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Economic Situation of Dairy Farms in Identified Clusters of European Union Countries

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Abstract: The economic situation of EU dairy farms is unstable and differs strongly between member countries. Most studies addressing the EU's agricultural sector focus on selected countries or selected groups of operators. Conversely, this paper seeks to determine the economic situation of dairy farms in EU countries grouped into types according to their production potential. The analysis relied on data collected and processed in the FADN (Farm Accountancy Data Network). The farms were classified based on a hierarchical clustering routine. The agglomerative technique was used. Distances between clusters were calculated using the Ward's method. In turn, the distance between countries was calculated as the Euclidean distance. This study enabled the identification of five different types of dairy farms in the EU. On an EU-wide basis, medium and large-sized highly specialized intensive farms play a key role in milk production. Despite their profitability being somehow restricted, they report high levels of labor productivity thanks to an advantageous production potential. In turn, an insufficient potential is among the main restrictions faced by other dairy farms in the EU; their advantageous financial indicators often fail to provide satisfactory levels of income which could drive investment and consumption opportunities.

Keywords: dairy farms; FADN; clustering; EU; economic situation; production potential

1. Introduction

Milk is among the key food products consumed by humans in many countries around the world [1]. Population growth, together with an increase in incomes, results in increased consumption of milk products. Similarly to meat, the consumption of milk reflects national wealth [2]. Milk is among the essential products of the agricultural market [3], and the key agricultural product for the European Union (EU) [2]. Considering its share in the turnover or its contribution to the value added of production, the dairy industry plays a more important role in EU countries than in the United States [4,5]. Moreover, exports of milk products play an important role in total agri-food trade in nearly all EU countries and in the global trade in dairy products [4]. Next to the United States and New Zealand, the EU is one of the major global traders in dairy products. Also, the EU and the United States, together with India, are the key global producers of milk [6]. In the EU, milk accounts for ca. 14% of agricultural production, and is ranked second after fruits and vegetables with an approximate share of 24% [2]. Furthermore, the production level in the EU follows an upward trend, and is estimated at ca. 170 million tons per year (as at 2017) [7]. Growth in milk production, as witnessed in the recent years, largely results from the increase in milk yield which, in turn, is driven by factors that include improved animals' genetics and better feeding practices [8]. According to the European Commission, continued growth in milk yield (at an annual rate of ca. 2.5%) can be expected in the EU in the years to come (by 2025) [9].

In the last several decades, the global dairy industry has experienced structural changes, including production relocation, increase in farm size and changes to agricultural production systems. The extent of these transformations differs between the countries [6]. The EU's dairy sector has also been affected by numerous changes, and is highly heterogeneous [10]. Undeniably, specialized dairy farms represent an extremely important type of farming in the EU, although their role differs between the countries. The share of specialized dairy farms in total milk production in the EU varies in the range of 24% (in the Czech Republic) to 99.9% (some Spanish and Portuguese regions) [11]. Considerable differences exist between dairy farms across the EU [12]. In the EU-15, farms are usually much larger and report higher milk yields than elsewhere in the EU. This is the consequence of differences in the natural potential, but also the result of various social, economic and regulatory contexts [11,13]. Therefore, the economic and financial situation of specialized milk production farms differs strongly between EU countries and between EU regions, and it is difficult to consider it stable [14,15].

The main milk producers in the EU are Germany, France, UK, Poland, the Netherlands, and Italy which together account for ca. 70% of the total milk production volume in the EU [16]. Hence, in the EU, only a few countries with a huge production potential have a decisive impact on the market situation. Most of the largest milk producers are EU-15 countries. Of the countries who joined the EU after 2004, only Poland is included in that group [13]. The conditions differ considerably between these countries, too. For instance, British dairy farms exhibit high labor productivity and relatively low investment amounts; their development was largely determined by the geographic mobility of milk quotas and low consumer prices of milk. In turn, Germany, France, and Italy have recorded a reduction in the number of dairies over the recent years, whereas the average herd size has remained relatively stable. In France, as another example, the poor mobility of milk quotas contributed to the growing emergence of more traditional, less specialized dairy farms [6,17].

The available literature on the subject provides a multitude of studies on the dairy sector, including in the EU. A particularly large number of studies focus on milk quotas or other market regulations, starting from an assessment of the milk quota system (e.g., [18,19]) or of its operational impacts on the performance of dairy farms (e.g., [20–22]), through to comparative analyses of agricultural policies for the milk market (e.g., [2]), studies on how the farmers respond to political and market change (e.g., [23]), and research on the impact of the abolition of milk quotas on the functioning of dairy farms (e.g., [24–26]). Often, research projects focus on the situation prevailing in selected countries, as it is the case in [18–21,23–26]. Selected countries are also addressed by analyses of the economic situation [27] and competitiveness [28] of dairy farms, or of the strategy of households in that sector [29]. Other topics covered are the impacts of the accession to the EU on the functioning of the market for milk and milk products [30]. Also, the studies often include international comparisons, e.g., [2] (EU and Turkey), [31] (46 selected countries, including in Europe), [6] (selected EU countries and the United States), or regional benchmarking [11,32]. Some researchers examine the competitiveness of milk production in the context of international trade: [3,4,33].

Most studies focus on selected countries or groups of operators (usually selected based on narrow criteria). Conversely, this paper attempts to verify the effects of the production potential of EU dairy farms on their broadly defined economic situation, including: Production, incomes, costs, productivity of inputs, and financial indicators. Hence, this paper seeks to determine the economic situation of dairy farms in European Union countries grouped into types according to their production potential. This will allow to identify different milk production conditions and strategies in place in European Union countries, and to verify the important differences which affect, and will continue to affect, the production of milk in EU countries.

2. Materials and Methods

2.1. Data

The analysis relied on data collected and processed in the FADN (Farm Accountancy Data Network). Operators covered by the FADN are farms of an adequate economic size which account for at least 90% of the production volume in the European Union country concerned [34]. Hence, the sample for which FADN data is available is representative for most farms in each country (which jointly account for no less than 90% of total output). FADN data is presented as average figures for fully representative groups of farms [35]. This means that database users have access to data which reflects the condition of an average farm drawn from the population which contributes no less than 90% to total output in the country considered. Data used in this paper covers farms with "dairy cows" as the type of farming, was collected in 2014–2016 (at the time of calculations, this was the most recent data available in the FADN), and is representative for a defined number of farms specified in Table 1 [36]. If the studies are not intended to analyze the pace of changes, economic and agricultural researchers usually set a three-year period which is enough to eliminate the impact of variability in natural phenomena. The type of farming covered by this study (code 45 in the FADN grouping scheme) includes farms where dairy cows account for more than 75% of ruminants kept in the farm [11]. The study covered 25 European Union countries (without Cyprus and Greece due to lack of adequate data, and without Malta due to the marginal importance of dairy farms and of the agricultural and dairy sectors).

