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Evolution of the Structure and Economic Management of the Dairy Cow Sector

Georgia Koutouzidou [1], Athanasios Ragkos [2,*] and Katerina Melfou [3]

[1] Institute of Plant Breeding and Genetic Resources, Hellenic Agricultural Organization—DIMITRA, Thermi, 57001 Thessaloniki, Greece
[2] Agricultural Economics Research Institute, Hellenic Agricultural Organization—DIMITRA, Ilisia, 11528 Athens, Greece
[3] Department of Agriculture, University of Western Macedonia, 53100 Florina, Greece
* Correspondence: ragkos@elgo.gr; Tel.: +30-210-2755086 (ext. 8)

Abstract: In this paper, we examine the changes in the structural, economic and managerial characteristics of dairy cow farms during their shift towards a new business model that operates under a highly intensified system. Based on farm accounting data from Greek dairy farms for the 2004–2017 period, the main technical and financial indicators are estimated and compared to provide a clear picture of the structural adjustment of the dairy cow sector during the last two decades. The outcomes and the implications described herein are relevant for specialized dairy farms in most European countries. The results indicate that modern farms breed a larger number of cows, achieve a higher milk yield, rely on high compound feed intakes and operate under an intensive pattern. This trend is even more evident in larger farms with an entrepreneurial nature, whose structural adjustments occurred in a more concise and effective manner. The latter benefited from a downward shift in their long-term average cost curves and the resulting economies of scale, achieving reasonable gross margins despite the ever-increasing feeding costs. Nowadays, the European dairy cow sector faces major economic, social and environmental challenges that must be properly addressed to secure its survival. The findings of this study provide insights concerning the efficient financial management of dairy farms that can support the development of strategies and policy recommendations that will enhance the resilience and sustainability of the sector.

Keywords: dairy cow farming; economic analysis; structural adjustment; sector transition

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1. Introduction

In the last two decades, the European dairy sector has experienced an important policy reform and faced two major market crises that have had a severe impact on its structural characteristics and economic performance. The abolition of milk quotas in 2015 required a smooth transition of the sector; however, the 2009 and 2014–2016 market crises when milk prices significantly fell put increasing pressure on the sector instead, resulting in a large-scale transition [1–3]. The dairy sector operates under complex dynamics and seeks to achieve conflicting objectives. On the one hand, there is increasing pressure to intensify production, driven by global markets and volatile milk prices; on the other hand, producers and processors need to address consumer expectations for "green" and environmentally friendly products and high animal welfare. Either way, these dynamics prepare the dairy sector for exposure to global competition, revealing a dire need for stronger market orientation [4].

Apart from the economic pressures and reforms of the policy framework, technological progress, demographic shifts and differentiating consumption patterns have contributed to the impetus for changes in the European dairy sector. A large-scale transition has taken place during the last twenty years, contributing to a gradual decline in the number of dairy farmers in the EU (approximately −6% a year, on average) [5]. Over this trajectory, many

dairy cow farmers have left the profession or changed their business orientation. This has been accompanied by an increase in the number of farms specializing in milk production. Milk yields, herd sizes and total milk production significantly increased following the abolishment of the milk supply restrictions and improvements in technology, genetics and feed efficiency [4,6,7].

Nowadays, EU-27 is the largest producer in the world of cow milk, followed by the United States and India [8]. After the developments described above, the European dairy sector is now characterized by the predominance of intensive production systems exclusively specialized towards milk production that heavily depend on capital investments, purchased feedstuff (forage and concentrates) and hired labor [9–11]. The dairy cow sector has shifted towards a new organization pattern with larger farms that rely on high compound feed intakes and highly controlled production conditions such as automatization processes, computerized optimal feeding, milking robots and sensors for individual measurements [7,12]. As part of the European Union, Greece constitutes no exception in this transition. The 21st century has seen important changes in the structure and orientation of farms and, equally, to the mentality and mindset of dairy farmers. As Ragkos et al. [11] pointed out, during the Greek financial crisis (after 2010), dairy farmers undertook active strategies and invested in modernization and intensification, adopting an entrepreneurial specialized business model.

