

Agricultural revenue in Latvia, Lithuania, and Poland: An application of the LMDI decomposition

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Abstract. This paper analyses the trends and sources of change in agricultural revenue for the new European Union (EU) member states, namely Latvia, Lithuania, and Poland. These countries still lag behind the old EU member states in terms of profitability, productivity, and farm size. Thus, assessment of the patterns in agricultural revenue changes in these countries may provide evidence for reasonable policy making. The period covered is 2011-2019. The analysis is carried out for selected agricultural products (wheat, milk, poultry, potatoes). The logarithmic mean Divisia index is applied for the decomposition. The results indicate that the effects of scale, productivity, and price change varied across the countries and products. Therefore, dedicated policy measures and pathways are needed for each particular context.

Keywords: change, agriculture, crop farming, animal farming, index decomposition analysis.

JEL Classification: C43, Q10

1. INTRODUCTION

The demand for agricultural production tends to rise with increasing population. Furthermore, the agricultural sector is important from multiple perspectives, including food provision and employment of rural population. Thus, properly functioning agricultural markets are vital for distributing the agri-food production and the resulting economic benefits among multiple stakeholders. Agricultural prices appear as a major carry-over factor linking the markets of agri-food goods across the world. There have been a number

Received:
November, 2021
1st Revision:
May, 2022
Accepted:
September, 2022

DOI:
10.14254/2071-
8330.2022/15-3/1

of studies on price transmission in the agricultural markets (Mundlak, Lartson, 1992; von Cramon-Taubadel, Goodwin, 2021).

The changes in agricultural prices impact farmers' decisions on production scale and scope. The major sources of price changes are shifts in supply and demand that may occur due to natural factors (e.g., weather conditions), policy measures (e.g., support payments and taxes) or economic situation (e.g., shifts in the demand due to introduction of new technologies for bioenergy) (Pánková et al., 2020; Oláh et al., 2020). Climate change has been noticed as a factor of increased volatility in agricultural output (and, hence, prices), but agricultural support policies can be adapted to combat it (Searchinger et al., 2020). Thus, agricultural production is impacted by a multitude of factors including random and deterministic ones. The scale size can be related to different economic mechanisms including support payments (Skalicky et al., 2021).

In this light, one needs to understand the underlying trends in farm revenue that are determined by both farming decisions and the situation in the global market. While price transmission mechanisms have been analyzed across many countries and sectors, the investigation of the dynamics in farm revenue remains a topical issue. Indeed, much of the existing literature focuses on the farm profitability and its determinants (Palkovič et al., 2022; Lee et al., 2020). The profitability (and its constituent terms) is mostly discussed in statistical editions, yet these lack analytical approach in the sense of the relationships to the quality and quantity of production.

Therefore, this paper presents an index decomposition analysis (IDA) model for relating the changes in the agricultural revenue to the scale indicators (e.g., herd size or area sown), productivity indicators (yield) and prices. These are affected by both the production and price risk. The proposed approach (indirectly) combines the available information on the farmers' decisions, climatic conditions and market fluctuations.

In this paper, we focus on the case of Latvia, Lithuania and Poland. These are the new European Union (EU) member states. From the viewpoint of agricultural structure, one can note that the countries chosen for the analysis have certain similarities and differences. The Polish agriculture relies on small family farms. Farm size is larger in Latvia and Lithuania, yet all the countries considered in this study are well behind the average values for the EU (and, especially, such countries as Germany). The accession to the EU allowed these countries for integration in the European and global markets. Also, the increasing public support has allowed for more investments in agriculture. Therefore, it is important to ascertain how all these developments contribute to the dynamics in crop and livestock revenue in these countries.

2. LITERATURE REVIEW

Agribusiness is highly impacted by unexpected events that may affect production output and/or prices (Ullah et al., 2016). The revenue from agricultural production depends on both quantity and prices. The quantity side relates to yields and area sown under a certain crop (or herd size for livestock production). In this paper, we focus on the crop and livestock production and associated issues.

