for meat in Indonesia. The objectives of the study are twofold. First, it estimates the demand for meat for the urban household in Indonesia using the censored demand system approach. Second, this study also analyzes the impact of changes in meat prices and income on demand for meat for the urban household. This study is different from previous studies of demand for meat in Indonesia. First, this study focuses on the demand for meat consisting of beef, goat, broiler chicken, and native chicken. Second, unlike Hutasuhut et al., (2002) applying LA-AIDS, this study applies a non-linear AIDS model with censored AIDS to investigate the demand for meat. As shown by Alston et al. (1994), LA/AIDS using a linear price index leads to inaccurate price and expenditure elasticities.

Materials and methods

Our study uses cross-sectional data from the 2013 Indonesian National Socio-Economic Survey (SUSENAS) of households. SUSENAS is a household survey of all provinces in Indonesia and records food expenditure for a week before the survey. SUSENAS conducts household surveys for four rounds (quarterly basis) during a year. The first quarter or first round is January to March, the second quarter is April to June, the third quarter is July to September and the fourth quarter is October-December. Based on SUSENAS in 2013, the number of total households surveyed for all rounds was 284,064 households. Out of these total households, households living in urban areas were 121,322 households. Our study investigates the demand for meat in the urban households throughout Indonesia for all rounds. Because of the different behavior of meat consumption between rounds, we also include dummy variables of the quarter.

The SUSENAS does not report information on prices for each meat product. The price of each meat product is unit value instead of the market price. This price is calculating by dividing expenditure by quantity. Deaton (1990) discussed the limitation of unit value as price in estimating demand system. Estimating the demand system needs to have complete information about price. If missing or unreported prices existed, these prices are calculated by regressing the observed prices on regional dummies, seasonal dummies, and income (Heien and Pompelli, 1989; Jensen and Manrique, 1998). SUSENAS provides the income of household but there is a lot of missing income data. Therefore, total household expenditure is used as a proxy for income (Deaton, 1997).

Our study applies the demand system to estimate the demand for meat in Indonesia. The demand system model for meat demand is the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980). The AIDS model is a widely used model for analyzing the demand for goods. By assuming weak separability, this study considers that meat is weakly separable from other food and non-food in the budget of the consumer. With this given assumption, the AIDS model can be written as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \, lnp_j + \beta_i ln\left(\frac{X}{a(P)}\right) + u_i \qquad (1)$$

where subscripts i and j denotes meat products (beef, goat, broiler chicken and native chicken), w_i is the budget share allocated for meat product i, p_j is the price of the j[th] meat product, X is household expenditure on meat in the system, $a(P)$ is price index, γ_{ij} and β_i are parameter being estimated, u_i is the error tem and ln stands for natural logarithm.

There are two approaches to estimating the AIDS model with respect to the price index. The first approach is calculating the price index by using a linear price index such as the Stones price index known as Linear Approximation AIDS (LA-AIDS). Second, the price index is calculated by using the non-linear price index as in equation (2). The first approach results in inaccurate parameter estimation of AIDS models and then leads also bias elasticity of demand for both price and income elasticity (Alston et al., 1994). This study applies the second approach to results in an unbiased elasticity of meat demand. The price index is calculated as

$$\ln[a(P)] = \alpha_0 + \sum_{i=1}^{n} \alpha_i \, lnp_i + \\ + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \, lnp_i lnp_j \qquad (2)$$

where p_i and p_j are price of meat product i and j.

Demographic variables can also affect the consumption of goods. This demographic variable can be augmented in the intercept of equation (1). So the intercept for the AIDS model is as follows:

$$\alpha_i = \rho_{i0} + \sum_{k=1}^{m} \rho_{ik} \, d_k \qquad (3)$$

Where d_k is the demographic variable consisting of household size (number of persons in a household) and dummy variable (quarters 2, 3, and 4). Due to differences in the timing of meat consumption in SUSENAS data, the study included a dummy variable to distinguish between quarters. The three dummy variables are the second, third, and fourth quarter while the first quarter is the basis of comparison. The characteristics of demand theory can be applied to equation (1) by restricting the parameters (Deaton and Muellbauer, 1980). The restrictions are adding-up $\sum_{i=1}^{n} \rho_{i0} = 1$; $\sum_{i=1}^{n} \rho_{ik} = 0$; $\sum_{i=1}^{n} \gamma_{ij} = 0$; $\sum_{i=1}^{n} \beta_i = 0$; and $\sum_{i=1}^{n} \lambda_i = 0$; homogeneity $\sum_{=1}^{n} \gamma_{ij} = 0$ for each i; and Slutsky symmetry $\gamma_{ij} = \gamma_{ji}$, $i \neq j$.

SUSENAS records all food expenditure as well as non-food expenditure. However, some households did not buy some meat products during the survey. Therefore, their expenditures on meat products were zero expenditure. Survey data from the 2013 SUSENAS show the percentage of urban households, who did not buy beef, goat, broiler chicken, and native chicken, were 93.58%; 99.8%; 60.1% and 96.82% at the time of the survey respectively. Zero expenditure in the dependent variable means that the dependent variables are the limited dependent variables or the censored model in the demand system.

The limited dependent variable in the demand system leads to biased estimation. To overcome this biased estimation, the demand system equation involves a two-steps estimation (Heckman, 1978). First, a probit regression is computed that determines the probability that a given household will consume the good in question. The probit regression is used to calculate the probability of each household. Second, we include the probability to estimate the demand system. Heien et al. (1990) apply the inverse Mills ratio as an instrument that incorporates the censoring latent variables in the second stage estimation of the demand system using seemingly unrelated regression (SUR). However, Shonkwiler and Yen (1999) prove that this method leads to an inconsistent estimator and propose the two-step estimation procedure for a system of equations with limited dependent variables.

This study applies consistent two-step estimation procedures to estimate the demand for meat in Indonesia (Shonkwiler and Yen, 1999; Yen et al., 2002). The first step is to estimate the probability of buying a given meat product using probit regression (Yen et al., 2002; Pan et al., 2008). The probit regression for meat demand can be written as follow:

$$prob(y_{it} = 1|Z_h) = \theta(\boldsymbol{Z_h'\tau_i}) \qquad (4)$$

$$prob(y_{it} = 0|Z_h) = 1 - \theta(\boldsymbol{Z_h'\tau_i}) \qquad (5)$$

where θ is the probit function model, Z_h is the vector of explanatory variables and τ_i is the vector of estimated parameters,

The explanatory variables in the first step include the logarithms of the prices of four types of meats, the logarithm of total household expenditure both for food and non-food items, and the demographic variables previously defined in equation (3). The probit regression results in the estimated probability density function (PDF) and cumulative

distribution function (CDF). The next step includes the PDF as well as the CDF in AIDS. Therefore, the censored AIDS model used in this study follows (Shonkwiler and Yen, 1999):

$$w_i = \{\alpha_i + \sum_{j=1}^{n} \gamma_{ij}\, lnp_j + \beta_i ln\left(\frac{X}{a(P)}\right) + \\ + u_i\}\Phi(.) + \tau_i \varphi(.) + \varepsilon_i \quad (6)$$

where Φ is the cumulative distribution function and φ is the probability distribution function.

The AIDS model in equation (6), therefore, is a censor demand system model. In the censored AIDS model, the adding-up condition does not hold in the demand system of equation (6). Therefore, following Yen et al. (2002), we should estimate an entire system equation in equation (6) in the second step by putting a restriction on homogeneity and symmetry conditions. This consistent two-step (CTS) estimation is estimated using the maximum information likelihood (FIML) (Zheng and Henneberry, 2010; Widarjono and Rucbha, 2016).

The price elasticity for each meat product based on the censored AIDS model is calculated as follows:

$$e_{ij} = \frac{1}{W_i}\{\gamma_{ij} - \beta_i(\alpha_{ih} + \sum_{j=1}^{n} \gamma_{ij}\, lnp_j)\}\Phi_i - \delta_{ij} \quad (7)$$

where δ_{ij} is the Kronecker delta, which is 1 as $i \neq j$, otherwise δ_{ij} =1. The expenditure elasticity for each meat product is calculated as:

$$e_i = 1 + \frac{1}{W_i}[\beta_i]\Phi_i \quad (8)$$

The price and expenditure elasticities are calculated on the basis of the estimated parameter and sample means of variables. For statistical inferences, the standard errors for price and expenditure elasticities are estimated using the delta method. Our study applies SAS software in all estimations.

The next step is to use the demand elasticity for meat both price and income elasticity to investigate the effects of price and income changes on the consumption of meat products. Through the interdependent demand relationship among meat products, the particular meat consumed is influenced by changes in a particular meat's price and/- or the per capita meat expenditure (Huang, 1996; Zheng and Henneberry, 2012; Zheng et al., 2019). The change in meat product per capita is a function of the price of meat product and income change as follows:

$$\Delta \ln \theta_k = \sum_j \pi_{kj} \Delta \ln p_j + \eta_k \Delta \ln y \quad (9)$$

where $\Delta \ln \theta_k = \Delta\theta_k/\theta_k$ is a percentage change in consumption of meat product per capita, $\Delta \ln p_j = \Delta p_j/p_j$ is a percentage change in the price of meat product, $\Delta \ln y = \Delta y/y$ is a percentage change in income of households, π_{kj} is the estimated price elasticity, and η_k is the estimated expenditure elasticity.

Results and discussion

Table 1 describes the consumption of meat products consisting of beef, goat, broiler chicken, and native chicken from the 2013 SUSENAS. Consumption of broiler chicken is the largest consumption of urban households in Indonesia, with an average of 0.7865 kg per capita per week followed by beef (0.0759 kg), native chicken (0.0729 kg), and goat (0.0031 kg). As the meat product consumed by most Indonesian urban households, expenditure for broiler chicken has the largest portion in the urban household in Indonesia by 83.46% of total household expenditure for meat consumption followed by beef, native chicken, and goat.

Before estimating the AIDS model, the first step is to estimate the probit model. Estimation results of the probit model for the demand for beef, goat, broiler chicken, and native chicken are shown in Table 2. The Household size has a negative impact and statistically significant at α = 1% on all probit models for each meat product. This means that household size affects the probability of buying meat. Of all dummy variables, ten dummy variables (83.3%) are statistically significant at α = 1%. These results indicate that temporal (quarter) effects are important in explaining meat consumption patterns in Indonesian urban households. Probit estimation shows that the price of each meat product and household expenditure is the dominant factor for buying meat products. Out of the 16 price variables, there are 12 price variables (75%) affecting the probability of buying meat products. Meanwhile, all expenditure variables have a positive impact and statistically significant in affecting the probability of buying meat products.

