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The role of subsidies in stabilising farm income: Evidence from Estonia

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This study examines the role of agricultural subsidies in the farm income (FI) variation in Estonia in the period 2006–2019 using data from a balanced panel of Farm Accountancy Data Network (FADN) farms. FI variability is decomposed to three components: market income, total subsidies, and the cost of external factors. The results reveal that subsidies have a larger share in income of smaller farms. Variability of FI differs in farm size quartiles and is significantly lower in case of largest 25% of farms. Revenues are the largest source of variation of FI. While subsidies reduce FI variation, there is no evidence that they are counter-cyclical. We argue that in addition to subsidies, smaller farms need advice on farm management to increase market income, improve its stability, and expand farm size, as larger farms have more stable incomes despite relatively lower producer support estimate (PSE) levels.

Key words: farm income volatility, farm management, agricultural subsidies, variance decomposition, Common Agricultural Policy

Introduction

Due to the changes in the global markets and attempts to liberalise trade, surplus production of agricultural products and associated budget constraints, enlargement towards Central and Eastern European Countries, and increasing public concerns about the environment, food safety and animal welfare, the European Union (EU) Common Agricultural Policy (CAP) has seen several rounds of reforms and resulting implications on EU agriculture and food security (Moehlher 2008, Pe'er et al. 2019, Balezentis et al. 2020, Rac et al. 2020). Apart from the food security issues, the CAP and other EU policies are also expected to increasingly address environmental sustainability (Pe'er et al. 2019) and vitality of rural areas, though not always with clear results (Bakucs et al. 2018, Lillemets et al. 2022). The CAP for the period after year 2022 is expected to significantly contribute to achieving the goals of the EU' arm to Fork Strategy, that ultimately aims to transform the EU food system and direct it to sustainable path (Shebesta and Candel 2020). Therefore, farmers involved in the production of agricultural products – one of the key commodities in global markets – are being caught in a difficult duel: they must confront the increasing demand for food, while having limited resources and increasing constraints on production practices (Fischer et al. 2012, Balezentis et al. 2020). Complexity of economic viability of agricultural production is exacerbated by different social, economic and sometimes environmental issues that cause the instability of FI. Therefore, one of the major objectives of the state intervention in agriculture and agricultural markets is FI stabilization (Meuwissen et al. 2008). Less volatile FI is also among the key objectives of the CAP. Starting in the 1980s and reinforced by the 1992 MacSharry and consequent reforms, the CAP has gradually drifted away from intervening in supply-demand mechanisms that used to favour higher prices, to the decoupled direct payments and other financial measures that help to ensure the financial stability of farmers (Tangermann 1998, Bojnec and Fertő 2019). Therefore, safeguarding sufficient food production and ensuring a fair standard of living for people involved in agriculture still remains one of the main aims of the CAP. That is why, in recent years, a significant interest has emerged in analysing the farm-level data to explore the role of agricultural subsidies in FI variability.

While the existing academic literature includes studies on the role of direct payments in stabilizing FI, empirical evidence on this subject is limited. E.g., Mishra and Sandretto (2002) measured the variability in real net FI among the U.S. farms from 1933 to 1999, and found that variability of FI far exceeds the variability of the income of non-farm households. Vrolijk and Poppe (2008) analysed the volatility of FI in several EU countries and found that while FI variability is generally high, there are differences among the EU countries and types of farms, more specialized farms and smaller farms are often faced with relatively higher FI variability. Wąs and Malak-Rawlikowska (2011) found that the risk of low incomes is much higher in smaller dairy farms in Poland. Also, Agrosynergie (2011) found that FI variability is higher in smaller farms in most types of farming and across regions. The significant role of

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direct payments in stabilizing FI in Switzerland was confirmed by El Benni et al. (2012), and for France and Italy by Enjolras et al. (2014). According to El Benni et al. (2012), the switch from market-based support to direct payments has decreased the variability of farm revenues and household income. Hadrich (2013) found that government payments and insurance payments increased farm revenue variation in crop and livestock farms in the Northern Great Plains. Severini et al. (2016a, 2016b) studied the role of CAP direct payments in stabilizing FI for Italian farms, using individual farm data of a decade. They established that small farms face a higher level of income variability than larger farms, but farms that did not benefit at all from direct payments had a relatively lower level of income variability. Van Asseldonk et al. (2008) conclude that farming is and will be a risky business, and arising from climatic conditions, substantial volatility remains despite risk management instruments.

In Estonia, risks in agriculture have been previously studied from the perspectives of yield and price risk in crop production (Läänemes et al. 2011, Nurmet et al. 2016, Nurmet et al. 2018). According to our knowledge, there are no previous studies in the last five years on the role of agricultural subsidies in stabilization of FI in the Baltic States. The aim of the study is, therefore, to assess whether the agricultural subsidies stabilize FI in Estonia. The current study follows the approach applied by Severini et al. (2016a, 2016b, 2017) in case of Italy, and by Bojnec and Fertő (2019) in case of Slovenia and Hungary, but our analysis is applied to different country (Estonia) that has different climatic conditions and agricultural structure, and covers longer time period (2006–2019). Further, in our study we analyse the role of subsidies in stabilizing FI also in different farm types (crops, livestock and mixed crops and livestock farms). Sectoral distinction has not been made in the previous studies. The analysis is based on a balanced data sample from the Estonian Farm Accountancy Data Network (FADN) from the period of 2006–2019.

