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DIVERSITY OF MILK PRODUCTION DETERMINANTS IN EU MACRO-REGIONS* WITH A PREDOMINANCE OF INTENSIVE AND EXTENSIVE PRODUCTION IN 2011**

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Abstract. The main objective of this paper is to identify the differentiation of factors determining the variability of milk production in the European Union macro-regions with a predominance of intensive and extensive production. Classification of regions is based on the analysis of the diversity of dairy farms FADN in the regions of the European Union, which was determined by the agglomeration cluster analysis using Ward method. In order to highlight the determinants of production factor analysis was performed. On the basis of the results, there were factors that have a decisive impact on milk production in dairy farms from regions with a predominance of intensive and extensive production model identified.

Keywords: milk production, EU macro-regions, production determinants, cluster analysis, factor analysis

INTRODUCTION

The European Union is diversified in many areas, primarily including the agriculture sector (Matuszczak, 2012, p. 156–174). In addition to the diversity of soil, climate and natural conditions beyond human control, there are also differences in the levels of production and economic performance indexes of agricultural holdings (Grontkowska, 2012, p. 58–69). The diversification of production and economic performance indexes of FADN dairy farms in EU macro-regions persists or even grows. This is demonstrated by the increased values of standard deviation and Gini coefficient in 2011 for most of the variables within the FADN field of survey, compared to 2004 data (Guth, 2015, p. 119–124). In the case of milk, the scale of production is of key importance for the development of differences in economic performance indexes, as confirmed by studies carried out by many economists specializing in the milk market topic: Parzonko (2006, 2013), Ziętara (2010), Świtłyk and Ziętara (2012), Seremak-Bulge (2011), Wójcik (2012) and Sass (2007). Another reason for production differentiation could be the different course of structural changes in the eastern and western part of the EU (Poczta et al., 2008). As shown by the above conditions, the determinants of milk production may significantly vary from one EU region to another. The purpose of this paper is to specify the determinants of milk production in dairy farms from EU regions with a predominance of extensive production in 2011, which include all of the Polish macro-regions.

*This paper makes no distinction between the terms "FADN region" and "EU macro-region," similarly to publications by specialists engaged in FADN development and implementation in Poland (cf. Goraj, 2005; Marcinkowski, 2006). To avoid repetition, the term "region" is often used.

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RESEARCH METHODOLOGY

Because of the identified increase in the diversity of FADN dairy farms in EU macroregions in 2011 compared to 2004 data (Guth, 2015), a decision was made to assess the factors with the largest impact on milk production in 2011[1] in specific macro-region groups comprising similar farms. The typology was based on three out of four initially chosen characteristics within the FADN[2] field of survey which describe the sample farms, i.e. the utilized agricultural area, dairy cow population and the yearly average milk yield per cow. The farms were grouped using the Ward's agglomerative hierarchical clustering method. The solution was validated with the S(i) Silhouette coefficient (separation of clusters by survey characteristics) which equaled 0.51 and exceeded the required critical level[3]. It may therefore be concluded that the clusters are disjunctive in terms of survey characteristics and, thus, meet the proper splitting conditions in the cluster analysis. The starting point for the analysis of production determinants in the selected cluster of regions was the creation of an observation matrix consisting of a set of 49 indexes originating from FADN. They illustrated various features of dairy farms in EU macro-regions with a predominance of intensive and extensive production in 2011. The variables were subject to standardization. The correlation analysis showed significant, highly complex relationships between the variables. In the case of the reference set of EU regions with a predominance of extensive production, the critical value at $\alpha = 0.01$ was 0.415549 (with $N = 42$). As a consequence, all $-0.415549 \leq r \leq 0.415549$ may be considered insignificant for the purposes of this analysis. Meanwhile, in the case of EU regions with a predominance of intensive production, the critical value at $\alpha = 0.01$ was –0,342945 (with $N = 60$), and therefore all $-0.342945 \leq r \leq 0.342945$ may be considered insignificant for the purposes of this analysis. The variables were grouped using a method based on the maximum correlation criterion. Afterwards, factor analysis (principal component analysis) was performed.