Having PDF and CDF from the probit model, the next step is to estimate the AIDS model by augmenting PDF and CDF into the AIDS model. Table 3 presents the results of AIDS parameter estimation with the non-linear price index where the independent variable is the budget share for each meat product. Three independent variables are demographic variables consisting of quarterly dummy variables and the number of families, economic variables comprising price and expenditure and probability

	Mean	Std Dev	Minimum	Maximum
	Consumption of meat products (kg/household/week)			
Beef (kg)	0.0759	0.2386	0	7.4
Goat (kg)	0.0031	0.0566	0	2.5
Broiler chicken (kg)	0.7865	0.6199	0	14
Native chicken (kg)	0.0729	0.3300	0	9.6
	Meat product expenditure share			
Budget share of beef	0.1016	0.2620	0	1
Budget share of goat	0.0032	0.0521	0	1
Budget share of broiler chicken	0.8346	0.3389	0	1
Budget share of native chicken	0.0605	0.2279	0	1

Source: The 2013 SUSENAS. The number of urban households is 121,322.

Table 1: Summary Statistics, Demand for Meat Products, Urban Households, Indonesia, 2013.

Variable	Meat products			
	Beef	Goat	Broiler chicken	Native chicken
Intercept	15.9421***	8.5636**	21.1080***	10.3163***
	(1.3337)	(3.7920)	(1.1052)	(1.7646)
Household size	-0.1344***	-0.0389***	-0.0269***	-0.0200***
	(0.0036)	(0.0121)	(0.0021)	(0.0041)
Dummy variable of quarter 2	0.0968***	-0.0309	0.0487***	0.1056***
	(0.0187)	(0.0627)	(0.0116)	(0.0213)
Dummy variable of quarter 3	-0.1198***	-0.2259***	-0.2273***	-0.0039
	(0.0274)	(0.0662)	(0.0200)	(0.0330)
Dummy variable of quarter 4	-0.2398***	-0.1883***	-0.3126***	-0.1100***
	(0.0250)	(0.0677)	(0.0181)	(0.0316)
Log of beef price	-1.5598***	-0.0602	-0.1011**	-0.3305***
	(0.0539)	(0.2313)	(0.0499)	(0.0732)
Log of goat price	-1.1010***	-1.5781***	-1.6542***	-0.2007
	(0.1329)	(0.1574)	(0.1054)	(0.1693)
Log of broiler chicken price	-0.0348	0.0474	-1.2660***	0.1253***
	(0.0386)	(0.1378)	(0.0248)	(0.0487)
Log of native chicken price	-0.2082***	0.0555	-0.0914*	-1.4538***
	(0.0815)	(0.2849)	(0.0579)	(0.0510)
Log of expenditure	1.0180***	0.3765***	0.8037***	0.5220***
	(0.0178)	(0.0423)	(0.0102)	(0.0202)

Note: ***; **; * are statistically significant at the 1%; 5%; 10%, respectively. The numbers in parentheses are standard error.

Source: Author's calculation

Table 2: Probit Estimation, Urban Households, Indonesia, 2013.

variables encompassing the CDF and PDF. There are 16 demographic variables estimated in the meat demand system. Out of the 16 variables, 14 variables (87.5%) are statistically significant at $\alpha = 10\%$ or lower. This means that most demographic variables affect the demand for meat in Indonesia, especially household size. Moreover, dummy variables, which show temporal effects, are also the key factor in determining meat consumption patterns in Indonesian urban households.

All 20 economic variables consisting of 16 prices of all meat products and four expenditure variables are statistically significant at $\alpha = 1\%$. The PDF variables are also statistically significant at $\alpha = 1\%$. The significance of all these PDF variables suggests

that there is a high probability that households who did not buy meat during the survey will buy meat at the outside survey as the SUSUNAS records household expenditure only for a week before the survey. This study, therefore, should include households who did not buy meat products during the survey in estimating the demand for meat in the AIDS demand system. Therefore, our estimation leads to bias results as we fail to include for those who are with zero expenditure in their consumer budget during the household survey.

The estimated parameter of AIDS in Table 3 is then used to calculate the elasticity of demand both price and expenditure. The price and expenditure elasticities are calculated using equations (7) and (8). The own-price elasticity is shown by the diagonal of the matrix while the cross-price elasticity is indicated by the off-diagonal matrix in Table 4 for each meat product encompassing beef, goat, broiler chicken, and native chicken. All own-price and cross-elasticities are statistically significant at $\alpha = 1\%$. All Expenditure elasticities, which are presented at the bottom of Table 4, are statistically significant at $\alpha = 1\%$.

All own-price elasticities are a negative sign. These results are consistent with the demand theory, which explains the negative relationship between the demand for goods and its price. The own-price elasticity for beef, goat, broiler chicken, and native chicken are - 0.9608; -0.7523; - 0.9864; -0.9811 respectively. Based on the own-price elasticity, the results indicate that if the prices of meat products rise (fall) then demand for that meat products decrease (increase). For instance, the 1% increase in beef price results in by roughly 0.9608% decrease in beef demand, holding other factors constant. The results show that each meat product is inelastic. The results may conclude that a variety of substitute meat product is not available for consumers. These findings are line with the previous study

	Meat products			
Variable	Beef	Goat	Broiler chicken	Native chicken
Intercept	0.6219***	-1.3999***	0.3927***	0.3477***
	(0.0032)	(0.0190)	(0.0032)	(0.0068)
Household size	-0.0059***	0.1433***	0.0235***	-0.0235***
	(0.0002)	(0.0036)	(0.0001)	(0.0006)
Dummy variable of quarter 2	-0.0160***	0.5291***	-0.0115***	0.0032
	(0.0011)	(0.0463)	(0.0007)	(0.0026)
Dummy variable of quarter 3	-0.0261***	0.7057***	-0.0092***	-0.0848***
	(0.0011)	(0.0265)	(0.0007)	(0.0033)
Dummy variable of quarter 4	-0.0006	0.8511***	-0.0078***	-0.1039***
	(0.0012)	(0.0215)	(0.0007)	(0.0044)
Log of beef price	-0.1146***	-0.3343***	0.2245***	-0.0715***
	(0.0015)	(0.0026)	(0.0013)	(0.0040)
Log of goat price	-0.3343***	0.5109***	-0.0670***	-0.1096***
	(0.0026)	(0.0070)	(0.0021)	(0.0075)
Log of broiler chicken price	0.2245***	-0.0670***	-0.3034***	0.1460***
	(0.0013)	(0.0021)	(0.0019)	(0.0028)
Log of native chicken price	0.2245***	-0.1096***	0.1460***	0.0351***
	(0.0013)	(0.0075)	(0.0028)	(0.0048)
Log of Expenditure	-0.5168***	-0.6770***	-0.4812***	0.0806***
	(0.0022)	(0.0217)	(0.0023)	(0.0037)
CDF	0.5664***	-0.4874***	0.4852***	-0.0788***
	(0.0044)	(0.0385)	(0.0028)	(0.0106)
PDF	2.7107***	2.8638***	5.0890***	0.5418***
	(0.0128)	(0.0425)	(0.0108)	(0.0164)

Note: ***; **; * are statistically significant at the 1%; 5%; 10%, respectively. The numbers in parentheses are standard error.

Source: Author's calculation

Table 3: Estimated Parameters of AIDS, Urban Households, Indonesia, 2013.

Variable	Meat products			
	Beef	Goat	Broiler chicken	Native chicken
	Consumption of meat products (kg/household/week)			
Price of beef	-0.9608***	-0.4353***	0.5073***	0.5073***
	(0.0022)	(0.0068)	(0.0019)	(0.0019)
Price of goat	-0.1035***	-0.7523***	0.3236***	-0.0631***
	(0.0057)	(0.0101)	(0.0117)	(0.0051)
Price of broiler chicken	0.2115***	-0.1226***	-0.9864***	0.0961***
	(0.0009)	(0.0037)	(0.0023)	(0.0029)
Price of native chicken	-0.0583***	-0.0512***	0.0551***	-0.9811***
	(0.0028)	(0.0048)	(0.0029)	(0.0028)
	Meat product expenditure share			
Expenditure	0.5449***	0.4434***	0.7268***	1.0487***
	(0.0019)	(0.0179)	(0.0013)	(0.0023)

Note: ***; **; * are statistically significant at the 1%; 5%; 10%, respectively. The numbers in parentheses are standard error.
Source: Author's calculation.

Table 4: Price and Expenditure Elasticity, Urban Households, Indonesia, 2013.

by Hutasuhut et al., (2002) using LA-AIDS who documented that beef is price inelastic but chicken is price elastic. However, estimating demand elasticity using a linear price in LA-AIDS leads to overestimate results (Alston et al.,1994). The price elasticities for meat products in this study are quite different from the empirical study of demand for meat products in Malaysia for which price elasticity is elastic due to the availability of various substitute meat products in Malaysia (Sheng et al., 2010).

The cross-price elasticity for each meat product results in different conclusions. On beef demand, the goat is complementary goods to beef because its cross-price elasticity is negative while broiler chicken and native chicken are substitute goods to beef. In the case of broiler chicken, the goat is a complementary good to broiler chicken while beef and native chicken are substitution goods to broiler chicken. On demand for goat, broiler chicken is a substitute to the goat while beef and native chicken are complementary goods to the goat. On demand for native chicken, broiler chicken is substitute goods and beef and goat are complementary goods. Generally, it can be concluded that broiler chicken and beef are substitute goods. These results are in accordance with the pattern of meat consumption in Indonesian urban households where broiler chicken is the main menu of meat products followed by beef. These results support the previous empirical study conducted by Hutasuhut et al., (2002) that indicated that broiler chicken and beef are substitute goods in urban households in Jakarta as a capital city of Indonesia and west java province which borders Jakarta.

At the bottom part of table 4 shows the expenditure elasticity. All expenditure elasticities are positive as expected for basic food as normal goods. The expenditure elasticities for beef, goat, broiler chicken, and native chicken are 0.5449; 0.4434; 0.7268; and 1.0487, respectively. The results may conclude that as income increases by %, demand for broiler chicken is expected to increase approximately by 0.7268%. The elasticity of expenditure indicates that beef, goat, and broiler chicken are income-inelastic goods while the native chicken is income-elastic goods because native chicken is a chicken product that is more delicious and healthier than broiler chicken (Ali et al., 2019). These results are in line with previous empirical study. Hutasuhut et al. (2002) using different SUSENAS data during 1990's revealed that demand for beef is income-inelastic but chicken demand is income-elastic. Nevertheless, Indonesia's income per capita has increased remarkably recently from US$ 1,026 per capita in 1995 to US$ 3,624 in 2013. According to Engle's law, moving from low-income country to middle-income country has changed considerably income elasticity for meat products which is expected to be inelastic, smaller than those of 1990s. Yet, the income elasticities for meat products are much smaller than those of the demand for meat products in Malaysia for which meat products are income-elastic (Sheng et al., 2010).

