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Foreword

After the first shock of the COVID-19 outbreak early this year, most of us have by now got accustomed to the new situation where our everyday activities are more online and home-based than ever. With the help of our new webpage and electronic submission system, however, the impact of the global virus situation on the everyday life of the journal has been minimal. What is more, our submission numbers have sky-rocketed during the previous months as most researchers had more time to concentrate on paper elaboration and submission.

We have six papers in this issue. The first paper, written by Vrolijk and Poppe, analyses the composition and volatility of the total income and wealth of dairy farmers and the importance and volatility of the different components contributing to their total income and wealth based on Dutch FADN data. The results confirm some existing findings on the stabilising impact of CAP subsidies and off-farm income on farmers' total income. The paper extends the existing analysis by exploring the impact of taxes on income volatility and the important role of savings in stabilising consumption of farm households. In this paper the authors show that a broader perspective (including off-farm income and wealth effects) provides a more realistic picture of the income and wealth effects as experienced by farmers.

The second paper, written by Spada, Rana and Fiore, investigate spatial and temporal characteristics of wine consumption in 45 countries belonging to World Health Organization (WHO) European Region and its relationship with the HDI. The authors used a balanced panel data by WHO database (2005-2015) with random effects panel data modelling. Results highlight that wine consumption decreases by increasing the HDI. The authors note higher values of wine consumption in EU countries and a positive gradient from West to East in the area considered. These findings highlight the presence of a new consumer profile seeking quality and healthy consumption and whose awareness increases with a rise in the degree of country development. National and international policies can address consumptions style and persuade consumers to have a new eating cultural approach in buying quality and healthy food.

The third paper, written by Pirkó, Koós, Szabó, Radimszky, Csathó, Árandás, Fodor and Szabó, presented results of Hungarian field test trials set up for establishing new maximum permitted N dose values. The advancement of crop production has not yet been followed by the increase in maximum permitted nitrogen doses set out in the Hungarian Action Programme of the Nitrate Directive. According to the farmers' observations, crops grown in nitrate vulnerable zones with good agricultural conditions already have much higher nitrogen uptake than the maximum permitted values, so the genetic potential of the plants cannot be exploited at the current level. In order to prove this, in the autumn of 2017, a small-plot long-term experiment was set up in three different regions of Hungary. The results were evaluated in a complex way, based on an agronomic approach, Nitrogen Use Efficiency (NUE) and an economic approach, resulting in different outcomes.

The fourth paper, written by Bakacsi, Laborczi, Szatmári, Horel, Dencső, Molnár, Ujj and Tóth, followed the topic of the third paper and compiled a C/N and total-N dataset to support countrywide soil nutrient emission models for Hungary. The paper investigates C/N ratio changes at different levels for diverse land management and land uses at plot-, catchment-, and country scale. For the plot- and catchment scale the study also presents data on seasonal variabilities of C/N ratio. Overall, the paper highlights the significance of land use, land management systems, spatial heterogeneity, time of samples collections, and the inconsistencies between different sampling and measurement methods.

The fifth paper, written by Igwe, analysed the determinants of household income and employment choices in the rural agripreneurship economy in Nigeria. The paper seeks to link the discussions on diversification and pluriactivity among farm business owners (FBOs) and examine the topic in the context of small-scale farming. It asks households if diversification and wage-seeking behaviour in the rural agripreneurship economy is prompted by "push" or "pull" factors. The quantitative method enabled the analysis of data generated from 480 rural FBOs from Nigeria (regarded as entrepreneurs or agripreneurs). The findings reveal that education, asset endowment, access to credit, and good infrastructure conditions increase the levels of household diversification.

The sixth paper, written by Degaga and Alamerie, searched for the determinants of coffee producer market outlet choice in Gololcha District of Oromia Region, Ethiopia. The study was conducted in Gololcha District of Arsi Zone with the objective of identifying determinants of coffee producer market outlet choice. The primary data were collected through personal interviews from a total of 154 producers, using structured and semi-structured questionnaires. The multivariate probit model result indicated that the sex of the household head, level of education, means of transport ownership and access to information had positively influenced choice of wholesaler and negatively influenced choice of agent middlemen. Level of education was significantly and negatively related with agent middlemen, and significantly and positively influenced cooperatives' and wholesalers' channel choice. Enhancing institutional and infrastructural (transportation and extension) facilities is necessary to enable coffee producers to select efficient channels.

On the whole, I think the diversity of topics and regions presented in this issue well reflect the diversity of agricultural economics and I hope this issue provides some new and useful insights to our, hopefully growing, European and Central Asian readership.

Attila JÁMBOR

Budapest, August 2020

Hans VROLIJK* and Krijn POPPE*

Impact of off-farm income and paid taxes on the composition and volatility of incomes and wealth of dairy farmers in the Netherlands

This paper analyses the composition and volatility of the total income and wealth of dairy farmers and the importance and volatility of the different components contributing to their total income and wealth based on Dutch FADN data. The results confirm some existing findings on the stabilising impact of CAP subsidies and off-farm income on farmers' total income. The paper extends the existing analyses by exploring the impact of taxes on income volatility and the important role of savings in stabilising consumption of farm households. In this paper we show that a broader perspective (including off-farm income and wealth) provides a more realistic picture of the income and wealth effects as experienced by farmers.

Keywords: farm income, off-farm income, paid taxes, income volatility, dairy farms

JEL classifications: Q12, Q18

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Introduction

Farmers' incomes show strong fluctuations over time due to fluctuations in prices and yields. Fluctuations in yields are caused by natural conditions such as drought, heavy rain, frost and animal diseases and such yield fluctuations lead to even stronger price fluctuations. Fluctuations in farmers' incomes is a theme of interest for policy makers. Recent discussions on the application of income stabilisation tools (IST) within the Common Agricultural Policy (for example Hungary, Italy, Spain and Germany) have increased the interest in the volatility of incomes of farmers (for example Liesivaara *et al.*, 2012; Severini *et al.,* 2018; EC, 2017). Due to data availability and political preferences the focus is often on the volatility of incomes from farming activities, including the (stabilising) impact of decoupled payments. It is, however, relevant to see how fluctuations in farm incomes are offset or amplified by fluctuations in other elements affecting the well-being of farmers, such as off-farm income, the payment of taxes and the wealth effects of an increase in land and quota values.

Income stabilisation tools, as recently introduced in the common agricultural policy so as to address income volatility, have received a lot of attention. Based on an analysis of Italian FADN data, Severini *et al.* (2019) conclude that the income stabilisation tool employed in that country will lead to a significant stabilisation of farm incomes in Italian agriculture. Lowering the subsidisation rate reduces the income stabilising effect of the IST. Furthermore, the results show that the way farmers contribute is also important in this regard: a flat rate approach is found to be less effective than a contribution proportional to the average farm income level in terms of income stabilisation. Other research shows that such tools stabilise farm-incomes and that this affects income inequality within the farming population (Finger and El Benni, 2014a). The benefits from such a tool might be highly heterogeneous across farm types (El Benni *et al.* 2016) and indemnification patterns are highly dependent on the calculation of the reference income (Finger and El Benni, 2014b).

Besides the income stabilisation tool, the CAP has an impact on the level and volatility of farm incomes through subsidy payments. Bojnec and Fertő (2019) analyse the specific role of CAP payments in stabilising farm incomes in Hungary and Slovenia. They conclude that variability in farm income over time is high due to the high variability in the market revenue component. Subsidies mitigate instability in farm incomes because their variability is lower than that of market revenue income. While CAP subsidies thus represent a stable source of farm income, they have played a limited countercyclical role in stabilising total farm income: they have not been raised in years with low incomes. Subsidies have not been found to be targeted at the farms that face the highest level of income variability and thus may not be an efficient tool for stabilising farm income (Severini *et al.*, 2016b).

Also at farm level, farmers can apply different strategies to reduce income volatility. Partly these are on-farm measures, and partly off-farm. Diversification into different agricultural production activities is one of the most adopted risk management strategies (Asseldonk *et al.*, 2016). Trestini *et al.* (2017) look at the impact of diversification on the income variability. The farm type with the lowest probability of income reduction is "mixed crops with livestock". Their results suggest that a significant reduction in income risk could be reached only at a high level of farm diversification, involving both crops and animal production.

Off-farm activities are relevant because a diversification of activities (inside the farm but especially outside the farm) is an important risk management strategy (van Asseldonk *et al.,* 2016; de Mey *et al.*, 2018). Ahmadzai (2020) analyses the link between off-farm income and diversification on farms in Afghanistan. The focus in most of the studies in the EU is on farm business income (i.e. off-farm income is not considered) due to data availability constraints and the agricultural policy orientation of the analyses (Severini *et al.*, 2016a). Outside the EU there are some studies that take into account off-farm income. An example is an analysis developed in Switzerland where the national farm data network also collects data on off-farm incomes (El Benni *et al.*, 2012; Finger and El Benni, 2014). A study for the USA shows that off-farm incomes stabilise the income of farm households (Mishra and Sandretto, 2002).

The studies that take off-farm income into account use total (household) income as an indicator to judge if income is more stable due to these non-farm income sources. These studies often neglect the role of taxes. Taxes are – in Europe – often progressive and based on real income. That influences the volatility of net-income of some groups relative to others. Another important effect of taxes on volatility is that the payment of taxes is often delayed by a few years. That increases the volatility of cash net-income.

Net-Income is one aspect of the economic well-being of farmers. Wealth is the other. The reappraisal of assets, especially land, has a strong impact on the wealth of farmers. The (expected) increases in capital values due to revaluation can influence business strategies: some farmers are happy with renting or leasing land to increase their size and income due to efficiencies of scale. Others prefer to own their land and profit from price developments of the assets. Sometimes the increased value of assets is used as a collateral for extra borrowing. This aspect of farmers' well-being is however much less investigated.

In this paper we will address some of these less investigated issues. We will analyse the composition and volatility of the total income and wealth of dairy farmers and the importance and volatility of the different components contributing to the total income and wealth based on Dutch FADN data. The Dutch FADN contains a broader set of data, allowing a more in-depth analysis of the different income components.

Method and data

In this study we use data on specialised dairy farmers from the Dutch FADN. The Dutch FADN has a broader focus than the EU-FADN and collects not only data on the financial economic performance, but also a broader set of data on the sustainability performance of farms, including environmental variables such as mineral balances, pesticides use, use of antibiotics and energy use (Vrolijk *et al.*, 2016). Furthermore, information on additional socio-economic variables such as off-farm income, paid taxes and innovation are collected. In the analyses described in this paper these additional economic variables are used.

Data from the period 2001 till 2017 is used. An unbalanced panel of dairy farms is constructed that consists of a minimum number of observations of 130 and a maximum of 178 observations per year. This is a sub-selection of the dairy farms in the Dutch FADN for which the financial information is judged to be complete by the data collector. Dutch FADN collects off-farm income data, but to ensure the representativity of the EU FADN sample, a farmer is not excluded from the sample if he/she is not willing to share the off-farm income information. Off-farm income consists of the income outside the farm from the farmer and its' spouse, assuming that the non-farm income of children who (still) live at home is used for their own personal expenses and savings, and not in financing the farm, nor reducing the need to use the farm income for household expenditure. However, this can be a questionable assumption if that child is the potential successor on the family farm (Poppe and Vrolijk, 2019).

Based on this unbalanced dataset, indicators for the different income components are calculated (such as income from farming activities, subsidies, different off-farm income sources as well as net-worth (own capital)). Volatility is described based on the coefficient of variation. The coefficient of variation is a standardised measure of dispersion.

Farmers are generally more concerned with movements of farm income on the left side of the distribution (Horcher, 2005). However, indices considering both sides of the distribution could perform equally well when the distribution of income over time is symmetric. Thus, the use of one type of variability index or the other should be chosen on the basis of the specific situation under study (Severini *et al.,* 2016a). As we are interested in the overall income volatility and the contribution of its components there is not an apparent and relevant advantage to account only for downside risk. Downside is explicitly addressed in this paper by comparing income levels (and the contribution of different income components) with an externally defined poverty threshold.

The coefficient of variation is often expressed as a percentage and is defined as the ratio of the standard deviation to the mean (or its absolute value). The median is used to describe the central tendency. Medians have the advantage that they are less sensitive to outliers or extreme values in the data set than average values.

Results

A first assessment of the volatility of incomes and its components can be made based on published group results. For the Netherlands, average group results are published on https://agrofoodportal.com. Looking at the published group results from 2005 till 2017 some preliminary conclusions can be drawn. Dairy farmers show a continuous increase in the scale of production during the analysed period. Average farm size (total output) in the panel increases from €190,000 in 2005 to €450,000 in 2017. Output volatility of dairy farms is rather low with a coefficient of variation (CV) of less than 10% (detrended, also in the subsequent CV). Farm income shows a much higher volatility of almost 50%. Direct payments are a stable factor in the farm income with a volatility of 9%. Volatility of total family income (including farm income) is substantially lower at 36%, showing that volatility of family income is reduced by off-farm income. Looking at the components in non-farm income the income from labour is the most important (43% of off-farm income), followed by social security payments like child allowances (40%) and income from non-farm assets (16%). Off-farm labour is the most stable income component with a volatility of less than 10%. The volatility of income from assets (48%) and social security payments (25%) are both much higher, indicating that farm income is mainly stabilised by off-farm labour.

These numbers are based on an analysis of group results. Different authors (Vrolijk and Poppe, 2008; Coble *et al*., 2007; Severini *et al.,* 2016a) show that volatility at farm level is underestimated by analysis at a higher level of aggregation. Therefore, the further results in this paper will be based on analyses of the volatility at farm level during the years that the farm took part in the panel.

Table 1 gives some descriptive statistics of the total income and the composition of the income for each analysed year. Farm income (without subsidies) clearly fluctuates between years. 2007 and 2017 were very good years for dairy farms with average incomes from farming of €58,000 and €81,000. 2009 was an extremely bad year with an average loss of €31,000. The average subsidies as received by dairy farmers reflect changes in the common agricultural policy. Off-farm labour income adds on average between €4000 to €7000 euros to the total income of dairy farmers. Off-farm labour income is the most substantial income source in all years, followed by social security payments. Revenues from private assets and received interest payments contribute to a lesser extent to the total income. The composition of the total income is graphically illustrated in Figure 1.

Group averages as given in Table 1 and Figure 1, however, ignore large differences between individual farms. Figure 2 shows that development of mean incomes hides the large differences between farms within one year. The left panel illustrates the income distribution per year. The upper limit of the line illustrates the 75th percentile and the lower limit the 25th percentile. In the year 2017, the median income was around €89,000 but 25% of the farms achieved total income levels of more than €146,000 and 25% of the farms achieved

Table 1: Composition of total income, farm income and off-farm income in euro on Dutch specialised dairy farms (2001-2017).

	On Farm		Off-farm						Total	
Year	Farm income without subsidies	Subsidies	Off farm labour income	Revenues private assets	Received interest	Other off farm income	Disability insurance payments	Other social security payments	Total income	Number of obser-vations
2001	47,751	3,616	3,795	-398	419	101	1,124	2,760	59,170	142
2002	32,385	4,991	4,092	-974	609	445	1,128	2,793	45,469	146
2003	32,181	4,614	4,513	1,620	636	111	1,208	5,028	49,910	144
2004	33,176	10,814	5,227	1,800	574	61	1,417	3,916	56,985	148
2005	34,890	16,746	5,357	3,039	443	41	1,336	3,854	65,706	142
2006	26,918	24,010	6,242	3,879	440	36	1,299	5,210	68,033	137
2007	58,041	24,316	6,728	485	1,016	-39	1,384	5,277	97,207	144
2008	35,399	24,435	6,949	-2,842	1,161	-60	1,265	4,927	71,235	139
2009	-30,824	24,659	6,870	5,828	803	55	1,528	5,886	14,804	136
2010	19,608	23,951	6,344	2,943	642	82	2,078	5,353	60,999	136
2011	37,187	23,347	6,486	-112	457	248	755	6,328	74,695	137
2012	11,971	23,517	6,452	2,681	570	6	903	4,212	50,312	130
2013	40,684	24,298	6,400	2,449	704	-16	897	3,220	78,636	177
2014	45,023	23,864	5,308	2,803	497	157	1,027	4,427	83,106	173
2015	14,343	21,995	5,220	1,704	444	236	686	4,006	48,633	178
2016	1,744	22,643	5,833	1,938	317	31	976	2,984	36,466	173
2017	80,965	22,651	6,583	739	215	103	952	1,671	113,879	161

Source: own calculations based on Dutch FADN data

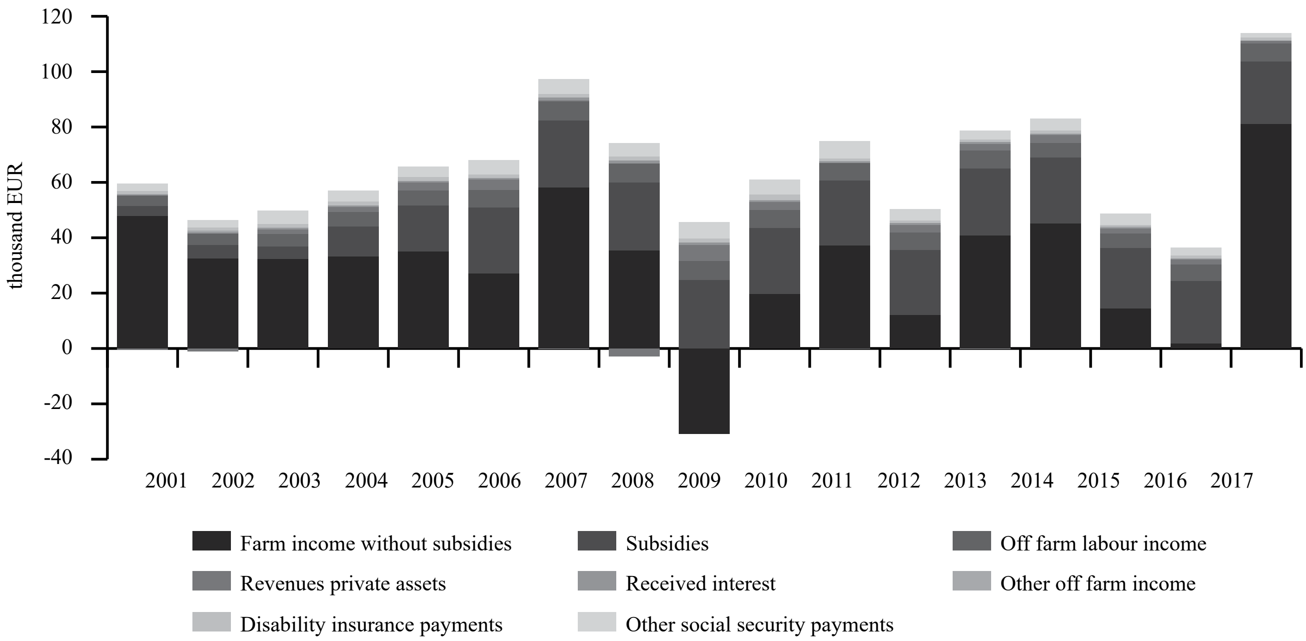

Figure 1: Composition of total income (2001-2017).

Source: own calculations based on Dutch FADN data income levels lower than €49,000. In the year 2016, with a median total income level of €27,000, almost 25% of the farms achieved negative total income levels. Although the range of income levels have increased slowly during time, large ranges in the total income levels can be observed for all years.

The right panel of Figure 2 shows the distribution of the yearly change at farm level. The yearly change at farm level is relevant because this is the change the individual farmer is confronted with. This distribution shows large differences. In 2009 (a bad year for dairy farmers) the median decrease of total income was €47,000. 25% of the farms managed to limit this change to a maximum of €24,000, but 25% of the farms were confronted with a yearly change of more than €89,000.

The two panels of Figure 2 clearly illustrate that there is a large dispersion of economic results of dairy farmers. Median or average income levels hide a lot of the dynamics in the income situation of farmers. Even in relatively good years, a substantial group of farms achieve low income levels and in bad years a group of farms is still able to achieve positive income levels. Moreover, in the yearly changes large differences can be observed. Although this picture yields an understanding of the differences in income levels and income changes from year to year it does not address the issue of volatility of income as experienced by a farmer during a range of years.

Table 2 addresses this volatility at farm level. The volatility (coefficient of variation) is calculated at individual farm level and then the median of the individual coefficients of variation is used to describe the volatility of a group of farms. Table 2 describes the volatility of different income components for the total group and the 3 different size classes. Looking at the individual income components subsidies are the most stable income source. Revenues from other assets, received interests and other farm income sources have a high median value of the coefficient of variation. How the volatility of the individual income components affects the volatility of the aggregate incomes (income from farming, off farm income and total income) depends on the correlation between these income sources. So, although the coefficient of variation of the off-farm income is comparable or even

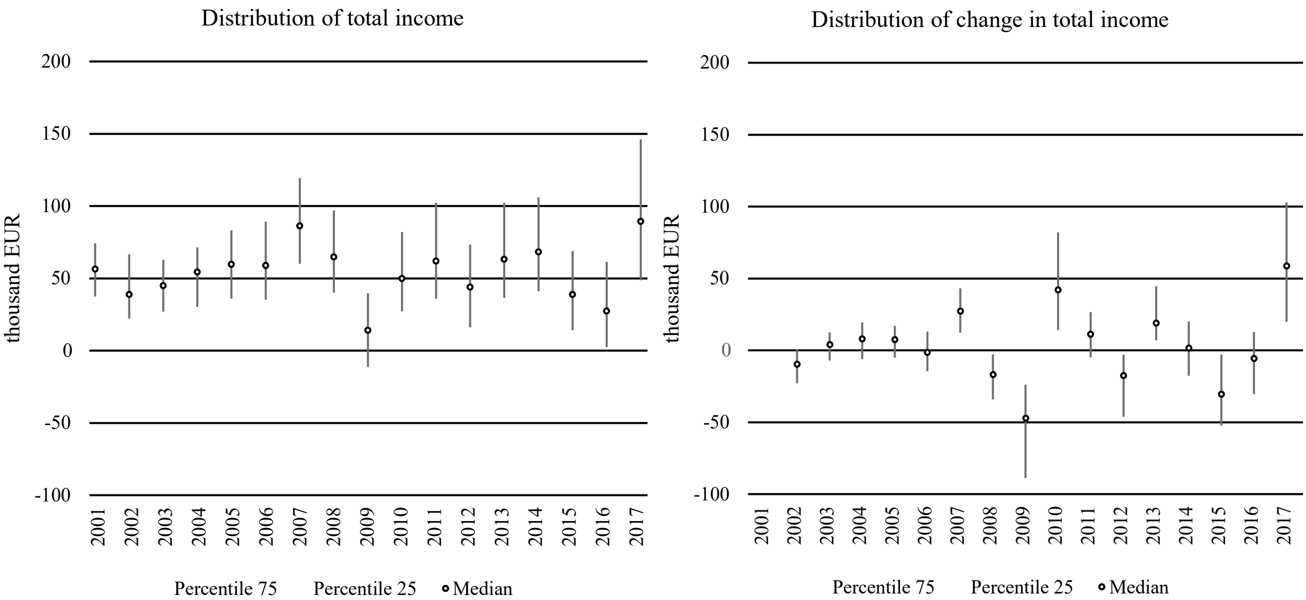

Figure 2: Distribution of total income and distribution of change in total income (compared to previous year).
Source: own calculations based on Dutch FADN data

Table 2: Volatility (median of coefficient of variation) of income and of different income components on Dutch specialised dairy farms; (weighted).

	Median of coefficient of variation			
	Total	**Size class small**	**Size class medium**	**Size class large**
Income of farming, of which:	0.62	0.55	0.64	0.72
Farming activities	0.86	0.79	0.92	1.16
Subsidies	0.31	0.39	0.19	0.11
Off farm income, of which:	0.66	0.59	0.76	0.98
Labour income	0.81	0.75	0.82	1.12
Revenues from other assets (excl. interest)	2.26	2.26	2.65	1.77
Received interest	1.40	1.10	1.72	1.73
Other off farm income sources	2.65	2.65	2.84	2.83
Disability payments	1.73	1.73	2.00	1.45
Other social security payments	0.95	0.77	1.14	1.28
Total income	0.47	0.42	0.53	0.66

Source: own calculations based on Dutch FADN data higher than the volatility of the income from farming the addition of off-farm income does result in a lower volatility of total income. Looking at the volatility across different size classes, the conclusion can be drawn that smaller farms experience less volatility than larger farms.

Another way of analysing the impact of the different income components is to see whether the relative position in the income distribution is affected by the different income sources. Table 3 shows the stability of the income distribution for three different income components (1) income from farming activities without subsidies, (2) income from farming activities (i.e. including subsidies) and (3) total income (off-farm plus farming). Concerning income from farming activities (excluding subsidies) for example 57.4 percent of the dairy farms which belong to the lowest quintile in year t-1, still belong to the lowest quintile in year t. 25.8% move up one quintile and 2.9% move up to the highest quintile (Table 3a). Looking at the best performing farms in year t-1 the table shows that 32.5% percent drop back to a less performing quintile, 2.8% of the farms drop back to the lowest quintile.

Table 3a: Stability of income distribution (income from farming excl. subsidies).

	Income from farming activities (without subsidies)				
	1	**2**	**3**	**4**	**5**
1	57.4%	25.8%	9.6%	4.3%	2.9%
2	25.1%	36.1%	24.7%	11.3%	2.7%
3	11.2%	24.2%	36.1%	21.9%	6.6%
4	4.1%	11.5%	24.1%	40.6%	19.7%
5	2.8%	3.8%	5.8%	20.2%	67.5%

Source: own calculations based on Dutch FADN data

Table 3b: Stability of income distribution (income from farming incl. subsidies).

	Income from farming incl. subsidies				
	1	**2**	**3**	**4**	**5**
1	55.9%	27.5%	9.3%	4.7%	2.5%
2	25.8%	38.1%	23.3%	10.9%	1.8%
3	8.3%	23.5%	40.3%	21.2%	6.7%
4	5.8%	11.6%	22.4%	43.0%	17.2%
5	3.4%	2.5%	3.8%	20.1%	70.1%

Source: own calculations based on Dutch FADN data

Table 3c: Stability of income distribution (total income).

	Total income				
	1	**2**	**3**	**4**	**5**
1	54.3%	26.8%	9.5%	4.8%	4.5%
2	22.4%	41.1%	23.5%	11.1%	1.8%
3	11.1%	23.0%	38.3%	22.2%	5.4%
4	7.4%	8.9%	24.6%	37.8%	21.3%
5	4.4%	1.7%	5.3%	23.0%	65.7%

Source: own calculations based on Dutch FADN data

Table 4: Volatility of disposable income and taxes (weighted).

Variable	Median of coefficient of variation			
	Total	**Size class small**	**Size class medium**	**Size class large**
Total income	0.47	0.42	0.53	0.66
Personal taxes	1.91	2.15	1.73	1.57
Disposable income	0.52	0.48	0.55	0.75
Consumption	0.20	0.20	0.20	0.19
Savings	1.53	1.76	1.30	1.26

Source: own calculations based on Dutch FADN data

Including subsidies in the farm income hardly changes the stability of the income distribution (see Table 3b). The number of farms that stay in the same income class increases slightly (with an exception of the lowest income class). Although the subsidies affect the variability of the income at farm level it does not distort the relative position in the income distribution.

Including also off-farm income only marginally changes the stability of the income distribution (see Table 3c). The number of farms that stay in the same income class decreases slightly (with an exception of the 2nd income class). Although the off-farm income affects the variability of the income at farm level it only marginally changes the relative position in the income distribution.

Having analysed the volatility of total income, the question is how income taxes affect volatility. Dutch income tax is progressive, with marginal rates up to 50%. However, entrepreneurs have some options to reduce taxes, including averaging their incomes over three years which reduces marginal rates if income is not very stable. Taxes are accounted on a cash-basis, as it is hard to estimate how much tax will be paid in future years given current income.

Table 4 starts where Table 2 stopped, showing total income. Volatility of personal taxes is high compared to all income components. The disposable income shows a higher volatility than the total income. This can be explained by the lagged effect of tax payments and the relatively low amounts of paid taxes. Larger farms show a lower volatility in paid taxes.

Table 4 also shows the lowest volatility in consumption. This low level of volatility of consumption can be observed in all size classes. This means that farm households maintain their consumption levels at a stable level during low- and high-income years. This is partly done by saving in good years and un-saving in bad years. This results in a high volatility in savings. The highest volatility of savings can be observed among the small farms.

Table 5 further analyses the impact of taxes on disposable incomes and the link between stable consumption levels and changes in savings. Although personal taxes do not result in a lower volatility of disposable income it does have a clear effect on disposable income levels over time. Low incomes in 2009 leads to lower tax payments in 2010 and 2011 (see Table 5). In addition, the rather stable consumption levels are confirmed by Table 5. In low income years 2009 and to a lesser extent 2016 negative savings are used to maintain consumption levels.

Although income volatility is linked with upside swings as well as with downward swings in income levels, governments care especially about downside risks and those farmers, that are faced with an income that is below a certain minimum level, e.g. the minimum standard of living or poverty threshold. Table 6 shows the number of farms that have a total farm income below that poverty threshold in a certain year.

Table 5: Impact of taxes on disposable incomes (weighted).

Year	Total income	3 year average	Personal taxes	Disposable income	Personal consumption	Savings
2001	59,170	-	2,104	57,066	31,221	25,845
2002	45,469	-	1,850	43,619	32,837	10,782
2003	49,910	52,053	1,807	48,103	36,754	11,349
2004	56,985	51,214	-2,474	59,460	36,581	22,879
2005	65,706	59,112	1,066	64,639	39,206	25,433
2006	68,033	64,152	1,227	66,806	41,228	25,578
2007	97,207	76,869	6,733	90,475	43,446	47,029
2008	71,235	76,213	5,133	66,102	48,947	17,155
2009	14,804	59,140	5,481	9,324	48,135	-38,812
2010	60,999	47,815	1,186	59,814	47,946	11,868
2011	74,695	50,584	1,673	73,022	48,096	24,926
2012	50,312	62,808	5,201	45,111	47,195	-2,084
2013	78,636	69,560	4,267	74,369	50,973	23,396
2014	83,106	70,958	7,806	75,300	45,272	30,028
2015	48,633	69,132	6,299	42,334	40,585	1,749
2016	36,466	53,804	5,798	30,668	43,732	-13,064
2017	113,879	67,770	4,581	109,298	54,224	55,074

Source: own calculations based on Dutch FADN data

Table 6: Percentage of farms and entrepreneurs with income levels above poverty threshold (2001-2017), weighted observations.