Table 1. Number of representatives of the "dairy cows" production type in European Union countries in 2014–2016.

Year	2014	2015	2016
Number of farms represented [1]	615,050	593,230	630,000

Source: own study based on [36]; [1] the table presents the number of farms whose FADN data allows the findings to be generalized, i.e., farms which contribute 90% to standard output in each country; data used later in this paper is delivered by the European Commission as average figures for a sample composed of 80,000–90,000 farms in each year covered by this study.

2.2. Methods

FADN data served as a basis for classifying the farms with the use of the clustering procedure. This method was already used in previous research to group the farms based on different sets of characteristics relating, for instance, to their production potential [37], economic situation [38] or financial standing [39,40]. In this study, the typology was based on the characteristics of the production potential identified with the use of substantive criteria.

The production potential of agriculture is defined based on natural resources, economic and natural conditions, available machinery and technical equipment, and owned labor resources [41]. At farm level, it is determined by considering the whole set of productive inputs [42]. The differences in production potential are related to factors which include different historical and natural conditions and the level of economic development of a country [43].

Two groups of variables were used for the purposes of this study: Variables responsible for the production potential and variables characteristic of farms specializing in milk production. The variables were selected based on substantive criteria, following a review of selected literature, including [14,41–50]. As a consequence, the production potential was assumed to include the resources, consumption and structure of, and relations between, productive inputs. The variables retained for this study include:

- Total labor inputs expressed in Annual Work Units (an AWU is equivalent to 2120 working hours per year [35]),
- share of hired labor in total labor inputs (%),
- agricultural land area of the farm (ha),

- share of additional leased agricultural land in total agricultural land (%),
- total assets less the value of land, permanent crops and production quotas (EUR thousand),
- share of fixed assets in total assets (%),
- assets-to-labor ratio (fixed assets per full-time employee) (EUR thousand/AWU),
- assets-to-land ratio (fixed assets per hectare of agricultural land) (EUR thousand/ha),
- agricultural land area per full-time employee (ha/AWU),
- production scale (number of dairy cows),
- share of livestock in fixed assets value (%), and
- livestock density, expressed as livestock units (LU) per hectare.

A three-year (2014–2016) average was calculated for each of the characteristics covered in order to eliminate the impact of random factors such as climatic or institutional conditions. Statistical features were considered as a next step, starting with the coefficient of variation. According to some authors [51], the characteristics can be considered statistically insignificant below the threshold of 10%. Others [52] believe that weak variation corresponds to a coefficient falling within the interval of 0–20%. In this study, the threshold was set at 20%.

According to Stanisz [53], variables used in cluster analysis cannot be excessively correlated. This is why a correlation matrix was created as a next step. Wysocki and Lira [54] specify the following intervals of the Pearson linear correlation coefficient reflecting the nature of a relationship: $0 \leq |\varrho| < 0.2$: virtually no relation between the characteristics; $0.2 \leq |\varrho| < 0.5$: weak relation; $0.5 \leq |\varrho| < 0.75$: moderate relation; $0.75 \leq |\varrho| < 0.95$: strong relation; $0.95 \leq |\varrho| < 1$: a nearly functional relation. The characteristics with a strong or nearly functional correlation (a correlation coefficient of no less than 0.75) were removed from the analysis. The variables used in this study differ in units. Hence, as a next step, a standardization routine was carried out to reconcile the differences in orders of magnitude and rescale the variables [55,56]. In view of all the statistical features discussed above, the following characteristics were removed from further analysis: Share of fixed assets in total assets (due to insufficient variation); total labor inputs; area of agricultural land; assets-to-labor ratio; and assets-to-land ratio (due to excessive correlation). This means that the clusters were ultimately established based on the following variables: share of hired labor in total labor inputs; share of additional leased agricultural land in total agricultural land; total assets less the value of land, permanent crops and production quotas; agricultural land area per full-time employee; number of dairy cows; share of livestock in fixed assets value; and livestock density.

The hierarchical clustering routine was employed to group the farms. The agglomerative technique was used. Accordingly, at the beginning of the clustering process, each country covered by the analysis is a singleton. Countries which are most similar to each other in terms of selected characteristics are gradually combined into new, increasingly larger clusters. The ultimate goal is to obtain a single cluster based on all the countries analyzed [57–59]. The distance between the clusters was calculated using the Ward's method which considerably contributes to minimizing the differences within the clusters [53]. It uses the analysis of variance in order to estimate the distance between units [60], and is one of the most commonly adopted methods for linking new clusters. It is believed that it usually delivers a near-optimum solution [61]. The Euclidean distance was used to calculate the distance between countries during the clustering process. The relationship between linkage distance and linkage stage was analyzed in order to determine the number of classes [53,59].

3. Results and Discussion

3.1. Classification of Dairy Farms in European Union Countries According to Production Potential

Table 2 shows the basic descriptive statistics of the production potential of dairy farms in the countries covered by this study. The greatest differences existed in the area of agricultural land, total labor inputs and assets-to-labor ratios (a coefficient of variation above 100%). More than half of

countries had an average of less than 2 full-time employees per dairy farm. As regards total labor inputs, the statistics were overestimated primarily by Slovakia and Czech Republic, with an average of over 10 full-time employees per farm. Note that specialized dairy farms require greater average labor inputs than other types of farms [10].

Table 2. Basic descriptive statistics for selected variables relating to the production potential of dairy farms in the European Union (average figures for 2014–2016).