As a part of the factor analysis, milk production determinants in EU macro-regions (with a predominance of both extensive and intensive production) in 2011 were specified with the use of 34 characteristics selected from 49 indexes under analysis, thus complying with the matrix size condition in the factor analysis. The sufficient proportion criterion (beyond 75% of variance explained) and the analysis of the scree plot were the basis for identifying mutually independent factors that explain over 75% of common (cumulative) variation. In order to narrow the scope of factors and unify their nature, the solution was subject to a rotation procedure. Further in this study, the solution obtained with the raw Varimax method was used.

RESULTS OF THE STUDY[4]

The cluster analysis allowed to identify three internally homogeneous region groups (among 108 regions) with a predominance of:

- intensive milk production: 1st typology group comprising 60 regions, including the vast majority of regions of UE-15 countries as well as Czech Republic, Estonia, Malta and Nyugat-Dunántúl in Hungary (192.53 ESU on average; with a relatively large agricultural area (80.43 ha) and dairy cow population (63.91), and a medium level of milk yield (7,560 kg per year));
- "milk factories": the 2nd typology group comprising five regions in northern and central Germany and Slovakia (950.07 ESU on average; with the largest agricultural area (598.06 ha) and cow population (nearly 250 cows per farm), and the highest yearly milk yield (nearly 8,000 kg; or over 8,500 kg excluding Slovakia, ranked far below the results of other regions));
- extensive milk production: the 3rd typology group comprising 42 regions with a predominance of UE-12 regions and Italian regions, three Spanish regions (Asturias, Cantabria and Balearic Islands), two French regions (Auvergne and Languedoc-Roussillon), Portuguese Azores, Ireland and Austria (56.40 ESU on average; with an agricultural area of 30 ha,

[1] 2011 data was the most recent project implementation data acquired in January 2015 in accordance with the schedule.

[2] Due to excessive correlation with other characteristics, the economic size of farms was excluded from the analysis.

[3] The Silhouette index (SI, Silhouette coefficient, SIL index) was proposed by P.J. Rousseeuw in 1987 (Migdał-Najman, 2011).

[4] The presented outcomes are a part of a broader research performed as a result of awarding the Preludium grant in monograph: Czyżewski and Guth, 2016.

Table 1. Factor solution for regions with a predominance of intensive and extensive milk production in 2011
Tabela 1. Rozwiązanie czynnikowe dla regionów z przewagą intensywnej i ekstensywnej produkcji mleka w 2011 roku

Factor Czynnik	Self-value of correlation matrix Wartość własna macierzy korelacji		Share in the variation use (%) Udział w wykorzystaniu zmienności (%)			
			wspólnej common		cumulative skumulowanej	
Production model Model produkcji	intensive intensywna	extensive ekstensywna	intensive intensywna	extensive ekstensywna	intensive intensywna	extensive ekstensywna
F_1	11.99	15.82	31.55	40.58	31.55	40.58
F_2	9.10	13.52	23.94	34.69	55.49	75.27
F_3	7.42	–	19.52	–	75.01	–

Source: own elaboration based on the results of own research using FADN data for the "dairy cows" type of production by region in 2011.
Źródło: opracowanie własne na podstawie wyników badań własnych z wykorzystaniem danych FADN dla typu produkcyjnego krowy mleczne w przekroju regionalnym dla 2011 roku.

an average population of 25 dairy cows and a yearly milk yield of 4,368 kg) (cf. Guth 2015).