Year	Total income > poverty threshold				Total income per entrepreneur > poverty threshold			
	Total	Small farm	Medium farm	Large farms	Total	Small farm	Medium farm	Large farms
2001	85.1%	81.2%	99.8%	100.0%	68.9%	62.7%	91.3%	100.0%
2002	74.9%	70.7%	88.8%	99.4%	57.3%	51.0%	78.0%	99.4%
2003	78.1%	73.8%	90.8%	100.0%	60.6%	54.5%	78.8%	89.0%
2004	84.8%	82.0%	93.0%	91.0%	67.3%	63.0%	79.5%	82.1%
2005	85.9%	83.4%	92.2%	100.0%	70.5%	67.7%	76.6%	100.0%
2006	84.5%	81.3%	91.7%	100.0%	72.5%	67.8%	82.6%	100.0%
2007	91.1%	88.4%	96.9%	100.0%	88.0%	83.9%	96.9%	100.0%
2008	84.9%	83.7%	86.8%	91.4%	75.2%	72.4%	80.3%	81.4%
2009	43.8%	44.3%	42.6%	47.2%	30.0%	28.6%	30.8%	44.7%
2010	75.8%	75.2%	74.8%	89.4%	65.3%	65.0%	63.4%	83.5%
2011	82.2%	79.4%	85.2%	88.6%	72.0%	68.2%	75.0%	88.3%
2012	64.5%	61.9%	66.2%	75.1%	55.9%	52.5%	58.2%	69.7%
2013	80.5%	71.8%	85.9%	82.5%	67.3%	54.3%	73.8%	77.5%
2014	77.2%	74.8%	77.9%	80.3%	66.9%	62.2%	67.5%	76.5%
2015	63.5%	51.8%	68.7%	70.3%	47.2%	34.2%	51.4%	60.4%
2016	50.7%	33.8%	54.3%	57.6%	39.7%	26.2%	42.5%	45.5%
2017	87.4%	79.7%	86.8%	95.5%	76.6%	62.1%	75.9%	90.7%

Source: own calculations based on Dutch FADN data

Table 6 shows large differences between years in percentage of farms achieving the poverty threshold. The percentage of farms above the threshold varies between 43% in the low-income year 2016 and more than 90% in the high-income year 2007. Taking into account the number of entrepreneurs involved in one farm, the percentage of farms where the total income per entrepreneur is higher than the poverty threshold is substantial lower. This varies from 30% in 2009 till 88% in 2007. For larger farms most farms are above the poverty threshold. The highest share of below poverty farms can be found at the smallest farms.

Table 6 only illustrates the percentage of farms and entrepreneurs achieving the poverty thresholds; it does not address the contribution of different income components. Table 7 further explores the contribution of subsidies and off-farm income towards achieving the poverty thresholds. The results show that the impact of subsidies depends on the level of incomes during a specific year. In general, it increases the percentage of farms achieving the poverty threshold by between 5 and 20 percentage points. Exceptions are the low-income years (2007 and 2016) where subsidy payments had a significant impact on farmers achieving the poverty thresholds. The impact of subsidies has increased over time due to the increase in subsidy levels that has taken effect as changes in the CAP have been implemented.

Off-farm income sources also increase the percentage of farms above the poverty thresholds substantially. Between 5 and 15 (in the year 2009) percent of farms achieved the poverty threshold due to the inclusion of off-farm income.

In Table 7 the impact of subsidies and off-farm income on achieving the poverty threshold have been analysed in this specific order. First, including the off-farm income and subsequently the subsidies would lower the actual impact of subsidies on achieving poverty levels.

Table 7: Percentage of farms and entrepreneurs achieving poverty thresholds, with and without subsidies and off farm income (2001-2017) (weighted observations).

Year	Per farm			Per entrepreneur		
	Farm income without subsidies	Farm income	Total income	Farm income without subsidies	Farm income	Total income
2001	75.1%	79.6%	85.1%	57.9%	61.4%	68.9%
2002	58.6%	62.5%	74.9%	40.2%	45.3%	57.3%
2003	60.0%	66.2%	78.1%	39.5%	44.5%	60.6%
2004	58.1%	71.5%	84.8%	40.1%	51.4%	67.3%
2005	60.5%	75.2%	85.9%	39.7%	56.8%	70.5%
2006	50.6%	73.1%	84.5%	36.4%	58.8%	72.5%
2007	76.3%	86.0%	91.1%	61.4%	75.9%	88.0%
2008	57.8%	74.6%	84.9%	40.3%	60.9%	75.2%
2009	12.1%	28.3%	43.8%	8.6%	17.5%	30.0%
2010	47.6%	66.6%	75.8%	35.4%	52.0%	65.3%
2011	57.1%	73.9%	82.2%	43.0%	61.5%	72.0%
2012	38.2%	53.8%	64.5%	25.9%	45.7%	55.9%
2013	59.1%	72.6%	80.5%	45.8%	58.4%	67.3%
2014	58.9%	71.3%	77.2%	45.7%	58.8%	66.9%
2015	35.8%	52.6%	63.5%	22.9%	38.1%	47.2%
2016	29.0%	45.0%	50.7%	19.1%	33.3%	39.7%
2017	72.1%	81.9%	87.4%	61.3%	72.8%	76.6%

Source: own calculations based on Dutch FADN data

Table 8: Development of capital formation and solvability (2001-2017), weighted observations.

Year	3-year average income	Solvability	Own capital	Intangible assets	Fixed tangible assets
2001	-	79	1,408,948	782,877	1,067,998
2002	-	77	1,415,536	872,755	1,068,638
2003	52,053	75	1,428,203	911,484	1,096,353
2004	51,214	74	1,426,032	965,627	1,099,071
2005	59,112	73	1,524,616	1,033,423	1,198,735
2006	64,152	71	1,456,255	807,673	1,289,658
2007	76,869	71	1,474,370	588,969	1,394,372
2008	76,213	71	1,580,237	638,957	1,509,978
2009	59,140	71	1,785,213	659,961	1,837,952
2010	47,815	72	1,926,573	594,614	1,996,950
2011	50,584	72	1,900,515	487,495	1,960,298
2012	62,808	71	1,936,848	348,280	2,123,223
2013	69,560	73	2,172,986	413,345	2,362,970
2014	70,958	69	2,021,619	129,135	2,464,656
2015	69,132	67	1,950,653	27,443	2,496,046
2016	53,804	67	2,076,033	34,154	2,663,059
2017	67,770	70	2,338,172	27,191	2,875,270

Source: own calculations based on Dutch FADN data

Finally, we will look at the impact of capital formation on the wealth of farmers. Farmers are said to live poor and die rich. For a policy debate on the need for governments to intervene in a sector with low incomes or (low) incomes with high volatility, it is relevant to consider the assets of the farm in case of low incomes. This is especially true if farms have low incomes due to risk taking in farm enlargement or investing in the hope to realise capital gains on assets. This analysis is relevant with a view to means-testing, as in other social security systems.

Concerning capital formation, the analysis shows that over the analysed period the values of tradable dairy quota have evaporated with the abandoning of the quota system (see table 8). Land values have increased considerably, partly as the rent is no longer translated into quota prices but rather into land prices. Land, being also a financial asset, has become much more valuable in recent years due to the decline in interest rates which have been managed down by the ECB. The increase in values have been used by (some) farmers to enlarge their farms with the help of outside capital: on average the solvability decreased from 79% in 2001 till around 70% in 2017.

Table 9 shows a positive link between own assets and the 3-year total income average. 26% of the farms belong to the group with low incomes and low assets (the lowest two quintiles of 3-year income and the lowest two quintiles of total own assets). Another 14% has a relatively low income (quintiles 1 and 2) but a more favourable net worth (median or highest quintiles). On the high-income side, 8% of the farms have a high income (quintiles 4 and 5) and low own assets (quintiles 1 and 2). 32% of the farms belong to the high-income farm category (quintiles 4 and 5) with a favour-

Table 9: link between 3-year income quintiles and total own assets quintiles (2001-2017), weighted observations.

Quintiles of 3-year average total income	Quintiles of total own assets				
	1	2	3	4	5
1	8.50%	4.28%	3.12%	3.12%	0.98%
2	7.62%	5.82%	3.78%	2.06%	0.72%
3	3.74%	7.06%	5.12%	3.08%	1.00%
4	3.24%	3.92%	5.06%	4.08%	3.70%
5	0.18%	0.70%	3.40%	5.64%	10.10%

Source: own calculations based on Dutch FADN data

able net worth (median or highest quintiles). These figures are relevant in designing policy instruments for safety-nets, as farmers with a low income but a high level of own capital have more options to get out of poverty or at least survive some bad years.

Discussion and Conclusions

Farm income has always been a central element in the CAP. In the last years policy makers have become more interested in volatility of incomes and methods to stabilise these incomes (income stabilisation tools, safety nets etc.). In this paper we show that a broader perspective (including off-farm income and wealth effects) provides a more realistic picture of the income and wealth effects as experienced by farmers. Although these analyses cannot be conducted for all member states, due to a lack of data, policy makers should be aware of these results.

It is very likely (given economic theory and empirical results) that farmers take off-farm income, taxes and wealth effects into account in their farm strategies and risk management. This means that if policy makers care for (low) income situations or want to provide a safety net, they have more options than simply influencing farm prices or providing a stabilising direct payment. Promoting off-farm income, social security and options in tax-law (like averaging incomes to reduce marginal rates, or setting up a special savings account with non-taxed income for leaner times) are alternatives.

The results also show that subsidy payments could be more targeted if the main objective is to achieve an acceptable standard of living. In the current situation only a limited number of farmers pass the poverty threshold due to the payment of subsidies. Within the group of low-income farms, there is still a sub-group with a low-income situation in combination with a more vulnerable own asset situation that requires special attention.

Designing policy instruments also requires a longer time perspective. The analyses show that farmers are well able to maintain their consumption levels with saving in good years and un-saving in more challenging years. Real problems occur with persistent low-income levels.

Policy makers should also not overestimate the income volatility issue by looking only to farm income. The fact that data sets are far from perfect should be an incentive to improve data collection (see for example Poppe and Vrolijk, 2018), and not lead to incomplete policy analysis. That could trigger policies that are inefficient and give wrong signals to farmers. Farming is a risky business, but in situations with efficient capital markets, farm-friendly tax regimes and risk-management by households that involves non-farm activities and income, farm households have several tools to cope with price and yield risks. Policy evaluations should take all these aspects into account.

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Investigating the evocative link among wine consumption, Human Development Index and geographical region

The Human Development Index (HDI) is a statistic composite index composed of life expectancy, education, and per capita income indicators. Currently, wine consumption is increasingly becoming significant both for reducing several diseases and for improving well-being and quality of life. The aim of this paper is to investigate spatial and temporal characteristics of wine consumption in 45 countries belonging to the World Health Organization (WHO) European Region and its relationship with the HDI. We use a balanced panel data by WHO database (2005-2015). Random effects panel data model was selected over the fixed effects model based on the Hausman test in order to assess the effect of HDI, European Union (EU) membership and geographical areas on wine consumption. Results highlight that wine consumption decreases as HDI increases. We noted higher values of wine consumption in EU countries and a positive gradient from West to East in the area considered. These findings highlight the presence of a new consumer profile seeking quality and healthy consumption and whose awareness increases coinciding with a rise in the degree of country development. National and international policies can address issues of consumption style and persuade consumers to have a new eating cultural approach towards buying quality and healthy food.

Keywords: HDI, wine consumption, WHO countries, health and well-being, random-effect panel data model, EU membership

JEL classification: Q13

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Introduction

Nowadays, food consumption models can be encapsulated within a composite behaviour characterised by several factors principally depending on the health and well-being expectations of consumers. As a consequence, the market tries to meet health, quality and safety needs of the new profile of conscious consumer (Vrontis *et al.,* 2011; Marotta *et al.,* 2014; Antonazzo *et al.,* 2015; Galati *et al.,* 2019a). Food represents increasingly, in the mind of consumers, a medicine that can help them to achieve a healthy life, to reduce disease risks, and in the same way to improve their well-being, life expectancy and quality of life (Mancini *et al.,* 2015; Maizza *et al.,* 2017; Galati *et al.,* 2019a; Fiore *et al.,* 2019b). The crucial importance of the food sector to both providing nutrition and building of "well-being" while guaranteeing health (Misso and Andreopoulou, 2017) appears clear. This should contribute to lead to a qualitative development of an area or population, resulting in higher life expectancy and lower incidence of diseases.

Since 1990, well-being, quality of life and qualitative development have become buzzwords that have resulted in new paths for international and supranational policies and strategies being outlined. Indeed, several measures alternative to gross domestic product (GDP) have been defined and proposed to avoid the limitations and weaknesses of quantitative indexes. In particular, the latter are not adequate to measure all dimensions of development because they do not take into account geographical variations in socio-cultural, ecological and 'good life' issues (Kangmennaang and Elliott, 2019; Ares *et al.,* 2016). Furthermore, over the time, several eminent studies have demonstrated that there is no significant correlation between GDP growth rate and quality of life of a country (WHO, 1997; Veenhoven, 2000; Asheim, 2000; Easterlin, 2001; Contò *et al.,* 2012; Roemer, 2014), thus shifting towards new concepts: subjective well-being, happiness and satisfaction. Happiness index as well as Human Poverty Index and Human Development Index are only some of numerous indicators that measure well-being and quality of life of a population (UNDP, 1990; Veenhoven, 2012; Alkire *et al.,* 2015; Senasu *et al.,* 2019). Within this context, the famous Human Development Index (HDI), developed by UN in 1990, is a statistic composite index composed of life expectancy, education, and per capita income indicators, that measures the well-being of a country taking into account the key dimensions of human qualitative development (UNDP, 1990; Jahan, 2019). Despite some limitations arising from the composite nature of the HDI (Jahan, 2019), this measure provides yearly a picture of the three essential levels of development necessary for a decent standard of living: it does not represent a comprehensive picture but is just an adequate measure for encouragement healthy development and for raising awareness. Therefore, the HDI can be considered a good proxy of the overall 'health' (which includes the economic health) of a population. The link among food, well-being and health push consumers to eat food not just for nutrition needs, thereby determining a conscious buying process driven by quality of food as main element of choice (Marotta *et al.,* 2014; Bailey *et al.,* 2018; Galati *et al.,* 2019a). Therefore, consumption of functional food, food supplements, organic food and food for life has been increasing because, in the consumers' mind, this typology of food products can reduce disease risks, save healthcare costs and improve quality of life, while at the same time achieving subjective well-being, happiness and hedonic pleasure (Ares *et al.,* 2014; Deshmuknh, 2018; Apaolaza *et al.,* 2018). Finally, a lifestyle and diet aimed at optimising health and well-being issues seem to be the core of current consumer choices. In all kinds of diet, a moderate intake of wine, the most popular and ancient alcoholic drink, has throughout history been considered to have a divine status for its properties, which are not only nutritional but also are perceived to offer health and psycho-social well-being benefits (Snopek *et al.,* 2018; Fiore *et al.,* 2019a; Lerro *et al.,* 2020). These proprieties are also highlighted in the famous and contradictory phenomenon named the "French paradox" (FP) that demonstrates French population consuming a diet rich in saturated fatty acids and wine has a low coronary heart diseases (CHD) incidence compared to the northern countries, who have the same diet but drink less wine (Parodi, 1997; de Lorgeril *et al.,* 2002; de Leiris and Boucher, 2008; Opie, 2008; Dumas *et al.,* 2011).

In this framework, the present paper aims to contribute, in a new and evocative way, to current debates concerning the link among food, wellbeing and quality of life (Morozova *et al.,* 2016; Kihlström *et al.,* 2019) that refer 'to the positive, subjective state that is opposite to illness' (Meiselman, 2016). The several dimensions of this link are related to physical, social, well-being, and quality of life aspects and can be crucial in studying how culture, development and geographical approach affect food consumption in particular of wine. Specifically, according to the literature on this topic, no paper has broadly compared two variables such as alcoholic drink (wine) and quality of life/human development of a country while considering spatial and temporal features. Therefore, the purpose of this work is to implement and investigate a model that considers both spatial and temporal characteristics of the wine consumption in 45 countries belonging to the World Health Organization (WHO) European Regions, and its relationship with the HDI. The Breuch-Pagan Lagrange Multiplier (LM) test and subsequently the Hausman test were carried out to verify the random effects model over a fixed effects model. Although others variables can affect wine consumption, the choice of investigating the HDI appears very interesting because the HDI is a composite index that collects important aspects (health, education, and income) which can influence the quantity of wine, drunk by consumers.

The paper presents the following structure: the next section draws the state of art on relationship between wine consumption and health, focusing on the FP. Then, the authors present materials and methods carried out for reaching the scientific aims. The third part is composed by the results section that displays and discusses the findings. Finally, the conclusions paragraph closes the paper by highlighting insights and suggestions for future research.

Health, well-being and wine consumption

In the last decades, the increase of life expectancy at birth observed worldwide is due to many factors, such as an improvement of the quality of life, characteristics of food eaten, increase of income, etc. In particular, diet represents the world top factor related to the disease onset. Food increasingly embodies, in the mind of consumers, a medicine that can help to reach a healthy life, reduce diseases risks and in the same way cut social costs of national health systems (Mancini *et al.,* 2015; Maizza *et al.,* 2017; Fiore *et al.,* 2019b). For instance, health-oriented consumers positively welcome health-enhancing wine (Samoggia, 2016). In this current framework, the scientific community has recognised that the Mediterranean diet (MD) has great effects on longevity, advanced cognitive impairment as well as lower incidence of chronic health problems such as cardiovascular disease, diabetes, stroke and cancer. This diet is characterised by consuming of vegetables, fruits and legumes, small amounts of dairy products (principally cheese and yogurt), low quantity of seafood and poultry, legume, olive oil as dressing and above all moderate amount of wine (Yarnell and Evans 2000; Martínez-González *et al.,* 2019). In fact, according to several studies (Dang *et al.,* 1998; Rotondo *et al.,* 2001; Annunziata *et al.,* 2016; Snopek *et al.,* 2018), moderate intake of alcohol, in particular red wine, reduces the incidence of heart disease and increases longevity. Wine and its nutritive properties have been recognised for thousands of years as being beneficial thanks to the synergic mixture of some biochemical components with antioxidants anti-inflammatory proprieties such as polyphenols (e.g. bioflavonoids), tocopherols, phytosterols, anthocyanin (that contributes red wine their dark colour) (Yarnell and Evans 2000; Martínez-González *et al.,* 2019).

Wine is an element crucial in the FP; France does not have characteristics of the south Europe countries, apart from a narrow strip along the Mediterranean coast, and most of its citizens do not follow a MD (de Lorgeril *et al.,* 2002). This could be the truth, since the consumption of alcohol, in particular wine, is high in France compared with most Western countries (de Lorgeril *et al.,* 2002). The term FP was first introduced in 1986 in a newsletter of the International organization of wine and vine (Fiore *et al.,* 2019a). Dr. Renaud, a researcher of the Bordeaux University, advised wine consumption explicates above all the FP (Fehér *et al.,* 2007; Lippi *et al.,* 2010; Wiciński *et al.,* 2018; Fragopoulou *et al.,* 2018). In line with this, the work by de Leiris *et al.* (2008) highlights on one hand that moderate intake of alcohol reduces the risk of mortality and on the other hand extra health benefits seem to derive from wine. Dudley *et al.* (2008) add that PF is not related to the red wine consumption but also to the white wine that is rich in tyrosol and hydroxytyrosol. Dumas *et al.* (2011) underline also women generally feel they are not concerned, and view the danger arising from alcohol consumption as being related to drinking strong forms of alcohol or concerning alcoholics. Therefore, there is a unanimously held idea that a moderate level of wine consumption delivers beneficial effects in respect of several diseases and contributes to longevity (Artero *et al*., 2015).

Indeed, several epidemiological studies on a wide cohort of patients demonstrate that moderate alcohol intake can prolong overall life expectancy (Goldberg and Soleas, 2011). According to a study conducted by Cosmi *et al.* (2015), moderate wine intake coincides with a professed and objective positive health status, which is also psychological (i.e. there is a lower depression incidence). Indeed, an article of the Encyclopedia of Food and Health highlights that wine health benefits are perceived as a pleasing accompaniment to the sensory attributes, 'if that is part of one's preferred lifestyle' (Jackson, 2015). Finally, Mediterranean and French-style diets encourage moderate alcohol intake with regard to their impact on human health and wellbeing, a point that is also underlined by the newest technologies and approaches such as ‘foodomics’ (Ndlovu *et al.,* 2019). In the light of what has been highlighted, the authors believe that there could be a relationship between wine consumption, country’s development and well-being level and its geographical location. For this reason, they have placed the HDI (UNDP, 1990) in relation to wine consumption. In fact, as has already been stated in the above sections, HDI represents a good proxy for well-being and health, as it is a composite index that takes into consideration three fundamental dimensions: a long and healthy life; access to knowledge on the population’s health and standard of living.

Therefore, the study focuses on the following research hypotheses:

- Human development and quality of life, considered through the HDI (ONU, 1990) value in the countries of the WHO European regions, is a determining factor for wine consumption;
- The belonging or non-belonging of the countries to the European Community is linked to significant differences in the consumption of wine;
- The WHO European region, which ranges from West coast of Greenland to the Pacific coast of the Russian Federation, is characterised by significant differences in wine consumption, from east to west.

These hypotheses will be verified through a model of fixed effects, which will allow verifying not only in relation to the statistical significance of the relationships, but also whether they are directly or inversely proportional.

Materials and methods

The WHO European Region considers 53 countries, with a population of almost 900 million inhabitants. Since the 1980s, the member states have communicated to the WHO the statistics relating to health and the sociological aspects connected to it, making it possible to create the HFA (Health for All) database. According to the geographical characteristics, the WHO European Region is divided into three areas (west, centre and east) (Figure 1).

From this database, the authors have selected and downloaded panel data of 45 countries from 2005 to 2015, based on the availability of annual data in relation to the analysed variables, i.e. 11 observations for each country that is a balanced panel dataset (accessed on 02/02/2020). According to the aim of the paper, we made use, as an outcome variable, the indicator of *Wine consumed in pure alcohol, litres per capita, age 15+ (WINE)* (WHO, 2020a). This indicator aims at monitoring the amount and trend of wine consumption in the adult population and is calculated as a ratio between the amount of recorded alcohol consumed per adult (15+ years) during a calendar year, in litres of pure alcohol, and midyear resident population (15+ years) for the same calendar year. We have considered its logarithmic transformation, indicating it with *ln_WINE*. The authors have considered as predictor the following variables: a) a dummy variable that divides countries into two groups. The first one have been members of the European Union (*EU*) since May 2004 (EU13) and the second one are not members of the EU (*non-EU*); b) location of the coun-

Figure 1: WHO European Region: the three main macro-areas.

Source: WHO (2019)

try based on Geographical Division *(G_D)* of European region according to WHO (2012) classification which considers three macro-areas: *west, centre* and *east*.

As already underlined, the HDI is a synthetic index of human development of a country, based on three fundamental dimensions: a *Long and healthy life*, measured by the indicator of *Life expectancy at birth (years); A decent standard of living* measured by the *Gross National Income per capita* (*in purchasing power parity, PPP, in $*), *Knowledge* measured by the arithmetic mean of indicators *Mean years of schoo*ling and *Expected years of schooling* (Figure 2).

These indicators are normalized by min-max transformation obtaining the following dimension indices: *Life expectancy index*, *Gross National Income Index* and *Education Index.* Finally, the HDI is obtained by calculating the geometric mean:

$$HDI = \sqrt[3]{Lifeexpectancyindex * GrossNationalIncomeIndex * EducationIndex} \quad (1)$$

HDI by countries is available at the UNDP Human Development Index web site (WHO, 2020b). We have considered its logarithmic transformation, labelling it *ln*_HDI.

The authors have started the present research with a descriptive analysis, in order to explore data and to highlight its characteristics according to the purposes and the research hypothesis of the work. There are not econometric models in the literature that relate wine consumption to the HDI. Instead, there is scientific literature that considers the relationship between alcohol consumption and level of human development, but with discordant results. Ferretti (2015) proposes an index called Unhealthy Behaviour Index (UBI), which classifies countries according to the average level of habits unhealthy (alcohol consumption, excess of calories, unbalanced diet and tobacco consumption) of their populations, following a method similar to that followed by the United Nations Development Program for the calculation of the HDI. By observing the index in 112 countries worldwide in 2012-2014 time range, the UBI values tend to increase together with the HDI value. Instead, Noel (2020), by investigating the low and middle-income countries of Latin America, proposes a linear regression model in which the adolescent exposure to alcohol was inversely associated with the HDI values.

Subsequently, in order to model the outcome variable *ln_WINE*, we adopted the LM test (Breusch and Pagan, 1980) in order to choose a random effects regression or a simple ordinary least squares (OLS) regression. The LM test foresees as a null hypothesis that the variances among the countries are equal to zero, namely no significant difference exists among the countries. By applying the test to a panel data, the null hypothesis is rejected ($p < 0.05$), i.e. a random effects model is more appropriate. Furthermore, the choice of the random effects model over a fixed effects model is confirmed by the Hausman test (Bell, 2019), if its p-value is not significant (for example >0.05) then we use random effects. According to Bell (2019), the following formula was used as a model for analysing the panel data:

$$Y_{it} = X_{it}\beta + v_i + \varepsilon_{it}, \quad (2)$$

where Y_{it} is the outcome variable in the country *i* at time *t*, *X* is the matrix containing the predictive variables, including the value of the constant, and β is the matrix of coefficients. As predictive variables, we considered *ln*_HDI, membership of the European Union (*Eu_not Eu)*, and geographical area *(G_D)* to check if they could affect wine consumption. The total variance in the model contains both the country error indicated by the term random effect υ_i and the country internal error indicated by ε_{it}. Finally, we calculated *rho* that is the proportion of the total variance among the countries considered. The statistical analyses were performed by using the software STATA 14 and SPSS 20.

Results

The summary statistics of the 45 sampled countries are presented in the Annex, which includes also their corresponding geographical area (west, centre and east) and the relative time span (2005-2015).

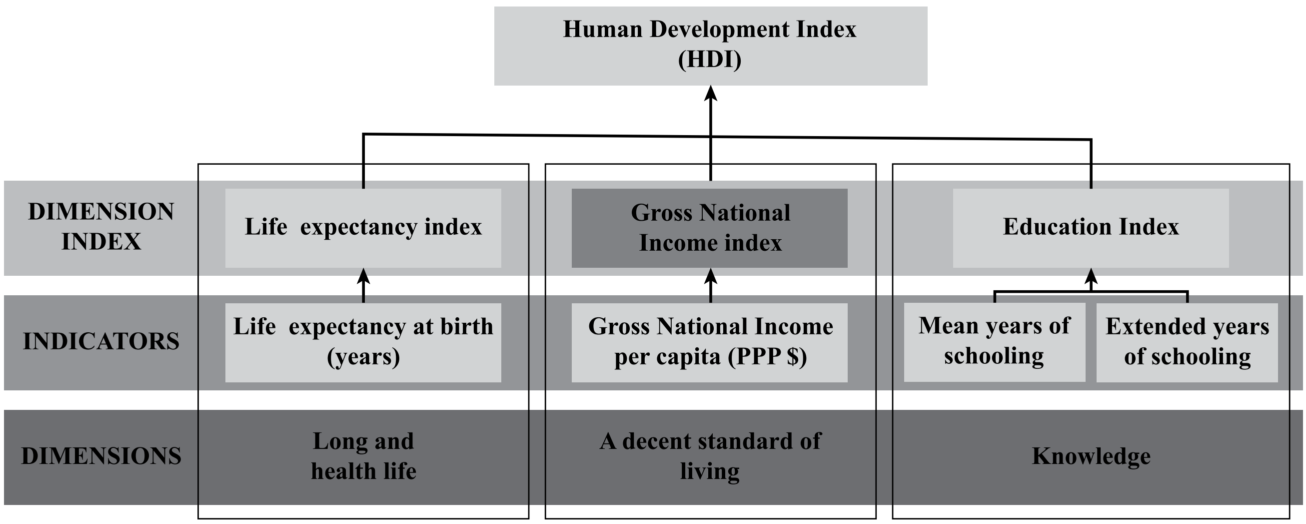

Figure 2: Graphical composition of HDI.

Source: ONU (1990)

With regard to indicator *Wine consumed in pure alcohol, litres per capita, age 15+*, in WHO European Region, the results show that the mean is equal to 2.43 L per capita, but with high variability (sd=1.87 L per capita, range 0.00-7.97 L per capita).

Regarding the relation between the three geographical macro-areas and wine consumption, the lowest value recorded was the east area, with an average wine consumption of 0.75 L per capita. On the contrary, the west area records the highest values, with an average consumption of 3.46 L per capita. However, in the same area a wide variability has been observed with a range from 0.11 to 7.97 L per capita. The average consumption of wine in the central area is 2.31 L per capita (sd=1.71 L per capita, range 0.00-5.47 L per capita). In particular, the study shows that the consumption of wine in the EU countries is about three times than that of the non-EU countries (3.31 L per capita *vs* 1.10 L per capita), with a greater range of variability in the former. Indeed, the countries with highest mean value of wine consumption are France (mean = 7.20 L per capita, sd =0.15 L per capita), following by Portugal with mean value very close to France ones (mean = 7.15 L per capita, sd = 0.53 L per capita) and Luxembourg (mean = 5.22 L per capita, sd = 0.19 L per capita) which show values distant from the previously mentioned figures. Conversely, the countries with the lowest values are Tajikistan (mean = 0.07 L per capita, sd =0.09 L per capita), Turkey (mean = 0.10 L per capita, sd =0.03 L per capita) in central area, and Kyrgyzstan (mean = 0.12 L per capita, sd = 0.01 L per capita) in east area which belong to the non-EU area.

As to the HDI, in WHO European Region, the average value of this indicator in the time span considered is 0.82, with a standard deviation of 0.08. Specifically, in the macro geographical areas: a) the east is characterised by the lowest HDI, with an average of 0.74; b) the western records the highest values, with an average of 0.88; c) and the central showing values between the previous area and equal to 0.80. Thus, the results show a positive gradient from east to west in accordance with the high HDI values that characterise these latter countries.