The study by Läänemets et al. (2011) pointed out that such small countries as the Baltic States cannot influence formation of the global commodity prices. Still, the global and regional events (e.g., climatic conditions, geopolitical restrictions leading to serious supply or demand shifts) may impact the agri-food prices. In general, the countries under assessment act as price takers rather than price setters.

The trade restrictions, both tariff and non-tariff ones, as well as political decisions on quotas may also affect production output (Svatoš & Smutka, 2012; Dvořák et al., 2021). In this case, the price may also be altered in case demand is not satisfied to full extent. El Benni et al. (2012) discussed certain cases of suchlike restrictions.

The variability in agricultural output is much more nuanced even in the case small countries are considered (Bartova & Fandel, P. 2020; Popp et al., 2018). Per Läänemets et al. (2011), one can consider

such factors as soil quality, agricultural technologies, irrigation regime and climatic conditions as precursors for changes in the crop output. Indeed, application of fertilizers and soil improvement are important for such countries as Lithuania where sandy soils are prevalent in certain regions of the country. Also, the use of the modern farming practices requires adjustments in both machinery and intermediate consumption. Following accession to the European Union, the three countries that this study focuses on have seen a surge in the investments into the agricultural production factors. This has led to increase scale of production at the country and farm level. Thus, political events and contexts have also had substantial influence on the variation in the agricultural output in the EU.

As regards the livestock farming, unexpected events include diseases that may affect the production output. As regards the EU and its new member states, the Russian embargo of 2014 has also played a crucial role in shaping the milk market (Špička & Kontsevaya, 2016). In addition, the abandonment of the milk quotas (Čechura et al., 2021) led to even higher volatility of milk prices.

The price-yield relationship rewards much attention in the economic literature (El Benni, Finger, 2013; Sriboonchitta et al., 2013). The adverse effects of climatic and other conditions on the yields are often offset by price growth. For instance, Sherrick (2012) provided the case of the US wheat market where an inverse relation between changes in wheat yield and price was observed for 1976-2012. Thus, crop revenue may not fluctuate to the same extent as the yield does.

3. METHODS

This paper considers growth in the agricultural revenue in the three countries (Latvia, Lithuania, and Poland) from the decomposition perspective. Thus, we seek to decompose the changes in the revenue with regards to scale and intensity (productivity) variables. As both livestock and crop products are covered in the analysis, one needs to develop tailored models for each case under consideration.

The approach followed in this study is the IDA. The latter approach quantifies the contributions of the sources of the revenue growth in the case of the selected countries. The IDA is applied for wheat, milk, poultry, potatoes, cabbages, and apples. The IDA has been extensively applied for revealing the effects of the factors contributing to growth in the energy-related variables (Ang, 2005).

Note that the prices used in this study are expressed in real terms. This is ensured by using the consumer price indices for respective countries. Accordingly, the results are expressed in the prices of 2015. The data come from the Eurostat database. As the data vary over time due to uncertainties, we use the stochastic growth rates that are expressed as the estimates of the slope coefficient, b , from the log-lin model $\ln x = a + bt$.

3.1. Crop revenue

The revenue for crop products is obtained as:

$$I_t = A_t Y_t P_t = A_t \frac{Q_t}{A_t} P_t, \quad (1)$$

where t denotes a certain time period, I is the real crop revenue (in Euro), A is the area sown under a certain crop (in hectares), Y is the yield (in tonnes per hectare), P is the real price (in Euro), Q is the harvest (in tonnes). This identity applies to the cases of wheat and potatoes. Then, the following identity holds:

$$\Delta I_{t-1,t} = I_t - I_{t-1} = \Delta_{t-1,t}^A + \Delta_{t-1,t}^Y + \Delta_{t-1,t}^P, \quad (2)$$