Clusters of regions with a predominance of intensive milk production concentrated in large holdings (1st typology group) and very large holdings ("milk factories," 2nd typology group) were dominated by relatively wealthier EU-15 regions. Meanwhile, EU-12 regions were clearly dominating the groups of regions with a predominance of extensive milk production (3rd typology group). Because of the observed diversity of FADN dairy farms in EU regions, it was concluded that milk production determinants in the identified clusters may differ from one another. Therefore, it was decided to perform a factor analysis of region groups with a predominance of intensive and extensive production, as identified during the cluster analysis. Based on the results of factor analysis, it was possible to specify three and two determinants of milk production in the sample farms located in EU regions with a predominance of intensive and extensive production, respectively (cf. Table 1).

In both cases, the first factor (F_1) should be considered the leading one as it explains the largest extent of common variation in this study. The smallest extent of common variation was explained by the third factor in the case of farms located in regions with a predominance of intensive production, and by the second factor (F_2) in the case of farms located in regions with a predominance of extensive production. This means these factors were determinant for the production to the smallest degree among those selected. When interpreting the results obtained, it was concluded that, in view of its features, the first factor may be defined as price-cost relationships in the case of farms located in regions with a predominance of intensive milk production in 2011[5], or as the financial and asset situation of farms located in regions with a predominance of extensive milk production (cf. Table 2). The analysis of indexes covered by the 2nd factor (F^2) concluded in determining that whether the farms are located in regions with a predominance of intensive or extensive milk production, it represents the variables reflecting the dairy farm costs not directly connected with production in 2011[6] (cf. Table 3). The third reference factor

[5] The structure of characteristics composing the factor F_1 in farms located in regions with a predominance of intensive milk production is also dominated by cost-related factors (9 out of 13 characteristics). The author believes that both the costs and the resources of the sample farms are indirectly affected by prices, because price levels and the price-to-costs ratio are the basis for decision making on production scale and type. This provides a justification for the nomenclature used.

[6] The author is aware that variables which represent costs in the factor's structure are linked to milk production. However, this is not a direct relationship. The characteristics composing the second factor also include two non-cost items, i.e. payments for rural development and decoupled payments. This could provide clear grounds for believing that subsidies had a significant impact on the cost structure of farms located in EU regions with a predominance of extensive milk production.

Table 2. The structure of factor F_1 in FADN milk farms in the EU regions with a predominance of intensive and extensive production in 2011
Tabela 2. Konstrukcja czynnika F_1 w gospodarstwach mlecznych FADN z regionów z przewagą intensywnej i ekstensywnej produkcji w 2011 roku

Intensive production – price-cost relationship Produkcja intensywna – relacje cenowo-kosztowe		Extensive production – financial and assets situation Produkcja ekstensywna – sytuacja finansowo-majątkowa	
name of characteristics nazwa cechy	factor load ładunek czynnikowy	name of characteristics nazwa cechy	factor load ładunek czynnikowy
Farmhouse consumption Zużycie wewnętrzne	0.86612	Net worth Kapitał własny	0.92853
Share of home grown feed for grazing livestock in total amount of feed for grazing livestock Udział pasz wytworzonych w gospodarstwie w ogóle pasz dla zwierząt żywionych w systemie wypasowym	0.86443	Farm net income Dochód z rodzinnego gospodarstwa rolnego	0.89926
Long-term liabilities Zobowiązania długoterminowe	0.84120	Cash flow (I) Przepływ pieniężny (I)	0.88594
Interest paid Odsetki	0.83955	Average farm capital Średnia wartość kapitału gospodarstwa rolnego	0.86680
Short-term loans Kredyty krótkoterminowe	0.83071	Farm net value added Wartość dodana netto	0.85263
Wages paid Wynagrodzenia	0.79701	Fixed assets Aktywa trwałe	0.83574
Subsidies on external factors Dopłaty do kosztów czynników zewnętrznych	0.73966	Current assets Aktywa obrotowe	0.81729
Beef and veal Wołowina i cielęcina	0.73277	Share of home grown feed for grazing livestock in total amount of feed for grazing livestock Udział pasz wytworzonych w gospodarstwie rolnym w ogóle pasz dla zwierząt żywionych w systemie wypasowym	0.80217
Share of feed for grazing livestock in direct inputs Udział pasz dla zwierząt żywionych systemem wypasowym w kosztach bezpośrednich	0.72902	Farmhouse consumption Zużycie wewnętrzne	0.79647
Fixed assets Aktywa trwałe	0.72070	Taxes Podatki	0.75570
Direct inputs Koszty bezpośrednie	0.71016	Total livestock output/LU Produkcja zwierzęca na 1 LU	0.72641
Farm use Zużycie pośrednie	0.70379	Total output crops & crop production Produkcja roślinna	0.72231
Current assets Aktywa obrotowe	0.70177		