Regarding the comparison between EU and non-EU countries, the results show a HDI on average equal to 0.86 and 0.76 respectively. Three non-EU countries have recorded the lowest mean such as Tajikistan (mean =0.61, sd = 0.02); Kyrgyzstan (mean = 0.64, sd = 0.02) and Uzbekistan (mean =0.66, sd = 0.03). Equally, countries with the highest HDI are not located in the EU area such as Norway (mean = 0.94, sd = 0.01) and Switzerland (mean =0.92, sd = 0.01) except the Netherlands (mean = 0.91, sd = 0.01).

Figures 3 shows bivariate plot of *ln*_HDI and *ln_WINE* by geographical zones (west, centre and east) and by membership of EU, for the years 2005 and 2015, which represent the first and last year of the time span considered.

According to the results of descriptive statistics, Figure 3 shows that the countries of the European Union are mainly characterised by high values of both variables, whereas considering the geographical area of origin, both the values of WINE and HDI increase from east to west. In particular, Figure 4 shows the average values of HDI and wine consumption in EU countries from 2005 to 2015.

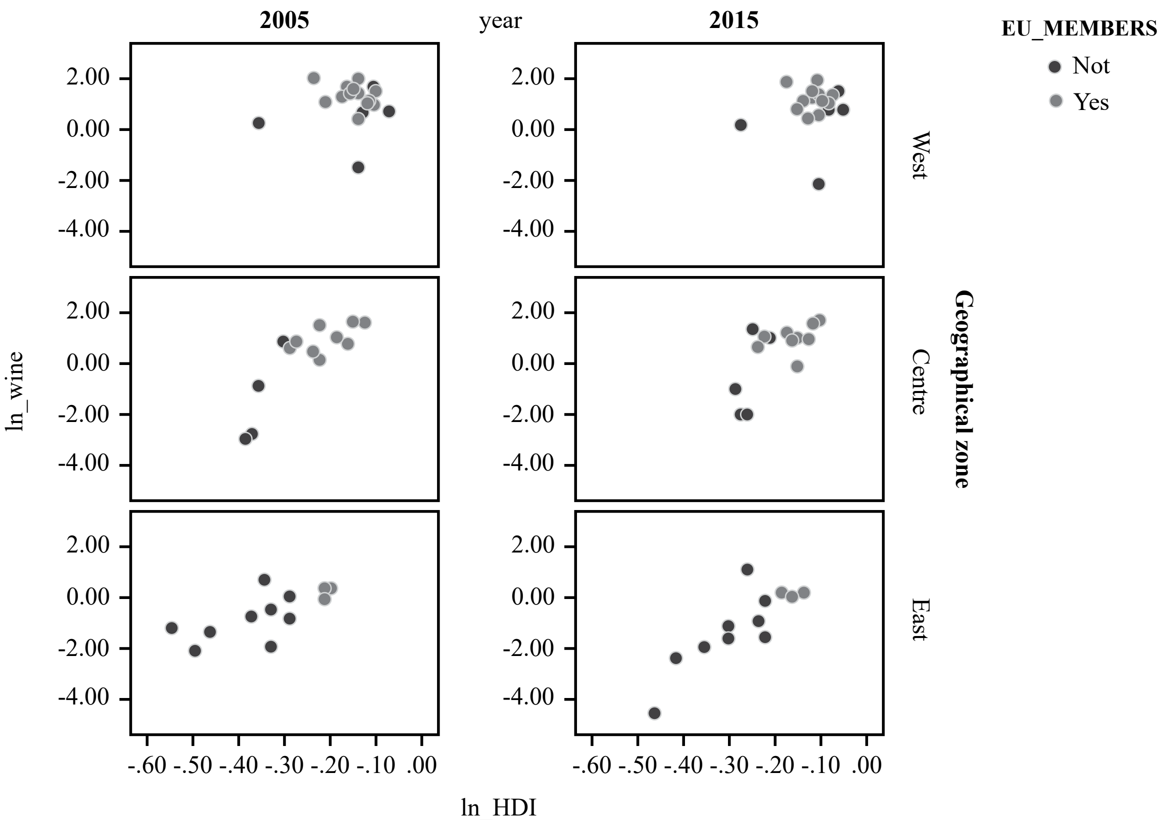

Figure 3: Biplot of ln_*HDI* and ln_*WINE*, from 2005 to 2015, by geographical zone and EU membership.

Source: our processing based on European Health Information Gateway

Furthermore, in Figure 5, the trend of the two indices considered in the same time span is reported. This shows that the HDI's positive trend corresponds to a decrease in wine consumption. All these findings led the authors, according to the aim of paper, to apply a panel data model to analyse the relationship between wine consumption and predictor variables that have been mentioned above. We applied Breuch-Pagan Lagrange Multiplier (LM) test to choose whether a random effects regression was more appropriate than simple OLS regression, and since the null hypothesis is rejected (Chi=1928.98 p <0.001), we adopted random effects.

In addition, the choice of the random effects model over a fixed effects model is confirmed by the Hausman test, in that its p-value is not significant (p >0.05) (Table 1).

Table 1: Results of the random effects model.

Variable	Coefficient	p value
*ln*_HDI	-1.054	0.050
EU_notEU (1; 0)	1.343	0.000
Geographical division (east)	-0.834	0.017
Geographical division (west)	0.585	0.052
Constant	-0.667	0.039
sigma_u	0.829	-
sigma_e	0.234	-
rho	0.926	-
Hausman Test	-	0.000
Breusch and Pagan Lagrangian multiplier test for random effects	Chi = 1,928.98	0.000

Source: Own composition based on European Health Information Gateway

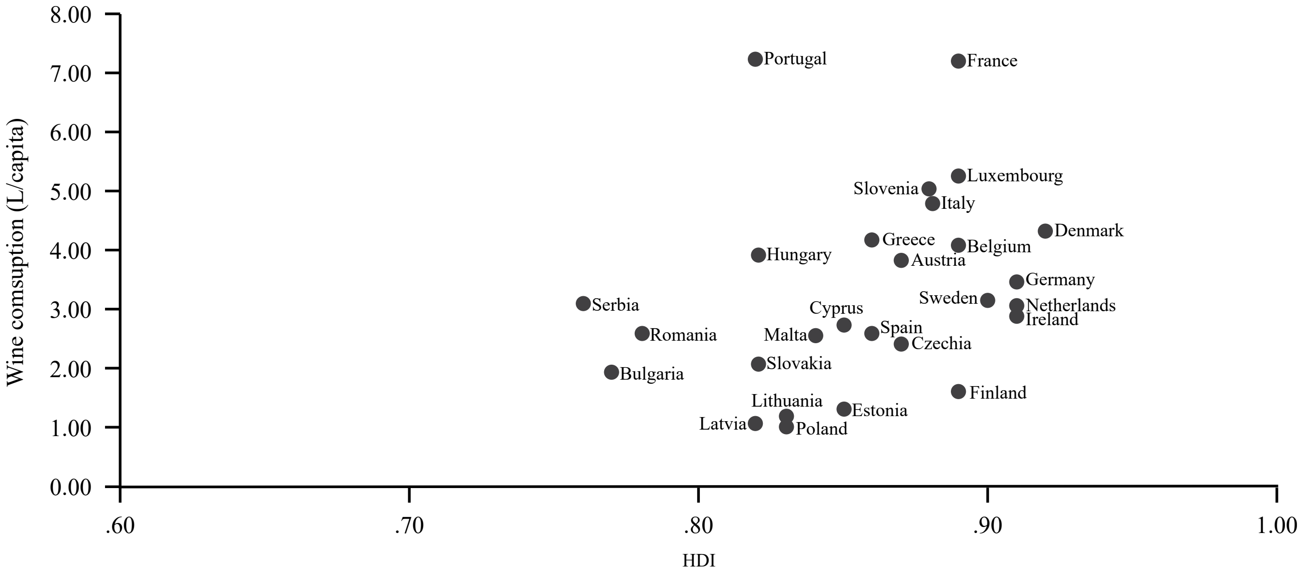

Figure 4: Average values of HDI and wine consumption in the European Union, 2005-2015.

Source: our processing based on European Health Information Gateway

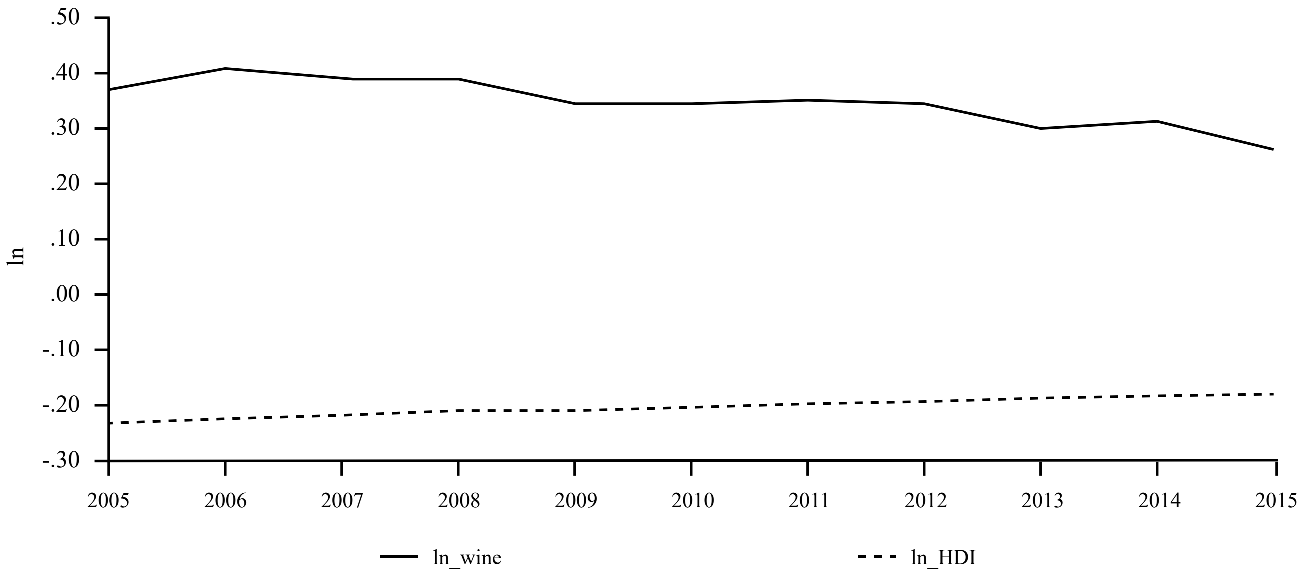

Figure 5: Trend of ln_HDI and ln_WINE in WHO European Region, from 2005 to 2015.

Source: our processing based on European Health Information Gateway

Therefore, random-effect panel data model is finally selected which functional form is as follows:

$$\ln\_WINE_{it} = \beta_{0i} + \beta_1 \ln\_HDI_{it} + \\ + \beta_2 Eu\_notEu_{it} + \beta_3 G\_D_{it} + v_i + \varepsilon_{it_0} , \quad (3)$$

Table 1 shows also the results of estimating the random-effect panel data model, confirming that the predictors taken into account are influential on wine consumption. In particular, there is a statistically significant reduction of -1.054 ($p < 0.05$) of *ln_WINE* for each unit of *ln_HD*.

The weak but statistically acceptable significance of HDI may be due to a variability within the countries analysed. The study was based on summary indices by each country which consequently lose information, but which have the advantage of providing results at level of panel data considered. Moreover, countries belonging to the European Community (i.e. *EU_not_EU*), show a positive and significant coefficient, in fact there is a statistically significant increase of 1,343 ($p < 0.001$) for *ln_WINE* in EU country. Furthermore, we detected a negative and significant coefficient (-0.834) for East and positive (0.585) for West, i.e. wine consumption increases from East to West, considering the centre geographical area as reference category (for both $p < 0.05$). Finally, *rho* value (0.926) shows that 92.6% is the proportion of the total variance that is between.

Discussion

This research represents the first study on a panel data of 45 countries belonging to the WHO European Region, over the period from 2005 to 2015, aimed at evaluating the relationship between wine consumption and HDI using all the three of WHO Europe large macro areas (west, centre, east) and subsequently of EU countries.

According to the descriptive results, the authors found that in the WHO European region the average wine consumption is 2.43 L per capita. However, this value is characterised by a wide variability in the region analysed. This is understandable considering that the WHO European region extends from the Pacific coast of the Russian Federation to the west coast of Greenland, from the Baltic Sea to the Mediterranean. The geographical vastness of the region implies a strong diversity of social, economic, cultural and health situations, which obviously are reflected in the different habits related to wine consumption.

In particular, the authors have noticed that the lowest values of wine consumption have been recorded in countries not belonging to the EU and mainly in the east area of the WHO European region. On the contrary, countries that belong to EU located in the western part of the region show the greatest wine consumption, although with greater variability. Clearly, this situation can be connected with the cultural heritage of this region, particularly in the south area where wine has been drunk since Roman times. Regarding the HDI, its average value in the WHO European region is 0.82, with a standard deviation of 0.08, over the period considered. In particular, the east area is characterised by the lowest values of HDI, while the western area records the highest values, and the central European area shows intermediate values. As to the EU membership, HDI on average is higher in EU countries than in non-EU countries.

According to the results of the descriptive statistics, *WINE* and HDI values increase from east to west and specifically in the EU countries, where these parameters are mainly characterised by high values (Figure 4). Indeed, French has over the time span analysed recorded the highest mean values of HDI and wine consumption compared to the other countries, at 0.89 and 7.25 L per capita, respectively. Moreover, also Portugal is well positioned in the chart (HDI=0.82 *vs WINE* = 7.26 L per capita), followed by Luxemburg (HDI = 0.89 *vs WINE* = 5.30 L per capita), Slovenia (HDI = 0.88 *vs WINE* = 5.06 L per capita) and Italy (HDI = 0.88 *vs WINE* = 4.82 L per capita) (Figure 4). Consequently, results confirm the “French paradox” and extend this phenomenon also to the other countries such as Luxemburg and Slovenia, which have a diet similar to the French. The high positioning in the chart for Portugal could be due to the high wine intake, even though the low HDI could be caused by the low income of population. Regarding Italy, its good positioning in the chart is probably due to the good quality of food, socialisation and income as well as to the high wine consumption. In addition, results seem also to show that the indicators examined have a spatial distribution that reflects the geopolitical characteristics of the WHO European Region. Although there are several aspects which can influence wine consumption in a country, HDI represents an important variable, which affects the quantity of wine drunk by consumers.

As already underlined, the findings have led authors to apply a panel data model to analyse the relationship between wine consumption and the HDI, considering also membership of the EU and macro geographical area. The Breuch-Pagan Lagrange multiplier test showed that random effects regression was more appropriate than a simple OLS regression, because, as already noted by the descriptive analysis, there is a significant difference among the countries, that is to say, there is a panel effect. Furthermore, the choice of the random effects model over a fixed effects model is confirmed by the Hausman test, since country error terms are unrelated to predictors. Therefore, a study of the relationship between the HDI and wine consumption is closely linked at country factor, in a panorama of great diversity, which, as already mentioned, characterises these regions. As already described in Figure 5, the results of the random model confirmed that in the observed time interval there was a significant reduction of wine consumption than the HDI growth. In addition, the model highlighted significant positive wine consumption in the EU countries.

In line with Fiore *et al.* (2019a), it is possible to stress an evocative role of the wine as a glue connecting well-being, health and culture. Since ancient times, both Greeks and Romans believed in the crucial role of wine to health and wellbeing and over the last decades, several studies have continued to highlight that moderate intake of wine decreases several kinds of disease, thereby improving quality of life and increasing longevity (Philippe, 1995; Samoggia, 2016; Snopek *et al.,* 2018). In agreement with other studies (Morozova *et* *al.,* 2016; Meiselman, 2016), food consumptions represent a significant indicator of the quality of life of a geographical region. Only a well-informed consumer can discern the advantages and disadvantages deriving from the wine consumption. Moderate intake is correlated to good health, general well-being and improved quality of life, whereas excessive intake can determine and cause disease and death. Higher levels of human development certainly correspond to higher culture's levels if considering that in the HDI, it is included the access to knowledge too. According to WHO (1997), quality of life is to be defined as individuals' perception in the context of the culture and value systems in which people live and other authors highlight the importance of subjective wellbeing, health and culture linked to food choices (Meiselman, 2016; Deshmuknh, 2018; Antonazzo *et al.,* 2018). In particular, we can observe that levels of wine consumption are linked to the country/area's culture and vice versa: culture may also determine consumption patterns and lifestyles.Regarding the wine consumption across the studied area, we have found a negative and significant coefficient in the east and a positive coefficient in the west. This trend means that wine consumption increases from east to west, namely the presence of a gradient from east to west geographical for the spatial distribution of wine consumption. Finally, the high *rho* value indicates that the repeated observations within the countries are highly correlated and that the proportion of the total variance among the countries is very large. This means that a strong characterisation of the phenomenon examined based on the country of origin always can be found, as further confirmation of this strong spatiality of the phenomenon.

Finally, the authors underline that the phenomenon of wine consumption, as well as other factors taken into consideration in this paper, is affected by many other important variables that change over time and among countries, such as the taste of consumers conditioned by advertising campaigns, or an ever greater consumption of wine by the young people (Ferretti, 2018) and less differentiated by sex than before. In addition, the increase in migratory movements and tourist flows influence wine consumption (Aizenman and Brooks, 2008). Moreover, in some Eastern European countries, wine is not, as in the past, a niche product sold at high prices but a mass-market product (Cicia, 2013). Instead, in countries where wine was part of the cultural model and was therefore a product sold at low prices, consumption patterns are changing from daily to occasional, but with better quality. In this article, wine has been considered as a homogeneous good, while there are different categories of wines (i.e. red, white, rosé) and therefore it would be necessary to study different consumption models.

Conclusions

The paper aimed at investigating how wine consumption patterns change according to geographical area's localisation, well-being and culture approach deriving from the level of human development. For these scientific purposes, the paper investigated the relationship between wine consumption, HDI and country geographical location. Findings highlight that wine consumption decreases as HDI increases and reveal the existence of a significant gradient from west to east and among EU and non-EU countries. However, the study also shows high values of HDI and wine consumption coinciding in an EU area, specifically in France. This result confirms the "French paradox" and these phenomena can be seen to extend to the other countries such as Luxemburg and Slovenia.

Far from being exhaustive, this work shows in an original and evocative way, the crucial importance of the link between the consumption choices, health and wellbeing of a population defined by the level reached of human development. National and international strategies and policies can address consumption choices and moving consumers towards a new cultural approach in buying quality and healthy food products.

It is necessary to highlight that HDI is a very useful tool to measure the development of a country but limited at three fundamental dimensions: a long and healthy life, access to knowledge and a decent standard of living. This index has the advantage of synthesising these three dimensions, while maintaining a good share of variance of the original dataset, but the HDI being a composite indicator could be negatively affected by some factors. These might include the presence of anomalous values, the sizes of the samples, or the minimisation of the contribution of an individual indicator that does not follow the behaviour of others (OECD/EC JRC, 2008). All these limitations are naturally also reflected in the model in which the HDI is incorporated, but in this regard, it is important to mention the thought of Mahbub ul Haq, the Pakistani economist who developed HDI. Although he recognises the limits of composite indicators, focusing on their potential, he argued "for any useful policy index, some compromises must be made" (Haq, 1995).

Future research steps could better investigate the variables of the trend moving toward replacement of quality consumption with quantitative consumptions, thus better addressing the link and investigating in depth the relationship between wine consumption, socio-cultural characterisation of countries and their geopolitical communities. All of these features are not enclosed or sufficiently contained in the HDI and are still not investigated in the literature. Lastly, we considered only the countries of the WHO European region, while it could be also interesting to study the trend of consumption in newly emerging markets such as Asia. Thus, further research could study the dynamics of consumption of specific categories of wines in different geographical areas of the world and according to other relevant socio-cultural factors.

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Appendix

Table 2. Summary of the statistics of wine consumption and HDI for 45 WHO European countries from 2005 to 2015 in relation to their EU Membership and their geographical zone.

Geographical/political data			WINE				HDI			
Country	Geographical zone	Eu/not EU	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max
Albania	West	not	1.24	0.09	1.17	1.33	0.74	0.02	0.70	0.76
Armenia	East	not	0.27	0.10	0.20	0.46	0.73	0.02	0.69	0.74
Austria	West	yes	4.02	0.30	3.60	4.10	0.88	0.01	0.85	0.89
Azerbaijan	Centre	not	0.14	0.03	0.05	0.13	0.73	0.02	0.68	0.76
Belarus	East	not	0.20	0.04	0.14	0.21	0.78	0.03	0.72	0.80
Belgium	West	yes	3.93	0.24	3.97	4.20	0.88	0.01	0.87	0.90
Bosnia Herzegovina	Centre	not	0.47	0.06	0.37	0.41	0.72	0.02	0.70	0.75
Bulgaria	Centre	yes	1.78	0.16	1.95	1.96	0.77	0.01	0.75	0.79
Cyprus	Centre	yes	2.73	0.16	2.71	2.79	0.85	0.01	0.83	0.86
Czechia	Centre	yes	2.52	0.15	2.23	2.67	0.86	0.01	0.85	0.88
Denmark	West	yes	4.45	0.26	4.21	4.44	0.91	0.01	0.90	0.93
Estonia	East	yes	1.27	0.12	1.23	1.42	0.85	0.02	0.82	0.87
Finland	West	yes	1.70	0.12	1.47	1.75	0.88	0.01	0.87	0.90
France	West	yes	7.20	0.15	7.09	7.40	0.88	0.01	0.87	0.90
Georgia	East	not	3.49	0.81	2.01	3.10	0.74	0.02	0.71	0.77
Germany	West	yes	3.35	0.22	3.13	3.84	0.91	0.01	0.89	0.93
Greece	West	yes	4.30	0.70	3.08	5.35	0.86	0.01	0.85	0.87
Hungary	Centre	yes	3.52	0.55	3.41	4.50	0.82	0.01	0.80	0.84
Iceland	West	not	1.99	0.09	1.95	2.15	0.90	0.01	0.88	0.92
Ireland	West	yes	3.00	0.20	2.75	3.06	0.91	0.01	0.90	0.92
Israel	West	not	0.19	0.04	0.11	0.22	0.89	0.01	0.87	0.90
Italy	West	yes	4.74	0.26	4.61	5.03	0.87	0.01	0.86	0.89
Kazakhstan	East	not	0.36	0.04	0.38	0.43	0.77	0.02	0.75	0.79
Kyrgyzstan	East	not	0.12	0.01	0.09	0.12	0.64	0.02	0.61	0.66
Latvia	East	yes	1.11	0.09	0.94	1.24	0.82	0.01	0.81	0.83
Lithuania	East	yes	1.08	0.18	1.03	1.40	0.83	0.01	0.81	0.85
Luxembourg	Centre	yes	5.22	0.19	5.12	5.47	0.89	0.01	0.88	0.90
Malta	West	yes	2.86	0.76	2.21	2.96	0.83	0.02	0.81	0.86
Montenegro	Centre	not	2.96	1.10	0.00	2.76	0.79	0.02	0.75	0.81
Netherlands	West	yes	3.23	0.18	2.88	3.30	0.91	0.01	0.89	0.92
Norway	West	not	2.21	0.11	2.00	2.22	0.94	0.01	0.93	0.95
Poland	Centre	yes	1.03	0.19	0.89	1.20	0.83	0.02	0.80	0.86
Portugal	West	yes	7.15	0.53	6.54	7.97	0.82	0.02	0.79	0.84
Romania	Centre	yes	2.97	0.33	2.33	2.92	0.79	0.01	0.76	0.80
Russian Federation	East	not	1.02	0.15	0.87	1.03	0.78	0.02	0.75	0.80
Serbia	Centre	not	3.32	0.65	2.38	3.89	0.76	0.01	0.74	0.78
Slovakia	Centre	yes	2.18	0.35	1.56	2.61	0.83	0.02	0.79	0.85
Slovenia	Centre	yes	4.79	0.47	4.90	5.22	0.88	0.01	0.86	0.89
Spain	West	yes	2.46	0.61	1.55	3.67	0.86	0.01	0.84	0.88
Sweden	West	yes	3.27	0.23	2.90	3.42	0.90	0.01	0.89	0.91
Switzerland	West	not	4.85	0.20	4.58	5.14	0.92	0.01	0.90	0.94
Tajikistan	East	not	0.07	0.09	0.01	0.29	0.61	0.02	0.58	0.63
Turkey	Centre	not	0.10	0.03	0.06	0.13	0.73	0.03	0.69	0.77
Ukraine	East	not	0.59	0.19	0.32	0.63	0.73	0.01	0.72	0.74
Uzbekistan	East	not	0.16	0.05	0.14	0.25	0.66	0.03	0.63	0.70
Geographical division	West	-	3.46	1.85	0.11	7.97	0.88	0.05	0.70	0.95
	Centre	-	2.31	1.71	0.00	5.47	0.80	0.06	0.68	0.90
	East	-	0.75	0.73	0.01	3.10	0.74	0.08	0.58	0.87
Membership EU	not	-	1.10	1.35	0.00	5.14	0.76	0.09	0.58	0.95
	yes	-	3.31	1.72	0.89	7.97	0.86	0.04	0.75	0.93
WHO European Region			2.43	1.87	0.00	7.97	0.82	0.08	0.58	0.95

Source: own composition based on European Health Information Gateway

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Results of Hungarian field test trials set up for establishing new maximum permitted N dose values

The advancement of crop production has not yet been followed by the increase in maximum permitted nitrogen doses set out in the Hungarian Action Programme of the Nitrate Directive. According to the farmers' observations, crops grown in nitrate vulnerable zones with good agricultural conditions already have much higher nitrogen uptake than the maximum permitted values, so the genetic potential of the plants cannot be exploited at the current level. In order to prove this, in the autumn of 2017, a small-plot long-term experiment was set up in three different regions of Hungary. The results were evaluated in a complex way, based on an agronomic approach, Nitrogen Use Efficiency (NUE) and an economic approach. In terms of the agronomic evaluation, no clear differences were found between treatments: the highest yields were obtained in respect of different treatments at the three experimental sites, but the differences were not significant. From the point of view of NUE, the N_{max} experiment on the Nagyhörcsök calcareous chernozem soil showed the highest values, which, according to the EU N Expert Panel (EUNEP), are already in the unfavourable soil depletion range. From the economic point of view, there was no significant difference in net profits between the Present and New planned N_{max} values. The EUNEP approach also confirms the need to increase N_{max} values in order to decrease the potential for soil depletion. However, with a view to establishing the final optimum range for the EUNEP, it seems necessary to take into account economic considerations as well, especially regarding the financial conditions of Central and Eastern European countries.

Keywords: Nitrate Directive, agronomic approach, Nitrogen Use Efficiency, economic approach, EU N Expert Panel

JEL classification: Q10, Q24

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Introduction

In 1991, the EU introduced the Nitrates Directive, which aimed to reduce water pollution caused or induced by nitrates from agricultural sources. The Directive requires Member States to apply agricultural action programme measures throughout their whole territory or within nitrate vulnerable zones (NVZs). Action programme measures are required to promote best practice in the use and storage of fertiliser and manure (EEA, 2018). Today, after 29 years, it can be stated that the regulation has failed to achieve its goal, namely that of reducing agricultural NP loads into the environment. The reason is that Nitrates Directive focused on diminishing point-source agricultural NP loads, which are by an order of magnitude less than diffuse NP loads derived from extremely high animal densities. In the review on the NP turnover of the EU countries, according to the Hungarian approach in estimating livestock units (Hajas and Rázsó, 1969), around 75 livestock units (LU) / 100 hectares of agricultural land proved to be the optimum (Csathó and Radimszky, 2012). Effective reduction of agricultural NP loads to the environment can only achieved by drastically reducing animal densities in the countries with the highest values, in other words, having the most positive / extreme NP balances within the EU (Stanners and Bourdeau, 1995; World Bank, 2005). In parallel, livestock densities should be increased to the optimum level in the EU countries with the lowest values i.e. in the Central- and Eastern European countries, for rural development purposes (Altieri, 2012; Csathó and Radimszky, 2009, 2012).

It is important to note that the Present N_{max} values in the 59/2008 Ministry of Agriculture decree, Appendix 3, were based on national average yield levels, which were much lower than those obtained in the best farms. As a result, the maximum permissible N doses, established for average farm conditions (soil quality, farmer's financial status, etc.), are not adequate for the farmers who have the most productive soils, and who consequently possess the best financial statuses. In addition, both the area of irrigated land and crop yield averages have increased significantly since 2008.

There are several indicators which characterise the efficiency of the nutrient supply. Agronomists most commonly use Agronomic efficiency (AEN), which is defined as units increase in yield per units input. To calculate AEN, it is essential to know the yield of the unfertilised plot (without nutrient input). It is possible mainly in field trials, due to the fact that agricultural farms usually don't have fields with zero nutrient input (Tillman *et al*., 2002).

Apparent Recovery Efficiency (AREN) is one of the more complex forms of indicators, representing the difference in nutrient uptake between the fertilised and the unfertilised plot relative to the quantity of input applied (Cassman *et al*., 2002). When tracers such as ^{15}N are used, the recovery is known as True Recovery Efficiency (TREn). The Nitrogen Use Efficiency (NUE) is an easy-to-use indicator for applying agricultural (crop and animal production) and food systems to control the N balance. The mass balance using N input and N output data may be calculated as: NUE = N output / N input. It looks easy to use but determining and measuring the exact value of the components is difficult (Oenema *et al*., 2009). NUE depends on the system and its management: it increases as the N output in harvested products increases and/or the N input decreases. Conversely, NUE decreases when the N output in harvested products is relatively low and the N input relatively high (Oenema *et al*., 2016).

NUE shows what percentage of the applied N is used by plants. The value of NUE can move over a wide scale: from only about 30% until up to 80% in a well-planned plot experiment. Besides fertiliser rate and timing factors, tillage, soil management, and environmental conditions can further influence the level of efficiency (Cassman *et al*., 2002). NUE indicators provide a measure for the amount of N that is retained in crop or animal products, relative to the amount of N applied or supplied. N surplus is an indicator for the N pressure of the farm on the wider environment; it also depends on the pathway through which surplus N is lost, either as NH_3 volatilization, NO_3 leaching and/or nitrification/denitrification. Management has a large effect on both NUE and N surplus (Tamminga, 1996; Mosier *et al*., 2004).