where $\Delta I_{t-1,t}$ is the absolute change in the crop revenue, and $\Delta A_{t-1,t}$, $\Delta Y_{t-1,t}$, and $\Delta P_{t-1,t}$ represent the contributions due to the changes in the area sown, yield, and real price. The logarithmic mean Divisia index (LMDI) is then applied to quantify the contributions of the three terms in Eq. 2 (A , Y , and P) to the change in the crop revenue. The calculations are based on Ang (2005). The LMDI attributes the absolute change in the crop revenue to the relative growth in the explanatory terms. The logged means are used to ensure the time reversal property. Note that the perfect decomposition is facilitated by using the LMDI. The following calculations are involved:

$$\Delta_{t-1,t}^A = L(I_{t-1}, I_t) \ln \left(\frac{A_t}{A_{t-1}} \right), \quad (3)$$

$$\Delta_{t-1,t}^Y = L(I_{t-1}, I_t) \ln \left(\frac{Y_t}{Y_{t-1}} \right), \quad (4)$$

$$\Delta_{t-1,t}^P = L(I_{t-1}, I_t) \ln \left(\frac{P_t}{P_{t-1}} \right), \quad (5)$$

where $L(a,b) = (b-a)/\ln(b/a)$. Function $L(\cdot, \cdot)$ normalizes the absolute change in the indicator of interest with respect to its relative growth. Therefore, crop revenue gains due to increase in the acreage, yield gains and real price growth are quantified by means of Eqs. 3-5.

3.2. Livestock revenue

The livestock revenue is decomposed with regards to changes in the number of animals, livestock productivity and price. Instead of crop area in Eq. 1 we now stick to the number of animals. Thus, the following relationship holds:

$$I_t = N_t Y_t P_t = N_t \frac{Q_t}{N_t} P_t, \quad (6)$$

where I is the real livestock revenue, N is the respective number of animals, Y and Q are the livestock production yield (kg per animal) and livestock production volume (in tonnes), respectively. This identity is applied to milk and poultry. The decomposition is carried out in the framework of the LMDI, analogously to the case of the crop revenue as discussed in the preceding sub-section.

4. RESULTS

The Baltic States and Poland are engaged in both crop and livestock farming. In this section, we overview the underlying trends in production scale, productivity, and prices of the selected agricultural products. This allows identifying the key challenges and possibilities for restructuring the agricultural production. The decomposition of agricultural revenue was carried out as described in Sections 3.1 and 3.2.

4.1. Wheat

Wheat farming comprises a major share of the total agricultural output in the countries analysed. However, there have been certain differences in the directions of the development of the wheat sector among the Baltic States and Poland. Over 2011-2019, the soft wheat harvest doubled in Latvia and Lithuania (growth of 152% and 106%, respectively), whereas Poland saw an increase in the harvest of 17%. As Table

1 suggests, the revenue from soft wheat sales increased in Latvia and Lithuania, whereas a slight decline is evident for Poland. The highest annual rate of growth (3.1%) is observed for Latvia where the revenue for soft wheat increased from 191 million Euro in 2011 up to 350 million Euro in 2019 (note that the real prices are used). As for Lithuania, the annual growth rate amounted to 1.2% and resulted in an increase from 4000 million Euro up to 571 million Euro throughout 2011-2019. Poland posted the annual growth rate of -1.7% which rendered a decline from 1.9 billion Euro down to 1.7 billion Euro during 2011-2019. The dynamics in wheat revenue are presented in Table 1.

Table 1

Revenue from sales of the soft wheat (million Euro of 2015)

Year	Latvia	Lithuania	Poland
2011	190.6	400.3	1 910.3
2012	330.8	641.0	1 822.6
2013	266.7	512.9	1 770.6
2014	227.9	504.7	1 867.3
2015	334.1	712.7	1 720.6
2016	277.3	553.7	1 515.2
2017	307.7	581.1	1 763.6
2018	232.7	455.0	1 600.6
2019	349.8	570.6	1 733.5
Geometric mean	274.7	540.8	1740.9
Change	159.2	170.3	-176.8
Growth rate, %	3.1	1.2	-1.7

Stochastic average annual growth rate is provided.