This trend of intensification and specialization in dairy farming sparked our interest in studying the evolution of the structural and economic characteristics during the shifting of dairy farming into a new business model. Hence, in this study we focus on Greece and seek to verify the transitioning of dairy farming to an intensified system to assess the structural and financial adjustment of dairy farms over a 13-year period and to pinpoint whether and how dairy farming has benefited from the transition that took place in the sector. Based on the farm accounting data from Greek dairy farms for the 2004–2017 period, the main technical and financial indicators of dairy farms are presented and compared, allowing benchmarking between diversified farm structures. Although the primary data of this study come from Greek farms, the outcomes and the implications described herein are relevant for specialized dairy farms in most European countries. Detailed analytical data on the economic performance of the Greek dairy farms can heavily be obtained only though a primary farm survey. This study refers to the 2004–2017 period because: (i) these years enclose the two major crises of the sector (2009 and 2014) and, hence, can be considered to be indicative benchmarks of the shift of the sector towards a modern business model; (ii) it covers the period after the 2003 Common Agricultural Policy reform, which was a milestone in the history of EU agricultural policy that introduced the decoupling of payments from volumes produced and made farms more market-oriented; and (iii) it encompasses the impact of the milk quota abolishment on the productivity of the farms.

Prior studies on structural adjustments in dairy cow farming have focused on the changes that took place and on the identification of the factors that affected farmers to make such changes. Indicatively, Zorn and Zimmert [13] analyzed the structural change in the dairy cow sector in Switzerland using annual panel data on the farm level for the years 2008 to 2018; Bórawski et al. [6] studied the direction and dynamics of changes in milk production in the EU in the years 1998–2017; and Barkema et al. [9] presented an overview of the most important recent changes in the industry that affected the health and welfare of dairy cows. Zimmerman and Heckelei [14] presented an EU-15 cross-regional analysis of the development of dairy farm numbers in different size classes over the period 1995–2005. A detailed analysis on the trends of the milk gross margin and farm incomes from 2008 to 2018 based on FADN data is also provided in the EC report [15].

Thiermann et al. [16] studied the factors making cattle and sow farmers exit the livestock sector; Bragg and Dalton [17], using data from 64 dairy producers, estimated the determinants influencing the decisions to exit dairy farming. The impact of the milk quota abolishment on the milk supply and on the changes to the herd size patterns was studied by Jongeneel and Gonzalez-Martinez [7] and Huettel and Jongeneel [18], respectively.

We contribute to the existing literature by empirically analyzing and evaluating the variations in the economic performance of dairy farms over time. To our knowledge, there is no other study that compares the major economic indicators and financial results of the sector in an analytical manner between two different periods that are far apart in time, providing an economic overview of dairy farms and revealing the transitions that took place in the sector during the last two decades. There are several economic, societal and environmental challenges that arise in the debate of the dairy sector and the consensus on the response regarding its future is not clear and concrete [19]. We believe that the outcomes of this study contribute to the debate and can be used for managerial suggestions and policy recommendations towards sustainable and profitable dairy farming. The results of the empirical economic analysis allow the detection of the advantages and weaknesses in the utilization of the available inputs, identifying potential cost reductions and revealing the most efficient structure for farms and, hence, implicitly indicate the best management practices in the dairy sector.

The paper is organized as follows: Section 2 provides a concise presentation of the dairy farm profile in Greece and a description of the available data and the empirical analysis. The results are presented in Section 3, followed by a discussion in Section 4. Section 5 concludes the paper.

2. Materials and Methods

2.1. The Greek Dairy Cow Sector

The Greek dairy cow sector has been severely affected in the last twenty years by: (i) the reform of the Common Agricultural Policy and the abolishment of the quota regime that held producer prices at high levels; (ii) the increased input prices (mainly feed and fuel), combined with a disconnection from land use (either for grazing or for home-grown feedstuff) that led to high production costs; (iii) EU enlargement and the accession of neighboring countries (Bulgaria and Romania) into the EU, allowing the import of cheap fresh milk into the country; and (iv) the extension of the shelf life of fresh milk, which intensified the competition from these countries. Moreover, the structure and viability of the sector was substantially affected by the economic crisis that the country experienced during 2010–2018, urging many farms—mainly small-scale farms—to exit livestock farming or change their business orientation to suckler cow farming [13].