The basis of the economic evaluation was the data of the European Farm Accountancy Data Network (FADN) system maintained by the Agricultural Research Institute. The (FADN) provides detailed financial economic information at farm level on more than 80,000 farms in Europe. The data is collected in a systematic way on an annual basis and the information collected for each sample farm contains more than 1,000 variables. FADN contains harmonised farm-level data across Europe: the data elements to be provided to the European Commission (EC) and bookkeeping principles (such as depreciation) are the same in all countries. The data to be uploaded and the exact definition of each data element are defined in the FADN Farm Return (Vrolijk *et al*., 2016).

Data collection extends to individual enterprises and joint ventures, which is justified because there are significant differences between the two categories in respect of almost all factors. Values also vary widely, depending on whether the national average or the average of the farms that determine sales are taken into consideration.

In autumn 2017, a new programme was started in Hungary which aimed to prove that maximum permissible N kg/ha doses for Hungarian arable crops are much lower than the N doses necessary for achieving high crop yield levels in the best farms. The first year results obtained in the three small plot field trials set up in characteristic Hungarian soil types are presented in this paper. Besides the agronomic approach, the NUE as well as the economic approach are shown in the paper.

Methodology

Agronomic evaluation

Soil properties of the three experimental sites are shown in Table 1. From the point of views of soil texture, reaction status, organic matter content, as well as available soil nutrient contents, the three sites show characteristic differences. Experimental soils represent the most widespread soil types of Hungary, only brown forest soils missing.

Expected yield levels as well as plant densities were adjusted to the soil and climatic conditions. Prior setting up the field trials, 5 kg/ha Zn was applied, while 2 t/ha $CaCO_3$ only in the Karcag site with low pH (Table 1).

Table 1: Soil properties and agronomic characteristics of the experimental sites.

	Experimental site		
Parameters	**Nagyhörcsök**	**Őrbottyán**	**Karcag**
	Soil properties		
Soil type	calcareous chernozem	humuseous sandy	meadow chernozem
K_A	38 (loam)	26 (sand)	47 (clay loam)
$CaCO_3$ [%]	3.3	0.4	0
pH_{KCl}	7.3	7.2	5
Humus %	2.95 (m)	1.20 (p)	3.14 (m)
AL-P_2O_5 [mg/kg]	59 (p)	82 (m)	106 (g)
AL-K_2O [mg/kg]	146 (m)	70 (p)	353 (vg)
KCl-Mg [mg/kg]	177 (g)	120 (g)	512 (g)
EDTA-Zn [mg/kg]	0.9 (p)	1.4 (m)	1.6 (m)
EDTA-Cu [mg/kg]	2.0 (g)	1.7 (g)	5.7 (g)
EDTA-Mn [mg/kg]	138 (g)	194 (g)	544 (g)
	Agronomic features		
Precrop	winter wheat	fallow	canary grass
Precrop yield [t/ha]	3.5	-	2.1
Fate of by-product	incorporated	-	incorporated
Crop	corn (grain)	corn (grain)	corn (grain)
Expected yield [t/ha]	14	10	12
Cultivar / hybrid	Pioneer 37N01	Pioneer 37N01	Pioneer 37N01
Plant density [1,000/ha]	80	60	70
Zn application [kg/ha]	5	5	5
Liming [kg/ha]	-	-	2 000

Nutrient supply categories: p = poor; m = medium; g = good; vg = very good.
Source: own composition.

The field trials were set up with 8 treatments, in 3 replications, in randomised block design, where the size of plots were 10x10 m (100 m^2). Treatments were as follows:

- Treatment 1.) Pro Planta (PP) NPK doses, as recommended by the economic and environmentally friendly advisory Pro Planta system, level 2 (Csathó *et al*., 2007);
- Treatment 2.) N: Present N_{max} value (59/2008. MA Decree, Appendix 3), PK: PP recommendation, level 4 (Csathó *et al*., 2007);
- Treatment 3.) N: New planned N_{max} level (KITE, 2016), PK: PP recommendation, level 4 (Csathó *et al*., 2007);
- Treatment 4.) MÉM NAK intensive recommendation. From treatments 5 to 8, the treatments of the classical NPK demand trial;
- Treatment 5.) PK;
- Treatment 6.) NK;
- Treatment 7.) NP;
- Treatment 8.) NPK.

The N-P_2O_5-K_2O kg/ha doses applied in the field trials can be found in Table 3.

Expected yield levels were estimated so that to explore the genetic potential of the maize hybrids. When optimum plant densities were determined, special soil and climatic conditions were taken into account. Adequate plant density is a prerequisite for obtaining high yields. When expected yield levels were estimated, optimum weather conditions were taken for granted. Obviously, this factor is the bottleneck among all the factors. There was no irrigation in the small plot field trials; therefore, under our continental climate, in breeding season all type of years (average, advantageous and disadvantageous) can occur, determining actual maize yields to an extent above all the other factors. With this approach, under disadvantageous weather conditions for maize production, there is a risk that there will be high difference between expected and obtained yield levels, affecting both NUE and economic evaluations.

Although in Nagyhörcsök and Karcag, the by-product of the precrop was incorporated to the soil, there were no extra N doses applied for counterbalancing the disadvantageously high C to N ratio of the by-product. It was taken for granted that the N doses calculated for high expected yield levels were high enough for providing extra N for cellulose decomposing soil microorganisms.

Meteorology data

The climate of the three experimental areas can be characterised as follows.

Nagyhörcsök: The average annual temperature is 10.1-10.3 °C, the summer half-year 17.0 °C. The annual precipitation is 570-600 mm. Precipitation during the vegetation period is 320-340 mm. The aridity index is 1.17-1.22.

Őrbottyán: Average annual temperature is 10.0-10.2 °C. The annual precipitation is 560-580 mm, of which 320-330 mm falls during the vegetation period. The aridity index is 1.20-1.25.

Karcag: The average annual temperature is 10.2-10.4 °C, the average temperature during the vegetation period is 17.4-17.6 °C. The annual precipitation is 490-510 mm and the precipitation during the vegetation period is around 300 mm. This is the driest region in the country. The aridity index is around 1.40.

NUE evaluation

Besides the agronomic approach, the three N_{max} small plot field trials were evaluated by the EU N Expert Panel (EUNEP) approach as well (Oenema *et al.*, 2016). It is well known that both the input and output blocks of the EUNEP approach were elaborated for the farm-gate system. Only N inputs entering farm-gate and N outputs leaving farm-gate are taken into consideration in this approach. Differences between N inputs and outputs are equal to the farm-gate N balance.

Obviously, only surface N balances can be calculated in the three N_{max} small plot field trials evaluated in this paper. The input side of the surface N balance approach is the amount of N (kg/ha) applied to the field or the plot. So as to adjust the surface N balance methodology to the farm-gate N balance approach, only the N content of harvested yield removed from the field was taken into account in the output side of the surface N balance approach.

According to the Hungarian Action Programme (59/2008 MA Decree, Appendix 4) standard, the specific N content of maize (N content of one tonne maize grain plus the N content of the stalk belonging to the one tonne maize grain) is 25 kg N/t. If we count only the amount of N removed by the grain yield, approximately 20 kg N/t maize grain should appear on the output side together with grain yields (t/ha). At the other end, according to EUNEP approach, within the input side, besides fertiliser N, entering farm-gate, wet and dry N deposition, as well as seed N content are also taken into account. In order to fit the surface N balance methodology to EUNEP approach, we considered that wet and dry N deposition plus maize seed N content comprise the input side, as extra N input amount is counterbalanced on the output side by increasing the 20 kg N/t specific N content (grain only), to 25 kg N/t specific N content of maize (grain plus stalk).

From the point of view of intensity, Hungarian farmers running their farms on high yield potential soils, with favourable agro-ecological as well as economic conditions can be comparable to some Western European farmers. As a consequence, besides the agronomic approach, the small plot and farm level N_{max} field trials, set up on characteristic Hungarian soils, must undergo the evaluation using the EUNEP approach as well. The principle of the model used in the EUNEP can be seen in Figure 1.

When determining NUE, using the EUNEP approach, adopted to single field units, only the ratio of and difference between crop N uptake (as outcome side) and applied N (as input side) are taken into account. According to this approach, soil N supplying capacity is not taken into consideration neither in determining NUE, nor in establishing maximum permitted N doses. According to this approach, when the ratio of crop N uptake versus applied N is between

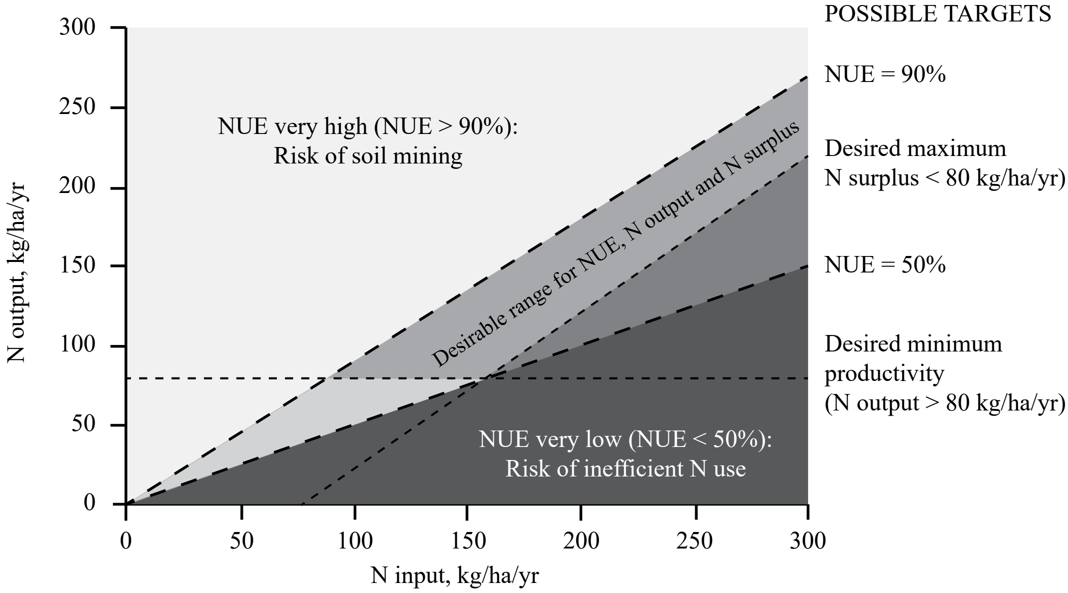

Figure 1: The principle and optimum interval of the required Nitrogen Use Efficiency (NUE), elaborated by the EU N Expert Panel
Source: Oenema *et al.* (2016)

0.5 and 0.9 (50 to 90%), crop N fertiliser practice is accepted as sound. Whenever this indicator comes close to or exceeds 90%, the risk of soil N depletion, while reaching or exceeding 50%, the risk of wasteful, uneconomic N fertilising practice with enhanced pollution of the environment increases. The optimum interval is considered to be between 0.8 and 0.9 (80 to 90%). Namely, N input must exceed crop N uptake by 10 to 20%. With this approach, N balances up to +80 kg/ha are stated as sustainable ones. According to the model elaborated by the EU N Expert Panel, the minimum N use intensity requirement is at least 80 kg/ha/yr N application for meeting crop N demands adequately.

As already mentioned, in this approach, the volume of both N inputs and N outputs are taken into account (Oenema *et al.*, 2016). As a comparison, of the 50 thousand parcels / fields (1.3 million hectares) of the Hungarian Nitrates Database, according to the year 2016 evaluation, 40% failed to satisfy this requirement, i.e. in 40% of the parcels there was less than 80 kg/ha N applied as N input. This indicates, from the point of view of agricultural N loads, the endangered areas are not in the Eastern- and Central European countries, but, rather, in the Western European ones (MTA ATK TAKI, 2018).

Economic evaluation

An important aspect of the evaluation of the experiments was that the effects of the increased doses of fertilisers were not only evaluated on the basis of their agronomic and efficiency aspects, but also in terms of their economic impact. To do this, we needed the main economic indicators of Hungarian maize production for 2018, which were provided by the Research Institute of Agricultural Economics. The data included the selling price and the yield, which were used to determine the average production value per hectare. In terms of costs, direct variable costs and total production costs were itemised. This was used to determine the total cost of maize production per hectare of the national average without fertilisation. To this, we added the cost of fertiliser per hectare to the treatments of the experiment, so we got the total cost of production. By multiplying the yields and the sales price the production value can be determined and the financial result can be calculated for each experimental treatment. The cost were determined in Hungarian Forint and Euro. The cost in EUR were calculate on this exchange rate: 1 EUR = 323.2 HUF (time period between September and December, 2018)

Results

Agronomic evaluation

The small plot field trials were first evaluated with the classical agronomic / agrochemical approach, where soil N supply is taken into consideration. In this approach, crop N demand is provided partly by soil N supply, and, only the missing part, by mineral fertiliser and/or manure. The amount of N provided by soil N supply is estimated by soil N test method calibrated in long-term field trials. In Hungary, soil organic matter content (SOM) is used as soil N test method. The small plot N trials were set up in the three sites with different agro-ecological conditions, and soil N supplies (Table 1).

A) Nagyhörcsök, calcareous chernozem soil

The most intensive maize field trial was conducted in this site with a fertile soil with good water regime and high yield capacities. Crop density (80,000 plants/ha) and expected yield level (14.0 t/ha) was the highest in this trial, as compared to the other two trials. Meteorological conditions in 2017/2018 were favourable for maize production, verified by the 12.1 t/ha grain yield obtained in the average of the trial (Table 2).

On average, maize grain yield was 12.0 t/ha, which, although high, yet 2.0 t/ha less than the expected yield level.

Table 2: Agronomic evaluation in field trials.

Treatment	N_{max} 1 field trial Calcareous chernozem, Nagyhörcsök (NH)				N_{max} 2 field trial Humuseous sandy soil, Őrbottyán (ŐB)				N_{max} 3 field trial Meadow chernozem, Karcag (KA)			
	N	P_2O_5	K_2O	Grain yield	N	P_2O_5	K_2O	Grain yield	N	P_2O_5	K_2O	Grain yield
	kg/ha			t/ha	kg/ha			t/ha	kg/ha			t/ha
PP 2	186	90	135	12.20	175	63	135	7.80	178	0	0	8.61
Present N_{max}	170	106	170	12.51	150	77	168	7.23	160	55	68	8.18
Planned new N_{max}	210	106	170	12.39	180	77	168	6.90	190	55	68	9.47
MÉM NAK	280	280	336	13.60	260	160	280	7.16	240	132	216	9.17
PK	0	100	200	10.80	0	100	200	5.89	0	100	200	7.18
NK	210	0	200	10.82	180	0	200	7.45	190	0	200	8.48
NP	210	100	0	12.29	180	100	0	7.24	190	100	0	8.96
NPK	210	100	200	11.99	180	100	200	7.71	190	100	200	8.56
LSD 5%	-	-	-	1.57	-	-	-	1.74	-	-	-	1.29
Mean	**185**	**110**	**176**	**12.08**	**163**	**85**	**169**	**7.17**	**167**	**68**	**119**	**8.58**

Nagyhörcsök, Őrbottyán, Karcag: 5.0 kg/ha Zn; Karcag: 2,000 kg/ha $CaCO_3$.
Source: own composition

In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), response to N fertilisation was 1.2 t/ha, to P, 1.2 t/ha, and, to K, 0.0 t/ha. Responses to N, P and K fertilisation – except for K– proved the soil NPK supply categories elaborated in the Pro Planta (PP) system to be sound.

In the four recommendation treatments (Treatments 1 to 4), which were elaborated by different advisory systems and approaches, there was no difference in the grain yields of the first three treatments (PP level 2; Present N_{max} value; New planned N_{max} value). The grain yield in the MÉM NAK intensive recommendation treatment was, however, 1.1 to 1.4 t/ha higher than in Treatments 1 to 3. The reason for that might partly be the enhanced PK doses, which were applied to this soil with poor-medium P supplies (Table 2).

It is important to remark that intensive MÉM NAK doses did not result in any yield surpluses over Treatments 1 to 3, neither on the Karcag meadow chernozem soil with good to very good soil PK supplies, nor in the Őrbottyán humuseous sandy soil with poor to medium PK soil supplies (Table 2). In practical terms, there was no difference between the yields of the treatments of the Present N_{max} values (170 kg/ha N) and the New planned N_{max} values (210 kg/ha N) (Table 2). It is also important to mention that, having the first year of the planned four-year field trial, LSD 5% values were higher than usual, and most of the differences among the treatments were not significant.

B) Őrbottyán, humuseous sandy soil

The less intensive maize field trial was conducted in this site with low clay content, low natural NPK pools, low NPK supplying capacity and a disadvantageous water regime. Crop density (60,000 plants/ha) and expected yield level (10.0 t/ha) was the lowest in this trial, as compared to the other two trials. Meteorological conditions in 2017/2018 were favourable for maize production, and grain yields obtained in the average of the trial (7.2 t/ha) was remarkable for a sandy soil with low soil NPK supplying and water holding capacities (Table 2).

This 7.0 t/ha average yield, however, was 3.0 t/ha less, than expected yield level was. This fact draws the attention to the importance of determining proper expected yield levels. Even in the field trials, either small plot trials, or farm level field trials, aiming to set new, higher planned N_{max} values than the present one (KITE, 2016; 59/2008 AM Decree). Net income can diminish if advised NPK doses – affected by both soil NPK supplies and expected yield levels – are above the optimum.

In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), response to N fertilisation was 1.8 t/ha, to P, 0.3 t/ha, and, to K, 0.5 t/ha. Among the three field trials, soil N and K supplies were the lowest in this trial, and, as a result, responses to N and K fertilisation, the highest ones. Responses to N, P and K fertilisation proved the soil NPK supply categories elaborated in the Pro Planta (PP) system to be sound.

In the four recommendation treatments (Treatments 1 to 4), elaborated by different advisory systems and approaches, the effect of soil heterogeneity common in sandy soils could also have an effect on the yields. Maize grain yields varied between 6.9 and 7.8 t/ha, practically independently from NPK doses (Table 2). Compared to the yield in Present N_{max} treatment (150 kg/ha N), there was no yield surplus on the New planned N_{max} treatment (180 kg/ha N) (Table 2).

C) Karcag, meadow chernozem soil

The Karcag field trial was in the middle of the three trials in respect of intensity of crop production. Medium crop density (70,000 plants/ha) and expected yield level (12.0 t/ha) were introduced in this trial.

On average, the maize grain yield was around 9.0 t/ha, i.e., 3.0 t/ha less than the expected yield level. Expected yield levels in all the three sites should be adjusted the really accessible yield levels, both for economic and environmental protection purposes. Meteorological conditions in 2017/2018 were more or less favourable for maize production: average grain yield was 8.6 t/ha (Table 2). Due to a summer windstorm, however, a maize stand was lodged. Harvested grain yields could also have been affected by that.

In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), response to N fertilisation was 1.4 t/ha, to P 0.1 t/ha, and, to K, 0.0 t/ha. Responses to N, P and K fertilisation proved the soil NPK supply categories elaborated in the Pro Planta (PP) system to be sound. In the four recommendation treatments (Treatments 1 to 4), elaborated by different advisory systems and approaches, the effect of summer windstorm and lodging could have an effect on the yields. Maize grain yields varied between 8.2 and 9.8 t/ha, practically independently from NPK doses (Table 2).

Comparing the grain yields of the New planned N_{max} value treatments (190 kg/ha N) to the Present N_{max} value (160 kg/ha N), there was a 1.3 t/ha surplus, which cannot be explained by the effect of the extra 30 kg/ha N application, but, rather, by the differences in the lodged maize stand. Due to the fact that the Karcag meadow soil with clay loam soil texture has a water holding capacity above the optimum, a temporary water stand can also affect maize grain yields (Table 2).

As a summary, it can be stated that there was practically no difference between the maize grain yields of the Present and the New planned N_{max} value treatments in two of the three sites (Nagyhörcsök and Őrbottyán). Further research is needed to demonstrate the real differences between the Present and the New planned N_{max} values in Karcag meadow soil (Table 2). Responses to N, P and K fertilisation proved that the soil NPK supply categories elaborated in the Pro Planta (PP) system were sound.

The differences between expected and real yield levels draw the attention to the importance of determining proper expected yield levels. Expected yield levels should be adjusted the really accessible yield levels, both for economic and environmental protection purposes. In the average of the three sites, the response to N application was 1.4 t/ha, to P-, 0.5 t/ha and to K-, 0.0 t/ha. Amongst the recommendation treatments, the highest average yield was obtained at the MÉM NAK advice. Average yields in the other three treatments were more as the same.

Evaluation of the NUE

In case the soil N supplying capacity is not taken into consideration when estimating N fertiliser use efficiency, Nitrogen Use Efficiency (NUE) is determined by the ratio between N uptake or output and N applied or input. According to the EU N Expert Panel (EUNEP) approach, which does not take into account soil N supplying capacity, the optimum range is within 80 kg/ha N balance surpluses and 90% efficiencies. Higher N balance values result in enhanced risk of environmental pollution. On the other hand, higher efficiency values can lead to soil N depletion, according to the EUNEP approach.

A) Nagyhörcsök, calcareous chernozem soil

In all the treatments, NUE reached higher than 100% efficiency (1.21 to 1.84), i.e. crop N uptake surpassed the amount of N applied. As a result, according to the EUNEP approach, among the three sites, this site showed the most unfavourable, the most soil N depleting NUE and N balance values (Table 3). In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), there was lower NUE value than in the four recommendation treatments (Treatments 1 to 4). The only exception was the intensive MÉM NAK treatment, in which the lowest NUE value was obtained all over the trial, but, still, far above the optimum interval (see Figure 1). According to the EUNEP approach, this treatment is considered to be the least soil N depleting one. Comparing the Present N_{max} to the New planned N_{max} treatments, the former one is higher, which, from the point of view of the EUNEP approach, is more disadvantageous (Table 3). It is important to mention that in the year of 2017/2018 weather conditions were favourable for maize production, with 10.8 to 12.3 t/ha maize grain yields achieved (Table 2).

B) Őrbottyán, humuseous sandy soil

Of the three experimental sites, according to the EUNEP approach, the Őrbottyán trial, set up on a humuseous sandy soil, showed the best NUE values, as well as N balance values (Table 3). In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), NUE values varied between 1.01 and 1.07. In the four recommendation treatments (Treatments 1 to 4) NUE values were between 0.69 and 1.21, with highest (most unfavourable) values in the Present N_{max} (2.) treatment. According to the EUNEP approach NUE evalua-

Table 3: NUE evaluation in field trials.

Treatment	Nmax 1 field trial Calcareous chernozem, Nagyhörcsök (NH)				Nmax 2 field trial Humuseous sandy soil, Őrbottyán (ŐB)				Nmax 3 field trial Meadow chernozem, Karcag (KA)			
	N input	N output	N input-N output	N output/N input	N input	N output	N input-N output	N output/N input	N input	N output	N input-N output	N output/N input
	kg/ha				kg/ha				kg/ha			
PP 2	186	305	-119	1.64	175	195	-20	1.11	178	215	-37	1.21
Present N_{max}	170	313	-143	1.84	150	181	-31	1.21	160	205	-45	1.28
Planned new N_{max}	210	310	-100	1.48	180	173	8	0.96	190	237	-47	1.25
MÉM NAK	280	340	-60	1.21	260	179	81	0.69	240	229	11	0.96
PK	0	270	-270	-	0	147	-147	-	0	180	-180	-
NK	210	271	-61	1.29	180	186	-6	1.03	190	212	-22	1.12
NP	210	307	-97	1.46	180	181	-1	1.01	190	224	-34	1.18
NPK	210	300	-90	1.43	180	193	-13	1.07	190	214	-24	1.13
Mean	**185**	**302**	**-118**	**1.48**	**163**	**179**	**-16**	**1.01**	**167**	**215**	**-47**	**1.16**

Source: own composition

tion, MÉM NAK treatment, with its 0.69 NUE value, and 81 kg/ha N balance, was situated below the optimum interval (Figure 1), and proved to less economic, as well as potentially polluting the environment (Table 3). It is important to mention that in the year of 2017/2018 weather conditions were favourable for maize production, with 7.2 to 7.7 t/ha maize grain yields achieved (Table 2).

The low NUE values were obtained due to the fact that expected yield levels were unrealistically high. The results in the Őrbottyán trial reveal that farmers, running their farms on fields with unfavourable soil properties and low natural soil fertility, should pay attention to their planned yield levels, as well as suggested N doses so that they would beset more realistically. In addition to this, the results verify that even with this being the case, there is no risk that the ratio between N output an N input should fall below the unfavourable level of 50% (Table 3).

C) Karcag, meadow chernozem

The N_{max} trial results set up in Karcag, on a meadow chernozem soil, were situated in between the other two experiments, however, showing more similar NUE and N balance values to the Őrbottyán trial, according to the EUNEP approach (Table 3). In the classical N-, P- and K- demand part of the trial (Treatments 5 to 8), in the treatments with N application, NUE values varied between 1.12 and 1.18, which, according to the EUNEP approach, is slightly soil N depleting. In the four recommendation treatments (Treatments 1 to 4) NUE values were between 0.96 and 1.21. In the Present N_{max} (2.) and New planned N_{max} (3.) treatments, NUE values were practically the same (varying between 1.28 and 1.25) (Table 3). It is important to mention that in the year of 2017/2018 weather conditions were favourable for maize production, with 8.5 to 9.0 t/ha maize grain yields (Table 2).

Economic evaluation

Before starting the evaluation, it is important to note that fertiliser doses in the experiments – and therefore the costs – were significantly above the national average. While the latter cost around 41,000 HUF (€120), the fertilisation cost of each treatment was several times higher, in some cases exceeding 200,000 HUF (€600). The MÉM NAK treatment was the most expensive in all cases. This system was developed decades ago at a time of low fertiliser prices and in many cases is based on the principle of soil fertilisation, leading to good, very good soil PK supplies. Due to the high expected yield levels, fertiliser doses exceeded the national average in all the other treatments as well. As a result, the cost of fertilisation in the experiment has become dominant within the total cost of production, something which is not true regarding the national situation. Because the purpose of the experiment was to investigate the effects of the highest fertiliser doses, we assume this change was justified and does not diminish the relevance of the evaluation.

Comparison of treatments

It can be seen that the doses recommended by the MÉM NAK system are far higher than in all the other treatments, and that as a result, the fertilisation costs are the highest. The value of the extra yield due to the excess fertiliser applied is far outweighed by the cost increase, and therefore the lowest net profit was achieved in this treatment at all the three sites (Table 4).

Comparing the Present and New planned N_{max} treatment, no significant difference can be detected in the average of the three sites. On the best and the least favourable production classes, the net profit was higher in the Present N_{max} treatments, however, on the production class in Karcag which has medium attributes, the New planned N_{max} treatment significantly increased profitability. This is due to the remarkable increase in yields at this site due to the higher nitrogen dose, which is not the case in the other two sites (Table 4).

From an economic point of view, PP 2 was clearly the most effective treatment. This is due to the fact that, even with low fertiliser input, that there was no noticeable reduction in yields, moreover, on sandy soil this treatment provided the best yield. All this confirms that the fertiliser doses recommended by the Pro Planta advisory system, based on the scientific evaluation of long-term experimental results,

Table 4: Economic evaluation of the field trials.

Treatment	N_{max} 1 field trial Calcareous chernozem, Nagyhörcsök (NH)				N_{max} 2 field trial Humuseous sandy soil, Őrbottyán (ŐB)				N_{max} 3 field trial Meadow chernozem, Karcag (KA)			
	Fertiliser cost	Total input cost	Production value	Net profit Ft/ha	Fertiliser cost	Total input cost	Production value	Net profit Ft/ha	Fertiliser cost	Total input cost	Production value	Net profit Ft/ha
	Ft/ha				Ft/ha				Ft/ha			
PP 2	140,856	392,758	551,968	159,210	123,085	374,987	352,898	-22,089	62,544	314,446	389,545	75,099
Present N_{max}	151,032	402,934	565,993	163,060	128,636	380,538	327,109	-53,429	99,228	351,130	370,090	18,960
Planned new N_{max}	165,087	416,988	560,564	143,576	139,177	391,079	312,179	-78,900	109,769	361,671	428,454	66,782
MÉM NAK	315,141	567,043	615,309	48,265	234,217	486,119	323,942	-162,177	198,950	450,852	414,881	-35,972
PK	94,686	346,588	488,627	142,040	94,686	346,588	266,483	-80,105	94,686	346,588	324,847	-21,741
NK	116,968	368,870	489,532	120,663	106,427	358,329	337,062	-21,266	109,940	361,842	383,663	21,821
NP	125,293	377,195	556,040	178,845	114,752	366,654	327,561	-39,093	118,266	370,168	405,380	35,212
NPK	168,473	420,375	542,467	122,092	157,932	409,834	348,826	-61,008	161,446	413,348	387,282	-26,065
Mean	**159,692**	**411,594**	**546,313**	**134,719**	**137,364**	**389,266**	**324,507**	**-64,758**	**119,354**	**371,256**	**388,018**	**16,762**

Source: own composition

are both environmentally friendly and economically efficient (Csathó *et al*., 2007; Németh, 2006) (Table 4).

The treatments in the classical N-, P- and K- demand part of the trial (Treatments 5 to 8) varied significantly in terms of profitability. Nitrogen application resulted in higher surpluses, and in its absence the most significant yield reduction occurred. This was not the case with potassium and phosphorus. Potassium had the lowest effect, and its absence did not cause any yield decreases in Nagyhörcsök and Karcag, but it did in the sandy soil with low K supplying capacity. The effect of phosphorus was placed between the other two nutrients from an economic point of view (Table 4).

The planned yield levels were not achieved in the treatments at any of the soil productivity sites. The biggest deficit was in Őrbottyán; furthermore, significant differences in profitability are observable between the three soil productivity sites. In all the treatments in Őrbottyán (sandy soils) negative net profits were obtained, which clearly indicates that the planned yield levels are unrealistic at this site. On the other hand, in Nagyhörcsök, with the highest yields, in all treatments significant net profits were obtained, with the highest value observed in the Present N_{max} treatment. The net profit in the PP 2 treatment is slightly less than that. At the Karcag site, PP 2 treatment was the most favourable, even ahead of the New planned N_{max} plots. Only the plots fertilised with the dose of MÉM NAK were loss-making at this site (Table 4).

If we examine the results of treatments on the average of the three sites, it can be concluded that the highest net profit can be achieved in the PP 2 treatment. Its value exceeds that of the New planned N_{max} treatment by 60% (about 30,000 HUF/ha or €90 /ha). Comparing the Present and the New planned N_{max} values, there is no significant difference, the profitability was more favourable at two production sites with the application of the existing values and at one production site with the planned values (Table 4).