Dynamics of Estonian agriculture 2006–2019

Estonia and the other Baltic States are known for their dynamic economies and agricultural sector that have been significantly influenced by the EU funds. After the EU accession, the sum and average rate per hectare of agricultural subsidies increased in Estonia (Viira et al. 2009, Olper 2011, OECD 2018). In the period 2006–2019, in Estonia, the total amount of subsidies on products and other subsidies in production increased by 96%, while output of the agricultural industry increased by 75% (Fig. 1). At the same time increase in crop output (by 139%) outpaced the growth of animal output (41%), agricultural services and non-agricultural secondary activities (19%). Of these three output categories, crop output has the highest variation, suggesting that further increase in the share of crop output in total agricultural output may increase FI variation in the future.

While the sum of agricultural subsidies has increased, the growth has not been stable. Figure 2 shows that in the period 2014–2016, there was a decline in the total subsidies, which could be attributed mainly to two reasons: 1) the political decision not to top-up direct payments with transitional national aid in this period; 2) decline in the CAP II Pillar payments due to end of the programming period 2007–2013, and beginning of the programming period 2014–2020. The fact that agricultural subsidies show some instability further necessitates the study on their role in stabilizing FI.

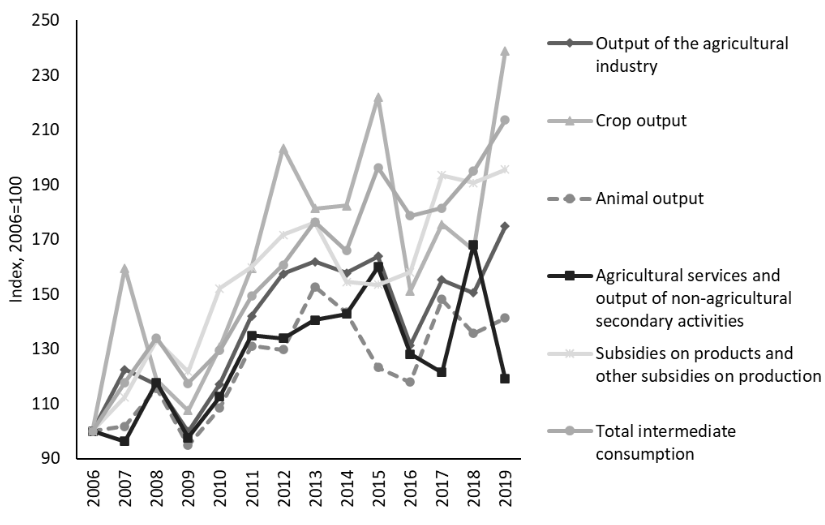

Fig. 1. Output of the agricultural industry, agricultural subsidies on products and production, and total intermediate consumption in Estonia, 2006–2019 (current prices, 2006=100). Source: Statistics Estonia (2021)

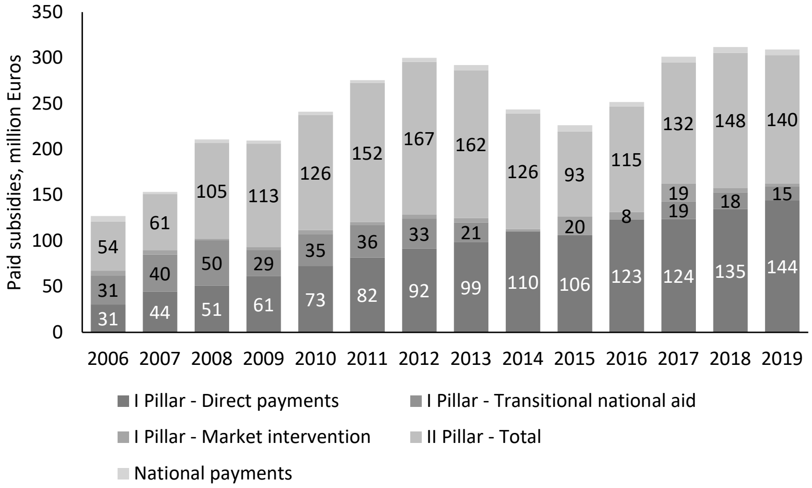

Fig. 2. Paid agricultural subsidies in Estonia, million Euros, 2006–2019.
Source: Estonian Ministry of Rural Affairs (2022)

Material and methods

Data

Our study examines the role of agricultural subsidies in FI instability in Estonia. For that, the analysis employed individual farm-level data from the Estonian FADN database from the period 2006–2019. In 2019, Estonian FADN database included 658 sample farms that represented the population of 7610 farms, which standard output exceeded 4000 euros (Aamisepp et al. 2020). The FADN sample is rotating, therefore, for panel data analysis of 14-years period a limited number of farms could be included. From the whole dataset, a balanced panel data subset was made that covered the 14-year period and contained 3164 observations from 226 farms. Following Bojnec and Fertő (2019), we analysed the role of total agricultural subsidies instead of only direct payments, even though direct payments comprise more than 50% of the total subsidies targeted at FI enhancement and stabilization. Estonia and other Member States that accessed the EU in 2004 and later initially had quite low level of direct payments. This is why payments from the CAP II Pillar have had relatively more important role in FI compared to the EU average or older EU Member States.