Variable	Mean	Median	Minimum	Maximum	Coefficient of Variation (%)
Total labor inputs (AWU)	3.43	1.87	1.01	26.09	149.13
Share of hired labor in total labor inputs (%)	28.56	18.66	0.76	97.12	98.51
Agricultural land per farm (ha)	107.02	53.32	4.23	927.76	172.53
Share of additional leased agricultural land in total agricultural land (%)	52.70	44.92	23.75	94.85	39.58
Total assets less the value of land, permanent crops and production quotas (EUR thousand)	506.87	408.06	20.13	1899.36	92.10
Share of fixed assets in total assets (%)	79.76	81.65	53.69	91.95	12.90
Assets-to-labor ratio (EUR thousand/AWU)	312.87	169.24	15.74	1336.85	114.68
Assets-to-land ratio (EUR thousand/ha)	10.81	7.69	1.41	46.60	91.98
Utilized agricultural area per FTE (ha/AWU)	27.64	26.68	4.20	55.91	58.35
Number of dairy cows	60.45	53.98	3.90	200.36	82.76
Share of livestock in fixed assets value (%)	12.08	10.45	3.89	32.57	61.18
Livestock density (LU/ha)	1.69	1.76	0.50	3.18	42.85

Source: own calculations based on [36].

Large differences also existed in the share of hired labor in total labor inputs. The level recorded in more than half of countries was below 20%. The largest share of hired labor was reported in countries which rely on large total labor inputs: Slovakia, Czech Republic and Estonia (over 78%). Conversely, the lowest level was found in Belgium, Austria, Poland and Slovenia (below 3%).

Half of the farms had approximately 50 ha (or less) of agricultural land. Large areas of agricultural land were owned by Slovakian, Czech, Estonian, Danish, and Swedish farms (over 140 ha on average). The number of full-time employees per farm was much lower in the three latter countries than in the two former. This could suggest that agricultural production in Estonia, Denmark and Sweden relies to a greater extent on machinery.

Additional leased agricultural land had a dominant share in total agricultural land in eleven of the countries covered by this study. The highest shares (80% or more) were recorded in Bulgaria, Czech Republic, France, Hungary, and Slovakia, whereas the lowest (below 32%) were found in Denmark, Ireland, Austria, Poland, and Romania.

In half of the countries, the average total value of assets less the value of land, permanent crops and production quotas was not in excess of EUR 400,000 per farm. The level recorded in Denmark and Slovakia (over EUR 1,500,000) was by far the highest. Conversely, the lowest values (below EUR 50,000) were found in Romania and Bulgaria.

As regards two variables (animal density and share of fixed assets in total assets), the median was higher than the mean. In both cases, the coefficient of variation was not above 50%. The high share of fixed assets in total assets is due to the particularities of farms which usually rely on a diversified range of machinery. The share of fixed assets was by far the lowest (54%) in Italy, which can be explained by climatic conditions. In this case, "other current assets" (a category which includes cash held in bank accounts and cash registers; and short-term receivables) accounted for over 90% of current assets.

High assets-to-labor ratios (over EUR 1,000,000 per AWU) were recorded in Dutch and Danish farms. The highest assets-to-land ratios (over EUR 19,000 per ha) were discovered in the Netherlands, Denmark, Ireland, Italy and Slovenia. Conversely, Latvia and Slovenia reported the lowest values (below EUR 1500 per ha). In the countries covered by this study, the average value of assets per hectare was at a level of ca. EUR 8000–10,000. In turn, there was 27.64 ha of agricultural land per

full-time employee, on average, with the median being very close to the mean. The highest ratios (over 50 ha/AWU) were recorded in Denmark, Luxembourg and Sweden, whereas Bulgaria, Croatia, Romania, and Slovenia had lowest levels (below 10 ha/AWU).

When analyzing dairy cow farms, it is important to take account of the number of animals. The highest numbers (over 100 animals) were recorded in farms located in the Czech Republic, Denmark, Slovakia, and the UK, while Latvia and Romania ranked at the bottom (below 10 animals). In this case, the median was barely 54 cows.

The average share of livestock in total fixed assets value did not exceed 1/3 in any of the countries covered. The highest ratios (over 20%) were mostly found in Southern European countries: Bulgaria, Spain, France, Hungary, and Portugal; this can be explained by a number of factors, including the lower value of buildings. The lowest share of livestock (below 6%) was recorded in Denmark, Luxembourg, the Netherlands, Austria and Slovenia.

The highest animal density (3.18 LU per ha of agricultural land) was recorded in Italy. Near-maximum levels of animal density were also witnessed in Portugal and Spain. The lowest density (0.5 LU per ha of agricultural land) was observed in Slovakia. Near-minimum levels were also found in Latvia and Lithuania. In these countries, the value share of feedingstuffs produced on farm in total feedingstuffs went beyond 38%, which is a quite high level compared to other European Union countries.

In 2014–2016, there was large variation in most of the selected characteristics of the production potential of dairy cow farms located in the Union. This is true both for productive inputs and for the relationships between them.

Dairy farms were classified based on the cluster analysis routine, taking into account the selected characteristics of their production potential. The routine ultimately yielded five clusters which differed in the characteristics of production potential (Figure 1):

- Typological group I: Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia,
- typological group II: Portugal, Spain, Bulgaria,
- typological group III: Slovakia, Hungary, Estonia, Czech Republic,
- typological group IV: Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark, and
- typological group V: France, Italy, Germany, Belgium.

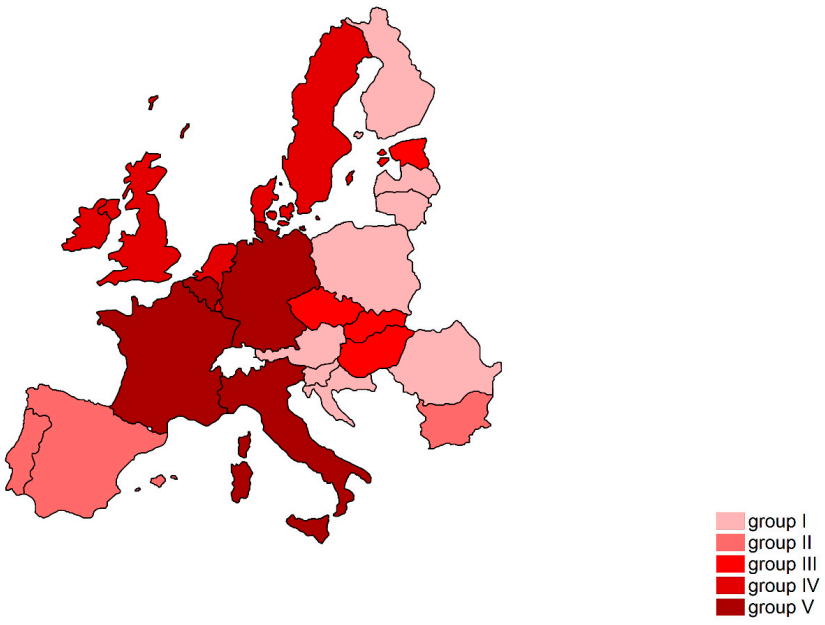

Figure 1. Dairy cow farms in selected European Union countries grouped into types by production potential in 2014–2016. Source: Own study based on [36]