Next, having estimated demand elasticity consisting of price and expenditure elasticities, both elasticities are then used to perform policy simulations. This policy simulation is to analyze the impact of changes in the price of meat products

Meat products	Average Consumption (kg)	Scenario 1		Scenario 2		Scenario 3	
		Quantity	%	Quantity	%	Quantity	%
Beef	0.0760	-0.00345	4.54	-0.0029	3.82	-0.0070	9.26
Goat	0.0031	-0.00005	1.67	-0.0002	5.95	-0.0003	10.39
Broiler chicken	0.7865	-0.06094	7.75	-0.0630	8.01	-0.1202	15.28
Native chicken	0.0729	-0.00002	0.03	-0.0075	10.35	-0.0152	20.84

Note: Scenario 1 refers to the prices of broiler chicken and beef rises by 10%. Scenario 2 refers to all prices rises by 10%. Scenario 3 refers to all prices rises and income fall by 10%.

Source: Author's calculation

Table 5: Effect of Change in Price and Income on demand for meat product, Urban Household, Indonesia, 2013

and expenditure on the consumption of meat products in Indonesian urban households. Huang (1996) states that change in per capita meat product consumption is a function of changes in the price of meat product and income. From this simulation can be investigated how the change of meat product consumption is as the price of meat product and expenditure of household change.

In this study, policy simulations are conducted with several scenarios to analyze the impact of price's meat products and expenditure changes on the consumption of meat products. The first scenario is the increase in prices of broiler chicken and beef by 10% to meat product consumption holding that household's income does not change. This scenario is based on the budget share in the 2013 SUSENAS where broiler chicken and beef are the main menus of meat consumption for households in urban Indonesia. The second scenario is an increase in all the prices of meat products by 10% to the consumption of meat products holding that household's income is unchanged. The third scenario is an increase in all prices of meat products by 10% and a reduction in household income by 10% to meat products consumption.

The results of the policy simulation are shown in Table 5. In the first scenario, it decreases all consumption of meat products. Consumption of broiler chicken, beef, goat, and native chicken decreases by 0.061094 kg; 0.00345 kg; 0.00005 kg; and 0.00002 kg per week, respectively. The first scenario causes a reduction in broiler chicken consumption by 7.75%, followed by beef (4.54%). Scenario 2 decreases the consumption of native chicken by 10.35%, followed by broiler chicken (8.01%), goat (5.95%), and beef (3.85%). The third scenario leads to a decline in the consumption of all types of meat with the highest decrease in native chicken, followed by broiler chicken, goat, and beef. A remarkable reduction in the consumption of native chicken indicates that native chicken is not the main menu of meat product consumption in Indonesian urban households. Beef is a meat product whose level of consumption is unresponsive to price and income changes.

Conclusion

This study estimated the demand for meat for Indonesian Urban Household using the demand system. The complete demand system was estimated using the non-linear Almost Ideal Demand System. The 2013 National Social and Economic Survey of Household in Indonesia was used to accomplish this study. This study finds some important results. First, all estimated own-price elasticities are negative and inelastic as expected. Broiler chicken is the most responsive to price changes and goat is the least responsive to price changes. The next finding shows that broiler chicken and beef are substitute goods based on the estimated cross-price elasticity. Broiler chicken is the main menu of meat followed by beef. These findings are consistent with the consumption pattern of meat products for urban households in Indonesia. Third, all estimated expenditure elasticities are positive. However, native chicken is the most responsive meat products and goat is the most unresponsive meat product to the income change. Fourth, based on policy simulation, beef is a meat product whose level of consumption is less responsive to price and income changes. On the other hand, native chicken is most responsive to price and income change.

The important implication can be inferred from this study. Broiler chicken as the main dish of meat products in urban households is very responsive to price change, implying an increase in price of broiler lowers meat consumption from this particular meat. Nonetheless, beef as a substitute meat product for broiler chicken

is very expensive. With limited available substitute meat products, consumption of meat products reduces considerably as the price of broiler chicken rises and then lowers protein intake which leads to protein deficiency. So, the government should stabilize the price of broiler chicken through ceiling price policy during the price crisis of meat products such as in 2013 in order to maintain the adequacy consumption of meat products.

There are some limitations to this study. First, by assuming the linear Engle curve, the AIDS model leads to inaccurate estimation because basic food such as meat products may not be linear related to income as to nonlinearity of the Engel curve. Second, this study examines only urban households. However, consumption patterns of meat product consumption are geographically different in Indonesia. Lastly, because of ongoing rapid urbanization in Indonesia, these results may not reflect the consumption of meat products in recent conditions.

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Brazil's Comparative Advantages and Specialization Dynamics in Agri-food Trade

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Abstract

In the last decades Brazil has become a global agri-food powerhouse. The article interrogates the shape and its stability of revealed comparative advantages in 46 of its agri-food products for the period 1995-2017. The results support the argument that the Brazil's agri-food trade was formed by comparative advantages of specific agri-food sectors. The results show that the external shape of agri-food specialization has strengthened, first since early 2000s and second when the trade shifted more towards China. The pattern was stable according revealed comparative (dis)advantage of particular products, more changes occurred in each product's score and in ranking of products. Products without initial comparative advantage seem to remain uncompetitive whilst the products with strong initial comparative advantage continue to be competitive. The persistence in distribution has increased. This suggests, the shape of Brazil's revealed comparative advantage in agri-food trade has evolved towards its finite structure (ceteris paribus).

Keywords

European Union, Liberalization, Markov Chain Model, MERCOSUR, Specialization.

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Introduction

Brazil is the most important country in Latin America as it is the most populous country and by far the largest economy in the region. Brazil has also the fastest growing agricultural sector in Latin America (Bojanic, 2017). From being a net-agricultural importer and food aid recipient as recently as the 1960s and 1970s, it has now become the world's third largest agricultural exporter. Brazil is the world´s leading exporter of soybean (oilcakes and soybeans), sugarcane products (sugar and bioethanol), meat (beef and poultry), coffee and cereals and orange juice and is becoming serious competitor to the global market dominance of the world's leading agricultural exporters, the US and EU (Hopewell, 2016). These changes also stressed Brazil's position and importance regarding provision of global food security and environmental sustainability.

The successful story of Brazilian agriculture attracts attention and intense interest from its competitors as well as from other developing countries. As pointed by Pereira et al. (2012) and Martha et al. (2010), Brazil has transformed its agriculture into one of the most competitive tropical agriculture model in the world within the relative short period of one generation.

Brazil has a number of competitive advantages in agri-food production. These include a favorable climate that allows for two or more harvests per year, large extensions of cheap arable land, abundant supplies of water, varied soils and climates that encourage product diversity and technology/know-how of producers and agro-industries (EIU, 2010). As pointed by Hopewell (2016), Brazil's emergence as an agricultural

powerhouse was the result not just of its natural factor endowments, but extensive intervention on the part of the Brazilian government which worked together with private sector. Also, Brazil has been able to attract a significant amount of foreign direct investment (Bojanic, 2017). Long-term investment in research and development, human capital, agricultural extension services and infrastructure were crucial and had the effect of constructing a new comparative advantage (Moreddu et al., 2017; Hubbard et al., 2017).

To put it more straight, the spectacular growth of Brazil's agricultural production in last two decades was caused mostly by following factors. Firstly, the agriculture sector could have built on profound modernization that happened between 60s-90s as a result of strong policies of the Brazilian state, aimed mostly at credit availability and incentives for farmers. Brazil's total factor productivity (TFP) for agriculture grew from a minuscule 0.17 percent annually in the early 1960s to 3.15 percent in 2012, what was one of the fastest TFP growth rates in the world (Maciel, 2018). In turn, TFP is one of the most crucial indicator of economic growth which causes preconditions for further economic development (Bilan et al., 2020). Second, macroeconomic stability after 1994 is often mentioned (Chaddad and Jank, 2006), together with the overall institutional stability (Mueller and Mueller, 2016). Third, Brazil invested vastly into the system of agricultural research - Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), thus providing necessary support to the innovations and its up-take within the sector (Martha et al., 2010; Mueller and Mueller, 2016). Fourth, overall cuts in tariffs levels helped Brazil to get market access and increase its integration in global agribusiness (Hopewell, 2016). Fifth, there were other exogenous factors in play, mostly rising prices on the world commodity markets that further enhanced investments in agriculture activities. The above findings reveal that the rise of Brazilian agriculture is a consequence of both developments of the Brazilian agricultural model and of exploitation of opportunities offered by more and more liberalized agrarian markets.

In the last decades, the ongoing economic globalization delivered incentives and changes in Brazil's overall production and trade structures. In the recent study, Nassif and Castilho (2020) concluded that Brazil's recent over-all trade pattern trajectory has been directed to a regressive pattern of specialization. By regressive specialization they refer to that in which both production and export structures are strongly oriented to primary and resource-based manufactured goods. Despite the significant increase of Brazilian trade flows, since the early-2000s the technological gaps of manufacturing sector have significantly increased. In other words, the international performance of Brazilian agribusiness became not just a matter of a specific segment of the economy; its development has significant implications for the entire external economic balance of Brazilian economy. As shown by Andrade (2017), the agribusiness sector became the most important part of foreign revenue for Brazil and the rising value of agricultural exports is offsetting the rising deficit in trade with manufactured products.

The fact that Brazil shows a comparative advantage (CA) and competitiveness in total agrarian foreign trade is quite obvious here. There is also a number of sectoral studies (e.g. Sterns and Spreen, 2010; Siqueira et al., 2011; Belova et al., 2012; Im and Hong, 2015; de Paula et al., 2018; Torok et al., 2018) investigating the CA of Brazil in its most exported agri-food products. To author's knowledge, surprisingly, there is no study that examines both the extent and the dynamics of specialization within the over-all segment of Brazil's agri-food trade. Our aim is thus to fill this gap.