Discussion

As the European Union does not compensate for crop and income losses due to restrictions in Annex 3 of FVM (MARD) Decree No. 59/2008., efforts have been made to establish scientifically based New planned N_{max} values so that agronomically justified N quantities can be applied without restriction to farms with higher yields in better soil potential areas. The N_{max} experiments conducted on typical Hungarian soils provide an opportunity to evaluate the impact of each soil and treatment in terms of a complex agronomic, Nitrogen Use Efficiency (NUE) and economical approach.

As a by-product of adopting an approach involving three different evaluations, various optimums were found at the experimental sites and treatments. The most significant differences were found between the optimum of the EU Expert Panel approach (NUE) and the economic approach (Figure 2).

Nevertheless, we consider it desirable and essential that the optimum interval of the new NUE approach should also take into account economic considerations, with particular attention to the much less favourable economic conditions faced by farmers in Central and Eastern European countries as compared to their counterparts in Western European countries. Economic considerations can prevail when, while determining the N needs of the cultivated plants, we take the N supply of soils into account. This modification is especially significant on soil characterised by loam to clay soil texture and deep and humus rich soil “A” horizon. The findings of the Hungarian long-term nitrogen fertilisation experiments

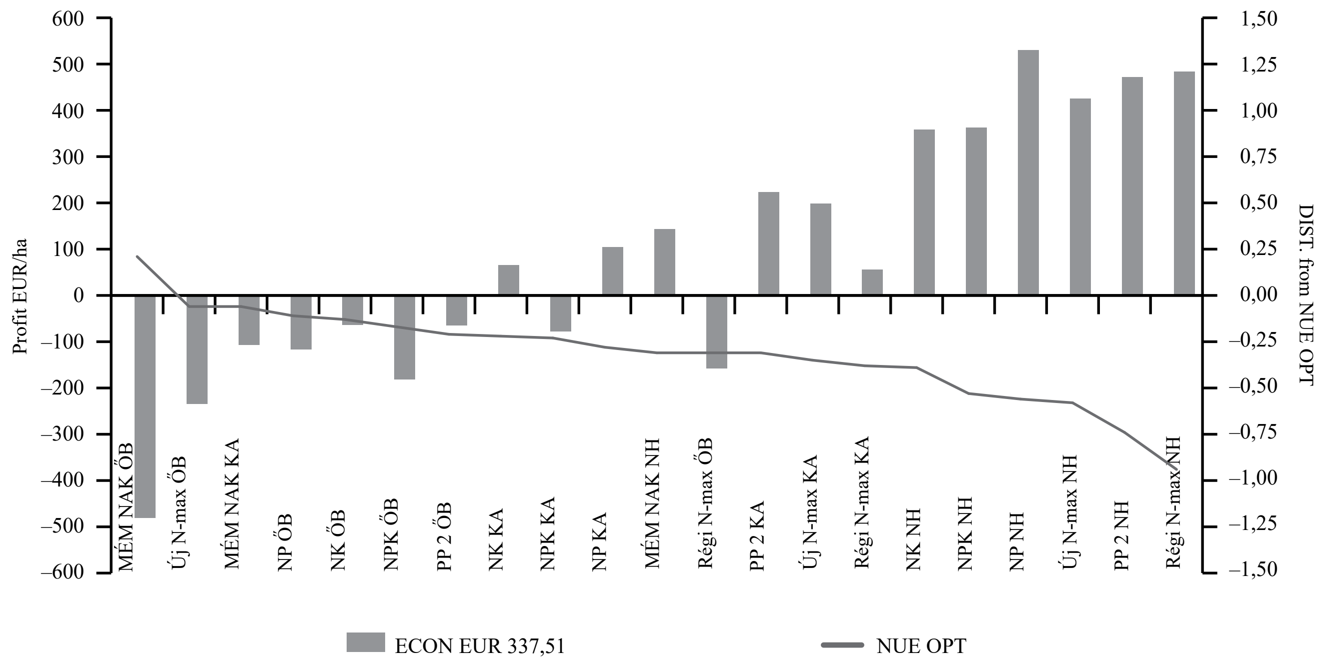

Figure 2: Correlation between the profit and the distance from the NUE optimum.

Columns: Net profits, line: Distance from the NUE optimum, i.e. NUE optimum minus actual NUE value.

Source: own composition.

Table 5: The New planned N_{max} values for maize.

Soil productivity class	Maize		
	weak	medium	good
	N service capacity		
I. Chernozem soils	230 [190]	210 [170]	180 [150]
II. Brown forest soils	230 [190]	190 [160]	180 [150]
III. Meadow soils	220 [180]	190 [160]	170 [140]
IV. Sandy soils	180 [150]	160 [130]	150 [120]

230: New planned Nmax value (kg/ha); [190]: Present Nmax value (kg/ha)
Source: own composition

confirmed that taking into account the nitrogen supplying capacity of the soils resulted high accessible yield levels and provided good net profit, while no decrease of soil organic matter content, or enhanced nitrate leaching was occurred.

As a result, and due to the compulsion to comply with the proposed NUE more intensive N farming requirements, it is an urgent task to develop and pass into law new and higher N_{max} values for the main arable crops. A possible example for the New planned N_{max} values can be seen in the next table (Table 5) for maize. When elaborating of the Present and the New planned N_{max} values, the natural N supplying capacity of the soils were taken into account, therefore they meet the economic requirements as well.

As a result, and due to the compulsion to comply with the proposed NUE more intensive N farming requirements, it is an urgent task to develop and pass into law new and higher N_{max} values for the main arable crops. A possible example for the New planned N_{max} values can be seen in the next table (Table 5) for maize. When elaborating of the Present and the New planned N_{max} values, the natural N supplying capacity of the soils were taken into account, therefore they meet the economic requirements as well.

Finally, it is important to highlight the need to continue the experiments in order to reduce the year effect and to refine the recommended values.

Acknowledgments

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Compiling C/N and total-N dataset to support countrywide soil nutrient emission models for Hungary

Soil carbon/nitrogen (C/N) ratios can provide essential information on soil health such as nitrogen limitations for plants or soil microorganisms. Determining soil C/N ratios can be challenging for larger geographic units such as for catchments, as nitrogen heterogeneity depends on several factors like land use, soil types, vegetation cover or seasonality. This paper investigates C/N ratio changes at different levels for diverse land management and land uses at plot-, catchment-, and country scale. For the plot- and catchment scale the study also presents data on seasonal variabilities of C/N ratio. For the countrywide evaluation, a digital soil mapping method was applied. Substantial differences were noted in total nitrogen amounts for arable lands, where the 'no till' system had up to 54.7% higher TN compared with ploughing. Catchment based monitoring showed the highest fluctuations for TN in the case of forest soils, while C/N ratios were relatively stable over the course of different seasons for the diverse land uses. Comparison of the topsoil C to N ratios in the European LUCAS and national SIM datasets shows that the difference in expected values is considerable (consecutively 10.35 and 7.41). The discrepancy can be explained partly due to different thematic representativity for land use and partly because of differences in analytical methodology. In addition, samples were taken almost twenty years apart. Overall, our study highlights the significance of land use, land management systems, spatial heterogeneity, time of samples collections, and the inconsistencies between different sampling and measurement methods.

Keywords: C to N ratio in soils, emission modelling, countrywide map

JEL classifications: Q10, Q24

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Introduction

Soil nitrogen (N) and carbon (C) ratio can provide essential information on soil health such as nitrogen limitation for plants or soil microorganisms. Determining soil C/N ratios can be challenging for larger geographic units such as for catchments, as nitrogen heterogeneity depends on several factors like land use, soil types, vegetation cover or seasonality. This paper investigates C/N ratio changes at different levels for diverse land management and land uses at plot-, catchment-, and country scale in Hungary. For the plot- and catchment scale the study also presents data on seasonal variabilities in C/N ratio. For the countrywide evaluation, a digital soil mapping method was applied.

The paper contributes to the existing literature by providing a dataset for supporting national soil nutrient emission modelling. The paper is structured as follows. Section 2 provides a review of the academic literature on the topic, followed by a demonstration of the methodology. Section 4 describes our results, followed by a discussion and conclusions.

Literature Review

C/N ratio is considered as an indicator determining the decomposability of soil organic matter, while the nitrogen (N) is a key component of nutrient cycling. Nitrogen is one of the main nutrients responsible for balanced crop production as well as the quality and quantity of the crop yield. Part of the N not used by the plants can pollute the environment in different ways. During nitrate (NO_3^-) leaching or surface runoff the portion of N can reach the groundwater and can enter the aquatic systems, resulting eutrophication. Another pathway of N loss is the N_2O emission or NH_3 volatilization (Zheng *et al.*, 2019). The agricultural sector is one of the main sources of groundwater nitrate pollution and atmospheric N_2O content increase (Van der Voet *et al.*, 1996).

The C/N ratio of soil represents the amount of total nitrogen (TN) per unit total carbon (TC) content of soil. It is considered an indicator determining the mineralisation, immobilisation and nitrification rate in the soil (Bengtsson *et al.*, 2003). From the C/N ratio value, the decomposition state of the soil organic matter can be estimated (Zhao *et al.*, 2015). In general, ratios above 25 indicate slow rates of decomposition, whereas ratios below 25 represent increasingly faster rates of organic matter decomposition (Blume *et al.*, 2010). It is also a good index from which to obtain information about soil fertility, since there is a strong interrelationship between soil organic carbon and total nitrogen content (TN) (Bogunovic *et al.*, 2018). TN content in soils is also a useful indicator to get information about soil nutrient status at a given time. The C/N ratio can be higher than 25 in peats, where organic matter accumulation occurs. However, it is usually between 10 and 12 in managed, arable soils under temperate climate. Lower rates generally occur in deeper soil layers (Bui *et al.*, 2013). The C/N ratio gives important information about the amount of nitrogen potentially available to the plants from the soil. Any change in the C/N ratio will have a profound effect on both the nitrogen cycle in the area and the structure and composition of the soil microbial community (Horel *et al.*, 2018a,b). Soil microbial communities show average ratios of 8, green cuttings and clippings between 7 and 15, decaying organic matter around 20 and raw humus between 25 and 40 (Blume *et al.*, 2010).

The C/N ratio value can be influenced by several factors. Miller *et al.* (2004) determined that the mean annual temperature and the mean annual precipitation influence the C/N ratio in soils. Increasing mean annual precipitation and decreasing mean annual temperature increase the C/N ratio. Moreover, the C/N ratio is also influenced by soil characteristics. Vejre *et al.* (2003) reported that the C/N ratio was negatively correlated with clay content in Danish forest soils. Callesen *et al.* (2007) obtained similar findings. They collected 198 soil profiles data into 4 groups (fine, coarse, medium and calcareous) based on clay content of the soil. In the 0-10 and 10-20 cm depth higher C/N ratio was observed in coarse soils than in medium ones (Callesen *et al.*, 2007). Since soil organic matter are more humidified in deeper soil layers than closer to the surface, normally the C/N ratio also decreases with soil depth. Since the C/N ratio is highly correlated with the quantity and quality of organic matter in the soil, the more diverse the surface coverage of a given area (such as small catchment), the more difficult it is to estimate or measure an average (single) value for that area. Moreover, not only is the C/N ratio highly variable in the areal base, its temporal variation can be also significant.

Vegetation, climate and organisms all together play a decisive role in the formation of certain soils, as well as in the quality and quantity of organic matter typical of a given soil type, and this might be traced broadly to the total nitrogen content of each soil types. Nitrogen compounds in soils are predominantly organic and proportional to humic substances (Stefanovits, 1963), as also confirmed by Ratner (1963). Measuring the total nutrient content of the upper soil layer, Ratner (1963) found that the N content in each type was as follows: Sandy soils: 0.05%; Brown forest soils: 0.1%; Meadow and Meadow-Chernozem transition soils: 0.2% and Wetland soils: 0.5%. The C/N ratio is also affected by the quality and stability of the humic substances present in the soil. Vegetation cover has a great impact on soil C/N ratio, moreover, in natural ecosystems it is highly climate dependent. It shows the equilibrium value formed by natural factors of a given soil. In the case of Hungary, Stefanovits (1963) stated that low C/N ratios were typical of two types: marshlands where nitrogen accumulation was actually occurring (typically high total nitrogen, may exceed 10,000 mg/kg) and nutrient-poor forest soils with low organic matter content.

The temperate belt has an equilibrium position of C/N between 17 and 33. Above 33, immobilisation occurs (nitrogen is incorporated into the soil humus pool). In European forest soils, this ratio varies in a wide range, between 16 and 44, depending on the forest type (Cools *et al.*, 2014). At the same time, Díaz-Raviña *et al.* (1995) found that along with soil type, season has significant effect on nitrogen flush when investigating forest soils, which can consequently influence the C/N ratio. Vegetation type can also influence soil C/N ratios, even within forest soils depending on the tree species such as conifers or broadleaves (Dawud *et al.,* 2016). In the long term, the C/N ratio can vary between a given range, depending on climatic conditions and vegetation types.

Agricultural management, especially intensive tillage application can cause carbon loss in soil (Tóth *et al.*, 2018, Mesic *et al.*, 2014). Soil disturbance followed by tillage results oxygen rich circumstances and the oxidation of carbon stocks (Jakab *et al.*, 2014, Jakab *et al.*, 2019). Even more, crop residues are also often removed from fields which also leads to carbon losses; however, the nitrogen content of the soil is kept in an appropriate level with fertilizer usage (Tóth *et al.*, 2018). The C/N ratio in cultivated surface layers is about 12 (median value) and is generally lower in the deeper part of the soil profile (Brady and Weil, 2010). The C/N ratio can decrease in managed soils with time. Mesic *et al.* (2014) found that after several centuries of agricultural use, SOC in surface horizons was reduced by 51-60% in Croatian Pannonian plain. However, good agricultural practice, when aboveground crop residue is also kept in field or minimum tillage, can increase carbons stocks, and also the C/N ratio in soil (Miller *et al.*, 2004, Puget and Lal, 2005, Six *et al.*, 2000.)

On a global scale, the ISRIC-WISE Soil Property Database (Batjes, 1996) can provide data for the C/N ratio, compiled in a map, and its range in legend is 8-29. In Europe, the Geochemical Mapping of Agricultural and Grazing land Soil (GEMAS) project aimed to detect and map natural background element (including C and N) variations in topsoil. In the GEMAS project, the participant countries collected paired geochemical data for ploughed agricultural soils and for non-cultivated (at least 10 years) ones (Reimann *et al.*, 2012, Fabian *et al.*, 2014; Birke *et al.*, 2017). The GEMAS sampling was made from summer 2008 to early spring 2009. 4132 soil samples (2108 samples: regularly ploughed agricultural fields (0–20 cm) and 2024 samples: land under permanent grass cover (0–10 cm)) were collected in 33 European countries. The average sampling density was 2500 km^2 per site (50 km × 50 km grid). For quality control, the participants collected duplicate samples at every twentieth field site. There were 35 sampling sites in Hungary. The C/N data and maps were published recently (Matschullat *et al.*, 2018), however, the TC, TOC and S (total and aqua regia) maps were released prior. On account of the uncertainty of the total C and S data in the original GEMAS dataset, all samples were analysed again. Matschullat *et al.* (2018) have interpreted the previously missing total nitrogen (TN) data and the new total carbon (TC) and total sulphur (TS) data. Very small TOC/TN ratios were measured at several locations, including the sampling point around Lake Balaton. According to Blume *et al*. (2010), under temperate conditions, common C to N ratios in grassland topsoil are around 11 and for arable soil approximately 14, while forest soils have ratios of around 21 and above. As a result, in GEMAS the median value of C to N ratio was 10.1, resembling soils under temperate forests, comprised of humified soil material, indicating healthy soil conditions. Most data represented C and N ratios between 8 and 15, indicating good biological decomposition rates.

In Europe, one of the most widespread models for countrywide nutrient load estimates is MONERIS. The purpose of the model is to determine the nutrient load at national level in which the data requirements for soils must be aggregated to a small hydrological catchment level. From a methodological point of view, it is a semi-empirical, conceptual model designed to characterize medium and large river basin nutrient flows. The aim of the modelling is to estimate the annual (multi-year) average total phosphorus and total nitrogen discharges to surface waters at national level. For the model, it is necessary to determine the total nitrogen content of the soil as input data. This can be derived either directly from the total nitrogen measurements of soil samples or from the soil (and vegetation)-specific total organic carbon to total nitrogen (C/N) ratio, derived from the amount of organic matter and land use types. As organic matter (or humus) content measurement is one of the basic soil tests done frequently in soil science, data on this is more commonly available than total-N values.

In addition to the different spatial pattern and number of available point data populations, differences in measurement methodologies may also result in differences in mean C/N ratios and total nitrogen contents for the same categories (soil type, texture variety). While the C/N determination of a given soil sample can be relatively straightforward by a variety of analytical methods, it is more difficult to provide a value representing larger areas due to spatial heterogeneity and depth of soil column changes due to large changes in soil characteristics such as microbial communities. Organic matter produced by soil microbes typically has a C to N ratio of 5:1 to 10:1, with an average of 8:1. Studies show that organic matter from microbial metabolic residues can account for up to 80% of soil organic carbon (Liang and Balser, 2010).

For countrywide modelling purposes, a more spatially representative database is needed to meet inputs at the small river basin level. Uniformly measured and countrywide collected data on soil carbon and nitrogen are provided for the national Soil Information and Monitoring System (SIMS) and a part of the international Land Use / Land Cover Area Frame Survey (LUCAS) point databases.

Methodology

We studied seasonal variability of C/N ratio within a small catchment and investigated the characteristic C/N ratio and total-N content in two independent datasets for different soil types. Our dataset is based on the data available in the ATK TAKI, as well as in the Hungarian Soil Information and Monitoring System (SIMS, 1995) and European LUCAS (Land Use / Land Cover Area Frame Survey) soil databases (Eurostat 2018). The LUCAS soil survey was carried out in the EU-25 in 2009, and in 2012 in two additional Member States and in Iceland in the 0-20 cm soil layer. Out of the more than 22,000 recorded points, nearly 500 cover Hungary. The 2009 samples were analysed at SGS Hungaria's Kecskemét laboratory. Organic carbon and total nitrogen data are available at 497 points. We selected those sites and profiles for which data from all N measurements (preferably supplemented with organic C data) were available.

Seasonal variability of C/N ratio in given sites within a small catchment was studied in Csorsza-catchment (which relates to Lake Balaton).

In 1993, total nitrogen measurements for the soils are available for 1235 sites in the Soil Information and Monitoring System (SIMS 1995). After unifying the nitrogen data in the SIMS database by filtering out internal contradictions (e.g. data recorded in different units at the beginning, year 1993), 1175 data remained and were used to characterize C/N data for soils. In 2007, SIMS data on total nitrogen were available for about 200 fewer sites than before. Because of the more complete data set of 1993, that was used in further spatial prediction, mapping the total carbon and nitrogen content of the soil. For the samples collected at the Csorsza catchment, the soil organic carbon (SOC) contents were measured by wet digestion method. In addition, we also measured $CaCO_3$ contents using Scheibler calcimeter for the arable and vineyard soils from the catchment.

The total-N content of soil samples can be determined by steam distillation and titration after acid digestion of the sample (this method was used in the Soil Information and Monitoring -SIMS points; MSZ-08-0458-1980). The total nitrogen for the Csorsza catchment samples was determined using the modified Kjeldahl method (ISO 11261:1995). The nitrogen content can also be measured by elemental analysis (e.g. with CNS analyser). This involves burning the sample at a given temperature to calculate the total element content, the retention times recorded during the process, and the area under the curves they describe (this method was used in the LUCAS European Soil Database). The results obtained by the two methods are comparable, but they have different reliability in low and high organic matter samples (Avramidis *et al.*, 2015) and cannot be converted by a single conversion factor.

Applied digital soil mapping methods

Nationwide map of Soil Organic Matter content was compiled by regression kriging (RK). RK is a hybrid model that combines geostatistics with classical statistical technique. In RK, the target variable is modelled at first by Multiple Linear Regression (MLR) of the environmental co-variables. Then Ordinary Kriging is applied on the difference between the reference and the modelled values (residuals). The prediction result map comes from the sum of the MLR model and the interpolated residuals.

Nationwide total nitrogen content mapping was carried out using the quantile regression forest (QRF) method. QRF is a novel approach in DSM, which is based on random forest (RF; Breiman, 2001). RF is an ensemble of classification or regression trees, generated by random subsets of training data, and then these trees can be used for prediction. The key difference between random forest and QRF can be summarised as follows: for each node in each tree, random forest keeps only the mean of the observations that fall into this node and neglects all other information, whereas QRF keeps not just their mean but the value of all observations in this node. Based on this information, not just a prediction but an empirical distribution function can be derived that can be used for quantifying the prediction uncertainty. In addition, QRF keeps the advantages of random forest, i.e. it can fit complex, non-linear relationships and the correlation between the environmental covariates is not a limiting factor. (Meinshausen 2006, Szatmári *et al.*, 2019).

The main reference datasets for digital mapping were as follows:

- Hungarian Soil Information and Monitoring System (SIMS, 1995) is a nationwide soil monitoring programme, which provides soil information from 1235 locations. Due to the standardised methodology and the accredited laboratory measurements, SIMS is the most unified and thematically detailed, up-to-date soil-related database in Hungary. We used sampling plots as reference data for SOM content as well as nitrogen content mapping.
- Digital Kreybig Soil Information System (DKSIS, Pásztor *et al.,* 2012) is the most detailed spatial dataset related to soils covering the whole country. It simultaneously contains two types of geometric datasets: soil mapping units (SMUs) and sampling plots. We used sampling plots as reference data for SOM content mapping. During the original survey, detailed soil properties (among them soil organic matter content) were determined and measured in soil profiles. There are representative profile descriptions in the database for about 22,000 plots, which are transferred for further locations summarizing approximately 250,000 plots. SMU layers of DKSIS were used as environmental co-variables (detailed in Section 'Applied environmental co-variables for digital mapping').
- Data of National Pedological and Crop Production Database (AIIR in Hungarian) was collected in 1970s and 1980s by the legal predecessor of National Food Chain Safety Office (NÉBIH, Hungary). The recently available data originate from the period 1984–1990. The database contains laboratory analysis data of soil properties (among them soil organic matter content) as well as cultivation information from 80,000 parcels (Kocsis *et al.,* 2014). We used reference points from AIIR only for SOM content mapping.

Environmental factors that are related to soil forming processes were also taken into consideration in the mapping process. The following so-called environmental co-variables were involved into the spatial prediction of SOM content and total nitrogen content mapping.

- Genetic soil type map of Hungary (Pásztor *et al.*, 2018) from DOSoReMI.hu database that includes 31 taxonomic soil types according to the Hungarian soil classification system. It was used only in nitrogen content mapping.
- Climate was represented by four relevant features: average annual precipitation, average annual temperature, average annual evaporation and average annual evapotranspiration. The spatial layers were compiled using the MISH method elaborated for the spatial interpolation of surface meteorological elements based on 30-year observation of the Hungarian Meteorological Service with 0.5′ resolution (Szentimrey and Bihari, 2004).
- Organisms, as vegetation types were taken into account based on the CORINE Land Cover (CLC) inventory products (CLC European Environment Agency).
- Digital Elevation Model (EU-DEM; Bashfield and Keim, 2011) and the following morphometric derivatives were applied as environmental auxiliary layers: Altitude, Channel network base level, Diurnal anisotropic heating, Horizontal distance to channel network, LS factor, Mass balance index, Multiresolution ridge top flatness index, Multiresolution valley bottom flatness index, Multi-scale topographic position index, Profile curvature, SAGA wetness index, Slope, Stream power index, Surface area, Terrain ruggedness index, Topographic position index, Topographic wetness index, Total curvature, Vertical distance to channel network. The terrain features were calculated from the DEM in SAGA GIS (Conrad *et al.*, 2015) environment.
- Lithology was represented by the Geological Map of Hungary 1:100,000. The units of the map were correlated with the nomenclature of parent material defined in the FAO Guidelines for soil description (Bakacsi *et al.,* 2014).
- Only in SOM content mapping, we applied SMU layers with physical and chemical soil property categories from Digital Kreybig Soil Information System (DKSIS, Pásztor *et al.,* 2012). Physical soil categories were attributed according to water retention capability, permeability and infiltration rate; chemical categories were derived from pH and calcium carbonate content of soils.
- Only in SOM content mapping, MODIS images from two dates (16 March 2012 and 7 September 2013) representing different phases and states of vegetation were chosen for mapping. Red, near-infrared (NIR) bands as well as Normalized Difference Vegetation Index (NDVI) were used from both dates (MODIS 09 products). Furthermore, two NDVI products (MOD13Q1) were involved, which provide information from a 16-day period (13–28 March 2012 and 5–20 September 2013). The spatial resolution of the images is 250 m.

Results and Discussion

Seasonal variability

In the last 10 years, total C and N data are available in 19 locations (and additional 4 points in time series) in the Institute for Soil Sciences and Agricultural Chemistry. There are available total N data under four different surface coverings (namely arable, vineyard, meadows, forest) for Csorsza catchment, measured consecutively each month in 2016 in topsoil. The area covered by weakly to moderately eroded, loamy textured brown forest soils (mostly Cambisols or Luvisols, according to World Reference Base for Soil Resources. One-year averages for C/N ratios and total nitrogen (mg/kg) values were as follows: arable: 7.71 and 2257; vineyard: 8.62 and 2336; meadows: 9.35 and 3486; forest: 9.65 and 4494. Measured at the same point, the annual data series (Figure 1) show that the degree of seasonal fluctuation in nitrogen content can be as much as double the lowest value. Based on this experiment, taking into account the possible extent of the seasonal variation in nitrogen content (Figure 1), in further data filtering we selected points showing excessive fluctuation and kept points for spatial prediction (915 points of SIMS) in which the difference between the values measured at two times was not more than twice.

Under the same land management, the total nitrogen content may vary with both soil types and textures. Table 1 shows the C/N ratio and total N content of samples collected during the last 10 years from 19 arable land sites under conventional tillage (Agárd, Kenyeri, Keszthely, Gyulatanya, Bicsérd, Iregszemcse, Nagyhörcsök, Karcag, Kompolt, Nagyhegyes, Orosháza, Szarvas, Szeged, Szekszárd, Őrbottyán, Mezőnagymihály, Martonvásár, Nagykálló and Öreglak), comparing with texture. The low organic matter content of soils with light mechanical composition (sand, sandy loam) can be traced to changes in the total nitrogen content (even within the same soil type).

The effects of different soil managements systems on soil N and C contents were investigated by Tóth *et al.* (2018) at Józsefmajor (Chernozems). Even at a same experimental site, the soil management can greatly influence the total nitrogen content (Figure 2), which was much lower in the case of mouldboard ploughing, than for the no tillage soils, based on samples collected after winter wheat harvest in late autumn 2019.

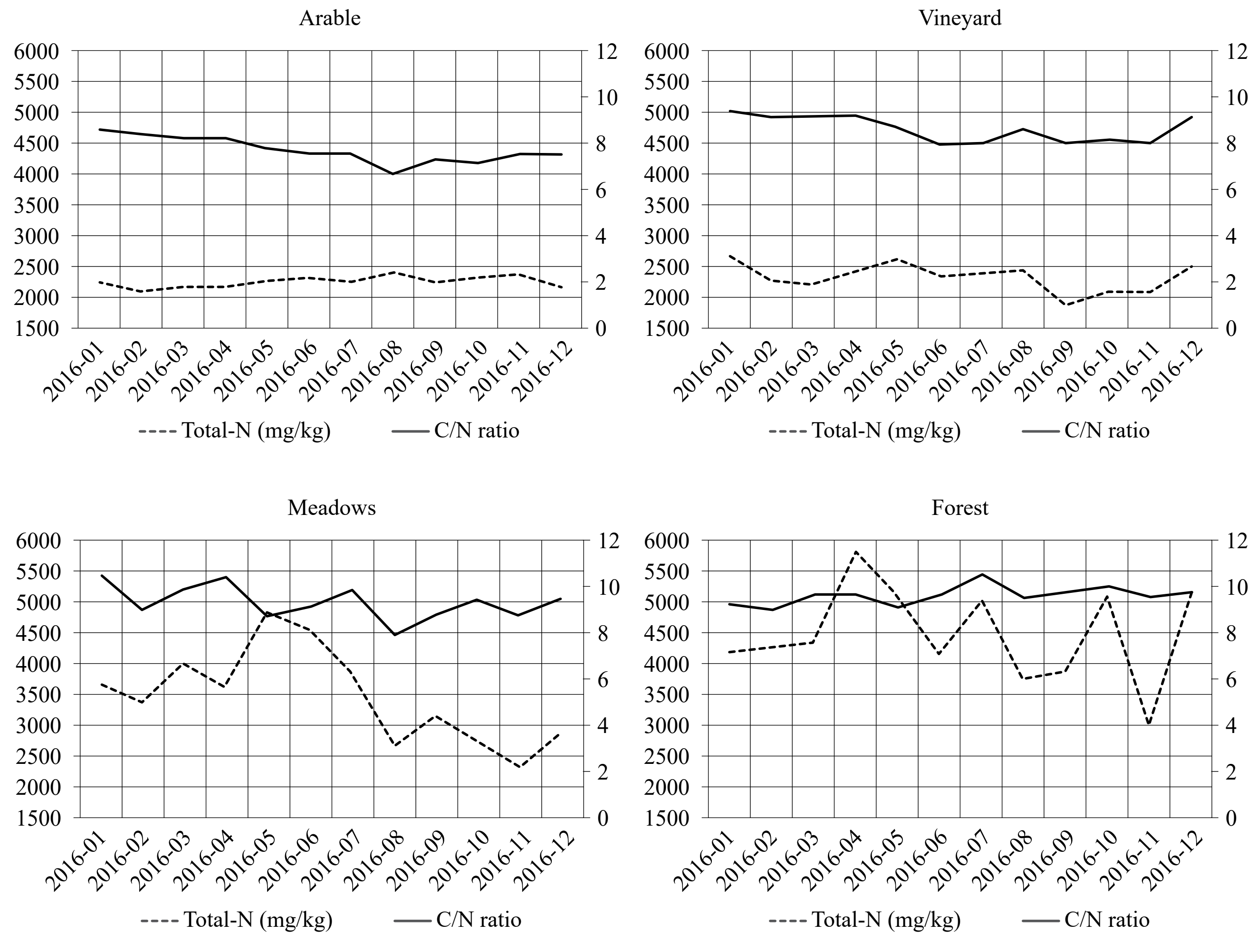

Figure 1: Seasonal changes in total nitrogen content of the topsoil and associated C/N ratio under four different surface coverings in samples from the Csorsza catchment area.