Estonian farms have a relatively high share of subsidies in their FI (Table 1). Therefore, subsidies are important for the level of FI and its stability, which can also depend on the type, economic size and specialization of the farm (Bojnec and Fertő 2019). In the FADN methodology, the type and economic size of farm households are determined based on the value of the standard output (SO) of the holding in Euros. In Estonia, the minimum threshold for inclusion in the FADN farm population is the SO of 4000 Euros (Aamisepp et al. 2020). The farm's SO determines its membership in the corresponding economic size classes that range between 3 (standard output 4000–8000 Euros) and 14 (standard output more than 3000000 Euros).

In the analysis the whole balanced data sample was divided in sub-samples according to: (i) farm economic size classes: (a) σ_1; (b) σ_2; (c) σ_3; (d) σ_4; (ii) relative share of subsidies in total FI, which is denoted as a PSE level: (a) σ_1; (b) σ_2; (c) σ_3; (d) σ_4; (iii) three farm type groups: crops, livestock and mixed crops and livestock (Table 1). These main farm types were selected according to the EU classification of types of farming (EC 2015). In the group crops, we included farm types 15 (specialist cereals, oilseeds and protein crops), 16 (general field cropping), 21 (specialist horticulture indoor), 22 (specialist horticulture outdoor), 36 (specialist fruit and citrus fruit), 38 (various permanent crops combined), 61 (mixed cropping). In the group livestock, we included farm types 45 (specialist dairying), 46 (specialist cattle – rearing and fattening), 47 (cattle – dairying, rearing and fattening combined), 48 (sheep, goats and other grazing livestock), 51 (specialist pigs), 52 (specialist poultry), 73 (mixed livestock, mainly grazing livestock), 74 (mixed livestock, mainly granivores). Mixed crops and livestock includes farm types 83 (field crops – grazing livestock combined) and 84 (various crops and livestock combined).

Table 1. The share of total subsidies in FI (full sample including observations with negative MI)

	Number of observations	Number of farms	Agricultural area (mean), ha	PSE (mean)	TS/FI (mean)
Quartiles of economic size					
σ_1	784	56	40.9	0.339	0.794
σ_2	798	57	113.7	0.295	-2.715
σ_3	798	57	225.6	0.275	0.798
σ_4	784	56	733.2	0.202	0.536
Quartiles of PSE					
σ_1	784	56	520.5	0.131	0.328
σ_2	798	57	256.5	0.229	0.632
σ_3	798	57	179.3	0.307	0.823
σ_4	784	56	155.2	0.441	1.172
Farm types					
Crop	1092	78	277.4	0.264	-1.835
Livestock	1470	105	307.8	0.296	0.874
Mixed crops and livestock	602	43	204.6	0.274	0.477
Total sample	3164	226	251.1	0.270	0.687

Source: authors' calculations based on FADN data

To reduce the effect of price inflation on the results of the analysis, the values of all variables were deflated by the total agricultural output price index, which was obtained from the database of the Statistics Estonia (2021). 2006 was considered as the base year.

The number of observations in our sample and subsamples must be divisible by 14 (as we use a balanced panel for 14 years). Due to this, the division of observations is slightly uneven in the sub-samples (3164/14=791 observations, but 791/14=56.5 farms). Therefore, sub-samples (i) and (ii) include observations of 14 years from either 56 or 57 farms. Sub-sample (iii) is classified into farm type groups, and farms are not evenly distributed between these groups.

Methodology

In this study, FI is defined as:

$$FI = REV - EC + TS = MI + TS, \quad (1)$$

where FI is farm income as given by FADN variable gross farm income (FADN code SE410). REV is revenues measured by the FADN variable coded total output (SE131), and defined as the total value of the output of crops and crop products, livestock and livestock products and other output, including other gainful activities of farms. EC is cost of external factors measured by the FADN variable total intermediate consumption (SE275), and defined as the total specific cost, including inputs produced on the holding and overheads arising from production, including machinery costs. TS is total subsidies, measured by the FADN variable total subsidies for current operations linked to production, excluding investments (SE605). Investment subsidies were excluded since not all farms apply and receive those, and for those farms who do, the flow of investment subsidies is very unstable. Moreover, the investment subsidies compensate certain proportion (usually 40–50%) of costs of certain investments and should not be considered as part of FI. Therefore, MI represents market income (FI–TS).

First, we analysed the relative importance of TS in FI using the following two indicators:

$$PSE = \frac{TS}{TS + REV}, \quad (2)$$

Where PSE is a proxy of producer support estimate. Strictly speaking, the PSE in this study does not fully correspond to the PSE as suggested originally by Josling in the 1970s (Cahill and Legg 1990) and used by the Organization of Economic Cooperation and Development (OECD) for decades. However, the proxy PSE as suggested by Severini et al. (2016a) and Bojnec and Fertő (2019) represents the relative importance of TS in the whole farm receipts (TS+REV), and:

$$TS/FI \tag{3}$$

that represents the share of subsidies in FI. Table 1 presents the results for both indicators (2) and (3).

Second, we use the coefficient of variation (CV) for measuring variability of FI. CV measures the extent of data variability in the sample relative to the mean and it was calculated to measure of variability of FI over the 14-year period for each individual farm using Equation (4):

$$CV = \frac{\sigma}{\mu}, \tag{4}$$

where σ is a standard deviation, and μ is the mean of FI of each individual farm over 14-year period.