Source: own elaboration based on the results of own research using FADN data for the "dairy cows" type of production by region in 2011.
Źródło: opracowanie własne na podstawie wyników badań własnych z wykorzystaniem danych FADN dla typu produkcyjnego krowy mleczne w przekroju regionalnym dla 2011 roku.

Table 3. Non-productive costs of running dairy farms from EU regions with a predominance of intensive production in 2011 (construction of factor F_2)
Tabela 3. Pozaprodukcyjne koszty prowadzenia gospodarstw mlecznych z makroregionów UE z przewagą intensywnej i ekstensywnej produkcji w 2011 roku (konstrukcja czynnika F_2)

Intensive production Produkcja intensywna		Extensive production Produkcja ekstensywna	
name of characteristics nazwa cechy	factor load ładunek czynnikowy	name of characteristics nazwa cechy	factor load ładunek czynnikowy
Short term liabilities Zobowiązania krótkoterminowe	0.843822	Long & medium-term loans Zobowiązania długo- i średniookresowe	0.934324
Decoupled payments Płatności „decoupled”	0.841233	Short term liabilities Zobowiązania krótkoterminowe	0.932029
Other direct inputs Pozostałe koszty ogólnogospodarcze	0.839008	Services Usługi	0.924623
Depreciation Amortyzacja	0.799758	Machinery & building current costs Koszty utrzymania maszyn i budynków	0.891014
Other cattle Pozostałe bydło	0.796507	Interest paid Odsetki	0.822666
Services Usługi	0.758656	Wages paid Wynagrodzenia	0.798685
Rent paid Czynsze	0.742905	Payments for rural development Dopłaty do rozwoju obszarów wiejskich	0.783862
Beef and veal Żywiec wołowy	0.706733	Other direct inputs Pozostałe koszty ogólnogospodarcze	0.765207
–	–	Decoupled payments Dopłaty *decoupled*	0.636327

Source: own elaboration based on the results of own research using FADN data for the “dairy cows” type of production by region in 2011.
Źródło: opracowanie własne na podstawie wyników badań własnych z wykorzystaniem danych FADN dla typu produkcyjnego krowy mleczne w przekroju regionalnym dla 2011 roku.

includes variables that present or affect the revenue of dairy farms located in macro-regions with a predominance of intensive milk production (cf. Table 4).

As demonstrated by the pattern of characteristics composing the F_1 factor and their weights, the price-cost relationships in dairy farms located in regions with a predominance of intensive milk production in 2011 were mainly conditioned by farmhouse consumption and total liabilities (predominantly long-term liabilities) (cf. Table 2). In this context, note the important share of feed for grazing livestock in direct inputs, as well as the stronger impact of the share of home grown feed in total amount of feed for grazing livestock. It may be therefore concluded that farms have compensated the risk of an increase in the price of feed by growing it on their own, at least to some extent. Note also that as regards farms located in regions with a predominance of intensive production, the price-cost relationships were strongly affected by interest paid, including financial fees and interest on borrowings made specifically for the purpose of purchasing land, buildings, machinery, equipment, animals and materials, as well as financial fees and interest on liabilities. This means the farms located in regions with a predominance of intensive milk production make numerous investments in upgrading and improving their production as an opportunity for further growth (cf. Table 2). In addition to costs, subsidies on external factors also had a strong impact on the price-cost