Generally, the trade theories give dissimilar predictions regarding specialization dynamics of a country. According to the Heckscher-Ohlin model, the specialization pattern is formed based on countries relative endowment in production factors. The change in trade specialization can be expected only if there is change in relative endowment of the country, relative to its trading partners (Nazarczuk et al., 2018; Maciejewski, 2019). A certain limiting feature of this framework is that assumptions of the model do not have to be met by the economic realities.

Removing tariffs on goods traded between countries and reducing nontariff barriers by harmonizing product standards and simplifying government formalities reduces the transaction costs of trade which should lead to an increase in the degree of specialization (Aiginger, 2001; Ricci, A., 2018). Higher specialization can lead to higher productivity and competitiveness (and vice versa). Other streams of theoretical literature emphasize the endogeneity of technological change (Grossman and Helpman, 1991; Krugman, 1987; Lucas, 1988; Redding, 1999; Brodzicki, T. and Kwiatkowski, J., 2018) or economic geography that underlines the importance of agglomeration economies (Krugman, 1991; Fujita et al., 1999). particularly for developing countries like Brazil and others (Kostiukevych et al., 2020). Each of these streams of theoretical research identifies some forces that lead to persistence in trade patterns and other that stimulate mobility (Brodzicki, et al., 2018). The predictions offered by trade

theories depend on assumptions which might be met. Empirical studies on agri-food production and trade (e.g., Milovanovic and Smutka, 2017; Hoang, 2019) suggest and support that changes in patterns and performance in trade are due to both demand and supply sides, both at domestic and international markets, both in factor-intensities and productivity differentials. Such changes are especially obvious when the world sugar market has been oscillating between surplus and deficit states (Smutka et al., 2020). Liberalization and integration are also channels for improvements in productivity, scale, and export expansion and a way to improve comparative advantage (Lisin et al., 2019). The above characteristics and context of Brazil's success as agriculture powerhouse points to the influence of factor endowment as well as endogenous and exogenous factors on the formation of Brazil's specialization in agri-food trade. It is the matter of empirical testing the shape of specialization, its evolution over time and the intra-distributional dynamics.

The presented paper interrogates evolution of the overall degree of specialization (the external shape) and the degree and the pattern of intra-distributional mobility (changes in the intra-distributional dynamics) within the Brazil's agri-food trade in the last almost 25 years.

The main contribution of this paper is that it takes a look at Brazilian agri-food sector over a long-period of years 1995-2017. This approach gives the authors the possibility to cover different stages and also to concentrate on the competitiveness in a larger period than other studies. The time period analysed includes neoliberal policies (until 2002), the neo-developmentalism (2003-2016) and first years of political and economic crisis in Brazil (since 2015). Importantly, our analysis contributes to the conclusion, that neo-developmentalism – focused on promotion of complex industrial production (skill, knowledge, technology intensive) aiming on both domestic and world market (Bresser-Pereira, 2009; Morais and Saad-Filho, 2012; Ban, 2013; Cypher, 2014) – did not succeed in Brazil and the dependence on agricultural exports altered during that period.

What´s more, our data covering this long time period suggests, that the export success of agribusiness with strong and strengthening comparative advantage and competitiveness was not dependent only on Chinese and/or commodity boom (2000-2014). That is why our analysis presents more valid and also policy relevant understanding of contemporary development of Brazilian agri-food sector.

Materials and methods

To assess the shape of trade specialization and its stability, it is relevant to determine the country's comparative advantage in the products trade. The traditional approach is based on the concept of 'revealed' comparative advantage (RCA). Balassa (1965) developed the empirical method and it is widely used to identify a nation's most robust and weakest export sectors (Benešová et sl, 2018). The Balassa index (BI) compares the share of a product in a country's total export with the same share in the total World's exports. The BI index is mathematically presented as:

$$\mathbf{BI_{ij}} = \frac{\frac{\mathbf{x_{ij}}}{\mathbf{x_i}}}{\frac{\mathbf{x_{wj}}}{\mathbf{x_w}}}, \qquad (1)$$

where x indicates exports, i represents a nation, j signifies a product and w represents a set of countries. The BI is not symmetric; values between 0 and unity signify that the economy reveals comparative disadvantage (CdisA); values that exceed unity signify that the country is specialized in exporting the product and the country reveals CA in that given sector. The theoretical foundation and empirical distribution characteristics of the BI have been debated and criticized in the literature (Bowen, 1983; Vollrath, 1991; Hinloopen and Van Marrewijk, 2001; Sanidas and Sin, 2010; De Benedictis and Tamberi, 2004; Gnidchenko and Salnikov, 2015). Because of the shortcomings of the BI, other indices have been proposed (i.e. Bowen, 1983; Vollrath, 1991; Lafay, 1992; Dalum et al., 1998; Proudman and Redding, 2000; Hoen and Oosterhaven, 2006; Yu et al., 2009; Leromain and Orefice, 2014). At this point, it is worth emphasizing, that none of alternatives seems to be without problems and the common practice in trade studies is to use more indices to see if there is a glaring difference.

In contrast to BI, the Lafay Index (LFI) uses both imports and exports. The LFI norms the trade balance of individual products with the overall balance and weights it in the trade structure. The LFI allows control of intra-industry trade and re-exporting flows, is symmetric and seems to be more reliable than the BI when comparing the values in time series. The LFI is defined as (Lafay, 1992; Zaghini, 2003):

$$\mathbf{LFI_j^i} = \mathbf{100}\left(\frac{\mathbf{x_j^i - m_j^i}}{\mathbf{x_j^i + m_j^i}} - \frac{\sum_{j=1}^{N}(\mathbf{x_j^i - m_j^i})}{\sum_{j=1}^{N}(\mathbf{x_j^i + m_j^i})}\right)\frac{\mathbf{x_j^i + m_j^i}}{\sum_{i=j}^{N}(\mathbf{x_j^i + m_j^i})}, \qquad (2)$$

where x and m represent the export and import values of every product group. Zero signifies

a comparative advantage neutral point. LFI's positive value indicates the existence of CA for a particular sector and a negative value signifies the presence of a CdisA. The higher index value indicates a higher degree of CA and specialization and vice versa.

The Normalized revealed comparative advantage index (NI) was proposed by Yu et al. (2008) as another alternative measure of RCA. Due to the fact that it is comparable across products, countries and time, the index should more precisely and consistently reveal the extent of CA that a country has in a certain product, making it another useful quantitative tool.

$$\mathbf{NI} = \frac{\mathbf{x_{ij}}}{\mathbf{x_w}} - \frac{\mathbf{x_j} \times \mathbf{x_{wj}}}{\mathbf{x_w} \times \mathbf{x_w}} \quad (3)$$

The NI index ranges from -0.25 to 0.25 and the comparative neutral point is zero. The sum (and the mean value) of scores is constant and equals to zero and a sum of positive scores equals the sum of negative scores. If NI is higher (lower) that 0, country reveal comparative advantage (disadvantage) in product *i*. The higher the value, the stronger CA and vice versa.

Statistical data were obtained from databases of the UNCTAD, for the period between 1995 and 2017. The commodity structure of individual sectors (products) in agri-food trade is defined according to the SITC (revision 3). The analysis is done at the level of 3-digit code for 46 various agri-food products traded (SITC 0 + 1 + 22 + 4). The values of BI, LFI and NI have been calculated for each agri-food product groups (table A1 in Annex) traded between Brazil and World market for the period from 1995 through 2017. The descriptive statistics of pooled data is presented in following table (Table 1).

Scores of BI, LFI and NI were analyzed regarding its consistency. Ballance et al. (1987) suggest empirical tests to examine the extent to which various RCA indices are consistent as a cardinal measure (the extent to which a country has a CA/CdisA in a product), ordinal measure (consistent in ranking product groups by RCA) and dichotomous measure (similarity in suggesting whether the product group have CA or CdisA).

Also, scores of BI, LFI and NI were examined regarding how weak or strong the comparative advantage of each product is. Following Hinloopen and Van Marrewijk (2001), BI scores were grouped using absolute thresholds: reveal CdisA (BI≤1), weak CA (BI>1 and BI≤2), medium CA (BI>2 and BI≤4) and strong CA (BI>4). There is no general guidance in literature for classifying the LFI and NI values into classes, so the data was grouped based on quartiles (relative thresholds) from positive LFI values: reveal CdisA (LFI≤0), weak CA (LFI>0 and LFI≤0.032; first and second quartile), medium CA (LFI>0.032 and LFI≤0.293; third quartile) and strong CA (LFI>0.293; fourth quartile); and positive NI values: reveal CdisA (NI≤0), weak CA (NI>0 and NI≤17.70; first and second quartile), medium CA (NI>17.70 and NI≤32.31; third quartile) and strong CA (LFI>32.31; fourth quartile).

First, a static view on the comparative advantage of individual products is applied using mean values (1995-2017) of BI, LFI and NI to assess and to identify the agri-food products revealing CA or CdisA and so the capacity to cope with competitive pressures of the world.

	BI	LFI	NI
Theoretical range	$0 \leq BI \leq +\infty$	$-\infty \leq LFI \leq +\infty$	-2,500 ≤ NI ≤ +2,500
CANP	1	0	0
Min	0.000	-9.604	-33.834
Max	7.215	8.170	144.695
Range	7.215	17.774	178.529
Mean	0.849	0.000	0.000
s.d.	1.448	1.621	19.083
Median	0.146	-0.064	-2.393
Skewness	2.073	0.235	2.842
Kurtosis	3.445	7.759	12.977

Note: CANP – Comparative advantage neutral point; following Yu et al. (2009), the scores are rescaled by multiplying 10,000 without affecting the results.
Source: Own calculation based on UNCTAD (2019)

Table 1: Descriptive statistics of pool data (Balassa, Lafay and Normalized indices; 1995-2017).

Following the recent empirical studies in agri-food trade (Hinloopen and Van Marrewijk, 2001; Ferto and Hubbard, 2003; Kostoska and Hristoski, 2018; Hoang, 2019), a battery of empirical approaches is employed to analyze structural stability of the Brazil's agri-food comparative advantage. According to Hinloopen and Van Marrewijk (2001), one can distinguish at least two types of stability; first, the stability of the distribution of the indices from one period to the next (Stability I); second, the stability of the value of the indices for particular product groups from one period to the next (Stability II).