3.2. Analysis of Production Potential in Typological Groups

The characteristics of clusters were established based on the farms' production potential (Table 3). Having in mind the percentage of cows distributed across the clusters, note that over 41% of them were found in countries of the fifth cluster. Nearly 29% and ca. 20% were located in the fourth and first group, respectively. Hence, countries attributed to the fifth, fourth and first group were of greatest importance on an EU-wide basis. Note that when this paper is published, the United Kingdom is no longer a member of the European Union. As a consequence, the fourth group would be smaller, and the percentage of cows in that cluster would be ca. 7 percentage points lower.

The first typological group includes Finland, Austria, and Central and Eastern European countries (Latvia, Lithuania, Slovenia, Poland, Romania, and Croatia). Farms located in these countries have the lowest cow numbers and a relatively small area of agricultural land (also in relation to the number of FTEs). That cluster recorded a strong dominance of family farms with the smallest total labor inputs and the smallest share of hired labor. Note that compared to other groups, these countries also had the lowest share of additional leased agricultural land. Just like in the fourth cluster, fixed assets represented a considerable proportion of total assets. Also, farms in this group had a small number of cows per farm which, in turn, translated into a low share of livestock in fixed assets.

The second cluster was composed of farms located in Southern European countries, i.e., Portugal, Spain, and Bulgaria, which had a relatively small area of agricultural land in relation to dairy cow numbers or FTEs. That cluster recorded the lowest value of total assets less land (similar to that found in the first typological group), a quite low share of fixed assets in total assets and a low fixed assets per FTE ratio. These variables were similar to what was recorded in the third cluster. The small area of agricultural land can be partially explained by specific climatic and soil conditions.

The third cluster included dairy farms from Central and Eastern European countries: Hungary, Estonia and Czech Republic. In these countries, farms had large resources of productive inputs compared to the rest of the region. This can be primarily explained by historical events and structural transformation. Collectivization processes resulted in the establishment of large commercial farms with a large area of agricultural land. Despite a large number of ownership transformation processes, a considerable part of these enterprises keep their original form and stick to old operating methods [62,63]. The importance of hired labor inputs was by far the greatest in that group, and can be explained by huge total labor inputs. By referring to relevant research, Ladvenicová and Miklovičová [64] suggested that the extremely high share of hired labor inputs was not advantageous due to remuneration costs being high and to productivity of particular inputs being often limited. This cluster also had the highest share of additional leased agricultural land in total agricultural land. The share of fixed assets in total assets was much lower than in the first and fourth typological group, and was similar to what was recorded in the two other groups. However, the high total value of fixed assets did not have a beneficial impact on the ratios of fixed assets per FTE and per hectare of agricultural land which reached the lowest levels compared to other clusters. That group also had a relatively low animal density which can be explained by a relatively large total area of agricultural land owned by farms in these countries (this is especially true for Slovakia).

Table 3. Selected characteristics of the production potential of dairy cow farms in European Union countries in 2014–2016.

Specification	Typological Groups				
	I	**II**	**III**	**IV**	**V**
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Number of countries in typological groups	8	3	4	6	4
Share of cows in typological groups (%)	20.05	7.10	2.22	28.80	41.83
Total labor inputs (AWU)	1.75	1.87	11.28	2.24	1.88
Share of hired labor in total labor inputs (%)	9.82	23.31	83.53	28.74	14.75
Agricultural land per farm (ha)	28.44	20.76	380.14	102.82	62.04
Share of additional leased agricultural land in total agricultural land (%)	36.40	56.89	79.25	41.34	72.65
Total assets less the value of land, permanent crops and production quotas (EUR thousand)	164.27	149.14	927.85	872.67	490.70
Share of fixed assets in total assets (%)	83.49	71.67	70.79	87.77	75.31
Assets-to-labor ratio (EUR thousand/AWU)	112.48	87.95	74.97	846.37	320.00
Assets-to-land ratio (EUR thousand/ha)	8.45	6.65	2.29	21.14	11.69
Utilized agricultural area per FTE (ha/AWU)	15.29	11.25	33.52	44.79	32.99
Number of dairy cows	15.76	34.01	106.55	101.77	61.60
Share of livestock in fixed assets value (%)	8.60	26.19	14.56	6.88	13.79
Livestock density (LU/ha)	1.25	2.58	0.95	1.97	2.22

Source: own study based on [36].

The fourth cluster included most Western European countries: Sweden, Luxembourg, UK, the Netherlands, Ireland, and Denmark. The characteristic feature of farms in this cluster was the relatively high level of productive input resources compared to their counterparts from most other European Union countries. Also, that cluster demonstrated advantageous relationships between productive inputs. This can be explained by a quite intensive use of machinery which results in smaller labor inputs in the context of a relatively large area of agricultural land and relatively big cow numbers. There were slightly less than 45 ha of agricultural land per FTE, which is nearly double the level recorded in other clusters. Also, the assets-to-labor ratio reported in that typological group was nearly six times greater than what is observed in other European Union countries. This was particularly noticeable in Danish dairy farms where the value of fixed assets was much higher even compared to other countries of the fourth cluster. That typological group had a large average number of dairy cows (it was slightly higher only in the third cluster). Due to an extremely high value of buildings and a widespread use of machinery, the share of livestock in fixed assets was relatively low.

The fifth typological group was composed of France, Italy, Germany, and Belgium. The characteristic feature of this cluster was a quite high level of the assets-to-land ratio compared to other groups. This can be explained by a medium area of agricultural land accompanied by a widespread use of production machinery and a high value of fixed assets. This, in turn, was related to a moderate area of agricultural land per FTE. Compared to other typological groups, the value share of livestock in fixed assets was low and the number of dairy cows was at a medium level. Livestock density was average in that cluster; this can be explained by the area of agricultural land being at an average level, as mentioned earlier.