Our sample includes farms with negative values of FI for some years (there are no farms with negative average FI over the 14-year period). Therefore, the average value of FI can be close to zero due to this. However, the sample includes farms with negative mean value of market income (MI). There are also farms with zero-values of TS for the whole period under analysis. The CV indicates the size of standard deviation compared to the mean. Comparing the CVs is therefore equivalent to comparing data on a logarithmic scale. If the mean values of variables are negative, close to zero or zero, then the CV becomes negative, very large or does not exist. Therefore, if the mean is zero, close to zero or negative, such comparison becomes meaningless (Grimmett 2020). To avoid this problem, for analysing the volatility of FI over time, we restricted our sample to farms that had a positive mean value of MI and non-zero values of TS for the whole period under analysis (81% of the whole sample) (Tables 2, 4, 5). The second caveat with the data is related to the fact that in general, from 2006–2019, agricultural output, subsidies and cost of inputs in current prices increased (Fig. 1). This generally increasing trend suggests that analysing variance of FI via CV might result with overestimated variation. Theoretically, one of the solutions in this situation could be detrending the data. However, this should be done at the individual farm level, because different farms are in the different stage (growth, maturity, or decline) of their life cycle (Viira at al. 2013). Also, since the values of all variables were deflated by total agricultural output price index, the price inflation effect was already removed from the time-series data. Another reason for not detrending the data was related to variance decomposition analysis used in this paper. According to Offutt and Blandford (1986) and Severini et al. (2016a), using detrended data in the variance decomposition analysis leads to biased results.

The significance of the differences in CV(FI) among the quartiles of farms' economic size and PSE level was statistically tested using the non-parametric Conover-Iman test (Conover and Iman 1979) (Table 2). The null hypothesis (H_0) was that, the median values of CV(FI) are equal for farms in different size quartiles, for different PSE level quartiles, and also for different farm type groups. The results of the Conover-Iman test were presented as a *p*-value and it was calculated at significance level α. H_0 was rejected, if $p \leq \alpha/2$ (Table 2).

Third, variance and covariance of FI were assessed. Variance is a measure of dispersion, i.e. it is a measure of how far a set of values is spread out from their average. Covariance is a measure of the joint variability of two random variables. If the greater values of one variable mainly correspond with the greater values of the other variable, and the same holds for the lesser values (that is, the variables tend to show similar behaviour), the covariance is positive. In the opposite case, when the greater values of one variable mainly correspond to the lesser values of the other (that is, the variables tend to show opposite behaviour), the covariance is negative (Grimmett 2020).

According to the literature (e.g., El Benni and Finger [2013], Severini et al. [2016a, 2017], Bojnec and Fertő [2019]), the importance of the three components of Equation 1, (i.e. revenues, costs of external factors and subsidies) on FI variability was evaluated by employing variance decomposition of income components, relying on multiplicative or additive identities. The variance was decomposed, using the general relationship (Hadrich 2013):

$$Var(x \pm y) = Var(x) + Var(y) \pm 2Cov(x, y). \tag{5}$$

When this general relationship (5) is applied to the FI (Equation 1), the result is a variance decomposition of FI (Equation 6):

$$Var(FI) = Var(REV) + Var(TS) + Var(EC) + 2Cov(REV, TS) - 2Cov(REV, EC) - 2Cov(TS, EC); \quad (6)$$

Dividing the result of Equation (6) by the sum of the first three variance terms gives a normalized form that is useful for interpretation (Equation 7):

$$\frac{Var(FI)}{Var(REV) + Var(EC) + Var(TS)} = p_1 + p_2 + p_3 + p_{12} - p_{13} - p_{23}, \quad (7)$$

where p_1, p_2, p_3, are the direct effects, and p_{12}, p_{13}, p_{14}, are the indirect effects of three considered income components:

$$p_1 = \frac{Var(REV)}{Var(REV)+Var(EC)+Var(TS)}, p_2 = \frac{Var(TS)}{Var(REV)+Var(EC)+Var(TS)}, p_3 = \frac{Var(EC)}{Var(REV)+Var(EC)+Var(TS)},$$

$$p_{12} = \frac{2Cov(REV,TS)}{Var(REV)+Var(EC)+Var(TS)}, p_{13} = \frac{2Cov(REV,EC)}{Var(REV)+Var(EC)+Var(TS)}, p_{23} = \frac{2Cov(TS,EC)}{Var(REV)+Var(EC)+Var(TS)}.$$

In Equation 7 the three direct effects sum to unity and an increase in the variance of any of these components increases the variability of FI. In the empirical analysis, variance and covariance of FI, REV, TS and EC (Equation 6) and its normalized version (Equation 7) were calculated for each individual farm over the 14-year period. The percent contribution of each variance and covariance source were calculated for each individual farm and it was averaged over all farms (Table 3).

Fourth, if variation of TS as FI component is lower than variability of remaining part of FI, i.e. MI, then subsidies stabilise FI. To understand this, we calculated the corresponding coefficients of variance, PSE and TS/FI for the restricted sample (with MI>0) (Table 4). Wilcoxon rank-sum test (Mann and Whitney 1947) was used to test the significance of the differences between median values CV(FI), CV(MI) and CV(TS) (Table 4).