Stability I

Based on procedures suggested by Hinloopen and Van Marrewijk (2001), summary statistics can be employed to investigate the external shape of the distribution of RCA indices. Also, following Ferto and Hubbard (2003), the correlation between the indices in time period t and the index in subsequent time periods was employed as the indicator of structural stability of Brazil's agri-food trade pattern. Another indicator of stability is the relative importance (in the export structure) of products that reveal CA in the period t, but reveal CdisA in the period t+1 or vice-versa (Kostoska and Hristoski 2018). Because the year-by-year fluctuation, the comparison is made between average value of indices at the beginning (avg.1995-1999) and at the end (2013-2017) of the observed period.

Stability II

To assess the structural changes in the over-all as well as at the sectoral level, the stability is analyzed in term of the RCA scores's distribution of specific products in mentioned 4 classes (CdisA, weak, medium and strong CA) from one period to the next. Following Quah (1996), Proudman and Redding (2000), Brasili et al. (2000), Hinloopen and Van Marrewijk (2001) and Zaghini (2005), the changes in distribution of products among the particular classes were analyzed using Markov chain model. The evolution of RCA distribution over time may be modeled formally to measure the probability that a product group moves from one class to another. Thus represent the RCA by the measure x and its distribution across sectors at time t by $F_t(x)$. Corresponding to F_t, it can be define a probability measure λ_t, where $\lambda_t((\lambda_{t-1},x)) = F_t(x)$. The evolution of the distribution of RCA over time is then modeled in terms of a stochastic difference equation:

$$\boldsymbol{\lambda_t = P(\lambda_{t-1}, u_t)} \quad (4)$$

where u_t is the error term and P is an operator which measures if an element, initially part of distribution F_{t-1}, will end in F_t. If the operator P is time invariant and the disturbances are equal to zero, by iterating the relation above, could be obtain:

$$\boldsymbol{\lambda_{t+s} = P \times \lambda_{t+s-1} = \cdots = P^s \times \lambda_t} \quad (5)$$

Allocating the RCA into the classes, the operator P becomes a transition matrix. An element of it, p_{ij}, represents the probability that a value, which at the beginning of the period was in the state i, will be, after s years, in state $_j$. If the larges values are situated on the main diagonal of the transition matrix, then the mobility inside the distribution is rather small and vice versa.

The general degree of mobility can be assessed using trace and the determinant of transition matrix, as follows:

$$\boldsymbol{M_1 = \frac{n - tr(P)}{n-1}}, \text{ respectively } \boldsymbol{M_2 = 1 - |det(P)|}, \quad (6)$$

n is the number of classes; $tr(P)$ is the trace of matrix P; $det(P)$ is the determinant of matrix P. M_1 captures the importance of diagonal and off-diagonal terms. In the case of total persistence, the value of M_1 would be zero. In the case of total mobility, the M_1 would be 1. The M_2 gives similar explanation. When the values on the main diagonal are close to 1 and those on the off-diagonal small (high persistence), the matrix determinant takes a value close to 1 and the mobility indicator is 0. The assessment of persistence resp. mobility was done over the entire reporting period. Furthermore, the year-on-year M1 and M2 indices were calculated to assess its changes from 1995 to 2017. This allows to evaluate, whether distribution of product among product's classes is already formed or is still undergoing changes.

Results and discussion

Brazil's agri-food trade dynamic

Brazil's total agri-food export value increased 5.9 times between 1995 and 2017 to 77,612 million USD. The value of total agri-food import to Brazil rose 1.7 times and reached 9,929 million USD in 2017. The share of agri food trade in the total foreign trade of Brazil has been around 20% and has slightly increased to 22.5% in 2017. The agri-food export still generates around 70% share on total foreign export, despite a slight decrease in the last decade (65.1% in 2017). Contrary, the agri food import generates only around 5% on total import. The trade balance

index (TBI) confirms the increasing position of Brazil as a net-exporter of agri food products. Agri-food represents a significant and positive contribution to Brazil's trade balance (+73 billion USD in 2017). The figure 1 (Fig. 1) shows the change in Brazil's agri food trade between 1995 and 2017.

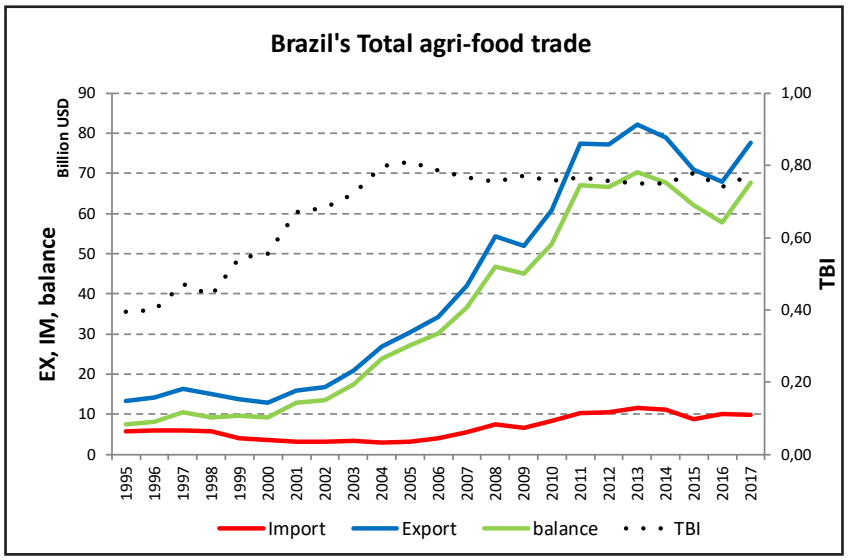
The dynamics of agri-food trade varied during the reviewed period. In the early 2000s agri-food exports saw a significant increase, when the implementation of Uruguay Round Agreement on Agriculture was completed. Together with decrease in unilaterally applied tariffs levels and preferential applied tariffs levels Brazil got market access and increased its integration in global agribusiness. Likewise, the overall rise in commodity prices (especially in the period before the Great Recession during the late 2000s and early 2010s) contributed to an increase in the value of the Brazilian agricultural exports. Brazil mainly exports soybean (oilcakes and soybeans), sugar, beef and poultry, coffee, tobacco, maize and orange juice.

Regarding the territorial structure, the regional integration within MERCOSUR has not stimulated the intensity of agri-food trade between Brazil and other MERCOSUR countries. On the other hand, the structure of extra-regional trade has changed significantly. The value of agri-food trade between Brazil and the EU28 has increased. However, the European Union is gradually losing its position as Brazil's most important agri-food trading partner. In the same time, China's position as a trading partner for agri-food products has increased in a large manner during the period of the Chinese commodity boom (2000-2014) and especially in the period after Great Recession.

The dynamics could be a bit changed if the ambitious and comprehensive trade agreement between the European Union and MERCOSUR was finalized. At the moment of finishing this article, a political agreement was found. The way to put the deal into practice will be difficult though, due to the fact that there is a strong resistance from some of the member states of the EU, based mainly on agricultural arguments. Concerning the changes in the commodity structure of the production and agrarian trade in the Central and Eastern European countries (Svatoš and Smutka, 2010; Maitah et al., 2016), meat and sugar exports coming from Brazil may further form changes in these sectors. More detailed summary of changes in Brazil's export and import and territorial structures of agri-food trade can be found in Zdráhal et al (2019).

Measuring Brazil's revealed comparative advantages in agri-food products

The revealed comparative advantage of 46 sectors of agri-food trade of the Brazil was evaluated using the BI, LFI and NI indices. The consistency of BI, LFI and NI was examined (Table 2) using tests suggested by Ballance et al. (1987).



Note: Trade balance index (TBI) compares the balance of trade (X-M) to its turnover (X+M); the value close to 1 would mean that the country only exports
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Figure 1: Change in Brazil's agri food trade (export, import, balance and trade balance index), 1995-2017.

			1995	2000	2005	2010	2015	2017	avg.
BI	LFI	Cardinal	0.725	0.730	0.751	0.789	0.823	0.848	0.752
		Ordinal	0.548	0.727	0.622	0.694	0.624	0.663	0.684
		Dichotomous	0.826	0.826	0.935	0.913	0.935	0.957	0.879
	NI	Cardinal	0.870	0.890	0.876	0.877	0.866	0.879	0.873
		Ordinal	0.657	0.680	0.635	0.643	0.650	0.656	0.656
		Dichotomous	1.000	1.000	1.000	1.000	1.000	1.000	1.000
LFI	NI	Cardinal	0.827	0.798	0.848	0.900	0.940	0.953	0.855
		Ordinal	0.838	0.748	0.793	0.841	0.860	0.865	0.831
		Dichotomous	0.826	0.826	0.935	0.913	0.935	0.957	0.879

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 2: Tests of consistency – correlation coefficients of paired RCAs indices.

The consistency test of the indices as cardinal measures of comparative advantage was based on the correlation coefficient between paired indices in each of the 23 years. The BI, LFI and NI show a high level of correlation (≥ 0.75), especially the BI↔NI and LFI↔NI pairs. This suggests that the indices are consistent as cardinal measures. The consistency test of the indices as ordinal measures (cross-sector ranking) was based on the rank correlation coefficient for each pairing. On average, the BI↔LFI and BI↔NI pairs show moderate level of correlation and LFI↔NI pair shows high level of correlation.

Results show that the LFI and NI indices are consistent in ranking product groups by revealed comparative advantage. On the other hand, LFI and NI indices give slightly different rankings in comparison to BI indices. The test of indices as a dichotomous measure was based on assessment of the share of product groups in which both of the paired indices suggest CA or CdisA. This test indicates that BI and NI have perfect match in the all years under analysis. The BI↔LFI and LFI↔NI pairs are also highly consistent with all the year-by-year shares higher than 70% (87.9% on average).

This indicates that BI, LFI and NI used in the analysis give very similar results (same results in the case of BI and NI) whether or not Brazil has a comparative advantage in a given agri-food sector and how many sectors are considered to have a CA according to each RCA index. Also, BI, LFI and NI should give similar results, when examining how much more of CA a given agri-food sector in Brazil has in comparison to other agri-food sectors in Brazil and how much has the sector gained through time. On the other hand, only moderately similar results (except of LFI↔NI) can be expected when ranking the Brazil's agri-food sectors according revealed CA or CdisA. This result gives support to the findings on consistency of BI, LFI and NI in studies of Sanidas and Shin (2010) and Hoang (2019).