In summary, productive input resources were large in the third and fourth typological groups; medium in the fifth group; and small in the first and second group. High total labor inputs and large areas of agricultural land were characteristic of the third cluster; a high value of fixed assets and large numbers of dairy cows were found in the fourth one.

The relationships between productive inputs were most advantageous in the fourth cluster; moderately advantageous in the fifth; and least advantageous in the first, second and third one. The largest area of agricultural land per FTE, and the highest assets-to-land and assets-to-labor ratios were recorded in the fourth group. The lowest assets-to-land ratio was observed in the third cluster; the second and the third cluster had the lowest assets-to-labor ratios; and the smallest area of agricultural land per FTE was recorded in the first and second cluster.

The above suggests that the clusters are composed of the following farms:

- Typological group I: small-scale medium-extensive farms,
- typological group II: small-scale extensive farms,
- typological group III: large-scale extensive farms,
- typological group IV: relatively large-scale highly intensive farms, and
- typological group V: medium-scale, medium-intensive farms.

3.3. Production and Incomes. Role of Subsidies in the Functioning of Dairy Farms

The characteristics of production processes in the farms surveyed are shown in Table 4. The best production characteristics were recorded in countries with an advantageous production potential (fourth and fifth cluster). This can be primarily explained by high milk yields and a high total output. The lowest levels of these two variables were found in the first group (with a low production potential and the smallest number of cows) whose situation was the opposite of what was discovered in the fourth and fifth cluster. Note that the fourth and the fifth group had a share of ca. 32% and 45%, respectively, in total production of cow milk and cow milk products (compared to only ca. 14% for the first group). Hence, countries of the fifth and fourth cluster contributed the most to the production value of milk on an EU-wide basis. Having in mind that the United Kingdom is no longer a member of

the European Union, note that the share in the production value of cow milk and cow milk products in the fourth group would be lower by ca. 7 percentage points.

Milk yield and total production value were significantly correlated to the amount of productive input resources which contribute to an adequate production scale. Clusters dominated by EU-15 countries (which generally have a more advantageous production potential) had a greater share of animal production in total output. In these countries, beneficial input/output relationships allowed to somehow offset the impacts of labor intensity of dairy cow farming. The share of milk production in total production value varied quire strongly, from 48.50% in the third group to 74.40% in the second.

In addition to production performance, incomes are another matter of importance. Payments, especially including operating subsidies, largely contribute to incomes and are the key instrument for supporting farm incomes under the Common Agricultural Policy (CAP). The characteristics of incomes and subsidies in the farms surveyed are presented in Table 5.

The highest incomes from family farming were recorded in countries enjoying an advantageous production potential, mainly driven by quite large amounts of productive inputs (fourth and fifth cluster). In turn, the lowest levels were found in countries with an unfavorable production potential (first and second cluster). When it comes to profitability, the most advantageous relationships were experienced in groups with a low (first and second) or medium (fifth) amount of total costs (cf. Table 6). Hence, the were countries with either large or small production potential which reported small or medium amounts of productive inputs. The different categories of profitability were relatively less advantageous in countries at a high level of total costs (third and fourth cluster). These were groups with a large production potential. Farms of the third cluster had by far the lowest profitability ratios. They recorded the highest level of costs accompanied by unfavorable relationships within their production potential. However, the low level of particular profitability ratios was mostly due to the amount of costs, especially including the large share of external productive inputs (hired labor and leased land). In these farms, high costs of external productive inputs resulted in considerable differences between gross value added and incomes derived from family farming.

The highest total subsidies were recorded in countries with large resources, i.e., mostly in the third and fourth group. The highest share of total subsidies in gross value added was found in the third cluster which relied on a large total area of agricultural land. Conversely, the lowest shares were reported in the fourth and fifth group. Note that the fourth and fifth group had a larger average area of agricultural land than the countries of the first and second cluster. However, the smaller importance of subsidies can be explained by a higher use efficiency of productive inputs (cf. Table 7).

Table 4. Selected production characteristics of dairy cow farms in typological groups of European Union countries in 2014–2016.

Specification	Typological Groups				
	I	**II**	**III**	**IV**	**V**
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Total output (EUR thousand)	55.03	90.59	492.88	406.25	211.19
Share of typological groups in total production of cow milk and cow milk products (%)	14.39	6.30	2.00	32.43	44.87
Share of animal production in total output value (%)	70.10	84.91	57.52	82.77	86.02
Share of cow milk and cow milk products in total output value (%)	58.17	74.40	48.50	69.57	73.02
Milk yield (tons per cow)	5.65	5.92	7.22	7.81	6.99

Source: own study based on [36].

Table 5. Selected characteristics of incomes and subsidies in dairy cow farms in typological groups of European Union countries in 2014–2016.

Specification	Typological Groups				
	I	**II**	**III**	**IV**	**V**
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Gross value added (EUR thousand)	29.78	38.17	247.70	163.84	102.47
Net value added (EUR thousand)	18.21	32.30	183.26	112.86	75.21
Family farming income (EUR thousand)	14.48	27.08	40.11	51.41	53.54
Land profitability (EUR/ha)	602.26	1214.42	171.83	612.09	1200.09
Milk production profitability (EUR/kg)	0.56	0.45	0.21	0.25	0.34
Income per dairy cow (EUR/animal)	912.65	751.45	417.09	588.25	899.08
Profitability of current assets used	0.51	0.46	0.13	0.26	0.42
Profitability of fixed assets used	1.91	4.43	1.03	1.66	3.12
Total subsidies (EUR thousand)	18.34	13.77	150.99	51.37	27.27
Share of total subsidies in gross value added (%)	52.64	38.76	56.94	31.93	27.33

Source: own study based on [36].

Table 6. Selected characteristics of costs and expenses in dairy cow farms in typological groups of European Union countries in 2014–2016.