According to the Milk Market Observatory [20], milk production was reduced by only 5% during 2004–2020 (from 687 to 650 thousand tons); the number of dairy farms was reduced by 68.3% (from 7730 to 2448 farms). Of a similar nature is the structural adjustment of the Greek dairy sector from 2004 to 2017, the period for which the economic performance of the farms is analyzed in this empirical study. Milk production was reduced by 12.3% (from 687 to 602 thousand tons) and the number of farms was reduced by 61.3% (from 7730 to 2989 farms). During this period, the transition of the sector was in progress with a clear trend towards the concentration of livestock into a small number of large-sized farms. Nowadays, most of the dairy farms in Greece operate under an intensive pattern that relies on relatively high compound feed intakes, exclusively rear Holstein cows, apply artificial insemination, have modern barns and milking parlors and employ specialized staff [11]. Further details on the Greek dairy sector can be found in the research of Theodoridis and Ragkos [21], Mitsopoulos et al. [22], Abas et al. [23], Siafakas et al. [24] and Koutouzidou et al. [25].

2.2. Survey Data and Economic Analysis

The technical and economic data were collected through farm management surveys from the samples of 165 dairy farms (2003–2004) and 47 dairy farms (2016–2017) in Northern Greece (Macedonia, Thrace and Thessaly). The data of the 165 farms are reported in [26]; access to these data was provided by Theodoridis for the empirical analysis of this study. The sample of 165 farms accounted for all farms sizes (from 10 dairy cows to over 200) whereas the 2016–2017 sample accounted for large-sized farms because the average size of

farms was already significantly higher by then (see Section 2.1) and also because the focus of the survey was to analyze the trajectories of large farms with an entrepreneurial orientation. The 47 farms surveyed in 2017 were members of the Holstein Association of Greece (the official breeding body of pure-bred Holstein cows) and constituted 1.5% of Greek dairy cattle farms and 9% of the national cow milk production. Therefore, in order to conduct a direct and consistent comparison between the two datasets, large-size farms (more than 45 cows per farm) were selected from the 2004 whole sample and were presented separately from the 2004 whole sample of farms in the analysis. Using these data, the "average" representative farm from each sample was depicted as the average of all observations (large farms of the 2004 sample and whole 2017 sample). This way, the two "average" farms (the large farms from 2004 and the 2017 farms) had similar structural and production characteristics as they were clearly farms of an entrepreneurial nature specializing in dairy production that heavily depended on capital endowments and achieved a high milk yield.

The technical and economic data in both periods were recorded using a specially designed detailed questionnaire tailored to the specific features of a typical dairy cow farm. The recorded data included fixed capital endowments (buildings and machinery, terrestrial improvements and herd size and composition), labor requirements and wages (family and hired), land and inputs for the production of feedstuff (acreage and land rent and expenses, e.g., for seeds, fertilizers, pesticides, fuel and irrigation), purchased feedstuff (quantities and prices) and expenses related to animal production (e.g., fuel, detergents, electricity, drugs and veterinary services) as well as milk yields and prices, meat yields and prices, the value of the animal capital and income support payments and farm compensations.

Based on these data, the technical and financial indicators were calculated and a comparative economic analysis was applied. The main financial results of the two "average" representative farms (2004 and 2017) were estimated and compared between the two periods under examination, indicating the adjustments that occurred in the structure and the economic performance of the dairy cow sector. The composition of gross revenues and the cost structure of the farms were calculated and the gross margin (over operating costs) and net profit or loss (gross revenues less total expenses) were estimated for the average 2004 whole farm, the average 2004 large farm and the average 2017 farm.

The classical economic analysis provided an in-depth description of the current structure and economic performance of the farms. The first part of the analysis concerned the organization of production factors (land, labor, variable and fixed capital), revealing the weaknesses in the efficient utilization of the available resources. The second part focused on the description of the cost structure (i.e., production costs by input) and the assessment of the financial results, which indicated the economic sustainability of the farms and their long-term prospects. Financial results are indicators of the economic performance of the farms. Each financial result demonstrates a different aspect of farm management, operation and performance and indicates if there are specific adjustments that are required to improve the viability of the farm. The calculations of the main financial results from the survey data and a brief description of their content is provided in Table 1.