As anticipated by the consistency tests of dichotomous and cardinal characteristics, the statistical findings (mean) for BI and NI (Table 3) exhibit similar patterns and both of them point, on average from 1995 to 2017, to a revealed CA for 12 products: 011 (reveals weak CA); 012 (medium/strong); 016 (weak); 017 (weak); 044 (weak); 059 (weak/medium); 061 (strong); 071 (medium/strong); 081 (medium/strong); 121 (medium); 222 (strong); 421 (CdisA/weak). The Lafay index takes into consideration also imports and it also eliminates various other factors (Zaghini, 2005) and points to a revealed CA also for 5 other products. But scores of 3 (listed here in SITC codes: 047, 074, 075) out of that 5 are close to comparative advantage neutral point (zero). The other two are: 036 (weak) and 122 (weak). Also, the LFI is revealing (although small) comparative disadvantage in a case of 421, contrariwise to BI and NI (Table 3).

As indicated by the consistency test of ordinal characteristics, the average RCA scores do not always match each other when ranking the products. However, the most competitive product groups of Brazil's agri-food trade are 222, 061 and 071. The cross sectoral comparison and revealed CA or CdisA of specific products is in line with general perception of Brazil as the world´s leading exporter of soybean (oilcakes and soybeans; codes 222, 081), sugarcane products (sugar; 061), coffee (071), meat (beef and poultry; 011-017), cereals (044) and orange juice (059). Average RCA's scores do not match when ranking the milk based products (022, 024), fish (034, 035, 037), cereals and cereals based products (041, 042, 043,

SITC	BI		LFI		NI		SITC	BI		LFI		NI	
	avg.	rank	avg.	rank	avg.	rank.		avg.	rank	avg.	rank	avg.	rank
001	0.24	**21.**	-0.10	25.	-5.84	**29.**	**057**	0.27	**18.**	-1.13	**40.**	-21.71	**45.**
011	1.77	**8.**	0.59	9.	11.78	**8.**	**058**	0.12	**28.**	-0.16	**29.**	-5.58	**28.**
012	2.04	**7.**	2.49	4.	25.58	**4.**	**059**	3.85	**5.**	1.46	**6.**	14.89	**7.**
016	1.07	**12.**	0.07	12.	0.37	**12.**	**061**	4.89	**1.**	3.38	**2.**	48.90	**2.**
017	1.68	**9.**	0.60	8.	4.17	**10.**	**062**	0.46	**16.**	-0.04	**20.**	-2.17	**23.**
022	0.07	**32.**	-1.32	42.	-12.94	**40.**	**071**	4.00	**4.**	3.02	**3.**	32.62	**3.**
023	0.02	**41.**	-0.07	22.	-2.66	**26.**	**072**	0.48	**14.**	-0.25	**32.**	-3.56	**27.**
024	0.01	**44.**	-0.31	33.	-10.10	**36.**	**073**	0.17	**25.**	-0.23	**31.**	-6.67	**32.**
025	0.26	**20.**	-0.03	19.	-1.23	**17.**	**074**	0.26	**19.**	0.01	**15.**	-2.11	**22.**
034	0.06	**35.**	-1.37	43.	-18.81	**43.**	**075**	0.79	**13.**	0.01	**14.**	-0.64	**14.**
035	0.03	**39.**	-0.82	37.	-2.10	**21.**	**081**	2.22	**6.**	2.49	**5.**	23.25	**5.**
036	0.17	**24.**	0.12	11.	-10.19	**37.**	**091**	0.13	**27.**	-0.06	**21.**	-1.59	**19.**
037	0.03	**40.**	-0.15	28.	-8.59	**33.**	**098**	0.21	**22.**	-0.67	**36.**	-16.50	**42.**
041	0.07	**31.**	-4.83	46.	-12.92	**39.**	**111**	0.06	**34.**	-0.09	**24.**	-6.15	**31.**
042	0.15	**26.**	-1.21	41.	-5.94	**30.**	**112**	0.04	**38.**	-0.99	**39.**	-25.66	**46.**
043	0.01	**46.**	-0.22	30.	-2.40	**25.**	**121**	4.51	**3.**	1.21	**7.**	16.12	**6.**
044	1.31	**11.**	0.05	13.	5.08	**9.**	**122**	0.19	**23.**	0.23	**10.**	-9.85	**35.**
045	0.06	**33.**	-0.10	26.	-1.17	**16.**	**222**	4.79	**2.**	3.96	**1.**	71.99	**1.**
046	0.01	**45.**	-0.38	34.	-1.84	**20.**	**223**	0.02	**43.**	-0.02	**17.**	-0.94	**15.**
047	0.38	**17.**	0.01	16.	-0.26	**13.**	**411**	0.11	**29.**	-0.07	**23.**	-1.56	**18.**
048	0.07	**30.**	-2.00	45.	-14.09	**41.**	**421**	1.46	**10.**	-0.02	**18.**	3.90	**11.**
054	0.02	**42.**	-1.47	44.	-20.23	**44.**	**422**	0.05	**36.**	-0.52	**35.**	-10.75	**38.**
056	0.04	**37.**	-0.95	38.	-9.55	**34.**	**431**	0.47	**15.**	-0.11	**27.**	-2.35	**24.**
BI/NI	1995	**2000**	2005	2010	2015	2017	**LFI**	1995	2000	2005	2010	2015	2017
NCA	10	**11**	10	11	11	11	**CA**	18	17	13	15	14	13
NCdA	36	**35**	36	35	35	35	**NCdA**	28	29	33	31	32	33

Note: Green – strong CA, blue – medium CA, yellow – weak CA; NCA – Number of sectors revealing comparative advantage; NCdA – number of sectors revealing comparative disadvantage; BI and NI revealed CA or CdisA for the same products (see dichotomous test of BI and NI)
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 3: Mean and ranking of specific sectors according to BI, LFI and NI values, Brazil.

046, 048), vegetables (054, 056), fruits and nuts (057), edible products and preparations (098) and alcoholic beverages (112).

There is also a link between RCA's scores and the shares of specific products in export and import structures. Products revealing CA are generally the export sectors of Brazil's agrarian and food sectors and account, on average, for 89.8%, 91.5% and 89.8% of total agri-food exports using BI, LFI and NI index. Products revealing CdisA are the import sectors and account, on average, for 87.1%, 87.2% resp. 87.1% of agri-food imports. The share of products revealing CA resp. CdisA on Brazil's agri-food export resp. import has increased from 1995 to 2017. This would seem to support the argument that the Brazil's agri-food trade has formed by following comparative advantage of specific agri-food sectors.

The results presented in the prior text show the Brazil's agri-food trade comparative advantages distribution in relation to all trade partners. As pointed by Smutka et al. (2018), certain weakness of such an analyses could be the fact that the above mentioned calculations do not take into consideration existing the differences among the individual countries (or groups of countries) and the trade policies.

The LFI index (which is suitable for analyses on the bilateral level) was used to interrogate the existence of differences in distribution of comparative advantages in relation to main agri-food trading partners of Brazil. The results (table A3 in Annex) indicate that such differences currently do exist. Brazil reveals more comparative advantage trading with other MERCOSUR countries and the Latin America and the Caribbean

when compare to EU28, USA, China or rest of the World (excl. the previous mentioned). With respect to specific product groups, some (e.g., sugars, 061; unmanufactured tobacco, 121) reveal CA with all territories. Others show existence of differences revealing CA and/or CdisA with specific trading partners. This would support the argument that differences in conditions for agriculture production as well as the degree of protectionism and set-ups of trading regimens are affecting the distribution of revealed comparative advantages in relation to main agri-food trading partners of Brazil.

Stability I (external shape of the distribution of RCA)

The number of products revealing CA has slightly changed and high coefficients of variation of some agri-food products (not presented here) indicate dispersion in the variables between 1995 and 2017. This could signal a relative instability of some RCA indices and possible ongoing structural change of Brazil's agri-food trade pattern. The summary statistics (mean, median, range, skewness i.e.; see table A3 in Annex) of the BI, LFI and NI were further investigated to assess the evolution of the external shape of the distribution of RCA and thus the overall degree of specialization.

Because BI is not symmetrical, the minimum values are very close to 0. The maximum values decreased between 1995 and 2001 and later fluctuated between 5.00 and 6.00 (but there is growing tendency in the last 5 years). The mean value of BI increased between 1995 and 2001 and started to decrease later. A probably better indication of central tendency is the median. The median values show slight increase between 1995 and 2007 and decrease in the later period. The kurtosis and skewness show same tendency. The skewness has the tail on the right and the distribution shifts to the left. This is signaling higher proportion of low values.

The LFI signals steadily increase in minimum values (from -9.60 to -2.30). The maximum values were decreasing till around 2005 and are increasing since that. The range dropped between 1995 and 2005 and started to slightly increase (standard deviation shows same tendency). The mean value of LFI is always zero. The median values first improved (from -0.20 in 1995 to -0.04 in 2001), but then started to decrease (-0.10 in 2017). The skewness first tended to the right (negative values), but then tended to the left (positive values) with the tail on the right. This signals higher proportion of low values as the skewness (positive) value is steadily increasing.

The NI signals steady decrease (increase) of minimum resp. maximum values and thus increasing gap between the loosing and flagship products. There is no change in trend as in the case of BI and LFI. This may be caused by properties of the NI index, because if country gains CA in some commodities, the NI deteriorates the scores in some other commodities (Yu et al., 2009). The median values show steady decrease since 1998. The skewness has the tail on the right. First (1995-2007), the distribution slightly shifted to the right but later (2007-2017) it significantly shifted to the left. This signals higher proportion of low values.

These results indicate certain weakening in Brazil's overall degree of agri-food specialization at the beginning of the analyzed period, followed by specialization tendency since beginning of 2000's when Brazil's agri-food export started to grow very rapidly. Thus, the boom of Brazil's soya (S222) production and its export to China significantly increased the degree of Brazil's specialization in the period after the Great Recession.

Following Ferto and Hubbard (2002), as indicator of structural stability of Brazil's agri-food trade pattern, the correlation between the indices in time period t and the index in subsequent time periods was employed. The test (table 4) shows similarity or difference in selected years relative to 1995. The test also examine to what extent each BI, LFI and NI are time-consistent in its cardinal, ordinal and dichotomous characteristics during the observed period (Table 4).

The results suggest that the change from the initial status was rather in cardinal and ordinal characteristics than in dichotomous one. In other worlds, products without CA in 1995 seem to rather remain to be uncompetitive. Similarly, the products with CA in 1995 rather continue to maintain its competitive position. However, partial changes have occurred. The BI, LFI and NI changed significantly according its cardinal and ordinal characteristics from 1995 to 2017. This supports the conclusion, that structure of Brazil's agri-food trade pattern is rather stable (according what product groups reveal CA or CdisA), much significant changes occurred in each product RCA score (how much CA) and in ranking of product groups.