Source: Authors' calculations

The results of the LMDI-based analysis are provided in Table 2. The relative price changes contributed negatively to the changes in the revenue for the soft wheat across all the countries under consideration. The highest impact of the price change was observed for Poland, where price component amounted to effect that exceeded the total change by 2.5 times. For Latvia, the negative effect of the price decline stood at some 57% of the total change and remained that of the lowest magnitude if compared to the other terms. In the case of Lithuania, the price effect was also negative and stood at 122% of the total change in the wheat revenue. Therefore, the real wheat prices tended to decline in the three countries under consideration albeit their overall effect was different depending on the interaction with scale and productivity terms.

Table 2

Cumulative relative contribution (in per cent of the total change) to the change in revenue for soft wheat, 2011-2019

Country	Effect		
	Area	Yield	Price
Latvia	82	75	-57
Lithuania	158	64	-122
Poland	102	55	-257

Source: Authors' calculations

The scale component, i.e., area sown, positively contributed to the change in the wheat revenue within the three countries under analysis. Indeed, the lowest contribution was observed in Latvia (82% of the total

revenue change over 2011-2019). The corresponding effects in Lithuania and Poland amounted to 158% and 102% of the total revenue change, respectively. Lithuania and Latvia posted the increase in the area sown under wheat of some 60% during 2011-2019, whereas this figure stood at 11% for Poland. Thus, the area sown under wheat increased in all the countries considered, yet these changes rendered different relative contributions to the overall change in the revenue.

The yield component is also positive for all the three countries. Indeed, this term shows rather similar contribution as the minimum value of 55% is observed for Poland, whereas the highest value is that of 75% for Latvia. Indeed, Latvia showed the highest growth in the wheat yield (over 57% during 2011-2019). The other countries saw an increase in the yields of 20% (Lithuania) or just 5% (Poland) over the same time span. Still, Latvia shows the lowest mean wheat yield (4.16 t/ha for 2011-2019) if opposed 4.38 t/ha for Lithuania and Poland. Obviously, yield changes were the major determinants in the contribution of the three terms to the total revenue change.

In general, the results suggest that wheat farming is losing its importance in Poland in terms of revenue generation. As regards Latvia, serious growth in the yields was observed, yet yield gap still persists if compared to Lithuania or Poland. In general, all the three countries could put more efforts in yield gains to approach the levels observed in, e.g., Germany.

4.2. Milk

Milk sector has seen serious structural shifts in the countries under consideration after dissolution of the planned economy in early 1990s. Still, the process of restructuring was evident during 2011-2019. The countries diverged in terms of the changes in the key indicators entering the identity of the milk revenue and the dynamics of the milk revenue itself. The volume of milk produced increased by 16% in Latvia and Poland, whereas a decline of 13% was observed for Lithuania during 2011-2019. This is an interesting result itself as it is tightly related to the selling price setting in different countries. Lithuanian dairy processing industry sets different prices depending on the milk volume supplied. Thus, small milk farms that are still numerous there face increasing difficulties in terms of profit generation and tend to exit dairy farming. The mean dairy farm size is similar in Poland (Skarzynska et al., 2013), yet there is higher density of the farm network (and more intensive cooperation activities) that allows maintaining more benevolent selling price levels for all size groups of dairy farms. The dynamics in milk revenue across the analysed countries is presented in Table 3.

Table 3

Revenue from sales of milk (million Euro of 2015)

Year	Latvia	Lithuania	Poland
2011	255.8	529.8	3 791.2
2012	240.9	465.5	3 632.8
2013	283.8	542.8	4 084.7
2014	283.0	499.8	4 225.9
2015	211.4	373.4	3 587.0
2016	211.3	343.9	3 369.4
2017	297.0	448.1	4 410.7
2018	263.7	413.7	4 363.2
2019	265.4	406.0	4 356.4
Geometric mean	255.2	442.2	3962.6
Change	9.6	-123.8	565.2
Growth rate, %	3.8	-23.4	14.9

Stochastic average annual growth rate is provided.