A classical economic analysis constitutes the cornerstone of agricultural economics and is the main tool for the assessment of a farming system [27,28]. Many studies on crop and livestock production apply an economic analysis to evaluate the economic performance of farms and estimate the production cost of products. Concerning the dairy sector, an economic analysis has been extensively used in numerous studies. The most recent applications can be found in the European Milk Board [29], Siafakas et al. [24], Poczta et al. [10] and Ragkos et al. [30]. The European Commission [15,31] uses the principles of classical technical and economic analyses to analyze the economic performance of dairy farms, providing an overview of the estimates of the production cost and gross margin indexes of milk production in the EU for consecutive periods.

Table 1. Financial results, calculations and a short description.

Financial Results	Calculations	Short Description
Gross revenue	Value of milk (production × price) + value of veal meat (production × price) + value of beef meat (production × price) + value of live animals sold + subsidies + compensations	The value of all outputs produced by the farm in one year and subsidies
Production costs	Land rent (owned and rented) + labor expenses (hired and family) + variable capital + annual expenses of fixed capital	Total expenses incurred (in one year) to produce all products
Net profit or loss	Gross revenue − production costs	Demonstrates how successful the combination of the production inputs is. Pertains to entrepreneurial dairy farms
Gross margin	Gross revenue − variable expenses	The availability of capital to cover the fixed expenses and obligations of the farm
Milk production cost	[(Value of milk/gross revenue) × total expenses]/(milk production per year)	Cost of producing one liter of milk

3. Results

The profiles of the main average farm for the whole 2004 sample, the average large farm in 2004 and the average farm in 2017 are presented in Table 2.

Table 2. Herd size and milk yields.

Time Period Farm Profiles (Average "Representative" Farms)	Number of Farms	Herd Size (Cows/Farm)	Milk Yield (L/Cow)
2004 (Total sample)	165	44.5	5443
2004 (Large farms)	56	73	6724
2017	47	142	7975

In 2004, 34% of the whole sample (56/165) were considered to be large-size farms (more than 45 cows per farm) that were achieving a net profit, ensuring their financial sustainability in the long-run. Nevertheless, an increase in the size of farms is evident between the two periods. The number of cows per farm increased from 73 to 142 cows (almost double) as did the milk yields per cow (18.6% increase, from 6724 to 7975 L/cow), showing the intensification of the production system in the sector in the past twenty years.

The acreage of the cultivated land for the on-farm production of feed (mainly maize, lucerne and cereals) for both periods is presented in Table 2. In 2017, the farms increased the cultivated area to significantly produce feed compared with the large farms in 2004 (from 1.6 to 2.6 ha/cow) and, to a lesser extent, when compared with the whole sample (2.1 ha/cow in 2004). The empirical results also showed that the cultivated land for the production of concentrated feed decreased from 1.8 ha/cow in 2004 to 0.75 ha/cow in 2017, mainly as a result of the decoupling of farm subsidies. Modern specialized dairy farms increased the provision of concentrates to achieve higher milk yields [32]; however, the results in Table 3 indicate that farmers preferred to procure concentrated feed from the market and cultivate crops for forage and silage on-farm.

Human labor used for animal treatments and feed production was reduced by 22.6% from 2004 to the 2017 period from 119 to 92 h/cow (Table 4). The reduction was smaller for the large farms (5.2%), verifying that the larger farms valorized the economies of scale and invested in labor-saving technologies [33].

Table 3. Land cultivated for the on-farm production of feed.

Time Period Farm Profiles (Average "Representative" Farms)	Number of Cows	Land (in Hectares)			Equivalent Irrigated Land/Cow *
		Non-Irrigated	Irrigated	Total	
2004 (Total sample)	44.5	8.09	6.17	9.35	0.16
2004 (Large farms)	73.0	9.62	7.91	11.68	0.21
2017	142	10.6	32.4	36.6	0.26

* Non-irrigated land was converted to irrigated using the 0.4 conversion index.

Table 4. Labor requirements.