From 1995 to 2017, according to BI and NI scores, 8 products (012; 017; 059; 061; 071; 081; 121; 222) were exhibiting the CA in every year; 3 products (011; 016; 044) status has improved and gain CA; 2 products status deteriorated (075; 421) and started to reveal CdiA. The LFI scores give the same conclusion. Also, LFI scores indicate more

		95-00	95-05	95-10	95-15	95-17	avg.
BI	Cardinal	0.929	0.817	0.753	0.667	0.635	0.809
	Ordinal	0.941	0.827	0.707	0.667	0.684	0.786
	Dichotomous	0.978	0.957	0.891	0.891	0.891	0.933
LFI	Cardinal	0.644	0.613	0.601	0.479	0.454	0.589
	Ordinal	0.811	0.773	0.687	0.674	0.657	0.753
	Dichotomous	0.891	0.804	0.761	0.783	0.761	0.835
NI	Cardinal	0.863	0.731	0.710	0.532	0.493	0.728
	Ordinal	0.931	0.902	0.825	0.806	0.797	0.872
	Dichotomous	0.978	0.957	0.891	0.891	0.891	0.933

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 4: Stability of revealed comparative advantage - the correlation in time.

changes. The product group *Other cereal meal, flours* (047) was maintaining weak CA (exc. 1997), product group *Live animals* (001) gain weak CA, and some product groups (036; 072; 074; 075; 091; 431) started to reveal comparative disadvantage. More significant changes indicated by LFI are consistent with (dichotomous) stability test of indices. The correlation coefficient decreased more in the case of LFI (0.761) than BI and NI (0.933).

Another indicator of (un)stability is the relative importance of products (in the export and import flows) that reveal a CA in the period t, but a CdisA in the period *t+1* (Table 5) or vice-versa (Ballance et al., 1987).

		RCAt	RCDt+1		RCDt	RCAt+1
		1995	2017		1995	2017
	No.	%	%	No.	%	%
BI/NI	2	8.67	1.86	3	1.44	12.96
LFI	8	14.90	2.66	3	1.44	12.96

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 5: Stability of revealed comparative advantage - relative importance of products.

Those product groups that revealed CA in 1995 but CdisA in 2017 (BI and NI: 075, 421; LFI: 036, 072, 074, 075, 091, 122, 421, 431) accounted for 8.67% (BI and NI) and 14.90% (LFI) of the total agri-food export in 1995 resp. 1.86% (BI and NI) and 2.66% (LFI) in 2017. The products showing opposite (revealing CdisA in 1995 and CA in 2017) movement (BI and NI: 011, 016, 044; LFI: 001, 011, 044) change from 1.44% to 12.96% of the total agri-food export. Although the values are similar (rounding effect), BI and NI marked different product than LFI in one case.

Results of this comparison again indicate certain but small change in the structure of Brazil's agri-food trade pattern between the first and last year of the period observed. It would again support the argument that the Brazil's agri-food trade has formed by following comparative advantage of specific agri-food sectors.

Stability II (intra-distributional dynamics)

Using previous analysis of overall specialization pattern, it is possible to gather only some information about the shape of the overall distribution of the BI, LFI and NI indices, but not much can be said as regards the changes in the relative position of any single product. The mobility of products within the distribution was analyzed to investigate intra-distributional dynamics and transitions among the subsequent classes: CdisA (class a), weak CA (class b), medium CA (class c) and strong CA (class d). The scores in Markov transition probability matrices are presented in the Table 6.

Diagonal elements of the matrix indicate that from one period to the next, the observations of the BI, LFI and NI indices are more persistent for the products revealing CdisA (class a) and strong CA (class d) than for products revealing weak CA (class b) and medium CA (class c). These also mean that the product without initial CA seem to remain to be uncompetitive whilst the product with strong initial CA continue to maintain its competitive position. Above that, in the case of products revealing CdisA, the probability maintaining the same status over the years is very high (BI: 0.98; LFI: 0.96; NI: 0.99). This represents, ceteris paribus, an adverse indication in terms of possible change of Brazil's agri-food RCA pattern towards its more divers' profile.

Products belonging to the central groups (weak CA and medium CA) show very similar (and relatively low) probability to change the status according to BI and LFI. Products revealing medium CA show lower probability (0.54) to maintain the status in comparison to products revealing weak CA (0.77) according to NI.

In general, the probabilities of shifts from less

Brazil ↔ World (BI)					
P_{ij} (-)	*i* (-)	a	b	c	d
j (-)					
a		0.98	0.01	0.00	0.00
b		0.10	0.75	0.12	0.00
c		0.00	0.11	0.80	0.07
d		0.00	0.00	0.12	0.88

Brazil ↔ World (LFI)					
P_{ij} (-)	*i* (-)	a	b	c	d
j (-)					
a		0.96	0.03	0.00	0.00
b		0.16	0.78	0.04	0.00
c		0.00	0.11	0.78	0.08
d		0.00	0.00	0.08	0.91

Brazil ↔ World (NI)					
P_{ij} (-)	*i* (-)	a	b	c	d
j (-)					
a		0.99	0.01	0.00	0.00
b		0.06	0.77	0.13	0.01
c		0.00	0.25	0.54	0.16
d		0.00	0.00	0.18	0.81

Source: Authors own representation, based on UNCTAD data (SITC, 3-digit level)

Table 6: Markov transition probability matrices for the RCAs indices.

advantageous groups to more advantageous groups are lower in comparisons to shifts from more advantageous groups backwards to less advantageous groups.

The probabilities of closer shifts are higher that the probabilities of longer moves between classes. Even so, the results indicate that there are shifts only between the next groups (lower or upper). Conversely, the probability of the change e.g., from strong CA to weak CA is zero and vice versa.

The general degree of mobility was assessed using traces and the determinants of transition matrixes for the whole period as well as in sub-periods (Table 7). In the case of total persistence, the value of M1 would be zero. In the case of total mobility, the M1 would be 1. For M2, when the values on the main diagonal are close to 1 and those on the off-diagonal small (high persistence), the matrix determinant takes a value close to 1 and the mobility indicator is 0.

RCA index	Mobility index	Period				
		95-17	95-00	00-05	05-10	10-17
BI	M1	0.20	0.32	0.27	0.17	0.10
	M2	0.50	0.75	0.63	0.45	0.29
LFI	M1	0.19	0.29	0.25	0.13	0.15
	M2	0.48	0.67	0.58	0.35	0.39
NI	M1	0.30	0.27	0.35	0.29	0.30
	M2	0.72	0.64	0.80	0.72	0.80

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 7: Mobility indices of the BI, LFI and NI.

The scores of M1 (BI: 0.20; LFI: 0.19; NI: 0.30) indicate rather persistence than mobility in general (the whole period between 1995 and 2017). For the same period, the M2 scores suggest neither mobility nor persistence (BI: 0.50, LFI: 0.48) or mobility in the case of NI (0.72).

Important insight gives the comparison of scores in specific sub-periods. Scores of both M1 and M2 for BI and LFI are declining thus the persistence is growing. In other words, the probability, that product groups will change its status is getting lower year after year. The NI does not indicate such a change, but it can be caused by the principal properties of the index.

Although the external shape of Brazil's specialization in agri-food trade is slightly increasing (especially in the post-crises period), this suggests that product groups to a greater extent keep their status regarding its class (CdisA, weak CA, medium CA or strong CA).

Conclusion

From being a net-agricultural importer and food aid recipient as recently as the 1960s and 1970s, Brazil has actively developed its comparative advantage in agri-food production and trade, has become a global agri-food powerhouse and serious competitor to the global market dominance of the world's leading agricultural exporters. Also, agriculture has become one of the main pillars for the Brazilian economy. The successful story of Brazilian competitive tropical agriculture model attracts attention and intense interest

from its competitors as well as from other developing countries. Contrary, this “regressive” trade specialization towards both production and export structures strongly oriented to primary and resource-based manufactured goods is currently discussed in terms of potential risks to the Brazilian economy. It also represents clear failure of most of goals of structuralist import substitution industrialization and also (in time period under scrutiny) of neo-developmentalist policies. On the global level, these changes also mean the rise up of Brazil's position and importance regarding provision of the global food security and the environmental sustainability.

Our study has covered the development of Brazilian agri-food sector in last 25 years in order to take a look at comparative advantage in particulars products.

The cross sectoral comparison and revealed CA or CdisA (based on scores of BI, LFI and NI) of specific products is in line with general perception of Brazil as the world´s leading exporter especially of soybean and soybean-based products (SITC codes 222, 081), sugarcane-based products (061), unmanufactured tobacco (121), coffee (071), orange juice (059) and meat (011-017). The share of products revealing CA resp. CdisA on Brazil's agri-food export resp. import has increased and it would support the argument that the Brazil's agri-food trade was formed by following comparative advantage of specific agri-food sectors. But it is necessary to take into consideration, that the differences in conditions for agriculture production as well as degree of protectionism and set-ups of trading regimens are affecting the distribution of revealed comparative advantages in relation to main agri-food trading partners of Brazil.

In line with existing empirical literature, the Brazil's revealed comparative advantages in sectors constituting its agri-food trade were assessed two-ways: 1) regarding the external shape of specialization, and 2) regarding the intra-distributional dynamics of specific sectors.

The result of the analyses (summary statistics, correlation between indices in time, relative importance of products that reveal CA or disA in the export and import flows) indicate three specific developmental phases in the overall degree of Brazil's specialization in particular agri-food products (the external shape). There was certain weakening in Brazil's overall degree of specialization at the beginning of the analyzed period, followed by strong specialization tendency since beginning of 2000's when Brazil's agri-food export started to grow very rapidly as an result of the tariff reduction and due to the commodity boom on the world agrarian markets. Also, the development of south-south trade linkage between China and Latin America and especially the boost of Brazil's soya production (and its export to China) intensified the changes; the degree of Brazil's specialization has amplified in the post-Great Recession period.

According to BI and NI scores, 8 products (012; 017; 059; 061; 071; 081; 121; 222) were exhibiting the CA in every year from 1995 to 2017. The comparative (dis)advantage status of only few products have changed: 3 products (bovine meat, 011; meat, ed. offl., dry, slt, smk, 016; maiz, 044) gain CA; 2 products deteriorated (spices, 075; fixed veg. fat, oils, soft, 421) and started to reveal CdiA. Beside these, the changes in scores of LFI indicated some other but minor changes.