Source: wn composition

Table 1: Topsoil data for C/N ratio and total nitrogen content vs. their texture in 19 samples from conventionally managed arable lands.

Texture	Number	mean C/N ratio (SD)	mean total N (mg/kg) and (SD)
sand	4	8.27 (*1.91*)	813 *(479)*
sandy loam	3	7.92 (*1.99*)	1,433 *(155)*
loam	8	9.55 (*1.91*)	1,713 *(153)*
clay loam	4	11.30 (*1.40*)	1,975 *(596)*

SD = standard deviation.

Source: own composition

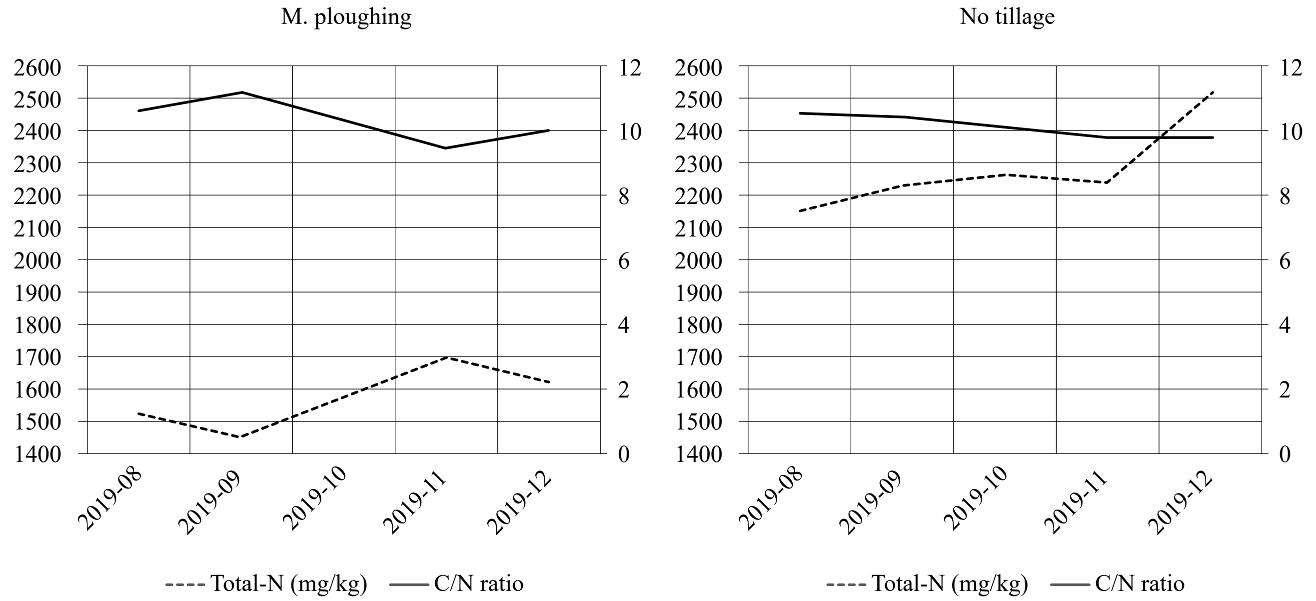

Figure 2: Seasonal changes in total nitrogen content of the topsoil and associated C/N ratio under mouldboard (M) ploughing and no tillage management, mulching in both cases, in Józsefmajor (Chernozems).

Source: own composition

Table 2: Descriptive statistics of LUCAS and SIMS databases.

	C to N data	
	LUCAS	**SIMS**
Expected value	10.35	7.41
Standard error	0.08	0.09
Median	10.29	7.52
Mode	10.00	8.12
Standard deviation	1.79	3.11
Variance	3.19	9.70
Kurtosis	9.19	3.68
Skewness	1.79	0.95
Range	17.32	24.94
Minimum	5.46	1.00
Maximum	22.78	25.94
Sum	5,144.59	8,708.67
Number	497	1175
95% confidental interval	0.16	0.18
Lower limit of the 95% confidental interval for expected value	**10.27**	**7.32**
Upper limit of the 95% confidental interval for expected value	**10.43**	**7.50**

Source: own composition

C/N ratio and total-N in SIMS and LUCAS databases

Comparison of descriptive statistics of LUCAS and SIMS databases concerning topsoil C to N ratios shows that the difference in expected values is considerable (Table 2). The lower limit of the 95% confidential interval for LUCAS' expected value is higher than the upper limit for TIM C/N data under the same condition.

The reason for the discrepancy originates partly from different thematic representativity for land use (Figure 3) and partly from different analytical methodology. In addition, samples were taken almost twenty years apart. The titration method (SIMS) is more accurate in low concentrations, while in the case of higher organic load the combustion method (LUCAS) gives better results (Avramidis *et al.*, 2015). The expected value for the whole database (497 cases) for LUCAS is close to the temperate grasslands' empirical value of 11. Evaluation of SIMS data showed that soil texture plays a crucial role in the same surface coverage (Table 3).

To demonstrate different thematic representativity of datasets and the effect of surface coverage on C/N ratio, we compared the two databases for the CORINE "forests and semi natural" land use categories (Figure 3). 96 points in LUCAS and 168 points in SIMS were available for C/N evaluation. Apart from two land use categories, the number of points in each CORINE units does not exceed 15. The

Table 3: Texture-averaged C/N and total nitrogen content within simplified CORINE land use categories, according to the SIMS database.

	forest		meadow		orchard/ vineyard		arable		texture average			
texture	**C/N**	**TN**	**C/N**	**TN**	**C/N**	**TN**	**C/N**	**TN**	**C/N**	**SD_C/N**	**TN**	**SD_TN**
sandy loam	13.45	991	12.59	1,849	9.47	1,065	12.84	1,120	12.58	±5.54	1,171	±1,441
loam	17.10	2,008	13.36	2,102	13.26	1,450	13.91	1,880	14.18	±4.84	1,909	±809
clay loam	7.80	1,961	14.52	2,719	15.63	1,567	14.53	2,075	14.48	±3.03	2,149	±726
clay	16.89	2,250	12.91	3,427	-	-	17.22	1,886	15.89	±6.77	2,385	±1,453
heavy clay	-	-	15.63	1,484	-	-	12.04	5,850	13.24	±6.71	4,395	±4,856
landuse average	15.30	1,598	13.14	2,092	11.26	1,244	13.65	1,724	13.60	±5.23	1,724	±1,114
standard deviation	±7.62	±942	±4.36	±2,144	±4.63	±629	±4.33	±835	-	-	-	-
N-cases	**146**	**146**	**120**	**120**	**48**	**48**	**581**	**581**	**915**	**-**	**915**	**-**

Source: own composition

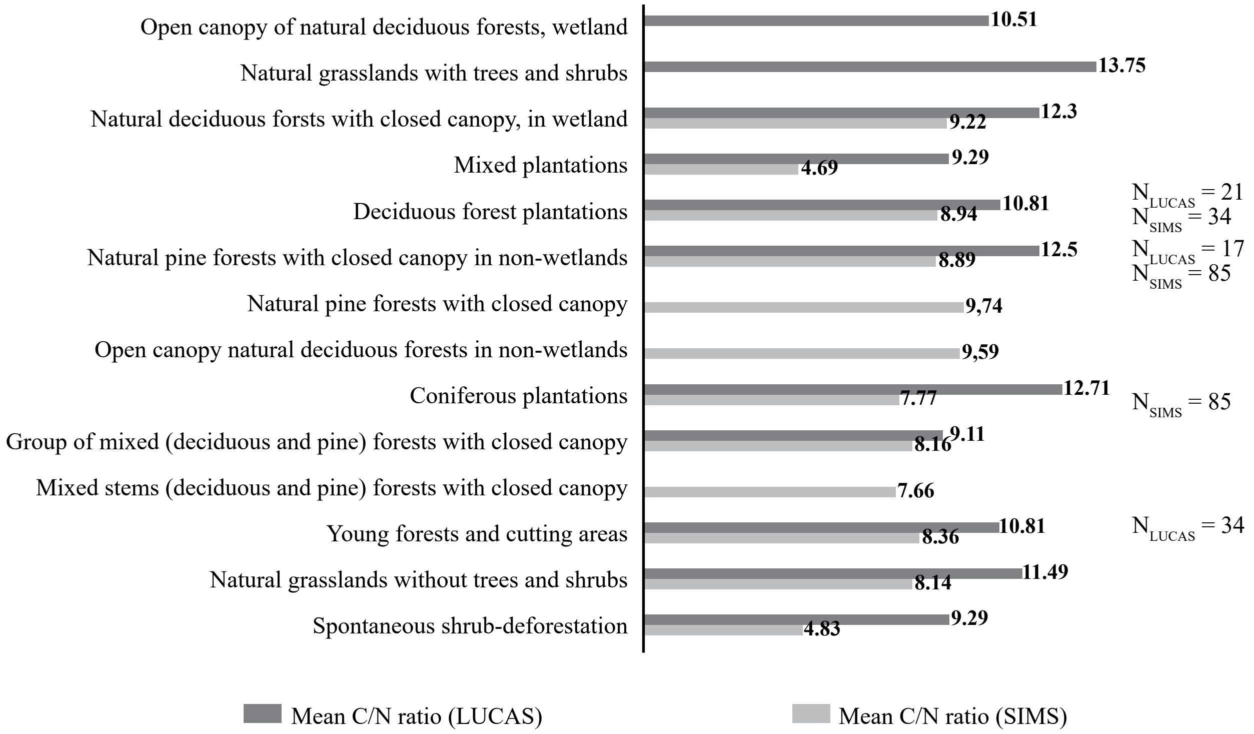

Figure 3: Mean C/N ratios in LUCAS (N = 96 points) and SIMS (N = 168 points) databases vs. CORINE "forests and semi natural areas" land use categories, computed for Hungary.

Categories for which at least 15 data are available are marked separately (e.g. coniferous plantations, young forests).
Source: own composition

average C/N ratio for the most common surface cover category as "Natural deciduous forests with closed canopy in non-wetlands" with a total 85 points from SIMS is 8.89 and 12.05 for the 17 points of LUCAS. In case of "Deciduous forest plantations" with similar case numbers, the difference is smaller. In general, the C/N ratio calculated from SIMS was below the LUCAS value in all cases, in accordance with the expected values of the whole dataset (Table 2).

Spatial prediction

The base map of the expected nitrogen content was Soil Organic Matter (SOM) content map (100 m spatial resolution) for 0-30 cm soil layer, compiled in the framework of the DOSoReMI.hu project. Digital, Optimized, Soil Related Maps and Information in Hungary (DOSoReMI.hu) database collects novel soil property- and soil type maps as well as functional soil maps, compiled by up-to-date digital soil mapping methods. Nationwide map of Soil Organic Matter content was compiled by regression kriging, involving environmental co-variables (described in "methods") into the prediction.

As first approximation, total nitrogen content was defined based on the C/N=11 ratio, which fits to the local climatic conditions, and was previously used in MONERIS models. We converted the values of the SOM content map to Soil Organic Carbon (SOC) content by the commonly acknowledged SOC [%] = SOM [%]/1.724 prediction ratio. This approximation assumes that the organic matter of soil contains ~58 % carbon (Figure 4).

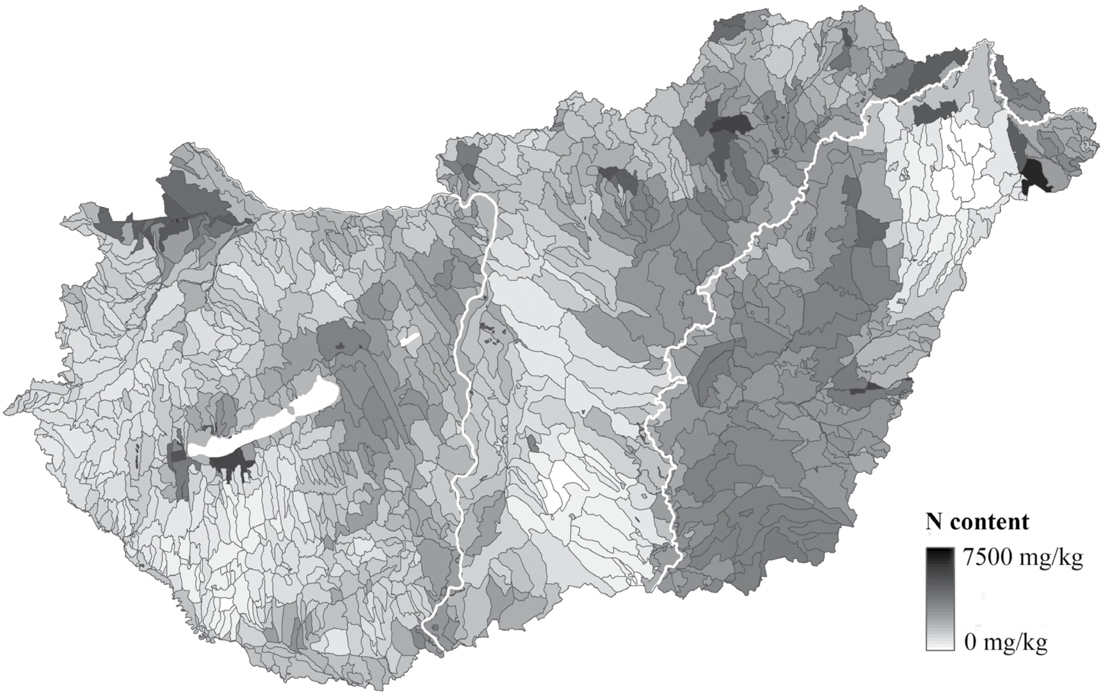

Figure 4: Map of total-N content (mg/kg) derived from SOM content map, according to C/N = 11 ratios, averaged over small river catchments.
White coloured: main surface water bodies, Pale coloured units correlate with light texture soils.
Source: own composition

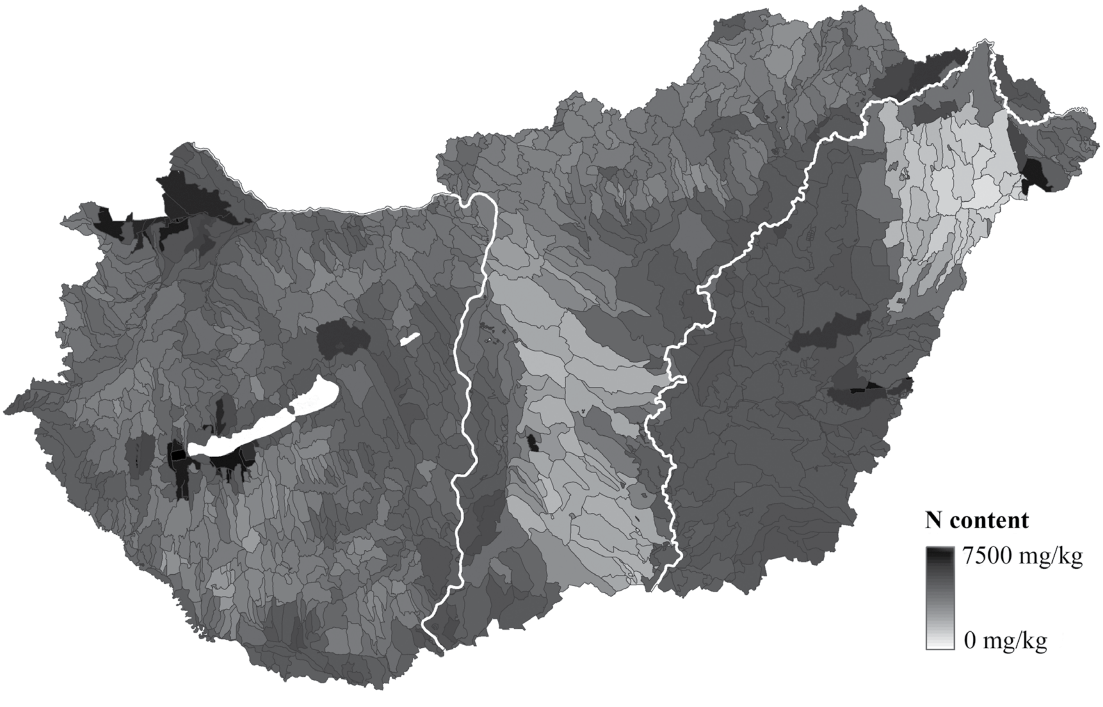

Figure 5: Map of total-N content (mg/kg) derived from SIMS nitrogen point data and environmental co-variables, with 100 m spatial resolution, averaged over small river catchments.
White coloured: main surface water bodies.
Source: own composition

At the second approximation, nationwide total nitrogen content mapping was based on the reference data of Hungarian Soil Information and Monitoring System (SIMS) by the quantile regression forest method (Szatmári *et al.,* 2019). Environmental co-variables were described above (Figure 5).

Comparison of the mean values of total-N maps calculated from C/N = 11 ratio and estimated from SIMS data and environmental co-variables (Figure 4, 5) shows that their spatial patterns are similar while values are shifting. The lowest nitrogen values outline the light-textured sandy areas (N-S directed Danube-Tisza Interfluve in mid-Hungary and the territory of Nyírség in the eastern part of the country). The darkest mapping units indicate the highest nitrogen contents usually related to wetlands (e.g. SW from Balaton Lake), river valleys and flood plains or in some cases accompanied by shallow soils developed on limestone in mid-mountain regions, with high SOC in topsoil (e.g. Rendzinas).

Conclusions

There are many factors influencing the total nitrogen content of the soil, including soil cover, vegetation types and period and soil texture. The light texture sand and sandy loam soils have low colloidal content compared to the other texture classes; their organic content is low, therefore their total nitrogen content was the lowest in each of the studied surface cover categories.

Both SIMS and LUCAS database showed that soil cover and soil types, which are intended to represent soil diversity, were correlated with total nitrogen. Using simplified land-cover categories, we found that in Hungarian soil vineyards and orchards have the smallest amount, grasslands (and wetlands) have the highest nitrogen content, while forests and arable lands are located between the two, with a slightly higher nitrogen content of arable lands, but with a high variance in data. Compared to climate definition, differences in land use management or soil type might have minor effect on the convergence of soil organic matter C/N ratios in agricultural soils (Khan *et al.,* 2016). However, environmental factors such as nutrient limitation can reduce microbial degradation of organic matter, resulting in a higher C/N ratio in forest soils compared to arable as found by Khan *et al.* (2016). Our findings were similar, the cultivated soils (arable, vineyard) had lower C/N ratios than forest or meadows (around 8 versus 9 or 10), which might be explained by the accumulation of less degraded plant residue in these land use types (Mesic *et al.*, 2014).

Not only natural factors (e.g. soil composition, vegetation) but also methodological factors of sampling and measurement (time of sampling and seasonal dynamics of nitrogen content, values were measured on the same or different samples, different sample volumes, measurement methods) significantly influence the data on total nitrogen in the soil. For the spatial prediction, we applied the pre-filtered data from the SIMS database using digital mapping tools ensuring that potential environmental factors that may affect soil nitrogen content were identified as environmental auxiliary variables and their cumulative effects would be present in the resulting maps.

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Determinants of Household Income and Employment Choices in the Rural Agripreneurship Economy

The paper seeks to link the discussions on diversification and pluriactivity among farm business owners (FBOs) and examine the topic in the context of small-scale farming. It asks households if diversification and wage-seeking behaviour in the rural agripreneurship economy is prompted by "push" or "pull" factors. The quantitative method enabled the analysis of data generated from 480 rural FBOs from Nigeria (regarded as entrepreneurs or agripreneurs). The findings reveal that education, asset endowment, access to credit, and good infrastructure conditions increase the levels of household diversification. Lack of access to capital, low farm income and fluctuations in farm income were the three most influencing factors (push factors) towards diversification.

Keywords: agripreneurship, non-farm Income, resource-based view, push and pull factors, african rural economy

JEL classifications: Q12, Q18

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Introduction

Globally, urban migrations and low farm income have put rural economies under stress. In the rural areas of developed and developing economies agriculture has been subject to extreme and rapid change which has led to many farmers becoming engaged in diversification activities (Hayatullah, 2020; Walley *et al.*, 2011). Also, small-scale farming dominates rural livelihood activities in many countries of the world. Entrepreneurs are affected by a three-way interaction between individual capabilities, resource availability and the constraints of the environmental conditions in which they operate (Bamiatzi *et al.,* 2016). Therefore, rural studies have become relevant in understanding the dynamics leading to the creation of new businesses, rural development and regional economic growth.

This study examines the determinants of household income and employment choices of farm business owners (FBOs) in the rural Nigerian economy. In the rural economy of most African countries, three choices of livelihood income exist – farming/agro-processing activities, micro/small non-farm enterprise and wage employment. In most cases, there are no social security benefits or state welfare payments. Therefore, households must choose one of the employment options to earn a living and support themselves. In rural areas, small-scale farming dominates as a livelihood option. Small farms are estimated to undertake more than 70 per cent of agricultural activities, thereby helping ensure food, employment and rural livelihoods (FAO, 2020).

Agripreneurship refers to entrepreneurship in agriculture. In both developed and developing regions, the need for diversification activities has led to high levels of "pluriactivity", off-farm work or non-farm employment. The discussion on pluriactivity and diversification started in Europe and the US in the 1990s (Arkleton, 1993; Brun and Fuller, 1992; Dax *et al.*, 1995). Since then, both concepts have been used in many studies referring to farmers' decision to have multiple income-generating activities (Morris *et al.*, 2017; Radicic *et al.*, 2017). These studies reveal that adopting a diversification strategy significantly increases farm profitability, adaptability and farm business resilience to seasonality, risk and vulnerability.

Rural development practices examine boundaries mapped into broadening, deepening and re-grounding (Ploeg *et al.,* 2012). This study applies a 'Resource-based View' (RBV) to examine the determinants of household income in constrained environments. As part of its objectives, it asks if moving out of farming is prompted by resource availability. The motives of farmers and external factors in the African rural context are different from those of developed nations that are commonly found in the literature (see, e.g. Morris *et al.,* 2017; Radicic *et al.,* 2017). This study focuses on Nigeria. Like many African countries, 52 per cent of Nigerian farmers cultivate less than 1 hectare of land (FAO, 2020) and 76 per cent operate on less than 2 hectares (Fabusoro *et al.,* 2010).

This article makes important contributions to knowledge of the critical issues concerning rural household income and local/regional employment opportunities in the developing country context. There have been calls for research to focus on the developing world context where entrepreneurship has recently been proved to be an important driver of economic growth (Pham, 2018). First, this article highlights the potential of diversification to contribute to increasing household income levels. Second, it explores the implications of agricultural change and adaptation, and the close interlinkages of agripreneurship, sectoral and rural development. A study by Hayatullah (2020) reveals that while landholding size, farm characteristics and assets, and proximity to markets significantly increase diversification, a significantly lower degree of diversification is found for households with higher non-farm income.

Third, it offers an empirical research approach towards previously unexplored elements of rural entrepreneurship in Africa such as the influence of individual characteristics (e.g. level of education, family size, size of farmland or membership of social club) on diversification decisions. Arguably, diversification involving both farm work and off-farm work, and the divergent involvement of household members in these employment arrangements, are largely influenced by individual factors (Nguyen *et al.*, 2015), as well as resource/ external factors (Nagler and Naudé, 2017). Finally, the data are drawn from a survey of rural farmers (heads of households) from South-eastern Nigeria selected purposefully from a list of farmers registered with the State government Ministry of Agriculture. The South-eastern region of Nigeria is also known for its agricultural activities, as well as a high level of entrepreneurial and small business activities (see, Igwe *et al.*, 2018, 2019 and 2020).

Resource-Based View (RBV) and Hypotheses

The RBV approach enables both internal and external analyses of the competitive environment of firms, industries and sectors. Agriculture in developing countries is constrained by a tendency to be growth-averse, underdeveloped capabilities in key business areas and often inadequate business support provision. However, the growth of entrepreneurial ventures results from the interaction between entrepreneurs' internal resources and capabilities and the constraints (Pindado and Sánchez, 2018). Since its introduction, RBV has become one of the most influential and cited theories in the history of management theorizing (Kraaijenbrink *et al.*, 2010).

At the heart of the RBV is the concept of organisational resources. These resources include tangible and intangible resources including human capital (know-how or tacit knowledge), financial, buildings, machinery and other resources. Successful entrepreneurs are those that create the most value from the resources available to them. This process creates "capabilities" (Walley *et al.,* 2011). The entrepreneurial process encompasses opportunity identification, which is either created or discovered (Goss and Sadler-Smith, 2017). Meanwhile, opportunity exploitation involves acquiring resources, bundling those resources into capabilities, and leveraging these capabilities to create and capture value (Sutter *et al.*, 2019).

Agripreneurship' denotes entrepreneurship in the areas of agriculture and agribusiness. Within the agripreneurship context, diversification is a strategy that takes farmers away from a focus on farming to other livelihood choices and opportunities. Also, diversification can be viewed as an evolving set of responses to market failures (Ploeg *et al.*, 2012). It could be argued that diversification behaviour is related to low prices of agricultural products and the dysfunctional or imperfect factor markets (low value of agricultural land and high cost of labour in the rural communities). As a consequence, low farm income led farmers into opportunity-seeking and exploitation through diversification, pluriactivity, off-farm work or non-farm work. This leads to the development of the first hypothesis.

H1: Household diversification capability will be positively and significantly associated with individual characteristics of FBOs.

The determinants of livelihood choices are supported by many empirical studies (Hayatullah, 2020; Morris *et al.,* 2017). However, less discussed in the literature are the environmental challenges (external factors that support or hinder diversification or pluriactivity). There are examples of many countries like Cambodia that has recorded remarkable economic growth driven mainly by rural economy, thereby reducing poverty from 50 per cent in 2004 to 20 per cent in 2011 (Seng, 2015). In Uganda, Ghana and Ethiopia, a sharp rise in local income inequality was evident due to differential capacities of households to diversify (Gautam and Andersen, 2017). This leads to the development of the second hypothesis.

H2: Household income and employment choice will be positively and significantly associated with resource availability and external factors.

A distinction between positive factors that 'pull' and negative factors that 'push' people into entrepreneurship has been explained by previous studies (Igwe *et al.,* 2019). Examples of 'pull' factors include the need for achievement or the desire to be independent (van der Zwan *et al.,* 2016). 'Push' motivations may arise from (the risk of) unemployment, family pressure, and individuals' general dissatisfaction with their current situation (van der Zwan *et al.,* 2016). Also, the literature on the decision to enter entrepreneurship has identified dichotomisation contrast between 'economic' and 'lifestyle' choices (Hansson *et al.,* 2013), the former being concerned with farm business strategies to reduce risk and capitalise on an additional resource, whereas the latter views strategy as supporting social motives and identity.

Ploeg *et al.* (2012) examined rural development practices through boundaries. The boundaries were mapped into three categories: broadening, deepening and re-grounding. Broadening refer to a range of productive activities beyond merely farming (although there might be considerable intertwinement and synergy) and enlarges farm income. Deepening describes the introduction of new practices that (re-) internalize processing and distribution within the farm (e.g., adding values to the end-products). Re-grounding involves reconstituting the resource base of the farm thereby reducing dependence on external resources and increasing the dependence on internally available resources. At the farm enterprise level, these shifts, and their interactions, increase multifunctionality (Ploeg *et al.,* 2012).

The Nigerian Rural Context

The Nigerian rural sector represents an unique environment where rural regions cover more than 90 per cent of the geographical landscape and where 49.66 per cent of the country's population live (World Bank, 2018). Like that of many countries in West Africa, the Nigerian rural economy is heavily concentrated in agriculture (World Bank, 2014) with over 70 per cent of the population employed in agriculture (Fasoyiro and Taiwo, 2012) which contributes over 40 per cent to GDP (World Bank, 2014). The average small family farm sources labour from family members with an almost balanced proportion of labour dedicated to off-farm and on-farm activities (FAO, 2018). Land tenure is characterised by a very unequal distribution of ownership and high level of tenure insecurity making commercial farming difficult.

Besides, the rural sector has numerous production challenges ranging from lack of modernised production inputs to lack of credit facilities for farm expansion; there is also poor linkage to market and post-harvest technology (Fabusoro *et al.,* 2010). Among small family farms, men usually have the decision-making power and women lack access to ownership of land (only a small share of farms of around 13 per cent are female-headed) (FAO, 2018). Nigeria's infrastructures are inadequate and poorly maintained. The Nigerian power sector's operational efficiency and cost recovery are among the worst in Africa, supplying about half of what is required (World Bank, 2011). There is a fitful supply of electricity and many local communities are not connected to electric power, water supply and telecommunications.

Only six per cent of the households benefit from agricultural extension services (FAO, 2018). Nevertheless, when compared to other West African countries, Nigerian farmers have developed growth-enhancing measures such as intensification of fertiliser application and adoption of new farming techniques. About 44.5 per cent of the households use fertilisers and rice and yam production are thriving as Nigeria produces more than 60 per cent of the entire world's yams (mainly exported to Europe and America - BBC, 2017). However, it could be argued that the high dependence on export production diminishes the scope for self-sufficiency and increases food insecurity in the country.

Methodology

First, a structured questionnaire was designed to collect quantitative and qualitative data from a household survey of farmers in rural communities in Nigeria. Second, the questionnaire was administered to 2700 rural FBOs (our empirical equivalent of entrepreneurs) who were engaged in farming (i.e. crop and livestock activities) and/or nonfarm businesses (see, for example, Radicic *et al.,* 2017). Therefore, all respondents operate/own a farm and may have diversified into non-farm activity or else engage in wage employment. These farmers were randomly selected from Farmers Registers from the States Ministry of Agriculture and Rural Development in Eastern Nigeria. FBOs were selected purposefully on two considerations (1) based on convenience sampling and (2) if they engaged in farming in the previous farming year.

Of the 2700 questionnaires that were distributed, 480 completed surveys were achieved (17.8% completion rate). The composition of the respondents could have influenced the research results given the purposeful approach. However, some measures were undertaken to mitigate other limitations (Rahman and Akter, 2014). The questionnaire was delivered by hand to households through research assistants employed for the data collection, and a date was fixed for collection. This method was chosen to eliminate the barriers associated with collecting data in Nigeria due to lack of postal facilities, email and business contact addresses. Another benefit is that the method ensured a high response rate. The data collection lasted six months.

