Efficiency of Investor Owned Firms and Cooperatives Revisited

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Abstract. Providing a performance measure of any firm is a crucial issue, not only for the stakeholders of the firm, but also for policy makers, labor unions, and economists. The relevant performance measures should consider the objectives of the firm's owners. The ownership structure of cooperatives is different from that of investors owned firms, which in principle implies the need of different tools to measure their performance. Typically, however, the performance of cooperatives and investor owned firm is mostly compared using the same approach. In this study, we use Data Envelopment Analysis (DEA) to compare the performance of dairy cooperatives and investor owned firms in major European dairy producing countries using a traditional approach, which views both types of firms as cost minimizers, and an alternative approach, which considers the objectives of the cooperatives. In the alternatives approach, two hyperbolic models were evaluated, one of them consider the firms to expand both output production and use of material to address the objective of the owners of the cooperatives. The performance of the cooperatives changes across the two approaches form being out performed by IOFs using the traditional approach to outperforming IOFs when using an approach that is in line with the objective of the cooperative.
Keywords: DEA, hyperbolic efficiency, cooperatives, Investor Owned Firms, Bootstrapping

1. Introduction

Dairy cooperatives in Europe have played an important role in the dairy processing sector. In major dairy producing-countries, such as Denmark, the Netherlands and Ireland, cooperatives process more than 85% of the total milk production (Van Bekkum, 2001). However, the performance of the cooperatives firms (CFs) and their ability to function efficiently in competitive and global markets in comparison to the Investor Owned Firms (IOFs) have been long debated in literature (see: Soboh et al., 2009). The debate has intensified due to major trends in the past few decades such as globalization, changes in related policies, international trade liberalization and treaties, and changes in consumers' preferences (Soboh et al., 2009). Recently, due to the expected abolishment of the quota system in 2015 and the current financial crisis, the debates are intensified on the competitive strength of the CFs and IOFs, and CFs are argued to have more suitable and sustainable organizational structure than IOFs (Van Campen, 2009).

Cooperatives are not easily defined (Hind, 1999) and do not have a standard ownership structure like IOFs (Chaddad and Cook, 2004). However, there is a general consensus in the literature that cooperatives are generally seen as user-controlled, user-owned and user-beneficit firm (Soboh et al., 2009). In the case of dairy CFs, this emphasis on members' control, ownership and benefit to members is reflected in the milk payment to members which includes, in addition to milk price, a proportion of the dividends (Zwanenberg et al., 1993). The members' role and objective in their cooperatives is a major reason for debating the argument and empirical findings that CFs are technically and economically inefficient when compared to the IOFs. Those who advocate CFs model reject this argument and demand a different approach to evaluate the performance of the CFs empirically. For instance, Van Dijk and Klep (2005) argued that CFs have double-objectives one of which is to benefit members while the other is to healthily function in the competitive market. Additionally, the members' control on the CFs investment decisions, makes the CFs less willing to be involved in risky ventures and therefore more immune to cope with policy changes (Soboh et al., in progress) or economical crises (Van Campen, 2009). It is argued, on one hand, that the CFs are more beneficial to farmers and the rural development than profit maximizing IOFs (Chavez, 2003). On the other hand, Hind (1999) argued that the control and ownership of members of the cooperative cause CFs to be less oriented to value added production, less efficient in input use (especially members' product) and more focused on exploiting economies of scale. Hence, cooperatives are argued to be less technical, scale and cost efficient.

Theoretically, both arguments, of those who advocate the cooperative form of firms and those who criticize it, are defendable but hardly disputed. However, empirically- as far as we know- there is no concrete evidence of any of the arguments neither for such comparison in general nor for the European dairy CFs in comparison to their IOFs counterpart in particular(see: Soboh et al., 2009).

In this study, using Data Envelopment Analysis (DEA), we first analyze technical, scale and allocative efficiency of dairy processing firms using the traditional efficiency techniques. Second we use a hyperbolic approach to dairy cooperatives and IOFs with a special emphasis on the role of raw materials (i.e. mainly milk deliveries by the farmers) in two models. The first model, measures the hyperbolic technical efficiency of the firms assuming they expand output and contract materials and other inputs simultaneously. The second model, measures the hyperbolic technical efficiency of the firms assuming they expand both output and materials and contract the other inputs. These two hyperbolic measures provide us with alternative approaches to evaluate the technical efficiency taking into account the cooperative general objective to serve the interests of their members as the major (if not the only) suppliers of materials. Subsequently, we use bootstrapping technique to allow for statistical inference.