Fifth, following Severini et al. (2016a) to explore whether agricultural subsidies have a countercyclical role against fluctuation of MI over time, we calculated Pearson's correlation between TS and MI based on the 14 years of data for each farm. Table 5 presents the average of these correlations between TS and MI for the whole sample and each sub-sample. To assess whether the share of agricultural subsidies in total revenues stabilise FI, Pearson's correlation between PSE and CV(MI) was computed. Since we had only one value of CV(MI) for each farm over the 14-year period, in this case the correlation was calculated at the whole sample and subsample levels. Table 5 shows these results as well.

The data was analysed using the program R (package "lmtest") and MS Excel.

Results and discussion

Share of agricultural subsidies in FI

On average total subsidies accounted for 27% of total farm receipts (PSE) and 69% of farm income (TS/FI) in Estonia in the period 2006–2019 (Table 1). In Italy, direct payments accounted for 13% of total farm receipts (PSE), and 43% of farm income (TS/FI) (Severini et al. 2016a). For Slovenia and Hungary, the average of PSE was 27% and 23% respectively and TS/FI was 17% and 44% respectively (Bojnec and Fertő 2019). In livestock farms the PSE was 30% and TS/FI was 87%; in crop farms, the PSE as 26% and TS/FI was -184%; in mixed crops and livestock farms the PSE was 27% and TS/FI was 48%. This implies that for livestock farms, the subsidies were slightly more important source of income compared to crop and mixed crop and livestock farms.

In Estonia, the PSE was higher in smaller farms. In the 1st economic size quartile the PSE was 34%, and in the 4th size quartile it was equal to 20%. In the PSE quartiles, the PSE level increases from the 1st quartile to the 4th PSE quartile accordingly from 13 to 44%. In the 1st PSE quartile, the farms have above average agricultural area. However, the differences in average agricultural area in 2nd, 3rd and 4th PSE quartile are not that marked. The TS/FI measure has a high volatility (ranging from negative to positive values) in the 14 years considered in the analysis. TS/FI in size quartiles ranged from –2.715 to 0.798 and did not have a clear trend related to economic size. For the 2nd size quartile, the TS/FI was negative due to negative FI, and it was lowest in the 4th size quartile. According to quartiles of the PSE, the TS/FI level ranges from 0.328 to 1.172, and it is higher in those quartiles that have higher PSE and smaller agricultural area. Such strongly scattered average values of TS/FI (ranging from negative to positive) can be explained by high volatility of FI in the 14-years period under analysis.

Concerning PSE indicators, similar results were observed for Slovenian farms, where PSE declined from the 1st economic size quartile to the 4th size quartile but not for Hungary (Bojnec and Fertő 2019). For Italian farms PSE decreased from small to large farms (Severini et al. 2016a). TS/FI was highest for the second economic size quartile (0.691) and lowest for the third quartile (0.076) in Hungary, and highest for the third quartile (0.945) and lowest for the first quartile (–1.543) in Slovenia (Bojnec and Fertő 2019). For Italian farms the TS/FI increased from 7% in the 1st to 100% in the 4th PSE quartile, but for quartiles of economic size classes it declined from 56% in the smallest to 31% in the largest farms' size class.

Variability of FI

For the analysis of FI volatility, restricted sample was used to avoid the interpretation difficulties that arise from the effects of negative MI on the calculation of the volatility measure (CV). According to the results (Table 2), the volatility of FI for Estonian farms is lower than reported for Italian farms and for Hungarian and Slovenian farms. On average, the median of CV(FI) was 0.34, while it was assessed to be 0.64 for Italian (Severini et al. 2016a), and 0.41 and 0.37 for Hungarian and Slovenian farms respectively (Bojnec and Fertő 2019).

Table 2. Median of the CV(FI), results of the Conover-Iman test for equality of median values of CV(FI) in different economic size and PSE level quartiles (restricted sample without negative MI observations)

	Number of observations	Number of farms	Agricultural area (mean), ha	CV(FI) median	Conover-Iman test (*p*-value)		
Total sample	2534	181	313.9	0.338			
Quartiles of economic size					σ_2	σ_3	σ_4
σ_1	476	34	34.8	0.477	0.760	0.160	0.000
σ_2	588	42	114.2	0.431	-	0.290	0.010
σ_3	714	51	217.4	0.400	-	-	0.060
σ_4	756	54	736.3	0.338	-	-	-
Quartiles of PSE							
σ_1	770	55	529.9	0.352	0.080	0.020	0.010
σ_2	798	57	256.5	0.400	-	0.360	0.140
σ_3	644	46	199.4	0.421	-	-	0.640
σ_4	322	23	168.9	0.479	-	-	-
Farm types						Livestock	Mixed crops and livestock
Crop	952	68	261.2	0.431		0.210	0.070
Livestock	1148	82	362.3	0.353		-	0.670
Mixed crops and livestock	434	31	301.7	0.341		-	-

the difference between medians of CV(FI) is not statistically significant at the 5% level;
the difference between medians of CV(FI) is statistically significant at the 5% level.
Source: authors' calculations based on FADN data

Even though, smaller farms had higher PSE level, variability of FI is highest for the smallest farms and then decreases for the 2nd, 3rd and 4th quartiles of economic size. Vrolijk and Poppe (2008), Severini et al. (2016a, 2016b), and Bojnec and Fertő (2019) also found a converse relationship between variability of FI and farm size. The null hypothesis was that the medians of CV(FI) in different economic farm size quartiles are equal. A Conover-Iman test (Conover and Iman 1979) rejected the validity of the null hypothesis as p-values indicate significant differences between 1st and 4th, and 2nd and 4th size quartiles at the 5% significance level. Therefore, the farms in the 4th size quartile had significantly lower FI variability compared to farms in the 1st and 2nd size quartiles.