Time Period Farm Profiles (Average "Representative" Farms)	h/Farm	h/Cow
2004 (Total sample)	5308	119
2004 (Large farms)	7093	97
2017	13,133	92

Analytical data were available for the labor provided from family members and hired workers for the 2017 farms. The synthesis of labor requirements showed that the farms depended on hired labor (45 h/cow; i.e., 49.2% of the total labor), a finding that verified the entrepreneurial nature of the dairy farms. As reported by Ragkos et al. [11], a reduction in the use of hired labor was not considered to be an effective strategy against the economic crisis by dairy farmers (also because young people did not choose to enter the sector); the opposite was witnessed in intensive sheep systems [34].

The composition of gross revenue for the average farm and per cow for each period was computed and the results are presented in Table 5. The results confirmed that milk production was the predominant activity, contributing 87% (on average) to the gross revenues of the 2017 farms. The gross revenues in 2017 significantly increased compared with 2004 (38% increase, from EUR 2901/cow in 2004 to EUR 4004/cow in 2017) and, to a lesser extent, when compared with the large farms in 2004 (17.1% increase, from EUR 3419 to 4004/cow). The increase in the share of milk production in the gross revenues could be attributed to the use of improved genetic material in 2017.

Table 5. Composition of gross revenues.

Time Period Farm Profiles (Average "Representative" Farms)	Milk %	Meat and Calves %	Subsidies %	Revenues EUR/Farm	Revenues EUR/Cow
2004 (Total sample)	66.4	24.6	9.0	129,031	2901
2004 (Large farms)	71.0	23.1	5.9	249,566	3419
2017	87.0	7.8	5.2	571,422	4004

Another source of income included the sales of young calves and/or of veal and beef meat. However, over the 2004–2017 period, the sales of calves for breeding and meat lost a significant part of their gross output share, from 24.6% in 2004 (23.1% for the large farms) to 7.8% in 2017. This stemmed from the high level of specialization of farms in milk production. The contribution of farm subsidies (including all support payments; i.e., basic and 'greening' payments, redistributive payments and coupled payments) was reduced from 9% in 2004 for the whole sample to 5.2% in 2017. However, the share of subsidies in the gross revenues of the large farms in 2004 (5.9%) was similar to that in 2017, indicating that large farms mainly resorted to the market for the procurement of concentrated feedstuff and did not rely on coupled payments for cereals or public support in general.

Table 6 presents the cost structure of the average farms for 2004 and 2017. As expected, the capital expenses stood for the highest part of the total farm expenditure during the

whole study period (85.7% for 2004, 88.1% for the large farms in 2004 and 89.1% for 2017), confirming that the dairy cow sector constituted a capital-intensive business. In general, the 2017 average farm operated under higher costs per cow compared with the 2004 farms (EUR 3767/cow in 2017, EUR 3041/cow in 2014 and EUR 3175/cow for the large farms in 2004; i.e., a 23.9% and 18.6% increase, respectively). Although the 2017 average farm reduced the fixed cost per cow (from EUR 1218/cow in 2004 and EUR 1198/cow for the large farms in 2004 to EUR 850/cow in 2017), this reduction was outweighed by higher expenses for feedstuff because the fixed capital expenses were apportioned to a larger herd, generating better economies of scale. The average farm in 2017 spent EUR 472/cow more than the 2004 farm (and EUR 501/cow less than the large farms in 2004) for the variable capital, the largest share of which were the expenses for the on-farm production of feed and EUR 648/cow more than the farms in 2004 (EUR 405/cow for the 2004 large farms) for purchasing feed from the market.

Table 6. Cost structure and production cost of milk.

Expenses (EUR/Cow)	2004 (Total Sample)	2004 (Large Farms)	2017
I. Land rent	83 (2.7%)	60 (1.9%)	118 (3.1%)
II. Labor wages	354 (11.6%)	317 (10.0%)	293 (7.8%)
III. Purchased feed	1111 (36.5%)	1354 (42.6%)	1759 (46.7%)
IV. Other variable capital	275 (9.1%)	246 (7.8%)	747 (19.8%)
V. Fixed capital	1218 (40.1%)	1198 (37.7%)	850 (22.6%)
Total	3041	3175	3767
Milk production cost (EUR/kg)	0.410	0.360	0.433

Following the trends in land use, the land rent increased by 42.2% from 2004 to 2017 (from EUR 83 to 118/cow); dairy farms in 2017 achieved 17.2% of savings in labor costs compared with the average farm in 2004. Even though the animals in 2017 achieved higher milk yields and expenses were reduced to a larger volume of production, the production cost of milk during the 2004–2017 period increased by 5.6%, from EUR 0.410 to 0.433/kg. This increase was higher when compared with the large farms in 2004 (20.3% increase, from EUR 0.360 to 0.433/kg).