This paper uses Data Envelopment Analysis (DEA), outlined in (Färe et al., 1994). The DEA was used by many authors to evaluate and to compare the performance of cooperatives to IOFs, such as Doucouliagos and Hone (2000), Singh, et.al. (2001) and Boyle (2004). However, this study contributes to the literature by addressing the nature of the cooperative which aims to serve its members, which is done in two ways. First, this study provides the first empirical comparison of the technical, scale and allocative efficiency of European dairy CFs and IOFs. The results of large IOFs and CFs are presented in more detail. Second, this paper presents an alternative approach to measuring technical and scale efficiency of cooperatives that explicitly, i.e. an approach that is in line with the different objectives of CFs versus IOFs.

The remainder of the paper is presented as follows. The next section presents the DEA models. This is followed by a discussion of the data of the dairy processing firms. In section four we present the results of the DEA models. The conclusion is provided in the fifth section.

2. DEA Models for Modeling Efficiency of the Firms

The performance of dairy cooperatives in comparison to IOFs has been studies by others using DEA. Doucouliagos and Hone (2000)used DEA to assess the technical efficiency of Australian dairy processing firms using data over the period 1969-1996. Their results show a modest technical progress and indicate some convergence in productivity levels across regions. They conclude that the Australian dairy sector is operating at a high level of technical efficiency. Singh, et.al. (2001) applied DEA to compare the performance of the dairy cooperatives to the private sector in India. They concluded that cooperatives are more cost efficient than IOFs. Boyle (2004) investigated the economic efficiency of Irish dairy cooperatives over the period 1961-1987. He argued that cooperatives are not efficient for two reasons: (a) cooperatives suffer from technical inefficiency because of principal-agent problems and allocation inefficiency due to horizon problems; (b) cooperatives prices for raw milk are inefficient. Each of the above studies used the same approach on CFs and IOFs to measure and compare their performance.

In this study we use two different approaches to evaluate the performance of the cooperatives. The first is the traditional, is measuring the overall efficiency of the firms and decomposes it input oriented technical, scale and allocative efficiency. The traditional approach views the firms as cost minimizers and ignores the different nature of CFs and IOFs. The second, i.e. the alternative approach, is measuring technical efficiency of the firms assuming that firms expand output(s) and materials and simultaneously contract other inputs with equal proportions.

2.1 Traditional Efficiency Approach and Models

In this approach we measure the input-oriented technical, scale and allocative efficiency. The models view the CFs and the IOFs as cost minimizing firms, in which all inputs, including the materials, are being contracted.

The input-oriented technical efficiency, in which inputs and materials are contracted while keeping output at fixed level, is expected to be higher for IOFs than for the CFs. For the IOFs, as owners are solely interested in profit, materials- mainly raw milk- are considered to be a regular input, while materials for the CFs are more complex and are not viewed as simply an input since the suppliers of raw milk are themselves the owners. The owners of the CFs, the suppliers of raw milk, aim to maximize their return by obtaining a high payment for raw materials while at the same time- like other firms- want cost minimization for all other inputs and production factors. Therefore, the cooperatives are expected to have a lower value of the input-oriented technical efficiency.

The scale efficiency of the CFs is expected to be lower than that of the IOFs. The CFs are not totally free in choosing their scale of operations, by default they are obliged to process and market all members' production. IOFs on the other hand choose the optimal scale to process the quantity of material that maximizes their profit.

The average allocative efficiency of the CFs is expected to be lower than of the IOFs. CFs are not assumed to be profit maximizers or cost minimizers; instead, they aim to minimize a different objective function which aims to pay higher milk price than the IOFs, in addition to minimizing all other costs. And since IOFs are profit maximizers, hence cost minimizers as well, they are expected to have a higher value of the allocative efficiency (equal to one), while CFs, as they are not cost minimizers for their raw material, are expected to have lower allocative efficiency than IOFs.