Specification	Typological Groups				
	I	**II**	**III**	**IV**	**V**
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Total costs (EUR thousand), including:	58.11	77.43	600.20	402.98	183.26
Direct costs (%)	48.62	64.56	45.21	50.18	47.95
Direct costs of animal production (%)	37.70	56.97	31.77	42.36	38.07
Feedingstuffs costs (%)	33.01	51.13	27.61	33.08	31.71
General farming costs (%)	24.19	16.98	21.58	21.98	25.73
Costs of external inputs (%)	6.61	9.81	23.32	14.02	11.88
Total costs per dairy cow (EUR thousand/animal)	2.99	2.08	5.16	3.83	2.99
Direct costs of animal production per dairy cow (EUR thousand/animal)	1.12	1.22	1.58	1.61	1.10
Total feedingstuffs costs per dairy cow (EUR thousand/animal)	0.85	1.32	1.09	1.31	0.98
Consumption of current assets per hectare (EUR thousand/ha)	1.37	2.85	1.22	2.79	2.45
Consumption of fixed assets per hectare (EUR/ha)	0.40	0.28	0.17	0.51	0.44
Consumption of current assets per dairy cow (EUR thousand/animal)	2.17	1.73	3.41	2.73	2.19
Consumption of fixed assets per dairy cow (EUR thousand/animal)	0.61	0.17	0.52	0.54	0.44

Source: own study based on [36].

Table 7. Selected efficiency characteristics of land, labor, and capital inputs in dairy cow farms in typological groups of European Union countries in 2014–2016.

Specification	Typological Groups				
	I	**II**	**III**	**IV**	**V**
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Agricultural output per FTE (EUR thousand/AWU)	29.23	49.71	49.84	172.93	112.66
Net value added per FTE (EUR thousand/AWU)	9.81	17.62	17.14	49.41	40.15
Family farming income per full-time family employee (EUR thousand/FWU [1])	8.75	18.21	17.16	33.99	34.00
Agricultural output per hectare of agricultural land (EUR thousand/ha)	1.97	3.94	1.56	4.04	4.03
Gross value added per hectare (EUR thousand/ha)	1.10	1.73	0.75	1.68	2.01
Capital productivity (%)	35.33	59.36	53.98	43.45	46.03
Agricultural output per dairy cow (EUR thousand/animal)	3.04	2.40	4.36	3.87	3.47
Gross value added per dairy cow (EUR thousand/animal)	1.70	1.08	2.11	1.65	1.69
Production value of cow milk and cow milk products per dairy cow (EUR thousand/animal)	1.78	1.82	2.08	2.67	2.52

Source: own study based on [36]; [1] one Family Work Unit is equivalent to 2120 working hours of a family member per year [35].

3.4. Costs and Expenses

A relatively low ratio of costs to total production value was characteristic of Mediterranean countries with an extremely high share of animal production (second cluster). This can be explained by the relatively low level of general farming costs. A higher amount of that cost category was recorded in the third group (where plant production played an important role). With a share in total costs varying in the range of 27.61% to 51.13%, feedingstuffs represented an important cost category in all clusters. Hence, the minimization of absolute costs (per cow) at a given production level was mainly based on cutting down feed expenses. This was noticeable in the first cluster where total costs were by far the lowest of all countries. Some authors, including Czyżewski and Guth [65], believe this to be an opportunity for these farms. They claim that the liberalization of the milk market will empower the farmers to leverage their price advantage which is due exactly to lower costs. The third cluster saw a great importance of costs of external inputs; this was related to large amounts of funds allocated to employee remunerations. High remuneration costs had a decisive impact on the highest amount of total costs recorded in the third group. Similar conclusions can be drawn from a study by Gołaś [14] who identifies remuneration costs as a major factor behind the high financial intensity of milk production in Slovakian and Czech dairy farms. Nevertheless, note that the financial intensity of farms which mostly rely on own labor would not be that advantageous if the costs of own labor were taken into account. Indeed, the incomes must make a living for the farmer and his/her family; from the social point of view, this also represents a cost, although it is reported neither in the FADN nor in other cost accounting systems (Table 6).

3.5. Efficiency of Land Resources and of Labor and Capital Inputs

The characteristics that reflect the use efficiency of productive input resources in EU's dairy farms are presented in Table 7. The best use efficiency of labor, land, and capital was demonstrated by countries of the fourth and fifth group; in each of them, the average of nine variables was above the general average for the entire population. Also, they demonstrated advantageous relationships between productive inputs. The fourth and fifth cluster had large and medium resources of productive inputs, respectively. In the second and third cluster, the use efficiency of land, labor, and capital was at an average level, except for Bulgaria where the efficiency of production potential was much poorer. In these two clusters, relationships between productive inputs were disadvantageous, and the amount of productive input resources varied greatly (small in the second cluster vs. large in the third). The lowest use efficiency of labor, land, and capital was recorded in the first cluster, with most countries (except for Finland) reporting values over 50% below the average level for the entire population. The features of that group are a small production value, small resources of productive inputs, and disadvantageous relationships between them. In this context, note also the differences in the use level of hired labor between the clusters. These findings seem to corroborate the thesis advanced by Špička and Smutka [11] that the substitution of labor with capital or hired labor is indicative of a higher technological level which may contribute to labor productivity and farm incomes. They observed the highest ratios of substitution of labor with capital or hired labor in Danish, French, Swedish, Dutch, Luxembourgian, and German regions. Conversely, the lowest ratios were found in Italian, Spanish, Portuguese, Maltese, Polish, Latvian, Lithuanian, Bulgarian, and Romanian regions.

It can be concluded that the use efficiency of productive inputs was primarily driven by the relationships between them. Usually, the more advantageous the relationships, the higher the use efficiency of inputs. If the total assets value was significantly greater than the total output value, this had an adverse effect on capital productivity. This was true in the first and fifth cluster, without limitation. Generally, the larger the resources of land, labor and capital, and the greater the total output value, the more beneficial were the relationships that drive the effective use of production potential. The above is consistent with research findings by Nehring et al. [6] who claimed that production scale was positively related to productivity and profitability. In this context, note also the research findings

by Zeng et al. [24] which suggest that farms with more cows and a greater degree of specialization attain higher levels of input productivity. Generally, similar patterns emerge from this analysis.

3.6. Analysis of Financial Indicators

The financial analysis relied on four groups of indicators (Table 8): Capacity to pay; financial assistance and debt sustainability; operational efficiency; and profitability. In the numerator of profitability ratios, the estimated costs of own labor were deducted from family farm income [66].