Table 7 summarizes the financial results of the dairy farms across the 2004–2017 period, providing a succinct picture of the economic performance of the farms and implicitly indicating the managerial decisions of the farmers during the transition process in the dairy cow sector.

Table 7. Financial results.

Time Period	Gross Revenues (EUR/Cow)	Variable Cost (EUR/Cow)	Gross Margin (EUR/Cow)	Fixed Cost (EUR/Cow)	Profit or Loss (EUR/Cow)
2004 (Total)	2901	1386	1515	1655	−140
2004 (Large)	3419	1600	1819	1575	244
2017	4004	2505	1499	1262	237

As already mentioned, the 2017 farms achieved the highest gross revenues per cow due to an improved milk yield due to high energy rations; however, these burdened farms with production or purchase costs for concentrates. The intensification of the feeding strategy was reflected in the gross margin of the farms. Despite higher gross revenues, the 2017 farms achieved a lower gross margin compared with the 2004 farms (EUR 16 and 320/cow less than the 2004 farm and 2004 large farm, respectively), which could be partially attributed to financial stress in the general economic environment due to the crisis. However, the significant reduction in the fixed cost per cow in 2017 resulted in a net profit of EUR 237/cow (5.9% of the gross revenue), indicating the long-run sustainability of the

dairy sector. Dairy farms in 2004 had a loss of EUR 140/cow whereas the large farms exhibited a net profit of EUR 244/cow. This finding shows that the resilience and the profitability of the sector in the long-run could be only achieved through modern large-size farms that valorized new technologies and utilized economies of scale, intensively operating with highly productive animals and deprived of old techniques and mindsets.

4. Discussion

The dairy cow sector has undergone a major structural transition during the last twenty years; livestock capital has been concentrated in large-size farms of an entrepreneurial nature that depend on external inputs [7]. The results of this study verified that dairy farms are larger in herd size nowadays and breed animals with higher milk yields compared with those 15–20 years ago. This trajectory of the sector towards a highly intensive production system converges with the findings of Bórawski et al. [6], Barkema et al. [9], Gonzalez-Mejia et al. [35] and Zimmermann and Heckelei [14]. Barkema et al. [9] also reported that a main driver for the increase in the average herd size in EU countries was the abolishment of the quota regime by March 2015. The EU, in an official briefing document by the European Parliamentary Research Service regarding the main features of the dairy sector [4], stated that EU dairy sector farms are large or very large, highly specialized and tied to a single output. However, it is stressed that such a dependence constitutes a significant threat to the resilience of farms as it increases their vulnerability to income shocks such as those during the 2012–2014 crisis [36]. Bragg and Dalton [17] showed that the larger the herd size, the more profitable the farm is and the lower the probability of exiting the sector. This may also explain the effect of the abolition of quotas on smaller and medium-sized farms in Greece and the exit that occurred in the dairy sector.

Evidently, milk production constitutes the main source of income for dairy farms, confirming the high level of specialization and intensification of the production system. This finding was in accordance with the results reported by Reijs et al. [37], Theodoridis and Ragkos [21] and Zanon et al. [38]. The importance of milk in farm incomes was also reflected by the reduced share of the value of meat in the gross revenues. In the last twenty years, the value of the gross output significantly increased, mainly due to increased milk yields [39], whereas the dependence on subsidies was reduced, making dairy farmers less vulnerable to policy changes and, hence, more competitive [2,7]. However, Koeck et al. [40] stated that high milk yields in dairy cows are linked to clinical mastitis, lameness and other diseases.

The cost structure indicated that dairy farms increased the use of variable capital to fully utilize investments in modern buildings and new equipment. The increases in the milk yield and productive performance were driven by the economies of scale as the cost of production per unit of milk decreased with an increasing variable capital and herd size. This outcome was in line with Wilson [41], Mitsopoulos [42] and Poczta et al. [10], who underlined that the intensification of the production pattern through an increased herd size and optimal feeding constituted a sound long-run strategy for modern dairy cow farms.