This suggests that the change in the external shape of Brazil's specialization in particular agri-food products has following characteristics 1) products that revealed comparative (dis)advantage in 1995 rather continue to maintain its (un)competitive position till 2017, in other words, the structure of Brazil's agri-food trade pattern was rather stable according what products reveal CA or CdisA, 2) some changes occurred in how strong the comparative advantage of each product was and in ranking of specific product groups.

The intra-distributional dynamics was further interrogated using Markov probability matrixes. Products with initial strong CA have maintained its competitive position. Products revealing weak CA or medium CA show high probability to maintain the status (according to BI, LFI and NI). Only exception was indicated by NI in the case of products revealing medium CA and it suggests the same probability to maintain or change the status. If any changes, the probabilities of closer shifts were higher that the probabilities of longer moves between classes. Results indicate that there were shifts only between the next groups (lower or upper). Further, the probabilities of shifts from less advantageous groups to more advantageous groups were lower in comparisons to shifts from more advantageous groups backwards to less advantageous groups. Further insight to intra-distributional dynamics was given by mobility indices. The comparison of scores in specific sub-periods indicates that the probability the product will change its status is getting lower year after year.

Our analysis shows, that Brazil agri commodity specialization, and agri business competitiveness was consistently strengthening through commodity boom and after its end. This pattern of specialization and export is lasting and robust feature of BRA economy in contrast with neo-developmentalist strategies of presidents da Silva and Rousseff (2003-2016).

This supports the conclusion that although the degree of Brazil's specialization in particular agri-food products has increased, specific product groups to a greater extent keep their status regarding its class (CdisA, weak CA, medium CA and strong CA) and the shape of Brazil's revealed CA and specialization in particular agri-food products has evolved towards its finite structure (ceteris paribus). It is also important to mention, that while the commodity (China) boom came to end in 2014-2015, even our most recent data do not suggest substantial weakening of this trend of production and trade specialization. This also represents, ceteris paribus, an adverse indication in terms of possible change of Brazil's agri-food specialization pattern towards its more divers' profile.

The results of the analysis could also contribute to the current discussion over the free trade between MERCOSUR and the European Union. As for now it seems the Brazilian agricultural sector has formed into its rather final shape, specializing on few particular products. It is likely that this trend will continue and Brazil will not "surprise" the European Union with a boom of other agricultural products that would be highly competitive.

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Appendix

001	Live animals	**057**	Fruit, nuts excl. oil nuts
011	Bovine meat	**058**	Fruit, preserved, prepared
012	Other meat, other offal	**059**	Fruit, vegetable juices
016	Meat, ed. offl., dry, slt, smk	**061**	Sugars, molasses, honey
017	Meat, offl. Prdd, nes	**062**	Sugar, confectionery
022	Milk and cream	**071**	Coffee, coffee substitutes
023	Butter, other fat of milk	**072**	Cocoa
024	Cheese and curd	**073**	Chocolate, oth. cocoa prep.
025	Eggs, birds, yolks, albumin	**074**	Tea and mate
034	Fish, fresh, chilled, frozn	**075**	Spices
035	Fish, dried, salted, smoked	**081**	Animal feed stuff
036	Crustaceans, Molluscs	**091**	Margarine and shorten
037	Fish etc. prepd, prsvd. nes	**098**	Edible prod. prepetns, nes
041	Wheat, Meslin, Unmilled	**111**	Non-alcohol. beverage
042	Rice	**112**	Alcoholic Beverages
043	Barley, unmilled	**121**	Tobacco, unmanufactured
044	Maize unmilled	**122**	Tobacco, manufactured
045	Other cereals, unmilled	**222**	Oil seeds and oleaginous fruits (excl. flour)
046	Meal, Flour of wheat, msln	**223**	Oil seeds, oleaginous fruits (incl. flour, n.e.s.)
047	Other cereal meal, flours	**411**	Animal oils and fats
048	Cereal preparations	**421**	Fixed veg. fat, oils, soft
054	Vegetables	**422**	Fixed veg. fat, oils, other
056	Vegetables, prpd, prsvd, nes	**431**	Animal, veg. Fats, oils, nes.

Source: SITC rev.3

Table A1: Sectors and their numeric designations (SITC rev.3, 3-digit code).

SITC	MCS	LAC	EU28	USA	China	RoW	SITC	MCS	LAC	EU28	USA	China	RoW
001	5.21	0.54	-0.05	-0.16	0.00	0.03	**057**	-2.01	-6.98	-0.85	-0.11	-0.05	-0.58
011	3.78	5.32	0.56	0.04	0.07	0.69	**058**	-0.02	-1.13	-0.08	0.04	-0.05	-0.02
012	6.08	5.22	0.31	0.04	0.21	1.63	**059**	0.15	0.17	1.54	3.25	0.03	0.03
016	0.01	0.01	0.41	0.00	n.d.	0.01	**061**	4.86	2.86	0.37	0.67	0.33	2.22
017	0.50	1.48	0.91	1.79	0.00	0.06	**062**	0.72	-0.15	-0.07	0.20	-0.04	0.00
022	-1.98	-0.28	-0.11	-0.50	0.00	-0.05	**071**	2.41	3.03	3.20	9.39	0.00	0.20
023	-0.09	0.01	-0.03	0.00	n.d.	-0.01	**072**	1.81	0.58	-0.14	0.54	-0.05	-0.82
024	-1.03	0.07	-0.24	-0.03	0.00	-0.01	**073**	0.52	0.12	-0.41	-0.59	-0.01	-0.10
025	0.51	0.10	-0.03	-0.78	n.d.	0.01	**074**	1.15	0.04	-0.03	-0.07	-0.01	-0.01
034	-1.34	-17.31	-0.60	0.18	-1.43	-0.79	**075**	0.18	0.44	0.11	0.65	-0.03	-0.15
035	0.00	-0.05	-0.38	0.00	-0.64	-0.91	**081**	1.28	3.45	3.16	-1.77	-0.76	0.38
036	-0.04	-0.27	-0.01	0.36	-0.08	0.00	**091**	0.03	0.07	-0.05	-0.10	n.d.	-0.05
037	0.17	-1.56	-0.06	0.04	-0.03	-0.12	**098**	1.72	2.02	-1.42	-4.01	-0.24	-0.18
041	-12.32	0.15	0.01	-10.68	0.00	-0.20	**111**	0.07	0.04	-0.52	0.01	0.00	-0.05
042	-2.31	2.08	-0.03	-0.06	n.d.	0.01	**112**	0.55	-4.16	-2.85	-0.54	0.00	-0.06
043	-1.10	0.00	-0.10	0.00	0.00	0.00	**121**	1.15	0.58	1.10	2.26	0.14	0.03
044	-0.40	5.66	0.39	0.65	0.01	0.82	**122**	0.60	0.09	-0.05	-0.04	0.00	-0.01
045	-0.11	-0.11	0.00	-0.04	-0.01	-0.03	**222**	-0.89	0.83	2.77	0.99	5.19	0.62
046	-1.61	0.00	-0.02	-0.01	0.00	-0.01	**223**	-0.05	-0.24	-0.03	-0.01	-0.01	-0.01
047	0.01	0.02	0.00	0.00	0.00	0.01	**411**	-0.21	-0.16	-0.03	-0.04	-0.02	-0.02
048	-3.33	0.25	-1.44	-0.20	-0.01	-0.05	**421**	-0.22	1.68	-2.76	-0.02	0.25	0.17
054	-2.44	-1.71	-0.73	-0.51	-2.18	-0.13	**422**	0.01	-1.33	0.00	0.00	0.00	-2.01
056	-2.06	-1.72	-1.68	-0.72	-0.56	-0.12	**431**	0.09	0.25	-0.04	-0.09	-0.01	-0.42

Note: grey colour – sectors revealing CA (LFI scores higher than 0.1); MCS – MERCOSUR, LAC – states of Latin America and the Caribbean (excl. MERCOSUR), RoW – rest of the World (excl. MCS, LAC, EU28, USA and China)
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table A2: Revealed comparative advantage of Brazil with respect to main trade partners (mean of LFI scores for specific sectors between 2010 and 2017).

	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017
	BI											
average	0.88	0.79	0.90	0.87	0.87	0.86	0.93	0.85	0.81	0.79	0.81	0.79
stand dev.	1.59	1.43	1.63	1.44	1.42	1.48	1.43	1.43	1.35	1.34	1.35	1.42
median	0.10	0.13	0.13	0.12	0.15	0.16	0.17	0.15	0.16	0.14	0.16	0.11
kurt	4.36	3.57	3.84	2.81	2.60	3.33	1.93	4.15	4.24	3.50	4.13	6.42
skew	2.26	2.18	2.19	1.98	1.91	2.06	1.73	2.15	2.16	2.05	2.11	2.50
min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
max.	6.57	5.27	6.05	5.12	5.48	5.59	5.17	5.89	5.77	5.07	5.86	6.35
	LFI											
average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
stand dev.	2.56	2.14	2.12	1.66	1.47	0.98	1.21	1.20	1.25	1.39	1.19	1.30
median	-0.20	-0.16	-0.13	-0.04	-0.04	-0.05	-0.06	-0.07	-0.09	-0.08	-0.09	-0.10
kurt	5.82	4.28	5.22	9.19	11.89	4.26	7.24	4.92	4.75	7.62	9.69	13.10
skew	0.12	0.92	-0.24	-1.38	-2.05	0.11	-0.85	1.01	1.23	1.17	2.15	2.85
min.	-9.60	-6.42	-8.10	-7.59	-7.15	-3.48	-5.14	-3.63	-3.51	-4.41	-2.61	-2.30
max.	7.83	7.41	6.28	3.84	3.25	2.63	3.13	4.33	4.29	5.80	5.56	6.51
	NI											
average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
stand dev.	11.98	14.34	12.64	14.12	15.31	17.94	17.10	21.69	24.09	25.31	24.46	26.73
median	-1.73	-2.09	-1.59	-1.84	-2.01	-2.38	-2.49	-2.58	-2.98	-3.39	-2.93	-3.46
kurt	4.66	4.94	3.83	3.62	5.84	3.49	2.46	7.40	7.57	13.03	16.25	18.63
skew	2.09	2.15	1.82	1.71	1.97	1.70	1.42	2.38	2.51	3.08	3.40	3.78
min.	-15.87	-19.77	-20.19	-23.60	-26.26	-29.17	-30.02	-29.23	-30.04	-30.81	-33.13	-33.83
max.	43.91	52.85	45.90	49.57	64.15	64.45	57.19	90.69	92.49	125.83	129.02	144.69

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table A3: Summary statistics of BI, LFI and NI (selected years).

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