Source: Authors' calculations

The changes in milk revenue are quite different from the changes in milk volume. Latvia and Poland showed similar growth in milk output, yet their milk revenue (in real terms) grew to different extent. Indeed, Latvia saw virtually no change over 2011-2019, whereas an average annual growth rate was observed for Poland where the real milk revenue went up by 565 million Euro during the period covered. Lithuania posted a decline of 124 million Euro which corresponds to a 23.4% annual rate of decline. The changes in the milk revenue were decomposed by applying the LMDI. The resulting relative contributions to the overall change in the revenue over 2011-2019 are presented in Table 4.

Table 4

Cumulative relative contribution (in per cent of the total change) to the change in revenue for milk, 2011-2019

Country	Effect		
	Herd size	Yield	Price
Latvia	114	292	-306
Lithuania	-56	13	-57
Poland	90	22	-12

Source: Authors' calculations

As Latvia showed a rather meagre change in the milk revenue, the decomposition rendered excessive relative contributions of the three terms in the IDA identity. The yield and price effects follow the same direction across the three countries under analysis (yet these effects are opposite to each other).

Price effect (in relative terms) reached the highest magnitude in Latvia. However, it was offset by the yield effect almost completely. In Lithuania, the negative price effect amounted to 57% of the total revenue change. Finally, Poland posted the relative price effect of the lowest magnitude (-12%). Indeed, the real prices declined in the three countries, yet Poland showed the smallest change (less than 2%), whereas the decline in Latvia and Lithuania amounted to more than 10% (2019 compared to 2011). In general, the price differences tended to increase among the three countries under consideration. The highest price level has

always been observed in Poland, whereas Lithuania and Latvia showed similar levels that were 13% and 10% lower if compared to the milk price in Poland (as of 2019). The period after 2014 marked the steepest decline in milk prices with a recovery thereafter.

The herd size increased in Latvia and Poland, whereas Lithuania showed a decline. Indeed, much of the milk revenue growth (90% of the total change) came from the increase in the herd size in the case of Poland. This effect was four times larger than the one of yield. In the case of Latvia, the herd size dynamics rendered an increase in the milk revenue that was twice lower than the one associated with milk yield. In Lithuania, the herd size effect was negative (-56% of the total change in the revenue) and its magnitude was almost identical to that of the price effect. Comparing 2019 to 2011, Poland and Latvia posted the increase in herd size of 14% and 4%, respectively. As for Lithuania, the decline of 16% was observed. These changes are impacted by the dynamics in milk prices (and, hence, profitability). Even though the milk selling price depends on the global market price, the existing spatial differences among the analysed countries call for a strategy to ensure proper functioning of the value chains.

The yield factor positively contributed to the change in the milk revenue across the three countries. As noted above, the relative contribution and its proportion to the other factors varied across the counties. In Latvia, the yield effect was positive and offset the negative effect of the declining real price. The highest milk price gains are indeed observed for Latvia (12% for 2011-2019) if contrasted to the other two countries (less than 3%). Also, Latvia showed the highest milk yield per cow as of 2019 (2.48 t/cow), whereas Lithuania and Poland followed with the values of 2.44 t/cow and 2.32 t/cow, respectively. The farm structure may have played an important role in this regard. As reported by European Commission (2022), Lithuania and Poland feature smaller dairy cow herd (10.6 and 17.6 dairy cows as of 2019) compared to Latvia (19.1 livestock units).

Therefore, milk sector has been under increasing pressure in the analyzed countries. As the real price declined, the gains in revenue due to productivity growth remained rather low. Thus, further managerial and technological measures need to be taken to ensure viability of dairy farms.