Table 4. Income of dairy farms in the macro-regions of the European Union with a predominance of intensive production in 2011 (construction of factor F_3)
Tabela 4. Dochody gospodarstw mlecznych w makroregionach z przewagą intensywnej produkcji mleka w 2011 roku (konstrukcja czynnika F_3)

Name of characteristics Nazwa cechy	Factor load Ładunek czynnikowy
Farm net income Dochód z rodzinnego gospodarstwa rolnego	0.964261
Cash flow (I) Przepływ pieniężny (I)	0.907015
Net worth Kapitał własny	0.810942
Farm net value added Wartość dodana netto	0.803390
Current assets Aktywa obrotowe	0.789202

Source: own elaboration based on FADN data.
Źródło: opracowanie własne na podstawie danych FADN.

relationships in the case of farms located in regions with a predominance of intensive milk production.

In 2011, the net worth and its average level[7] was the factor with the strongest impact on the financial and asset situation of farms located in regions with a predominance of extensive milk production. Moreover, the financial and asset situation of farms located in regions with a predominance of extensive milk production was also affected by the assets value itself (including fixed assets having a stronger impact than current assets), the farm net income and the farm net value added. Agricultural yields, measured as the animal production value per livestock unit and, indirectly, by the impact of farmhouse consumption, turned out to be an important index of the financial situation of farms located in regions with a predominance of extensive milk production. This is perfectly understandable, bearing in mind they need to compete on the unified European market with more efficient farms from regions with a predominance of intensive production patterns. What seems interesting is the relatively strong impact of crop production on the financial situation of farms located in regions with a predominance of extensive production. This also contributed to the important role of the share of home grown feed for grazing livestock in total amount of such feed (cf. Table 2). This suggests that farms located in regions with a predominance of extensive production were able to compensate the risk of an increase in the price of feed by growing it on their own, at least to some extent. Note however that such practices resulted from the nature of extensive production which is dominated by grazing livestock farms. As regards farms located in regions with a predominance of extensive production, the leading factor also included indexes describing the farms' self-financing capacity and ability to make savings as a part of their operations (cash flow 1). This may be explained by the need to repay long-term loans taken out for the purposes of farm modernization in order for the EU-12 farms, dominating in this group, to meet the accession requirements.

The component analysis of the 2nd factor concluded in determining that the covered characteristics may be described as farm costs not directly connected with milk production borne in macro-regions with a predominance of intensive and extensive milk production in 2011. Among the characteristics composing the F3 factor, short-term liabilities (intended mainly for providing operational financing) had the strongest impact on dairy farm costs not directly connected with milk production borne in macro-regions with a predominance of intensive production. Decoupled payments also played an important role which may suggest that subsidies significantly affect the costs even in farms with intensive production systems. Note that the amount of costs not directly connected with milk production was significantly affected by farming bovine animals other than dairy cows, and by beef and veal sales revenue (cf. Table 3). Among the variables composing that factor, long-term and short-term liabilities had the strongest impact on non-productive costs of running dairy farms in EU regions with a predominance of extensive production in 2011. Operating costs were also significantly affected by services, machine and building maintenance costs, and other direct inputs (cf. Table 3). In 2011, the costs of external factors had a significant impact on non-productive costs of running dairy farms in EU macro-regions with a predominance of extensive production. Interest seems

[7] According to FADN, the net worth of an agricultural holding includes the value of animals, permanent crops, drainage facilities, buildings, machines, equipment and working capital. It does not include amounts and other rights which cannot be separated from land value.

to be an item of special importance as it represents a relatively significant determinant of non-productive costs of running dairy farms in EU macro-regions with a predominance of extensive production in 2011. This may suggest that liabilities were a heavy burden for the contemplated entities. Nevertheless, it could also mean that dairy farms in macro-regions with a predominance of extensive production seek an opportunity in increasing the production scale and concentration in order to reduce the costs of external factors. Note also that the level of non-productive costs of running dairy farms in macro-regions with a predominance of extensive production in 2011 was significantly impacted by rural development subsidies and decoupled payments (however, to a smaller extent than in the case of farms located in regions with a predominance of intensive production) (Guth, 2016).