In order to examine farmers' motives for diversifying their farm business, a five Likert-point scale of 1 – 5 (1 for low impact, 5 for high impact and 0 for no influence) was used to allow the farmers to express how much they agree or disagree with some factors identified from the literature that motives farmers to diversify into the non-farm businesses. To test the hypotheses presented earlier, we use multinomial regression.

Descriptive Statistics and Motives for Diversification

Given one of the research objectives were to examine diversification capabilities of FBOs, this study examines and reveal both household characteristics and farm business performance factors. The majority (68%) of the farm and non-farm businesses are micro/small informal businesses since the owners reported that the businesses are not registered with the government and do not pay business taxes. In the breakdown of the dataset, the percentage of FBOs engaged in a non-farm activity as the primary employment was the highest at 59.6 per cent. The average age was 56.6 years with a range between 32 and 72 years. The FBOs were male-dominated (91.7%) and only a small minority were women (8.3%). More than one-third (41.26%) do not have any qualification beyond primary school education. While less than half of the business owners (47.5%) received vocational training in specific areas such as technical works and general trading apprenticeships, however, most were self-trained (52.5%). About 79.6 per cent of the FBOs cultivate on 1.0 – 3.0 hectares of farmland.

The results showed that farm sizes have been decreasing over the years as business owners downsize farming and diversify into non-farm activity (with a mean of 1.16 hectares in the current year of study and 2.8 hectares five years ago). Despite the predominantly small size of farms, FBOs were further downsizing their farms and capacity. There were several reasons attributed to this trend – low farm income, seasonality of farming, farm income fluctuation, high prevalence of diseases and pests, lack of high yielding varieties and limited resource availability (such as labour due to rural-urban migration, and skills and low financial capital).

Most of the FBOs (92%) had an annual household income measured in Nigerian naira of between ₦18,000 and ₦650,000 (the equivalent of $50 and $1800, respectively). Further analysis of the household income revealed that the majority of the FBOs (63.7%) earn income below ₦300,000.00 (the equivalent of $830) per annum. Also, most of them operate in micro easier-to-start activities and only fewer engage in activities that require technical or higher starting costs. The non-farm activities include manufacturing of local crafts and equipment, textile and weaving, merchandise or trading, food and drink processing, repair work, woodwork (carpentry) and hairdressing, building, electrical work and other activities.

The findings reveal that non-farm income contributes about 36 per cent of household income (excluding salaried work) and as much as 64 per cent when salaried income is incorporated into household income. These results are expected, given that the studied region (South-eastern Nigeria), is known for a high rate of entrepreneurship and business activities (Igwe *et al.,* 2018 and 2019). Moreover, data revealed that most of the FBOs have a large family size (mean of 10.35 persons). A large family is associated with maintaining a high proportion of labour dedicated to off-farm and on-farm activities (FAO, 2018). This is typical in the rural agrarian communities as households tend to have a large family, as large households may be leveraged into more resources, such as labour and finance, which in turn facilitate entrepreneurship (see, e.g., Nagler and Naudé, 2017).

However, these variables differ between rural and urban locations. The downsizing of farmland, off-farm and non-farm activities and tendency to have small family size were more prevalent in semi-rural locations (communities closer to urban centres). Whereas farmers in remote rural locations tend to have large family size, high farm size and a focus on farming more than on non-farm activities. Data revealed that about 52.4 per cent of household's non-farm businesses are made up of only the owner and no paid employee. The result show similarity to pluriactivity outcomes in Europe at the beginning of the 1990s (Brun and Fuller, 1991; Dax *et al.,* 1995).

The mean number of employees was 2.2 persons, but most (1.90 persons) were family members or apprentices related to FBOs. This is in line with other studies that state that a typical rural business in Africa sources labour from family members (FAO, 2018). Also, within the age categories, farming appears to be a secondary occupation among young farmers (32 – 50 years), that supplements off-farm and non-farm income (primary occupation), while older farmers (50 years and above) appear to depend on farming as a primary occupation and less on non-farm or off-farm activities (secondary activities).

One of the objectives of this study is to examine the motives of the farmers in diversifying their farm businesses outside conventional agriculture and how these motives are dependent on the resource availability, economic and external factors. To examine farmers' motives for developing ventures outside agriculture, a measurement Likert-scale was adapted. The exact wording used for measurement items was developed to fit the context of this study but modified to reflect the context of the motivations and factors relevant to rural African context categorized into "push" (necessity) "pull" (opportunity created) developed on a Likert scale of 1 – 5 of the degree to which FBOs agreed with the proposed statements.

Mean scores and per cent of the population within and above the mean scores of the measurement items were used to capture farmers' motives (push and pull factors) for starting new nonfarm ventures (Table 1). The strongest "push" factors include the lack of capital to expand the farm business (4.126), followed by farming business did not provide enough income for the family (3.868). Another high score of "push" factor is unavailability or high cost of agricultural labour has forced the change in the business (3.509). Lack of capital factor may reflect the fact that there is a lack of access to formal credit and loans in rural areas in Nigeria. The most important of the "pull" factors is starting a new business to employ family members who have no jobs. Again, this may reflect the fact that there are high unemployment and under-employment in rural communities in Nigeria.

Determinants of Household Income and Employment Choices

Multinomial logistic regression was used to analyse the determinants of income and factors affecting the occupational choices made by rural FBOs. Multinomial regression was applied since it allows for more than two categories of the dependent or outcome variables. In this case, it enabled the examining livelihood diversity (determinants of non-farm and wage employment). However, there are two main limitations to letting dichotomous variables represent livelihood options according to Rahman and Akter (2014).

Table 1: Likert-scale Motives for starting new Nonfarm ventures.

Suggested motives	Pull/ Push	Average Score	Proportion within or above the mean score (%)
We always wanted to start a new nonfarm business	Pull	2.104	31
We started a new business to employ family members with no jobs	Pull	2.568	36
The farming business did not provide enough income.	Push	3.868	68
The unfavourable farming situation in the villages.	Push	3.145	61
There was a capital that could not be fully used on the farm.	Pull	1.786	28
The low demand and market demand for farm products.	Push	3.243	52
We perceived market demand for the new business.	Pull	2.277	38
We wanted to mitigate the fluctuations in farm income over the year.	Push	3.542	66
It was a way of being able to secure the family wealth.	Pull	2.146	24
It is just a lifestyle motive rather than profit-making.	Pull	1.106	18
The commercial value of land makes it unprofitable to use it for farming but to sale the land and start a nonfarm business.	Push	3.352	48
The unavailability or high cost of agricultural labour has forced the change in business.	Push	3.509	52
Lack of capital to expand the farm business caused downsizing and starting nonfarm business.	Push	4.126	69

Source: own composition

First, the zero cut-offs could be problematic since a farming household will diversify income sources by choosing agricultural and non-farm options, simultaneously. Second, the dichotomous dependent variable fails to consider the variation within the 0–1 range (choose an option or not).

In order to evaluate the measurement of model fit, a series of confirmatory factor analysis was undertaken to check violations of the normality assumption, missing data, and outliers. Also, single variable and F-test analysis with different categories of the dataset (e.g. small, medium and large dataset) was undertaken before the multinomial analysis. The test found strong support for the reliability and internal validity of measures. The standardised factor loadings are all above 0.59 (recommended minimum in the social sciences is usually 0.40) (Edelman *et al.,* 2010) and a Cronbach's alpha of 0.74. Figure 1 illustrates the model for household income and employment decision determinant.

For testing our hypotheses, we employed three dependent variables to control for the effect of the entrepreneur's personal and demographic characteristics. The measurement model was estimated using a confirmatory factor analysis to test whether the constructs exhibited sufficient reliability and validity (Edelman *et al.,* 2010). The second process identified the structural model(s) that best fit the data and examined the hypothesised relationships between the constructs.

The determinants of household income, as independent variables, include individual characteristics such as age, gender, family size, level of educational, family size (van der Zwan *et al.,* 2016). Besides, multiple external factors that support or hinder diversification or pluriactivity) described earlier, were also regressed in the model as shown in Figure 1 and Table 2.

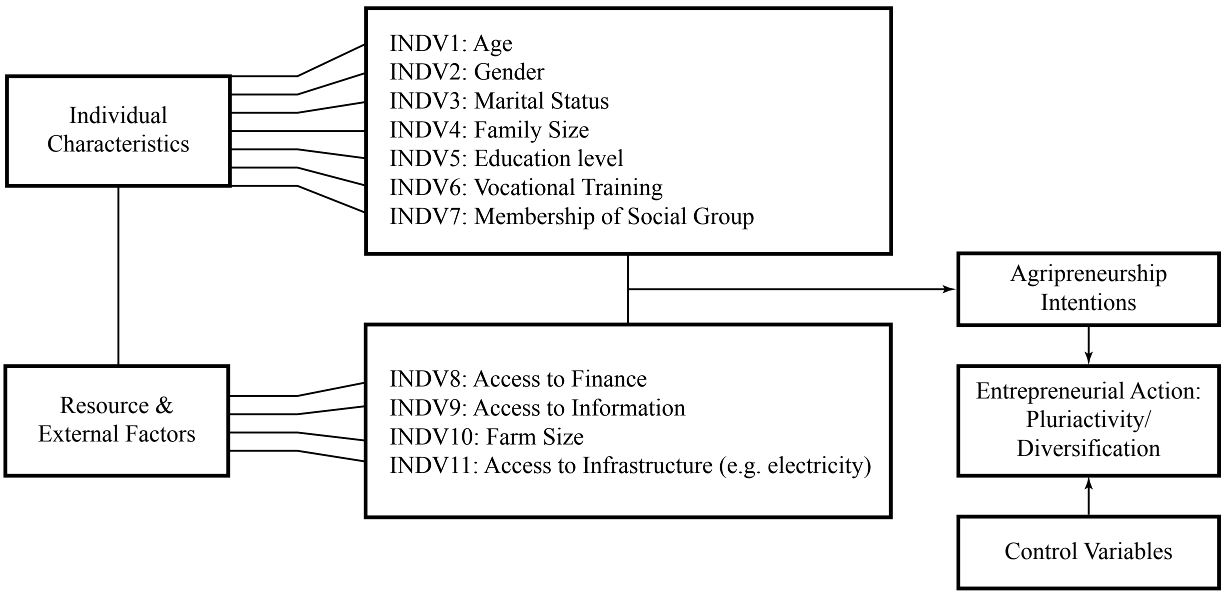

Figure 1: Determinants of Household Income and Diversification Decisions.
Source: own composition

Table 2: Determinants of Household Income: Multinomial Logit Analysis.

Variable	Nonfarm Enterprise		Wage Employment		Marginal Effects	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Constant	4.2623***	1.1232	1.4905	1.5365		
Age of FBOs	-0.0743***	0.0267	-0.1682***	0.0407	0.0216***	0.0650
Gender of FBOs	0.1848	0.5748	-0.2345	0.7604	-0.0289	0.1405
Marital Status of FBOs	-0.9095*	0.5316	1.2658	0.7861	0.2154**	0.1003
Year of Schooling	0.4241***	0.0533	0.9058***	0.0808	-0.1212***	0.0125
Technical Education	-0.8848***	0.3127	0.6952	0.4470	0.2117***	0.0762
Household size	0.1479*	0.0624	0.2215***	0.0798	-0.0390**	0.0151
Farm size	-1.0359***	0.2856	-0.3212	0.3609	0.2309***	0.0650
Access to credit	0.0516	0.3082	-0.2280	0.4708	-0.0031	0.0752
Membership of Social Group	0.0768	0.4893	-0.1540	0.7088	-0.1040	0.1203
Business access to Electricity	0.5385*	0.3190	0.6088	0.4714	-0.1333*	0.0741
Community access to Electricity	-0.3390	0.3383	0.3991	0.5156	0.0608	0.0804
Access to Services & information	-0.7321**	0.3154	0.2062	0.4337	0.1428*	0.0753

Note: Asterisks *, **, *** implies significance at 10%, 5% and 1% respectively.
Model Diagnostics: Log likelihood -283.484, LR Chi2 = 452.53, Prob Chi2 = 0.000 Pseudo R2 = 0.4439 Source: own composition
Source: own composition

The result of the analysis showed a model diagnostic of the log-likelihood of -283.484 and LR χ^2 of 452.53 measures which explain the significance and suitability of the model. Among the twelve variables modelled, age, education, technical education and farm size were significantly related to non-farm income (p< .001). Specifically, age has a significantly negative association with non-farm and wage employment at 1 per cent. The result implies that older people were less likely to take up non-farm and wage enterprises. Young people have a negative attitude and aspiration regarding farm work and farms in Nigeria are too small to employ skilled workers. Hence, young people are more attracted to work in non-farm rather farm businesses. FBOs who are married and have large household size are less likely to earn higher nonfarm farm income (path estimate -0.9095; p< .010), (see Table 2).

Large households are associated with holding large-scale farming, hence, may not have the extra resources to engage in non-farm activities. Similarly, FBOs with higher years of formal education (schooling) were more likely to engage in non-farm and wage enterprises. As noted by previous studies, rural enterprises are known to be less productive and wage earnings are lower when compared to urban enterprises; hence, educated people are more likely to migrate or seek for more skilled employment (Nagler and Naude, 2018). Household size affects income and employment choices because rural enterprises labour mostly comes from family due to the scarcity of labour in rural areas as a result of youths rural-urban migration.

Also, land is an important factor in the rural economy. If the value of the land increases, landowners must decide whether to sell or keep the land for their use. Due to lack of social security services in Nigeria, membership of social club enables households to productively engage in the pursuit of livelihoods. As such, many belong to cooperatives and social clubs to support each other in labour supply, production and marketing information. Finally, access to infrastructure (such as electricity and road) plays a major role in increasing productivity.

Discussion

This study examined the determinants of income and employment choices in a typical rural agriculturally based economy and outlined two alternative forms of employment among farmers already engaged in agriculture and provided robust econometric analysis with two of these alternatives regressed against many possible independent variables. The findings suggest that income derived from nonfarm employment and wage employment offer farmers extra income or security and unfavourable farming environment led many to reduce or engage in non-farm activities (either due to financial or security motives).

Therefore, households must choose to earn extra income through nonfarm or wage employment. However, the motives are either push or pull factors. In the past two decades, rapid population growth has put farming systems under stress, while rapid urbanisation and economic growth have provided new market opportunities in many countries (Binswanger-Mkhizea and Savastano, 2017). The strongest "push" and "pull" factors with mean scores of 2.0 and above has been applied to develop the determinants of Livelihood Choices Framework (Figure 2).

Although farming is the primary occupation, a relatively high share of income come from nonfarm and wage employment, indicating that smallholders diversify their income-generating activities beyond agriculture, particularly by running an own business in retail or manufacturing (FAO, 2018). Previous studies reveal that livelihood diversification reduces seasonality shocks in agricultural production; contributing to increased income, livelihood improvement (FAO, 2018; Hayatullah, 2020) and poverty reduction (Sutter *et al.,* 2019).

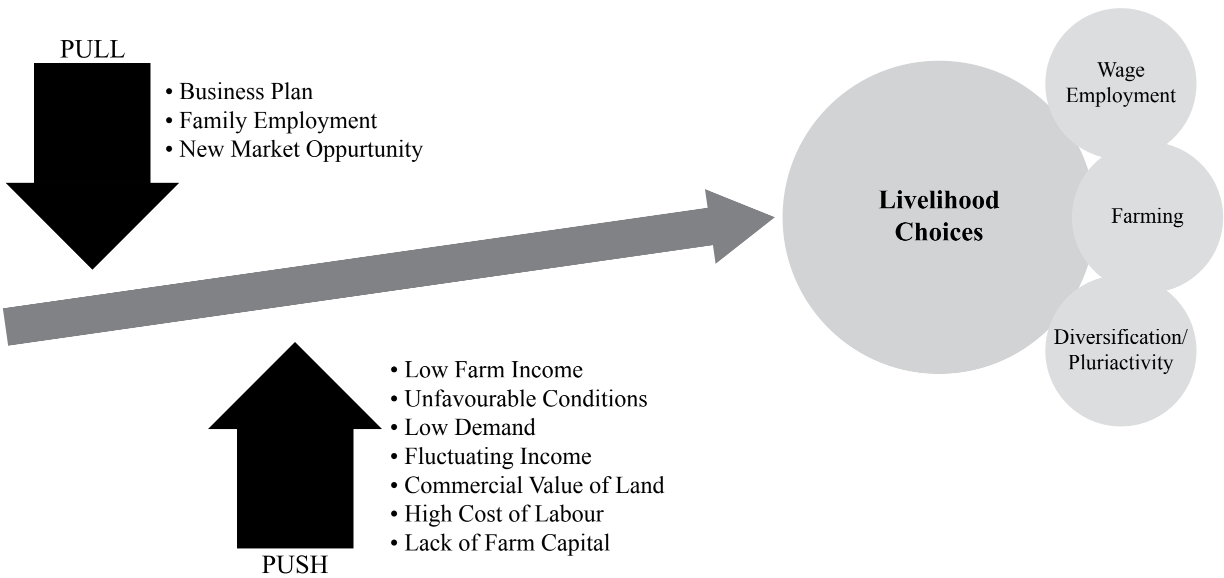

Figure 2: Determinants of Livelihood Choices.

Source: own composition

Notably, like many West African countries, Nigeria rural sector has numerous production challenges ranging from lack of credit facilities to poor linkage to market. Another problem is the ageing of the farmer's population as the majority of replacement generations of youth do not intend to get involved in agriculture. Also, nearly all the food produced by the household is consumed because productivity is low and large family size. Households are usually large because of the demand for family labour for farming and average educational attainment is low (FAO, 2018). Lack of access to education, capital and infrastructure constrain rural livelihoods. These factors contribute to the push or pull factors determining the choice of employment but also determines household income.

For many decades governments and international agencies have substantially focused their rural development and poverty alleviation plans on agricultural support policies. Past support programmes often linked to a "growth" model copying Western development objectives and trajectories. Very often these are doomed to fail. This is what Chang (2002) described as 'kicking away the ladder' by which rich countries climbed to development. Mozambique is cited as an example of how good governance rhetoric has been misused to retard development and poverty reduction (Hanlon, 2012). Some studies have proven that entrepreneurship can be a solution to extreme poverty (Sutter *et al.*, 2019). Therefore, with the increasing rise in rural poverty and inequality (especially in countries like Nigeria) a rural development policy rethink has become necessary.

Conclusions and Policy Implications

This article investigated the determinants of non-farm income and employment choices of FBOs. The findings were in line with previous literature, which has shown that pluriactivity and diversification among rural farmers are widespread and only a few of farmers globally work on the farm as the only source of income (Hayatullah, 2020; Radicic *et al.,* 2017). Among the twelve variables examined, age, education, technical education and farm size were significantly related to non-farm income. Due to the crude nature of farming and low farm incomes, young people are more attracted to work in non-farm rather farm businesses. Hence, non-farm diversification has implications towards youth employment and social mobility. Rural households produce on small farms and consume a large proportion of what they produce, leaving only a smaller percentage for sale in an underdeveloped market.

"Greater pressure is being applied on developing economies by the developed world and international policy establishment so that it controls the adoption of a set of good policies and institutions to foster their economic development" (Chang, 2002, p. 63). In this context, rural livelihood policies have critical and long-term implications concerned with reducing poverty in low-income developing countries. Lack of access to capital, low farm income and fluctuations in farm income were the three most influencing factors (push factors) towards diversification. Perhaps, rural development policies could focus on strengthening the capabilities of the small farmers (within the deepening, broadening and re-grounding boundaries) to produce high-quality products, engage in regional specialities and hybrid products that will improve food availability at the same time increase farm income. Good examples include the provision of extension services to educate farmers on new improved varieties and farming approaches, provision of subsidised input such as fertiliser, pesticides, improved seeds and availability of low interest and flexible agricultural loans/credit.

These measures could lead to improving the resilience of farming to market failures and environmental shocks brought on by weather, pest and diseases. However, non-farming activities are also important in rural development. Therefore, rural development policies should also incorporate measures that led to increasing non-farm business activities, thereby decreasing income inequality and poverty rates in the rural communities. Policies that focus on strengthening the quality of education, vocational and technical training and access to small machinery and tools will strengthen the capacity of the rural non-farm sector. This will lead to an improvement in wage employment opportunities in rural industries and reduced labour migration to urban industries thereby increasing farm labour availability in the rural areas. This is important given that the findings indicate that young farmers depend on non-farm activities as their primary employment in rural areas. Policies aimed at reviewing the land tenure system has implications concerning younger generation access to land that will enable them to engage in farming to maintain rural economic sustainability.

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Determinants of Coffee Producer Market Outlet Choice in Gololcha District of Oromia Region, Ethiopia: A Multivariate Probit Regression Analysis

The study was conducted in Gololcha District of Arsi Zone with the objective of identifying determinants of coffee producer market outlet choice. The primary data were collected through personal interviews from a total of 154 producers, using structured and semi-structured questionnaires. The multivariate probit model result indicated that the sex of the household head, level of education, means of transport ownership and access to information had positively influenced choice of wholesaler and negatively influenced choice of agent middle-men. Level of education was significantly and negatively related with agent middle-men, and significantly and positively influenced cooperatives' and wholesalers' channel choice. Enhancing institutional and infrastructural (transportation and extension) facilities is necessary to enable coffee producers to select efficient channels. In addition, the study recommends that steps be taken to establish and support multi-purpose coffee farmers' cooperatives – grow their membership, as this should increase farmers' income through marketing activities and supply of important inputs.

Keywords: coffee, market outlet, choice, Ethiopia

JEL classification: Q13

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Introduction

Agriculture accounts for 33.3% of total GDP, 78% of total exports and more than 70% of total employment to the Ethiopian economy (NBE, 2019; USDA, 2019). Development of smallholder crops and pastoral agriculture will be further enhanced and hence will remain the main source of growth and rural transformation during the GTP II period (NPC, 2016). However, development of the agricultural sector has been hampered by a range of constraints which include land degradation, low technological inputs, weak institutions, and lack of appropriate and effective agricultural policies and strategies (Aklilu, 2015).

Ethiopia is known to be the birthplace for coffee. Coffee is the major export commodity cultivated in Ethiopia. Coffee grown in Ethiopia is known all over the world for its excellent quality and flavour. Today, Ethiopia stands as the biggest coffee producer and exporter in Africa and also ranks amongst the leading producers and exporters in the world. According to NBE (2019) report, export earnings from coffee grew by 13.5 percent over last year same quarter due to 36.0 percent increase in export volume despite a 16.5 percent decline in the international price; coffee's contribution to total export earnings remained close to 32 percent.

There are structural changes taking place in the coffee export sector in Ethiopia. Cooperatives and commercial farms are on the increase, with lower concentration ratios in the export sector. On the other hand, the share of the incumbents in the local coffee market is large. While the Ethiopian Commodity Exchange, which was established in 2008, introduced regulatory, institutional, and organisational innovations in the coffee market, informal norms and conventions remain the primary institutions governing transactions in the local markets (Fekadu *et al.*, 2016). An efficient, integrated, and accurately responsive market mechanism is of critical importance for optimal allocation of resources in agriculture and for stimulating farmers to increase output.

A total area of 6,606.55 ha was allocated for coffee production (in 2016/17 *meher* season) in Arsi Zone (CSA, 2017) and Gololcha district is found on the 14th from top 18 coffee producing districts in Oromia (Warner *et al.,* 2015). A total area of 13,466 Ha of land was allocated for production and 35,750 quintals of coffee clean bean was obtained in 2018 (GDOoANR, 2018). However, the study conducted by Degaga *et al.* (2017) showed farmers in the study area sold dried cherries to local traders at a low price which could not cover their cost of production.

Various studies on coffee producers' market outlet choices (Diro *et al.*, 2017; Engida, 2017; Negeri, 2017; and Asefa *et al.*, 2016) were conducted in different parts of the country. However, past studies conducted on different regions of Ethiopia, did not address the market outlet choice decision of coffee producers in the study area. Therefore, given the potential of Gololcha District for coffee production, the results of this study are of real importance as they shed light on factors affecting the choice of appropriate market outlets. Hence, this study has aimed to identify the determinants of market outlet choice decision of coffee producers in the study area.

Literature Review on Determinants of Market Outlet Choices

Negeri (2017) employed a multinomial logistic model to examine the major determinants of market outlet choice of coffee producing farmers in Lalo Assabi District of West Wollega zone, Ethiopia. The model showed that the choice of end consumer outlet is positively and significantly affected by access to transportation facilities, access to price information and access to credit compared to private trader outlet, whereas the quantity of coffee sold and access to extension services negatively affected the main choice of end consumer outlet. Similarly, the choice of cooperative outlet is positively and significantly affected by distance to the market, access to transportation facilities, access to price information and access to training as compared to a private trader outlet.

Similarly, Hailu and Fana (2017) used a multinomial logit model to analyse the determinants of market outlet choice for major vegetables crops in Ambo and Toke-Kutaye Districts, West Shewa, Ethiopia. The result indicated that family size and access to market negatively affected choice of retailer channel. In the same manner, dummy model farmer, education level, and access to credit decrease the likelihood of a retailer channel being chosen while having the opposite effect on the wholesaler channel. Livestock in TLU and access to market meanwhile decrease the likelihoodof a wholesaler channel being selected.

Similarly, Diro *et al.* (2017) studied the share of coffee market outlets among smallholder farmers in western Ethiopia by employing a multinomial logistic regression model. Consumers, brokers, cooperatives, urban, and rural traders were found to be the main coffee market outlets in the area. They further noticed that sex was a positive and significant factor, which implies that male farmers prefer cooperatives to sell their coffee as compared to female farmers. According to the study, the logic behind this could be male farmers have more resources for transportation and time to sell their coffee product to markets even when the markets are far away from their residence.

Negeri (2017) in his study of the determinants of market outlet choice by coffee producing farmers in West Wollege zone, Ethiopia, used a multinomial logistic regression model and the results of the model showed that the choice of end consumer outlet is positively and significantly affected by access to transportation facilities, access to price information and access to credit as compared to a private trader outlet, whereas the quantity of coffee sold and access to extension services negatively affected the main choice of end consumer outlet. Similarly, the choice of cooperative outlet is positively and significantly affected by distance to the market, access to transportation facilities, access to price information and access to training as compared to a private trader outlet.

On the other hand, Sori (2017) identified factors affecting market outlet choices of groundnut producers in Digga District of Oromia State, Ethiopia by using a multivariate probit model. The result of the model identified that variables like educational level, distance to the nearest market, access to extension service, size of land allocated for groundnut, quantity of groundnut produced, transport facilities, buyers' trust and access to off/nonfarm income affected the choice of appropriate market outlets of producers.

Efa and Tura (2018) also employed multivariate probit model to analyse the determinants of tomato smallholder farmers' market outlet choices in West Shewa, Ethiopia. The result of the study revealed that distance to nearest markets, access to credit, family size, age of household head, education status, farming experience and volume of tomato produced significantly influence choices of tomato market channels. Retailer market outlet choices were negatively affected by age of household head, education status and distance to the nearest market whereas access to credit had a positive affectto varying levels of significance. However, wholesaler market outlet choices were negatively affected by access to credit, family size and amount of tomato produced to varying levels of probability.

Resource endowment (economic factors) such as ownership of market transportation, size of land allocated to coffee production, quantity of coffee produced and nonfarm income have an influence on producers' market outlet choices. Figure 1 illustrates the key variables used in the study and shows how they influence the market outlet choice of coffee producers in the area studied.

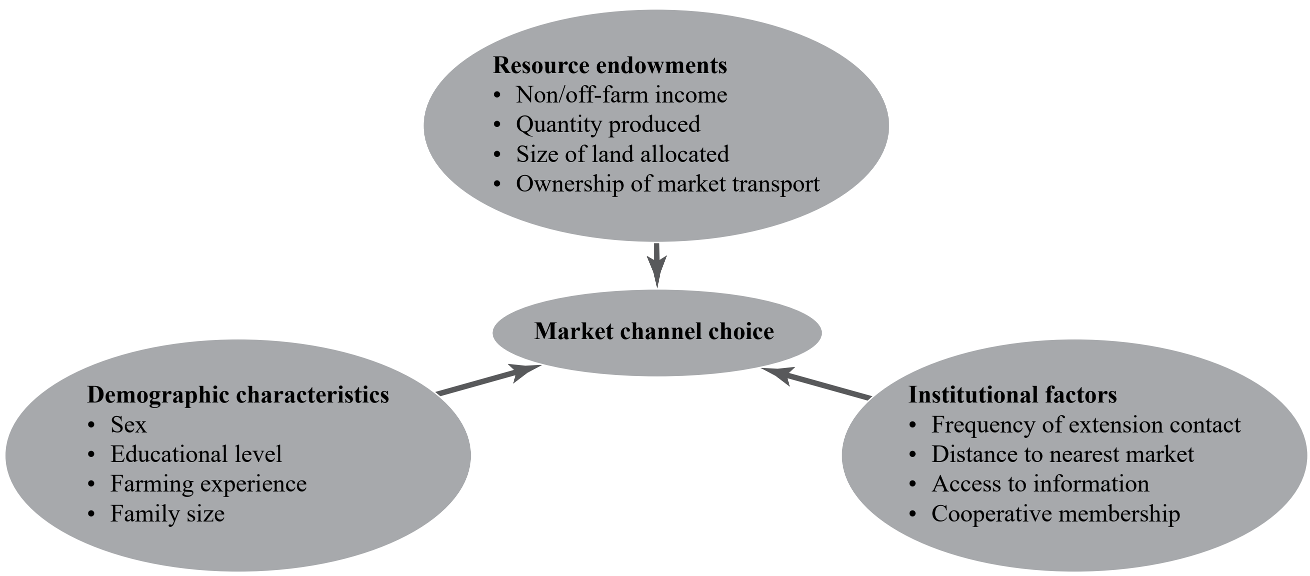

Figure 1: Conceptual framework of the study.

Source: own compilation from literature review

Methodology

Description of the Study Area

The study was conducted in the Gololcha district. It is one of the districts in Arsi zone with potential of coffee production. Gololcha is located at about 281 km from Addis Ababa, the capital city of Ethiopia and 206 km from Asella, which is the capital town of Arsi zone. It is bordered by Aseko district in the north, Amigna district in the south, Shenan Kolu district in the east and Chole district in the west. The district has 23 rural *kebeles* and from this 20 *kebeles* are coffee producers. The altitude of the district ranges from 1400 to 2500 metres. Generally, the district has a total area of 178,102 hectares and is classified into two agro-ecologies, the midland (25%) and the lowland (75%). The average temperature of the district is 35 °C and the average rainfall is 900 mm/year.