The finding that in Estonian farms, CV(FI) increased with increasing PSE level is consistent with the earlier results for Slovenian farms, but not for Hungarian farms (Bojnec and Fertő 2019). In the Hungarian study, except for the 4th quartile of PSE level, variability of FI slightly declines with an increase in PSE. Variability of FI for Hungarian farms was the highest for the 1st quartile of PSE, and then decreases (Bojnec and Fertő 2019). For Italian farms, Severini et al. (2016a, 2016b) report only very limited differences between farms with different PSE levels without a clear link between PSE level and variability of FI. A Conover-Iman test rejected the validity of the null hypothesis for equality of median values of CV(FI) between the 1st and 3rd, and the 1st and 4th PSE quartiles. The null hypothesis could not be rejected for other pairs of quartiles. Therefore, in the 1st quartile of PSE level that includes larger farms, the variability of FI was significantly lower than in the 3rd and 4th quartiles of PSE that included smaller farms.

The variability of FI for crops farms was higher than for livestock and mixed crop and livestock farms but the differences were not statistically significant.

Components of the FI variation

To identify the FI components that contribute the most to the FI instability in different economic size and PSE quartiles as well as in different farm type groups, the variance decomposition of FI was used as suggested by Severini et al. (2016a), and Bojnec and Fertő (2019). Table 3 shows that most of the variance of FI (62%) is due to variance in revenues (p_1). Total intermediate consumption (p_3), and the subsidies (p_2) comprise a smaller part, respectively 31% and 7% in the FI variation. Variance in REV is higher for farms in the 4th (largest) size quartile, and 1st (smallest) PSE quartile. For Italian farms the variance in revenues comprised 65%, the variance of EC comprised 30% and the variance of direct payments comprised 5% of the FI variation. For Hungary, these indicators were 91% (REV), 6% (EC) and 3% (TS) respectively, and in Slovenia 84% (REV), 15% (EC) and 2% (TS) respectively. In comparison of farm types, the variance in TS and EC is higher for livestock farms and these indicators are 10% (TS) and 33% (EC) respectively (Table 3).

Table 3. Results of variance decomposed of FI (full sample including observations with negative MI)

	Variance decomposition						Relative importance of income sources		
	Direct effect			Indirect effect					
	p_1	p_2	p_3	p_{12}	p_{13}	p_{23}	REV/FI	TS/FI	EC/FI
Quartiles of economic size									
σ_1	0.612	0.110	0.278	0.081	0.497	0.126	1.404	0.794	1.245
σ_2	0.620	0.065	0.315	0.042	0.283	0.046	-1.081	-2.715	-4.793
σ_3	0.616	0.061	0.323	0.037	0.258	0.047	1.992	0.798	1.788
σ_4	0.642	0.042	0.316	0.039	0.328	0.041	2.204	0.536	1.733
Quartiles of PSE level									
σ_1	0.656	0.033	0.311	0.060	0.684	0.052	2.279	0.328	1.592
σ_2	0.654	0.031	0.315	0.066	0.541	0.080	2.172	0.632	1.759
σ_3	0.620	0.077	0.303	0.087	0.547	0.104	1.900	0.823	1.716
σ_4	0.559	0.137	0.304	0.101	0.465	0.157	1.415	1.172	1.565
Farm types									
Crop	0.683	0.038	0.278	0.051	0.520	0.073	-0.459	-1.835	-3.281
Livestock	0.568	0.098	0.334	0.084	0.580	0.143	2.104	0.874	1.968
Mixed crops and livestock	0.581	0.096	0.323	0.105	0.559	0.121	1.637	0.477	1.173
Total sample	0.622	0.069	0.309	0.078	0.558	0.098	1.981	0.687	1.640

Source: authors' calculations based on FADN data

Indirect effects, related to covariance between income components show that covariance between revenues (REV) and intermediate consumption (EC) (p_{13}) provided the highest contribution (56%, Table 3) to the total variability of FI. This also confirms that often, increase in revenues is correlated with increase in intermediate consumption, and together they increase overall variation of FI. Covariance between revenues and intermediate consumption was higher for farms in the 4th size quartile and 1st PSE quartile, i.e. for larger farms. Covariance between revenues (REV) and total subsidies (TS) (p_{12}, 8%) and covariance between total subsidies (TS) and intermediate consumption (EC) (p_{23}, 10%) contributed less to the overall variation of FI. For different types of farms, the result was similar: the covariance between revenues (REV) and intermediate consumption (EC) had the highest contribution to farm income variability for all farms types (Table 3).

For Italian farms, the covariance effect between revenues and direct payments was negative suggesting that direct payments could play a countercyclical role in comparison to fluctuations of revenues over time (Severini et al. 2016a). We cannot draw the same conclusion for Estonian farms.