The highest and the lowest ratios of the capacity to pay were found in the fifth and third cluster, respectively. Note that the liquidity ratios were consistent with widely adopted standards only in the third group. However, in agriculture (due to high level of stocks, the changing value of livestock, and low amounts of current payables), liquidity should not be assessed based on widely applicable standards. As regards financial assistance and debt sustainability, the first and the second cluster recorded a low share of total liabilities and a high creditworthiness. It was the opposite (the highest debt levels and low creditworthiness) in the third and fourth group. Higher debt levels can be observed to be related to a larger production scale. The operation of smaller farms (in the first and second group) was mainly based on their own productive inputs, including equity. When it comes to productivity, the highest indicators were reported by farms from the second cluster whereas the fourth group ranked at the bottom. This can be explained by the fact that a higher amount of inputs entails a reduction in their marginal efficiency. As regards profitability indicators, the best performance was exhibited by the second cluster, whereas the first, third and fourth cluster were in a worse condition. Lower levels were recorded in countries with a high value of total assets in relation to incomes. Low profitability indicators in farms of the fourth cluster seemingly reflect their poorer financial performance. However, their incomes (including the per FTE figure) was clearly higher than in other groups (and could only be compared to the fifth cluster).

Table 8. Selected financial indicators of dairy cow farms in typological groups of European Union countries in 2014–2016.

Specification	Typological Groups				
	I	II	III	IV	V
	Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, Croatia	**Portugal, Spain, Bulgaria**	**Slovakia, Hungary, Estonia, Czech Republic**	**Sweden, Luxembourg, UK, the Netherlands, Ireland, Denmark**	**France, Italy, Germany, Belgium**
Capacity to pay					
Current ratio	48.44	15.71	1.92	9.02	123.03
Quick ratio	32.55	12.15	1.25	6.82	116.03
Fixed assets financed with fixed capital (%)	92.84	120.21	71.40	41.41	82.33
Financial assistance and debt sustainability					
Indebtedness (%)	11.92	8.40	33.31	33.55	24.70
Debt structure (%)	19.09	31.13	51.84	12.71	19.77
Share of fixed capital (%)	98.16	97.40	83.84	96.48	94.81
Creditworthiness	2.45	1.86	0.28	0.26	1.35
Operational efficiency					
Productivity of assets	0.25	0.45	0.48	0.19	0.29
Productivity of fixed assets	0.31	0.63	0.68	0.22	0.39
Productivity of current assets	1.65	1.76	1.67	1.68	1.65
Days Payable Outstanding	167.48	67.33	255.39	640.31	281.89
Days Sales of Inventory	55.36	23.31	40.11	24.99	13.12
Profitability					
Profitability (%)	8.91	23.09	4.72	9.49	17.96
Return on sales (%)	10.60	23.94	6.72	8.93	14.65
Return on assets (%)	1.94	9.35	2.68	1.25	3.30
Return on equity (%)	2.29	10.41	3.61	1.42	4.30

Source: own study based on [36].

3.7. Assessing the Economic Situation of Typological Groups

In 2014–2016 countries of the first cluster (Finland, Latvia, Lithuania, Slovenia, Poland, Austria, Romania, and Croatia) were in an intermediate economic condition (if measured with the indicators shown above). However, the production potential and low amounts of income are among the unfavorable aspects which result in reduced development (investment) opportunities and make it more difficult to ensure satisfactory incomes (comparable to the national average figure) that may be allocated to consumption. The small scale of production was a contributing factor. The main reason for that situation was the insufficient number of cows and, as a consequence, the small value of milk delivered to the dairy. However, on the other hand, a large part of these farms relied on feedingstuffs produced in their own agricultural land which enabled cost savings. This was also possible thanks to low costs of external inputs (because hired labor was of marginal importance). These farms may improve their economic situation primarily by gradually increasing their dairy cow numbers. The adequate modernization of buildings and other constructions should also be taken care of. These are necessary measures because prices of productive inputs keep increasing over time whereas milk prices do not follow a long-term upward trend. However, a large part of these farms will be unable to take out a long-term loan due to low levels of income. There will be more and more risks to their continued existence. Therefore, some of them should focus on gradually scaling up their animal production operations.

Countries of the second typological group (Portugal, Spain, Bulgaria) enjoyed a relatively advantageous economic situation despite small productive input resources and unfavorable relationships between them. This can be explained by factors such as good performance in terms of profitability and financial intensity of production. Incomes per full-time family employee were higher only in the fourth and fifth group which exhibited much more beneficial relationships between productive inputs. An important aspect is that their operations were based on an extremely high share of animal production. Hence, feedingstuffs accounted for a large part of total costs (75%, on average [36]). This empowered them to reach higher milk yields and, as a consequence, a higher total output value. Factors that could contribute to the advantageous economic condition of that group include the low level of external input costs, resulting from the fact that they mostly relied on their own labor resources. These farms should preferably seek to gradually scale up their production operations. The area of agricultural land and dairy cow numbers should grow at a similar rate in order to keep the high share of animal production in total production. With a strong creditworthiness, a large part of these farms can access long-term loans to finance relevant investments.

In 2014–2016, the economic situation of farms in the third cluster (Slovakia, Hungary, Estonia, Czech Republic) was rather disadvantageous due to factors such as the level of total costs which was by far the highest. These costs did not contribute to reaching an equally high output value and, as a consequence, failed to provide the family farms with relatively high incomes compared to other clusters. The reasons for this condition include the fact that these farms had the lowest assets-to-labor and assets-to-land ratios of all the clusters considered. This is explained by the small value of fixed assets (primarily including machinery and technical equipment) in relation to owned resources of labor and land. Hence, these farms relied on a highly extensive farming system. The largest area of agricultural land had an impact on the highest amount of operating subsidies which were of great importance to this cluster (as they accounted for nearly 57% of gross value added). Thus, operating subsidies were a key co-determinant of incomes earned in that group of countries. They also had a remarkably high share of hired labor inputs which contributed to the considerable amount of costs. Cechura et al. [32] carried out a study on input productivity in 2004–2011 and found that only a few regions, mainly in Slovakia, Czech Republic, and Hungary, kept pace and caught up with the development of EU-15 countries. Nevertheless, this paper suggests that the economic situation of dairy farms in these countries continues to be relatively poorer than what is experienced in old member countries. Aligning the number of dairy cows with the area of agricultural land owned could be a way to improve the economic standing of these farms. It is also important that the financial surplus

be invested in high-performance agricultural machinery and enhancements of animal housings with state-of-the-art technical equipment (which will ultimately result in reducing total employment). This could contribute to improving the relationships between productive inputs and to reducing some costs of external inputs.