4.3. Poultry

Poultry farming constitutes an important sub-sector of agriculture in Poland, Lithuania, and, to a lesser degree, in Latvia. However, this sector was particularly damaged during the COVID-19 pandemic crisis (however, this period falls outside of our analysis). As of 2011-2019, all the countries under analysis showed an increasing trend of the poultry production. Poland emerged as a major poultry producer at the EU level – its poultry output increased from 1.4 million t in 2011 up to 2.6 million t in 2019 (an 87% increase). Lithuanian showed a 33% increase during the same period (from 75.6 thousand t up to 101 thousand t). Latvia posted a high level of growth – 53% during 2011-2019 – yet its production volume remained rather low as it increased from 23 thousand t up to 35 thousand t. The dynamics in the revenue for poultry production is provided in Table 5.

Table 5

Revenue from sales of poultry (million Euro of 2015)

Year	Latvia	Lithuania	Poland
2011	38.5	73.4	1 221.2
2012	41.3	78.8	1 399.8
2013	49.0	90.2	1 502.9
2014	53.6	88.1	1 588.4
2015	49.6	89.6	1 721.0
2016	50.7	86.6	1 840.1
2017	54.8	86.2	1 815.2
2018	55.2	86.8	1 981.0
2019	60.2	78.0	2 079.7
Geometric mean	49.9	84.0	1 661.8
Change	21.7	4.6	858.5
Growth rate, %	4.7	0.7	6.2

Stochastic average annual growth rate is provided.

Source: Authors' calculations

The levels of poultry revenue are highly different across the analysed countries due to the different scales of operation. Note that all the three countries posted positive growth in the revenue for poultry. Poland is the largest poultry producing country among the analysed ones (mean annual revenue was 1.7 billion Euro). It also showed the highest rate of growth amounting to 6.2% p.a. Lithuania posted the mean revenue of 84 million Euro for 2011-2019 along with meagre growth rate of 0.7% p.a. Finally, Latvia exhibited the lowest sales revenue of 50 million Euro, yet the growth rate was 4.7% p.a. Thus, it is particularly interesting to ascertain what are the causes behind the differences in the poultry revenue among the three countries under analysis. The results (in cumulative terms) of the LMDI decomposition are provided in Table 6.

Table 6

Cumulative relative contribution (in per cent of the total change) to the change in revenue for poultry, 2011-2019

Country	Effect		
	Number of birds	Yield	Price
Latvia	57	39	4
Lithuania	422	103	-425
Poland	80	39	-19

Source: Authors' calculations

The relative contributions are excessively high for Lithuania due to meagre absolute change in the total revenue. The increasing competition in the poultry market has contributed to the poultry price decline in Lithuania and Poland. Latvia showed the highest average price level of poultry among the analysed countries (1.7 Euro/kg), whereas Lithuania and Poland posted almost twice lower average selling price for 2011-2019 (8.9 Euro/kg and 8.4 Euro/kg, respectively). In Latvia, the real selling price also slightly went up by some 2% contributing the 4% of the total revenue change. As for Lithuania and Poland, these countries showed decline in the selling price of 20% and 10%, respectively. Therefore, price effect in Lithuania was negative

and offset positive scale effect. In Poland, the negative price effect amounted to 195 of the decline in the revenue over 2011-2019.

Even though two of the three countries saw a negative price change, the number of birds increased in all the countries under analysis. The highest growth was observed for Poland (47% comparing 2019 against 2011). Latvia and Poland showed similar growth of 29% and 25% respectively. Accordingly, the contribution of the scale of farming was 80% of the total revenue change in Poland and 57% in Latvia. As it was mentioned above, the revenue gains from increasing scale of operation were netted of by price disadvantage in Lithuania (422% of the total revenue change).