Agricultural subsidies and FI stabilization

Table 4 presents the results about PSE, TS/FI, CV(FI), CV(MI) and CV(TS) for restricted sample with only non-negative MI values. The CV(TS) ranges from 0.169 for large farms to 0.262 in case of smaller farms; for crop farms the CV(TS) was 0.173 while for livestock farms the respective value was 0.210. As expected, in average, CV(TS) was lower than CV(FI) and CV(MI). Therefore, one can conclude that, due to lower variability of CV(TS), subsidies have a role in stabilising FI. The income-stabilizing role of subsidies increases as one moves from the 1st to the higher quartiles of economic size. This finding is in line with findings for Hungarian and Slovenian farms (Bojnec and Fertő 2019) and with findings for Italian farms (Severini et al. 2016a). The CV(TS) decreases when moving from the 1st to 2nd quartile of PSE level, increases from 2nd to 3rd quartile of the PSE level and decreases in the 4th quartile of the PSE level. Wilcoxon rank-sum tests (p-values< 0.000) confirmed that the differences between the median values of CV(TS), CV(FI) and CV(MI) are always statistically significant at 1%. The variability of FI in general is around 56 percentage points lower than the variability of MI. This confirms total subsidies help farms to cope with a high level of MI variability (El Benni et al. 2012).

Table 4. The share of total subsidies in farm revenues and income, and the variation of subsidies and farm income measures (restricted sample without observations with negative MI)

		Importance of subsidies (mean)			Median			Wilcoxon rank-sum test
	N	Agricultural area (mean), ha	PSE	TS/FI	CV(TS)	CV(FI)	CV(MI)	
Quartiles of economic size								
σ_1	476	34.8	0.272	0.657	0.262	0.477	1.596	***
σ_2	588	114.2	0.258	0.513	0.209	0.431	1.095	***
σ_3	714	217.4	0.250	0.696	0.200	0.400	0.928	***
σ_4	756	736.3	0.186	0.495	0.169	0.338	0.564	***
Quartiles of PSE level								
σ_1	770	529.9	0.132	0.329	0.277	0.352	0.471	***
σ_2	798	256.5	0.229	0.632	0.163	0.400	0.836	***
σ_3	644	199.4	0.309	0.816	0.205	0.421	1.320	***
σ_4	322	168.9	0.415	1.084	0.168	0.479	3.971	***
Farm types								
Crop	952	261.2	0.234	0.484	0.173	0.431	0.896	***
Livestock	1148	362.3	0.258	0.730	0.210	0.353	0.906	***
Mixed crops and livestock	434	301.7	0.219	0.614	0.187	0.341	0.661	***
Total sample	2534	313.9	0.237	0.592	0.199	0.388	0.881	***

Source: authors' calculations based on FADN data

Table 5 shows the results of correlation analysis between the TS and MI and CV(MI) and PSE. If TS is negatively correlated with the MI, the income stabilizing role of TS is higher (Severini et al. 2016a). Our empirical results suggest that subsidies have played a limited countercyclical role in terms of reduction of fluctuations of MI over the last 14 years. For the whole sample, the correlation between TS and MI was positive but small (0.03). In the 1st and 3rd economic size quartile, the correlation between TS and MI was negative but in the 2nd and 4th size quartile it was positive. In the quartiles of the PSE level, the correlation between TS and MI was positive in the 1st quartile, and negative in other quartiles. For field crop types the correlation between TS and MI was negative (–0.028) but in other types it was positive with highest value (0.174) in case of livestock farms. Therefore, we can conclude that if subsidies were designed in a way that they were negatively correlated with the MI over time, the agricultural payments could have a stronger income stabilising effect, especially so in case of larger farms in the 4th size quartile and for livestock farms. Such subsides could be, e.g. counter-cyclical payments for farmers when the marketing year average price received for a covered commodity is less than the target price. Bojnec and Fertő (2019) obtained similar results for small Hungarian and Slovenian farms.

The overall average of the correlation coefficient between PSE and CV(MI) was 0.325, i.e. positive and with a medium strength. This suggests that farms with higher PSE levels have higher volatility of market income. Among the economic size quartiles, the correlation between CV(MI) and PSE was highest in the 4th quartile. This may indicate that larger farms that have higher PSE level take more risks and therefore have more volatile MI. However, if we divided the whole sample in quartiles according to the PSE level, it appeared that the correlation between CV(MI) and PSE was negative in farms with the lowest and highest PSE level. Among the farm types, the correlation between CV(MI) and PSE varies from 0.270 in case of crop farms to 0.511 in case of mixed crops and livestock farms.

Table 5. The results of Pearson's correlation between MI and TS, and between CV(MI) and PSE (restricted sample without observations with negative MI)

	Sample size number	Agricultural area (mean), ha	MI and TS (mean)	CV(MI) and PSE
Quartiles of economic size				
σ_1	476	34.8	-0.104	0.349
σ_2	588	114.2	0.051	0.298
σ_3	714	217.4	-0.014	0.267
σ_4	756	736.3	0.153	0.624
Quartiles of PSE level				
σ_1	770	529.9	0.162	-0.229
σ_2	798	256.5	-0.008	0.325
σ_3	644	199.4	-0.049	0.101
σ_4	322	168.9	-0.002	-0.127
Farm types				
Crop	952	261.2	-0.028	0.270
Livestock	1148	362.3	0.174	0.311
Mixed crops and livestock	434	301.7	0.009	0.511
Total sample	2534	313.9	0.034	0.325

Source: authors' calculations based on FADN data

Conclusions

This research examined the farm income stabilizing role of the CAP subsidies in Estonia, during the period 2006–2019. For the analysis, we used a balanced data sample from the Estonian FADN database, which was subsequently divided into quartiles based on farm economic size and relative share of subsidies in FI, which was denoted as a producer support estimate (PSE) level. Additionally farm income figures and their variation was studied in crop, livestock and mixed crops and livestock farms. For the analysis of FI variation, the farms with negative MI values were removed, to assure that the results are meaningful and interpretable.