Due to the sufficient proportion criterion, the third factor (F_3) was identified only for farms located in macro-regions with a predominance of intensive milk production in 2011. As shown by the analysis of the characteristics covered, it was represented by variables that present or affect the revenue of dairy farms located in macro-regions with a predominance of intensive milk production. Among the variables composing that factor, the strongest impact was exerted by the farm net income, defined as the payment for engaging the farm's own productive inputs in farming operations and the payment for the risk taken by the farmer during the financial year (cf. Table 4).

As implied by the construction of F_3, the revenue of dairy farms located in macro-regions with a predominance of intensive milk production was also affected by cash flow 1 which shows the farms' self-financing capacity and ability to make savings as a part of their operations. The net worth, reflecting the total asset value minus total liabilities, was also of significance for the revenue of dairy farms located in macro-regions with a predominance of intensive milk production. Note that the structure of this factor also includes current assets. This could suggest that the ratio of current assets to liabilities had a significant impact on the amount of revenue of dairy farms located in macro-regions with a predominance of intensive milk production in 2011 (cf. Table 4).

SUMMARY

The following conclusions may be drawn from the studies:

- Clusters of regions with a predominance of intensive milk production concentrated in large holdings and very large holdings ("milk factories") were dominated by relatively wealthier EU-15 regions. Meanwhile, EU-12 regions were clearly dominating the groups of regions with a predominance of extensive milk production. This confirms the polarization of the European milk production sector.
- Production in dairy farms located in regions with a predominance of intensive milk production was determined by the following, in order of descending priority: price-cost relationships, non-productive costs of running dairy farms, and revenue (to the smallest extent among the selected factors). Meanwhile, milk production in macro-regions with a predominance of extensive production mainly depended on the farms' financial and asset situation, and (to a lower degree) on non-productive costs of running dairy farms. The latter were affected the most by liabilities and costs of external factors (remunerations and interest) which may suggest that dairy farms in regions with a predominance of extensive production seek an opportunity in increasing the production scale and concentration in order to reduce the costs of external factors.
- In regions with a predominance of extensive production, milk yield per cow turned out to be an important index of the farms' financial and asset situation. This means that farms located in these regions were committed to improve their production efficiency as they had to compete on the unified European market with more efficient farms from regions with a predominance of intensive production patterns. What seems interesting is the relatively strong impact of crop production on the financial situation of farms located in regions with a predominance of extensive production. This also contributed to the important role of home grown feed for grazing livestock. This suggests that farms located in regions with a predominance of extensive production, similarly to those located in regions with a predominance of intensive production, were able to partially compensate the risk of an increase in the price of feed by growing it on their own, at least to some extent.

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ZRÓŻNICOWANIE DETERMINANT PRODUKCJI MLEKA W MAKROREGIONACH UNII EUROPEJSKIEJ Z PRZEWAGĄ PRODUKCJI INTENSYWNEJ I EKSTENSYWNEJ W 2011 ROKU

Streszczenie. Głównym celem rozważań była identyfikacja czynników warunkujących zmienność produkcji mleka w 2011 roku w makroregionach Unii Europejskiej z przewagą produkcji intensywnej i ekstensywnej. Wyboru regionów dokonano na podstawie analizy zróżnicowania gospodarstw mlecznych FADN w regionach Unii Europejskiej, które określono za pomocą aglomeracyjnej analizy skupień metodą Warda. W celu wyróżnienia determinant produkcji dokonano analizy czynnikowej. Na podstawie jej wyników zidentyfikowano czynniki, które miały decydujący wpływ na produkcję mleka w gospodarstwach mlecznych z makroregionów z przewagą produkcji intensywnej i ekstensywnej.

Słowa kluczowe: produkcja mleka, makroregiony Unii Europejskiej, determinanty produkcji, analiza skupień, analiza czynnikowa

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