The yield effect (the increase in the poultry weight sold per one bird kept) was positive for all the three countries. In Latvia and Poland, it amounted to 39% of the total change in the revenue for poultry. Lithuania posted the relative contribution of 103%. Looking at the initial data, one can notice that the yield of poultry farming differed across the countries: Latvia posted the average value of 0.05 kg/bird, whereas Lithuania and Poland exhibited the values of 10 kg/bird and 12 kg/bird, respectively (average values are provided for 2011-2019). Thus, there exist substantial differences in weights gains across the three countries. These can be related to different farming modes, technologies, and consumer preferences. Poland also showed the highest rate of growth in the yield (28% for 2019 compared to 2011). Next came Latvia with growth of 19%. Lithuania showed modest yield gains of 6% over the same period.

The results suggest that Lithuanian poultry sector faces stagnant revenue that is highly affected by price decline. Also, the yield gains did not reach those for, e.g., Poland. This implies Lithuanian poultry sector requires new solutions in order to develop competitive advantage and adjust to the dynamic market situations.

4.4. Potatoes

The three analysed countries are important producers and consumers of potatoes. This sector represents the most important part of the vegetable farming. Indeed, all the three countries saw a decline in the potato harvest over 2011-2019. However, vegetable prices are rather elastic, and this may not preclude farmers from revenue growth. Szajner (2018) reported that the demand for potatoes has been declining due to changes in the lifestyle and tastes.

The mean potato output for Poland amounted to some 7.8 million tonnes during 2011-2019. Lithuania and Latvia showed the average values of 399 thousand tonnes and 219 thousand tonnes, respectively. Indeed, the difference between potato output in Lithuania and Latvia has narrowed over time. Lithuania showed the steepest decline in the potato output (-43.2% during 2011-2019), whereas the decline for Poland (-28.9%) was also rather similar. Latvia posted the smallest decline of -9.4%. The dynamics in revenue from potato sales is presented in Table 7.

Table 7

Revenue from sales of potatoes (million Euro of 2015)

Year	Latvia	Lithuania	Poland
2011	49.1	142.0	1 138.2
2012	32.0	62.2	973.9
2013	37.8	72.2	1 085.0
2014	33.3	70.6	916.4
2015	27.7	45.1	751.7
2016	28.8	48.3	1 035.2
2017	28.6	34.3	1 088.2
2018	29.7	46.5	969.9
2019	41.4	70.9	1 216.5
Geometric mean	33.7	60.6	1010.8
Change	-7.7	-71.1	78.3
Growth rate, %	-2.7	-9.2	0.6

Stochastic average annual growth rate is provided.

Source: Authors' calculations

The stochastic rates of growth in the revenue for potatoes indicate that the three countries analysed did not post any significant improvement in the revenue or even saw a decline. Poland saw a slight increase in the potato revenue from 1.1 billion Euro in 2011 up to 1.2 billion Eur in 2019. This corresponds to a 78.3 million Euro increase or 0.6% annual growth rate. Lithuania posted a decline in the potato revenue from 142 million Eur down to 70.9 million Eur (annual rate of decline of 9.2%). This implies the revenue declined by some 71.1 million Eur in Lithuanian potato sector. As for Latvia, the revenue for potatoes stood at the 49.1 million Euro in 2011 and declined down to 41.4 million Euro in 2019. This represents a 7.7 million Euro decline (annual rate of decline of 2.7%). The reported changes in the revenue are further decomposed by the LMDI (Table 8).