Total population of the district is estimated to be 201,247, out of which 102,502 are males and 98,745 are females. The main rainy season of the district is in April, May, June, July, August and September. The soil type of the district is silt soil and sandy soil. Major crops produced in the district are coffee, maize, sorghum, *teff* and groundnut (GDOoANR, 2018).

Methods of Data Collection and Sampling

The study has utilised both primary and secondary data sources. Primary data was collected from sample respondents using a structured interview schedule. Before data collection, the questionnaire was tested on some farmers to evaluate the appropriateness of the design, clarity and interpretation of the questions, plus the relevance of the questions, to make sure important issues had not been left out and to estimate the time required for an interview. Training was given to enumerators regarding the objectives of the study and, in particular, on the detailed contents of the questionnaire.

Secondary data on the population size of the study areas and the agro-climatic condition of the study area were taken from unpublished documents of the district agricultural and natural resource office, and the coffee and tea development and marketing authority.

A two-stage random sampling technique was used to select coffee producing *kebeles* and sample farm households. In the first stage, 4 coffee producing *kebeles* were purposively selected from 20 coffee producing *kebeles*. In the second stage, from the total number of coffee producers, 154 household heads were selected randomly based on probability proportional to population size.

Knapp and Campell (1989) suggested a rule of thumb which states that for most multivariate analysis, the number of observations should be at least 10 times the number of variables and exceed the number of variables by at least 30.

This means, $n \geq 10\ v + 30$ (1)

where, n = is number of observations,
v = is number of variables

The number of variables hypothesized in this study were 12 and therefore, the minimum size of total sample would be, $n \geq 10\ (12) + 30 \rightarrow n \geq 50$. Table 1 summarises how the number of sample households is related to the total number of coffee producers.

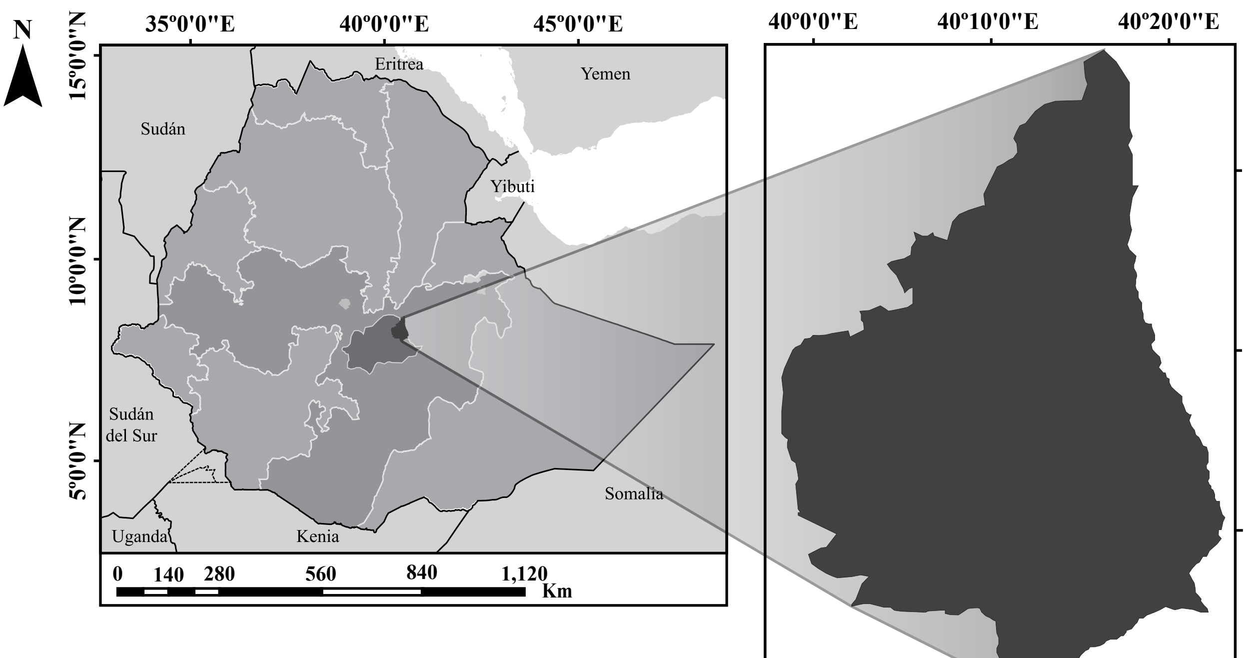

Figure 2: Geographical map of the study area.

Source: own sketch From Ethio-GIS

Table 1: Sample size selection proportional to population size.

No	Kebeles	Total number of coffee producers	Number of sample households
1	Mine Gora	782	47
2	Jinga Sokoru	305	18
3	Tibi Sebata	932	55
4	Ungule Hara	569	34
	Total	**2,588**	**154**

Source: Gololcha District Office of Agricultural and Natural Resource, 2019.

Method of Data Analysis

Both descriptive statistics and econometric analysis were used to analyse collected data from households. Descriptive statistics such as mean, maximum, minimum, standard deviation, frequencies, percentages and graphs were used. The multinomial logit model is the most frequently used nominal regression model (Long and Freese, 2014). In a multinomial logit model, there is a single decision among two or more alternatives. Odds ratios in the multinomial logit are independent of the other alternatives. This property is convenient as regards estimation, but it is not a particularly appealing restriction to place on consumer behaviour. The independence assumption follows from the initial assumption that the disturbances are independent and homoscedastic (Greene, 2003).

In the study area, cooperative, wholesalers and agent middle-men were coffee producers' outlets and the decision to sell to existing outlets reflected this. According to Belderbos *et al.* (2004), the multivariate probit model takes such correlations into account. If a correlation exists, the estimates of separate (probit) equations for the cooperation decisions are inefficient. Therefore, multivariate probit model was used to for the determinants of marker outlet choice. Following Greene (2012), the multivariate probit model can be specified as;

$$Y_m^* = X_m^{'} \beta_m + \varepsilon_m, Y_m = 1 \text{ if } Y_m^* > 0, 0 \text{ otherwise}, \quad m = 1, \ldots, m \tag{2}$$

In a multivariate model, where the choice of several market outlets is possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity;

$$E\lfloor \varepsilon_m \mid X_1, \ldots, X_m \rfloor = 0, \tag{3}$$

$$Var\lfloor \varepsilon_m \mid X_1, \ldots, X_m \rfloor = 1, \tag{4}$$

$$Cov\lfloor \varepsilon_j \varepsilon_m \mid X_1, \ldots, X_m \rfloor = \rho_{jm}, \tag{5}$$

The joint probabilities of the observed events; $\lfloor Y_{i1}, Y_{i2}, \ldots Y_{im} \mid X_{i1}, X_{i2} \ldots, X_{im} \rfloor$, $i = 1, \ldots n$, that form the basis for the log-likelihood function are the m-variate normal probabilities,

$$L_i = \phi_m \left(q_{i1} X_{i1}^{'} \beta_1, \ldots, q_{im} X_{im} \beta_{im}, R^* \right), \tag{6}$$

Where, $q_{im} = 2_{yim} - 1$, $R_{jm}^* = q_{ij} q_{im} \rho_j$

Hypothesis and Definitions of Variables

Dependent Variable

Market Outlets (MRKTUOT): This is a binary dependent variable measured by the probability of producers sell coffee to either of the alternatives market outlets. It was represented in the model as Y_1 for those households who choose to sell coffee to cooperatives, Y_2 for producers who choose wholesalers, and Y_3 for producers who choose commission men to sell their coffee.

Independent Variables

The explanatory variables hypothesised to influence market outlet choice of coffee producers were the following.

Sex of the household head (SEXHH): It is a dummy variable taking a value of 1 if the household head is male and 0 otherwise. Male farmers have more resource for transportation and time to sell their coffee product to markets even when the markets are far away from their residence (Diro *et al.*, 2017). Therefore, the sex of the household head (being male) was expected to affect the likelihood of choosing cooperatives and wholesalers positively, and choice of commission men negatively.

Education status of the Household Head (EDHH): It is a continuous variable that refers to the number of years of formal schooling the household head attended. Educated household heads are expected to have better skill, better access to information and to make better use of their available resources. The more educated the farmers are, the more likely they are to participate in retail channels, possibly as higher levels of education may help farmers to adjust to new market requirements and making them more likely to adopt innovative production practices (Efa and Tura, 2018). Medeksa (2014) also reported that education level provides positive predictive power, whether or not the household chooses a cooperative as its market outlet. Therefore, it was expected to affect the likelihood of choosing cooperatives and wholesalers positively, and of commission men negatively.

Family size in terms of adult equivalent (FAMSZ): It is a continuous variable measured in terms of adult equivalent. The availability of an active labour force in a household is assumed to affect the household's decision in choosing a given market outlet within the coffee market chain. Honja *et al.* (2017) reported that family size is positively correlated with the choice of wholesaler outlet and demonstrated that households with a larger family size have plenty of labour force to deliver mangoes to their final market. Hence, it was hypothesised that family size influences the likelihood of choosing cooperatives and wholesalers positively and of commission men negatively.

Size of land allocated to coffee production (AREACOFE): This is a continuous variable measured in terms hectare of land allocated for coffee production by the household. The likelihood of choosing private traders and cooperative market outlet was positively and significantly affected by size of land allocated under coffee (Engida, 2017). According to Diro *et al.* (2017), the size of land allocated for coffee production has positive and significant impact on choice of farmers for consumers. The implication was that those farmers who have large total amounts of coffee land harvest more yield and supply products to fair and efficient markets. Medeksa (2014) also reported that the size of land allocated for coffee production has a positive and significant impact on choice of farmers for cooperatives. Similarly, Asefa *et al.* (2016) identified that the total coffee land of the household has a positive and significant effect on the preference of farmers for formal markets and brokers, and has a negative and significant effect on the preference farmers for cooperatives as compared to informal market. Hence, land allocated to coffee production was hypothesised to influence the likelihood of choosing cooperatives and wholesalers positively and of commission men negatively.

Quantity Produced (QUANP): An increase in the quantity of production has a significant effect on market supply and motivates farmers to increase the supply of a commodity to the market. According to Negeri (2017), if the quantity of coffee to be sold is low, farmers are not forced to search for price and market information. However, if the quantity to be sold is high, they search for a market outlet, which buys with the most effective price. Hence, it was hypothesised to influence likelihood of choosing cooperatives and wholesalers positively and of commission men negatively.

Farming Experience (FARMEX): This is a continuous variable, measured in terms of the number of years of experience the households had in coffee farming at the time of interview. Farmers with longer production experience are expected to be more knowledgeable and have good weather forecasting ability, this improves the productivity and quantity of output sold. Efa and Tura (2018) reported that farming experience has both positively and negatively affected tomato farmers' choices of wholesaler and consumer market outlets, respectively. The study by Asefa *et al.* (2016) indicated that the farming experience of the household had a positive and significant effect on the preference of the farmer for formal markets and brokers as compared to informal markets. Hence, it was hypothesised to influence the likelihood of choosing cooperatives and wholesalers positively and of commission men negatively.

Distance to the nearest market (DMRKT): This is a continuous variable, measured in km from the nearest market the household used to sell their coffee produce. The farther away a household is from the market, the more difficult and costly it would be to get involved. Usman (2016) reported that distance from the closest market place positively and significantly affected accessing millers/processors market outlets as compared with accessing assembler market outlets of wheat. It also affected the wholesaler market outlet negatively and significantly. Hence, distance from the nearest market was hypothesised to affect the likelihood of choosing cooperatives and wholesalers negatively and of commission men positively.

Frequency of Extension contact (FEXCONT): It is a continuous variable, measured in terms of number of visits per year made by the extension service to the sampled households. Extension service helps in making information available regarding technology, which improves production. Negeri (2017) reported that access to extension services negatively and significantly affected the choice of end consumer outlet of coffee producers. According to Asefa *et al.* (2016), the frequency of an extension contact has a negative and significant effect on formal markets and brokers and a positive and significant effect on cooperatives as compared to their informal counterparts. Hence, it was hypothesised to affect the amount of coffee sold positively, and thelikelihood of choosing cooperatives positively, wholesalers either positively or negatively, and commission men negatively.

Ownership of market transport facilities (TROWR): This is a dummy variable and takes the value of 1 if the household owns transportation facilities and zero otherwise. Ownership of transport facilities plays a vital role in lowering transportation costs, as well as enabling farmers to go to distant markets,choose more than one market to sell their produce, and achieve a higher price. Abera (2017) found that number of equines owned was found to have a positive and significant influence on the probability of haricot bean producer farmers deciding to choose direct consumers and urban traders outlets and a negative and significant influence as regards rural assemblers' outlets. Hence, it was hypothesised to affect the likelihood of choosing wholesalers positively and of commission men negatively.

Cooperative Membership (COMSHIP): This is a dummy variable that takes a value of 1 if a household head is a member of agricultural cooperatives and 0 otherwise. Membership of a cooperative can also contribute towards reduced transaction costs and strengthen farmers' bargaining power through networking and the provision of up-to-date information to members. Being a member of a cooperative increases the likelihood of a farmer choosing an urban trader's outlet (Abera, 2017). Therefore, cooperative membership was hypothesised to affect the market likelihood of choosing cooperatives positively, and of wholesaler and commission men negatively.

Non/off-farm income (NONFRM): This is a continuous variable, measured in monetary value (ETB), and showing the amount of income obtained from non/off-farm activities undertaken by the household heads. The availability of off/non-farm income has a negative and significant relationship with the likelihood of choosing a private trader outlet and positive and significant relation with the likelihood of choosing a consumer market outlet of coffee producers (Engida, 2017). Hence, it was hypothesised that non/off-farm income was expected to influence the likelihood of choosing cooperatives and wholesalers positively and of commission men negatively.

Access to market information (INFO): This is a dummy variable that takes a value of 1 if a household head has access to market information and 0 otherwise. According to Ababulgu (2016) access to coffee market information affects the choice of collector outlet negatively and significantly. Hence, it was hypothesised that access to information influences the likelihood of choosing cooperatives and wholesalers positively, and of commission men negatively.

Table 2 summarises the most important characteristics of the variables used.

Table 2: Summary of variables definition, measurement and hypothesis for coffee market supply.

Variables	Category	Measurement	Expected effect on market outlet choice		
			Cop	Whole	Agent
Sex	Dummy	1 if male, 0 otherwise	+	+	–
Education	Continues	Years of schooling	+	+	–
Family size	Continues	Men equivalent	+	+	–
Area allocated	Continues	hectare	+	+	–
Quantity	Continues	Quintal	+	+	–
Experience	Continues	Number of years	+	+	–
Distance	Continues	Kilometers	–	–	+
Extension	Continues	Number of visit/year	+	±	–
Transport	Dummy	1 if owned, 0 otherwise	+	+	–
Cooperatives	Dummy	1 if member, 0 otherwise	+	–	–
Non-farm	Continues	ETB	±	±	–
Information	Dummy	1 if access, 0 otherwise	+	+	–

Note: "Cop", "Whole" and "Agent" refers to Cooperatives, Wholesalers and commission men, respectively.
Source: own composition

Results and Discussion

Socio-economic characteristics of sample respondent for categorical variables

From the total households interviewed, 20.1% were female-headed households and 79.9% were male-headed households. Education is instrumental to attaining developmental goals through the application of science, technology and innovations. Consequently, the educational status of coffee producers in the study area was assessed and it was found that the maximum years of education completed were 12 grades with the mean of 5.15 and standard deviation 3.72. According to CSA (2017), nearly half of women (48%) and 28% of men aged 15 up to 49 in Ethiopia have no education. The illiteracy rate for male and female households in the study area was 15.45% and 58.06%, respectively. This implies that the illiteracy rate of coffee producers was below the national average for male households on the one hand, and was above the national average for female household heads on the other hand.

Table 3 indicates that 81.85% of the respondents had no access to off/non-farm income and only 18.2% had access to non/off-farm income. Their major sources of non/off-farm income were shopping, fattening, selling of food and others which accounted for 31.1%, 21.1%, 21.1% and 26.7%, respectively. The mean value of non/off-farm income received per year was 2802.60 birr with the high standard deviation of 8568.01 and ranges to 60,000 birr. The highest value of non/off-farm was obtained from fattening. Means of transport ownership is also critical in transporting coffee cherries and searching for better place and price. Accordingly, 52.6% of the farmers were transporting coffee to the nearby market using their own donkey. Means of transporting coffee for those who had no donkey were a hired donkey (67.12%), human labour, own or hired (24.66%) and hired vehicles (8.22%).

Another crucial factor made available by institutional services is market information. It is especially important for market-oriented crops, such as coffee. Table 3 indicates that around 44.8% of the respondents had access to market information while the rest had no access to information. Their major sources of market information were friends (19.7%), traders (18.2%), own assessment (16.7%), radio (13.6%), own assessment and traders (12.1%), own assessment and friends (9.1%). Access to extension services also plays an important role in boosting coffee production and productivity. Half of the respondents had contact with an extension agent. Their contact organisations (body) were developmental agents (62.7%), developmental agents, the district agricultural and natural resource office (201.9%), and the district agricultural and natural resource office (16.7%). Their time of making contact was harvesting time, during land preparation, during seeding and the application of fertilisers, and during planting. The mean frequency of contacting extension agents per year for coffee producers was 1.52 times with the maximum being 12 times and the standard deviation being 2.11.

Primary cooperatives enable farmers to pool coffee products together and sell at a better price. However, Table 3 reveals that only 26% of coffee producers were members of multi-purpose cooperatives. The reasons for being a member were to obtain oil and sugar, the fact that a cooperative provided better price than traders and the perception that the weighting of coffee was fairer with a cooperative than with traders. The reasons for not joining a primary cooperative in the study area were corruption on the part of committee members in respect of benefit sharing, cooperatives being located far from their home and there being no perceived benefit.

Socio-economic characteristics of sample respondent for continuous variables

The other variables used to describe demographic characteristics of sampled farmers were age, family size and farming experience. Accordingly, the age of the respondents ranges from 16 to 75 with a mean of 38.96 and a standard deviation of 11.49. The mean family size was 3.7 persons with a standard deviation of 2.17 and results ranging from 1 to 12 persons. According to CSA (2017), the average household size in Ethiopia was 4.6 members. This implies that the average family size of coffee producers in the study area was below the national average.

Table 3: Socio-economic characteristics of sample respondents for categorical variables.

Variables	Category	N	Mean coffee supplied to the market			
			%	Mean	Std. Dev.	t-value
Sex	Female	31	20.1	3.90	2.58	3.54***
	Male	123	79.9	8.37	6.69	
Educational status	Illiterate	37	24	3.73	2.66	4.23***
	Literate	117	76	8.66	6.92	
Obtain non/off farm income	No	126	81.8	7.13	6.43	1.41 (NS)
	Yes	28	18.2	9.04	6.78	
Own means of transport	No	73	47.4	6.19	5.10	2.36**
	Yes	81	52.6	8.63	7.40	
Had access to information	No	85	55.2	6.24	5.38	2.65***
	Yes	69	44.8	8.99	7.44	
Had extension contact	No	77	50	6.09	4.94	2.68***
	Yes	77	50	8.85	7.56	
Cooperative membership	No	114	74	6.68	5.44	2.59**
	Yes	40	26	9.73	8.58	

Note: *** and ** indicate significance level at 1% and 5% respectively. NS stands for not-significant.
Source: own survey results

Table 4: Socio-economic characteristics of sample respondents for continuous variable.

Variables	Observations	Mean	Std. Dev.	Min	Max
Age of the respondent	154	38.96	11.49	16	75
Family size	154	3.70	2.17	1	12
Farming experience of the respondent	154	16.58	9.71	2	45
Total land owned in hectare	154	0.98	0.49	0.13	2
Total land allocated to coffee (*Coffea arabica)* in hectare	154	0.58	0.27	0.13	1
Quantity of coffee produced (with husk)	154	9.03	6.85	1	41
Distance to the nearest market (km)	154	3.93	5.57	0.500	16

Source: own survey results

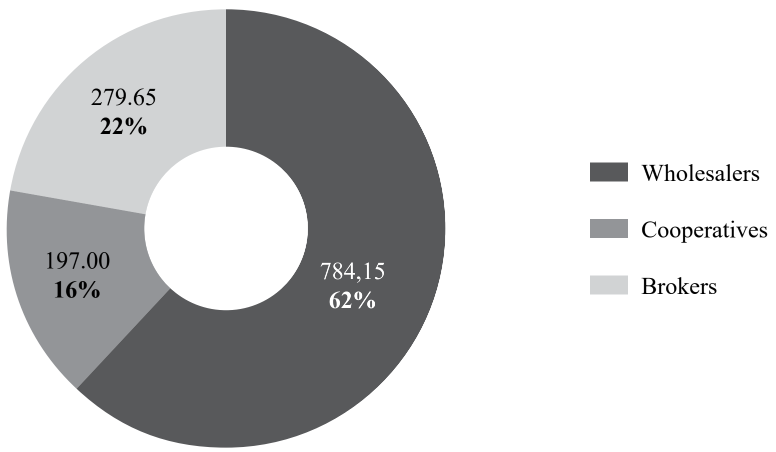

Figure 3: Number of channels available and their purchasing capacity per one production year.

Note: Amount of coffee sold in quintals (with dry husk).
Source: own survey results.minants of Market Outlet Choice

Availability of land is one of the most important factors that influence crop production. The mean amount of land holding in the study area was 0.98 hectares. According to CSA (2014), the average land holding in Ethiopia was 1.14 hectares. Hence, the average land holding of coffee producers was below the national average. From the total land owned, around 59.18% was allocated to coffee production. Distance to the nearest market was also estimated by the respondent in km and the result indicated that on average, one household sold coffee by travelling 5.57 km with the minimum and maximum distances travelled being 0.5 km and 16 km, respectively.

Major outlet existed for coffee producers in the study area

Farmers are not permitted to sell coffee outside of the district. But, within the district, they can sell their coffee to

Table 5: Multivariate probit estimation for determinants of coffee producer market outlet choice.

	Cooperatives		Wholesalers		Agent middle-men	
Variables	**Coeff.**	**Std. Er.**	**Coeff.**	**Std. Er.**	**Coeff.**	**Std. Er.**
Sex of household heads	-0.566	0.514	1.487***	0.378	-0.706**	0.323
Educational level	0.140**	0.063	0.074*	0.042	-0.101**	0.040
Farming experience	-0.026	0.019	-0.009	0.015	0.005	0.013
Land allocated	-0.017	0.182	0.049	0.139	0.031	0.128
Access to non-farm	0.121	0.434	0.009	0.327	-0.288	0.304
Means of transport	-0.255	0.364	0.628**	0.266	-0.484**	0.241
Frequency of extension	0.105*	0.062	0.104	0.065	-0.097*	0.057
Access to information	-0.371	0.333	0.674***	0.247	-0.506**	0.231
Cooperative membership	2.685***	0.401	-0.418	0.300	-0.107	0.287
Distance to market	0.055	0.040	-0.069**	0.034	0.011	0.032
Output level	-0.014	0.024	0.019	0.025	0.004	0.021
Family size	0.092	0.079	0.015	0.062	-0.003	0.059
Constant	-2.026***	0.772	-1.753***	0.582	1.303**	0.520
Multivariate probit (MSL, # draws)			100			
Number of observations			154			
Log likelihood			-155.320			
Wald $\chi 2$ (36)			114.210			
Prob> $\chi 2$			0.0000***			
Predicted probability	0.246		0.606		0.415	
Joint probability of success			0.005			
Joint probability of failure			0.027			
Correlation matrix	$\rho_1(Y_1)$	$\rho_2(Y_2)$	$\rho_3(Y_3)$			
$\rho_1(Y_1)$	1					
$\rho_2(Y_2)$	0.025	1				
$\rho_3(Y_3)$	-0.224**	-0.756***	1			
Likelihood ratio test of $\rho_2\rho_1 = \rho_3\rho_1 = \rho_3\rho_2 = 0$ $\chi 2(3) = 72.11$ Prob > $\chi 2$ = 0.0000***						

Note: ***, ** and * indicated significance level at 1%, 5% and 10%, respectively. Y_1, Y_2 and Y_3 are Cooperatives, Wholesalers and Commission-men, respectively.
Source: own survey results

wholesalers, cooperatives and agent middle-men. The major receivers of coffee from farmers were wholesalers (784.15 quintals), agent middle-men (279.65 quintals) and cooperatives (197 quintals).

Determinants of Market Outlet Choice

Coffee producers in the study had three major types of market outlets via which to sell their coffee beans. A multivariate probit model was used to analyze producers' channel choice. The p-value of Wald $\chi 2$ (36) = 114.21, Prob> $\chi 2$= 0.0000*** is significant at 1% significance level and indicated that the coefficients of regressors are jointly significant. The value of $\chi 2$ (3) = 72.11, Prob> $\chi 2$ = 0.0000*** implies that the null hypothesis which states the choice of available market channels are independent is rejected and therefore, coffee producers market outlet decisions are interdependent. The correlation matrix showed that the likelihood of choosing agent middle-men and cooperatives is negative and significant at a 5% significance level. Similarly, it revealed that the decision of choosing wholesalers and agent middlemen is negatively correlated at a 1% significance level. Table 5 further reveals that the probability of choosing cooperatives, wholesalers and agent middlemen of coffee producers were 24.6%, 60.6% and 41.5%, respectively. The joint probability of choosing all market outlets was 0.5% and whereas the probability of a failure to jointly choose was 2.7%. As can be seen in Table 5, out of twelve explanatory variables, one commonly affected the entire outlet choice. The table also shows that three variables significantly affected cooperatives, and that five variables significantly affected wholesalers and agent middlemen.

Sex of the household heads (SEXHH): Sex of the household head had positively influenced the likelihood of choosing a wholesaler and negatively influenced the choice of agent middle-men at 1% and 5% levels of significance, respectively. Males have more time to sell and also hold large amount of coffee bean to sell, and consequently search for wholesalers even if the market place is far from their home. However, female households were more likely to opt for agent middle-men. Similarly, Diro *et al.* (2017) demonstrated that male farmers have more resources available for transportation and time to sell their coffee product to far away markets.

Educational level (EDHH): The educational level of the household head was significantly and positively related to the choice of cooperatives and wholesalers market channels, and significantly and negatively related to the choice of agent middle-men at 5%, 10% and 5% levels of significance, respectively. This is due to the fact that most of the educated farmers in the study area were members of a cooperative and hence were more likely to sell through that cooperative than through other outlets. Moreover, education enhances the capability of farmers when making decisions with regard to the choice of market outlet based on the marketing margin and marketing cost. This finding is consistent with Medeksa (2014) who reported that educational level provides positive predictive power, whether or not the household chooses a cooperative as the market outlet for their coffee.

Means of transport ownership (TROWR): The result indicated that ownership of a donkey positively and significantly affected the choice of wholesaler channel and negatively influenced the choice of agent middle-men market channel at 5% level of significance. This is due to the fact that in the study area, the means of transporting coffee to the market was through donkey and those who owned it were more likely to sell it at the village and district market to wholesalers at a better price. The finding is in line with Addisu (2018) who reported that having equines positively correlates to the likelihood of choosing wholesalers outlet.

Access to market information (INFO): A positive relationship was found to exist between access to price information and choice of wholesalers' market outlet at a 1% significance level, and a negative relationship was found to exist between access to price information and agent middle-men market outlet at a 5% significance level. The rationale behind this could be that access to market information might encourage farmers to sell to a better market and thereby increase their profit. The result of the study is in line with Ababulgu (2016) who demonstrated that access to coffee market information affected the choice of collector outlet negatively and significantly. Diro *et al.* (2017) meanwhile observed that farmers who had no information preferred brokers over urban traders.

Cooperatives membership (COMSHIP): This significantly and positively affected cooperatives' channel choice at a 1% significant level. The reason is that members are required to supply their coffee as the norm of cooperatives. Additionally, cooperatives provide input and training to their members and provide a share dividend at the end of each year. The finding is consistent with Engida (2017) who showed that cooperative membership has a significant and positive relationship with the likelihood of choosing a cooperative to sell to.

Frequency of extension contact (FEXCONT): This affected choice of cooperatives positively and choice of middlemen negatively at a 10% level of significance. This might imply that extension agents advise farmers to sell their coffee to cooperatives rather than brokers. The finding of the study is in line with Asefa *et al.* (2016) who found that frequency of extension contact had a negative and significant effect on choice of brokers and positive and significant effect on cooperatives.

Distance to the nearest market (DMRKT): This result indicated that distance to the nearest market negatively and significantly affected the choice of a wholesaler channel at a 5% level of significance. The reason for this was that wholesalers were purchasing coffee at village and district markets and consequently, those farmers who were far from the market were less likely to sell to them. The finding is consistent with Usman (2016) who reported that distance from the closest market negatively and significantly affected wholesaler market outlets.

Conclusions and Recommendations

Coffee producers in the study area have different levels of access and ranges of options to select from among the existing market channels. Nevertheless, to choose the best suitable channels, farmers should take account of the limitations and act wisely to sell coffee through appropriate and feasible channels. The study therefore aimed to identify the determinants of coffee producer market outlet choice in the study area. To address the objectives of the study, both quantitative and qualitative data were used. The data were generated from both primary and secondary sources. The primary data were collected in 2019 through personal interviews (face-to-face) from a total of 154 producers using structured and semi-structured questionnaires.

The study has been conducted in one district and important information was collected from sample households in the study area. However, there were spatial as well as temporal limitations to make the study more representative in terms of both a wider range of area coverage and time horizon. Furthermore, since Ethiopia has wide range of diverse agro-ecologies, institutional capacities, organisations and environmental conditions, the result of the study might limit possible generalisations applicable to the country as a whole.

A multivariate probit model was used to analyse producers' channel choice because coffee producers' market outlet decisions were found to be interdependent. The results from the multi-variate probit model showed that the sex of the household head, their level of education, their means of transport ownership and access to information all positively influenced choice of wholesaler and negatively influenced choice of agent middle-men. Level of education was significantly and negatively related to the choice of agent middle-men, and significantly and positively influenced cooperatives' and wholesalers' choice of channel. Frequency of extension contact affected choice of cooperatives positively and choice of middlemen negatively, and distance to the nearest market negatively and significantly affected choice of a wholesaler channel.

To conclude, the study shows that enhancing institutional and infrastructural (transportation and extension) facilities is necessary to enable coffee producers to select efficient market channels. In addition, it is recommended that steps be taken to establish and support multi-purpose coffee farmers' cooperatives and grow their membership,as this should increase farmers' income through marketing activities and supply of important inputs.

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