In the studied farms, the average PSE level over the 14-year period was 26%, and total subsidies comprised 69% of the FI. Therefore, in Estonia, the CAP subsidies have a more significant role on FI compared to Italy, Hungary and Slovenia. The PSE level was higher in the smallest farm size quartile and increased in the subsequent size quartiles. While the first PSE quartile included larger farms, and in general the average farm size decreased in the following PSE quartiles, the differences were not marked. Among different farm types, livestock farms had highest PSE level.

Coefficient of variation was used to measure variability of the FI. On average, the CV(FI) was 0.34 for the 14-year period, which was lower than in Italy, Slovenia and Hungary. Lower income variation in Estonia may be related to higher PSE and TS/FI levels in Estonia, compared to the above-mentioned countries. We found that despite higher PSE levels, smaller farms had higher variation in FI. This suggest that smaller farms experience significantly higher volatility of MI compared to larger farms, and even higher PSE level cannot offset the arising effects on FI volatility.

Our results showed that most of the variance of FI is due to variance in revenues. Variance of revenues was highest in the 4th size quartile and smallest in the 1st size quartile, and in crop farms. Analysis of indirect sources of income variation revealed relatively high covariance between revenues and intermediate consumption, especially so for the farms in the 4th size quartile and 1st PSE quartile, and in livestock farms. This suggests that for larger farms that are more market oriented and have lower level of PSE, increased stability in use of inputs would reduce variation in revenues and FI. It appears also from Figure 1 that in 2009, 2014 and 2016, which, due to crises, were difficult years for agricultural sector, both intermediate consumption and total output decreased. Covariance between revenue and total subsidies was small but positive. Therefore, according to our results, total subsidies did not have countercyclical effects on variation of FI.

Nevertheless, variation in total subsidies was lower than variation in FI and MI. Therefore, total subsidies are more stable than market income and total income, and could be considered as stabilizing element of FI. This is also confirmed by the fact that in average, CV(FI) was 56 percentage points lower than CV(MI). It also appeared that the income stabilizing role of subsidies was higher in the 4th farm size quartile, i.e. in case of larger farms, and also in case of crop and mixed crops and livestock farms.

Among the economic size quartiles, the correlation between CV(MI) and PSE was highest in the 4th quartile and in case of mixed crops and livestock farms, suggesting that larger farms, and also mixed crops and livestock farms with higher PSE level take more risks and therefore have more volatile MI.

Policy implications

The results suggest that subsidies have played only a limited countercyclical role in terms of reduction of fluctuations of MI. Therefore, policy makers should make efforts to design subsidies in a way that they are negatively correlated with the MI over time. That would increase the income stabilizing effect of the agricultural payments, especially so in case of larger, and presumably more market-oriented farms.

The results of our study show that even though farms in smaller size quartiles generally have higher PSE level, variation in FI is still larger in smaller farms. Therefore, in smaller farms, the subsides were not sufficient to offset high volatility of MI. This raises questions about the appropriate policy for improving incomes and reducing income variation in smaller farms. Theoretically, increasing the subsidies for smaller farms would result in reduced variation in their FI. However, it does not help to reduce volatility of MI. Therefore, the extension and knowledge transfer programmes should also provide smaller farms with adequate expertise on how to improve farm management, and increase farm size to improve its financial stability.

Also, more counter-cyclical farm payments would help to improve FI stability, especially so for farms in the largest size quartile, where the correlation between market income and total subsidies was positive and larger than in other quartiles. This may be related to additional subsidies paid in times of crises, which are often delayed, so that the farmers receive actual support next year. Therefore, the crisis payments should be paid with as small delay as possible.

While theoretically appealing, introduction of countercyclical elements to the CAP either in the form of countercyclical direct payments or revenue insurance payments, would require establishing EU-wide harmonized farm accounting system for participating farms. In Estonia, where most of the production comes from relatively large farms and national registry of invoices, and online tax declarations already exists, this might be technically more easily feasible than in the EU member states that have large number of very small farms. Therefore, it should be kept in mind that these new instruments would not bring about additional differentiation between larger and smaller farms and member states with different farm structures.

Limitations

As the limitations of our study, we can note the following: (i) the analysis disregards off-farm income that has been found to reduce the variability of the overall income of farm households (see e.g. Mishra and Sandretto 2002); (ii) in the analysis of volatility of FI we restricted our sample to farms with non-negative MI, thus the analysis omits almost 20% of farms. This shortcoming should be addressed by future studies.

Future studies could also address more thoroughly the relationship between total intermediate consumption and farm revenues, which had a positive covariance in our study, as our data was not sufficient to analyse the causes of variation in total intermediate consumption.

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