Table 8

Cumulative relative contribution (in per cent of the total change) to the change in revenue for potatoes, 2011-2019

Country	Effect		
	Area	Yield	Price
Latvia	-174	131	-57
Lithuania	-65	20	-55
Poland	-358	-112	570

Source: Authors' calculations

As Poland showed negligible growth in the potato revenue, the relative contributions to the total change are rather high. The price effect was the major reason for increase in the potato revenue in Poland (570% of the total change), whereas the other two factors indicated a negative contribution. The price effect induced a decline in the potato revenue in Latvia and Lithuania (cumulative contributions of -57% and -55%, respectively). Indeed, Poland showed the lowest real price for 2011-2019 of 133 Euro/t. as for Latvia, the mean value of 156 Euro/t was observed, whereas the corresponding figure for Lithuania was 163 Euro/t. Even though Lithuania showed the highest mean price, it also faced the steepest decline in the

selling price of some 12% over 2011-2019. As for Poland, a 50% increase was observed, whereas Latvia showed a 7% decline. Therefore, there has been some convergence in prices, yet the price movements were impacted by unfavorable weather conditions and other short-term factors.

All the three countries saw a declining area sown under potatoes. As for Latvia and Lithuania, this was the strongest effect in terms of its relative contribution to the total change (-174% and -65%, respectively). The highest decline in area, nevertheless, was observed in Lithuania. Here, the potato area went down from 37.3 thousand ha down to 18.2 thousand ha during 2011-2019, i.e., a 51% decline. Latvia saw a 31% decline from 14.4 thousand ha down to 10 thousand ha. As regards Poland, the relevant area went down from 393 thousand ha in 2011 to 302 thousand ha in 2019 (a 23% decline). Therefore, all the countries faced a decline in the area sown under potatoes, yet the relative contributions varied in interaction with the other two terms (yield and price).

The yield effect showed different directions for Poland and the other two countries. In Poland, the yield effect was the least important among the three terms of the IDA identity for the revenue and comprised -112% of the total revenue change. The yield effect was also least important in Lithuania as it comprised 20% of the total change in the revenue. Finally, Latvia saw a positive effect of 131% of the total revenue that offset negative price effect. Therefore, Latvia and Lithuania managed to improve the productivity levels but the revenue for potatoes sold went down there during 2011-2019. A closer look into the data on yield dynamics in Poland suggests that there was a slight decline from 23.1 t/ha down to 21.4 t/ha over 2011-2019. However, this is still higher compared to Lithuania and Latvia. In Lithuania, the potato yield went up from 15.6 t/ha up to 18.1 t/ha (a 16% increase). Latvia showed higher levels of productivity as the potato yield increased from 14.1 t/ha up to 22.4 t/ha. Obviously, Lithuania and Latvia need to address the yield gap in order to remain competitive in the potato market.

The results clearly indicate that decline in the area sown under potatoes in Poland, the country saw a slight increase in the revenue for potatoes sold. Therefore, there have been multiple trends affecting the potato sector in the countries analysed. A general trend of decline in the demand for potatoes caused declining prices in Lithuania and Latvia, whereas increasing competition (and competitiveness) allowed Poland to enjoy an increase in the real prices. Thus, increasing productivity of the potato farming is a key issue for such countries as Latvia and Lithuania in order to maintain competitiveness.

5. CONCLUSION

The present study discussed the dynamics in the revenue for selected crop and livestock products in Latvia, Lithuania, and Poland. The analysis spanned over years 2011-2019. The decomposition of the revenue was carried out by applying the logarithmic mean Divisia index.

The results suggest that the price effect was negative for most of the countries and products covered in the research (note that real prices were used). Therefore, the countries analysed should focus on the productivity gains and adjust the operation of scale. Indeed, positive yield effects were observed as a general trend. However, yield growth did not close yield gaps in certain cases (e.g., potato yield in Poland only recently was approached by that in Latvia). The adjustments of scale should take into account the specialization and advantages that are available in certain region. Also, the existing infrastructure (e.g., processing plants) is highly related to the specialization in certain agricultural products. The increasing processing capacities may also increase the price levels.

Further research may analyse the revenue change at the farm-level. The determinants of revenue change and efficiency could also be assessed. Also, the cost component could be included in the analysis to provide a more comprehensive view on farm operation. Inevitably, similar studies need to be carried out by

using most recent data due to numerous perturbations of supply chains the countries analysed in this study have faced due to disruptions of the global and local scale.

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