Regarding labor use in dairy farming, the results converged with those of Wilson [41] and Sauer and Latacz-Lohmann [43], who reported that modern farmers implement labor-saving technologies that utilize human labor more efficiently. In a challenging environment with high input costs that tighten financial margins, farmers must keep their operations resilient and meet the growing demand for dairy products. Hence, effective time management is a critical success factor for modern dairy cow farmers who are turning to smart technologies and innovative machines for help. Remote monitoring technologies, automated dairy installations and cleaning systems as well as feeding technologies and herd management systems maximize labor productivity and improve the welfare and safety of animals.

Feeding is the main cost driver in modern dairy farms affecting milk yields [44–46]. The adoption of an optimal feeding regime has a significant impact on the profitability and sustainability of dairy cow farms. The results showed that the dairy farms preferred to

disconnect the feed procurement from the market, mitigating any uncertainty prevailing in the market. This disconnection could be an effective strategy during times of prosperity, which could also boost the emergence of even larger and more specialized dairy farms. On the other hand, a feeding strategy that involves a specialization in home-grown feedstuff increases the control that farms have on the feed quality and availability, although they are burdened with subsequent land rent and costs for machinery and crop storage [47]. Siafakas et al. [24], who studied the impact of feeding strategies on the efficiency of 78 dairy farms in Greece, reported that home-grown feedstuff did not reduce the feeding cost and did not make the farms more efficient. However, this requires that the cost of the purchased feed remains at a reasonable level; when feed prices are high, as with the current market situation, on-farm feed production may be proven to be more beneficial.

Dairy cow farming is a highly specialized operation requiring large investments in machinery, livestock capital, new technology and infrastructure that lead to significant sunk costs and an inelastic milk supply [7]. However, the share of the fixed capital in the total expenditures was significantly reduced over the years as fixed capital expenses were apportioned to a larger herd, generating better economies of scale. Moreover, the fixed capital expenses were counterbalanced by increased variable capital expenses, mainly for purchasing and producing feedstuff, confirming the trajectory of the dairy cow sector towards a modern business model for dairy cow farms that operate under highly intensive patterns and base their profitability on high milk yields [6,48].

5. Conclusions

This study presented an economic analysis of the dairy sector and assessed its structural and economic changes for the 2004 to 2017 period. During this period, dairy farming shifted into a new, fully market-oriented business model to face numerous interlinked challenges across all three pillars of sustainability (i.e., economic, social and environmental). The empirical analysis was based on the farm accounting data from dairy farms in Greece and confirmed the transition of the more dynamic part of the sector towards a highly intensive system with explicit entrepreneurial elements. The fact that the 2017 farms, which were larger in herd size and produced more milk, achieved a satisfying gross margin and a large net profit shows that the transition of the sector followed the right path. Moreover, the results of this study revealed the strengths and weaknesses in the structure of dairy farms, determining the major cost drivers of the production system and implicitly indicating the best management practices in the dairy sector. Thus, these findings could be used to re-define policy objectives concerning European dairy cow farming, which is currently operating in a highly competitive but, at the same time, uncertain and volatile environment. It is commonly argued that the structural changes in the sector combined with the shift in the business model of dairy farms point towards negative future developments for Greece. However, our analysis showed that this was not the case and that the new business model strengthened the sustainability of the sector. Larger farms are more viable, open to innovation and have maintained the same level of milk production (note that Greece was never able to utilize the milk quota allocated to the country until 2016, when this system was abolished) and they are able to control cost drivers more effectively. Therefore, the comparative technical and economic analysis employed here pinpointed the specific domains where this new business model is beneficial to the future of the sector (feeding costs, access to innovation and productivity). However, the development of strategies for re-designing the dairy sector to contribute to the goals of the new European Green Deal strategy and the FAO Sustainable Development Goals should be based on a holistic sustainability assessment of dairy cow farms, with the involvement of all the actors involved in the value chain; i.e., input suppliers, the dairy industry, policy makers and a broad range of stakeholders including retailers and consumers. Therefore, the analysis in this paper provides a basis for future in-depth research with regard to value chain dynamics and how the structural and socioeconomic developments in the sector may impact other actors in the dairy supply chain.

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