Farms based in countries of the fourth cluster (Sweden, Luxembourg, UK, the Netherlands, Ireland and Denmark) were in an intermediate economic condition. High levels of family farm incomes (including the amount per full-time family employee) should be regarded as a positive aspect. The contributing factors include large resources of, and advantageous relationships between, productive inputs. The effective use of inputs was another advantage, and was related to the excess of total output value over costs (among other factors). These farms also reported relatively high amounts of subsidies. However, at the same time, subsidies had a relatively small share in gross value added compared to other clusters (31.93%). Therefore, these farms can be considered financially independent to a certain extent. Nevertheless, income generation and financial intensity indicators were much less favorable in the fourth cluster. This was mostly reflected in the low levels of profitability and capacity to pay. The level of incomes did not fully match the extremely high value of total assets. Farms in this cluster could improve their economic situation primarily through a partial reduction of costs.

In the fifth cluster (France, Italy, Germany, Belgium), the economic situation of farms was quite favorable. This was largely driven by the highest level of family farm incomes (including the amount per full-time family employee). These results were partially consistent with the advantageous indicators of profitability. Considering the relatively small total area of agricultural land, the total amount of subsidies was also small. At the same time, they had the smallest share (27.33%) in gross value added. Hence, these farms were observed to be largely independent from CAP funds. Their sales proceeds were quite high. The advantageous economic situation was largely driven by the quite large value of total assets and the adequate relationships between (and a high use efficiency of) productive inputs. It therefore needs to be emphasized that a favorable economic situation does not necessarily require scaling up production operations. Similar conclusions can be drawn from a study by Nehring et al. [6] who found that a technically efficient business does not necessarily involve greater scale of production. In accordance with their findings, high efficiency was reported by large-scale Spanish farms, medium-scale Danish farms and small-scale German farms. The above suggests that a competitive advantage largely relies on regional characteristics and structural conditions of a country. The absence of a single definition of the optimum farm size was also addressed by Cechura et al. [32] who believe this variable to be dependent upon multiple correlated conditions. In the context of the recent abolition of milk quotas and the future of these farms, note also that compared to other clusters, the fifth group exhibited a relatively high degree of specialization. According to Zeng et al. [24], farms with a higher ratio of incomes derived from milk production (calculated as the share of milk production incomes in total farm incomes), i.e., farms focusing on milk production, experience a more positive effect of the abolition of milk quotas. In the fifth group, the relatively high financial intensity of certain characteristics covered, the low operational efficiency and the long Days Payable Outstanding can be regarded as adverse developments. The above can be explained by factors which include the great importance of animal production, the considerable value of total assets, and the high share of long-term liabilities. However, these features did not significantly affect the quite strong general economic situation of farms in the fifth cluster.

4. Conclusions

European dairy farms differ strongly from one another in production scale and manufacturing intensity. The cluster analysis enabled the identification of five different types of dairy farms in the EU. The differences are also noticeable between the major producers of milk in the EU. This is reflected in the fact that Germany, France, UK, Poland, the Netherlands and Italy were allocated to three different clusters in the typology routine. Considering the share of cows distributed between the groups and the share in milk production, farms of the fourth and fifth cluster are of key importance to the EU. Together,

in 2014–2016, they had a yearly average share of over 77% in the value of milk production in the EU. As revealed by the analysis of production potential, farms of the fourth cluster had a relatively large production scale and highly intensive production processes. In turn, the fifth group was composed of medium-sized farms at a medium level of production intensity. They shared certain characteristics, e.g., a high degree of production specialization, reflected by the high share of animal production and the high share of cow milk and cow milk production in the total output value. These farms reported high levels of labor productivity. Based on a relatively small share of subsidies in gross value added (ca. 30%), it can be concluded that CAP instruments were not the main driving force behind their advantageous situation. Only the fourth cluster witnessed certain limitations posed by profitability figures, especially in relation to their assets and equity. This is the conclusion from the analysis of profitability ratios.

The other three types of farms had a rather low intensity of production. Farms of the first and second cluster were based on a medium–extensive and extensive production systems, respectively, and ran their production activities on a small scale. Their differed in the importance of milk production on an EU-wide scale because in 2014–2016, they had an average annual share of ca. 14% and 6%, respectively, in the production value of milk. Based on the analysis of incomes and the role of subsidies, it may be concluded that farms of the first group strongly relied on CAP funds; the subsidies represented a large proportion in their gross value added (over 52%). Their strength consists in relatively cost-efficient production processes. However, at the same time, they recorded extremely low levels of labor productivity which resulted from resource restrictions facing these farms. Most of them were located in Central and Eastern European countries; their situation continues to be affected by certain historical events and by the resulting structural conditions. Note that farms of the second cluster exhibited a high degree of production specialization and high profitability ratios which, however, failed to translate into adequate incomes and satisfactory levels of labor productivity. They were not major players on an EU-wide basis; the way they operate is somehow determined by such factors as climatic or natural conditions.

Farms of the third group demonstrated an extremely large scale of production and highly extensive production patterns, making them stand far apart from other types. Such a large scale of operations forced them to largely rely on hired labor. They accessed great amounts of subsidies due to their large acreage; the subsidies also largely contributed to gross value added (nearly 57%). The financial intensity of these farms was relatively high and translated into low profitability of production (the output value did not even cover the costs). Profitability figures were low, especially as regards the return on sales. The current condition of agriculture in this cluster was largely shaped by historical events and structural transformations. Note however that they play a marginal role as a milk producer in the EU.

In summary, it may be concluded that on an EU-wide basis, medium and large-sized highly specialized intensive farms play a key role in milk production. Despite their profitability being somehow restricted, they report high levels of labor productivity which is largely enabled by an advantageous production potential. In turn, an insufficient potential is among the main restrictions faced by other dairy farms in the EU; their advantageous financial indicators often fail to provide satisfactory levels of income which could drive investment and consumption opportunities.

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