Before representing the linear programming needed to measure the traditional models, to measure the input-oriented technical efficiency and scale and allocative efficiencies, it is necessary to introduce some notations. Consider a firm that uses a vector of inputs (x) and a vector of raw material (m) to produce a vector of output (y).

The DEA input-oriented model to measure the technical efficiency for firms i, $i=1,...,N$, that produce one output using three inputs including the raw material is calculated form the following non-linear program:

$$
\begin{aligned}
&\min_{\phi,\lambda} \phi_{vrs}, \\
&-y_i + Y\lambda \geq 0, \\
&\phi m_i - M\lambda \geq 0, \\
&\phi x_i - X\lambda \geq 0, \qquad (1) \\
&N1'\lambda = 1, \\
&\lambda \geq 0,
\end{aligned}
$$

Where ϕ_{vrs} is the overall technical efficiency score $(\phi \in [0,1])$ for the i th firm, Y is the $(1\times N)$ vector of observed output, M is the $(1\times N)$ of observed use of raw material, X is the matrix of observed inputs and λ is a $(Nx1)$ vector of intensity variables (firm weights). The constraint $N1'\lambda = 1$ (with $N1$ being an $Nx1$ vector of ones) implies the sum of the lambdas equals one and allows for a variable return to scale (*VRS*) technology. Here, the overall technical efficiency measures the minimum proportional contraction in observed inputs (x) and raw material (m) subject to the constraints imposed by the observed inputs and the technology. This is illustrated in Figure 1 line (1).

To measure the scale efficiency for the two models above we modify both models to exclude the constraint $N1'\lambda = 1$ [1]. This will produce ϕ_{crs} - the input oriented technical efficiency assuming constant return t scale- which will be used to measure the scale efficiency (SE), which equals to $\frac{\phi_{crs}}{\phi_{vcrs}}$.

The cost efficiency is computed by solving the LP model (2):

$$
\begin{aligned}
&\min_{\lambda, \dot{x}_i, \dot{m}_i} \quad w_x \dot{x}_i + w_m \dot{m}_i \\
&s.t: \\
&-y_i + Y\lambda \geq 0 \\
&\dot{x}_i - X\lambda \geq 0 \\
&\dot{m}_i - M\lambda \geq 0 \\
&N1'\lambda = 1 \\
&\lambda \geq 0
\end{aligned}
$$

where $\dot{m}_i$ and $\dot{x}_i$ denote material cost and other inputs quantities, respectively, of the ith firm that minimize the cost given the input prices (w_x) and raw material prices (w_m). The overall efficiency is defined as the ratio of actual to minimum cost: $OE_i = \frac{\dot{C}_i}{C_i}$, where C_i is the actual cost defined as $(w_x x_i + w_m m_i)$ and $\dot{C}_i$ is the minimum cost which is obtained by solving model (2).

The overall efficiency OE_i of the dairy processing firm is calculated as following:

$$
OE_i = TE_i \times SE_i \times AE_i \qquad (3)
$$

In which TE_i is input oriented technical efficiency assuming variable return to scale, SE_i is the scale efficiency and AE_i is the allocative efficiency of the firm (i).

[1] We don't write down the models of the constant return to scale here to avoid repetition.

2.2 Hyperbolic Models to incorporate CFs Nature

In this alternative approach we consider two hyperbolic models. In the first model, we measure the hyperbolic technical efficiency considering the firm to radially expand output and radially contract inputs and materials simultaneously with equal proportions; this is presented in model 4 which is illustrated in Figure 1 with line (4). In the second model, we measure the hyperbolic technical efficiency considering an aspect of the CFs which aim, not only to expand the total turnover, but also materials, while contracting all other inputs simultaneously with equal proportions (see model 5). In the first model (model 4), we view each firm (of both types) as an IOF, while in the second model (model 5), we view each firm (of both types) as a cooperative.

Our expectation is that, on average, the CFs will score lower with the first hyperbolic technical efficiency model rather than with the second one. This is due to the nature of the CFs which is assumed to maximize the revenue of the milk delivered by its members (raw milk which makes up the major part of materials).

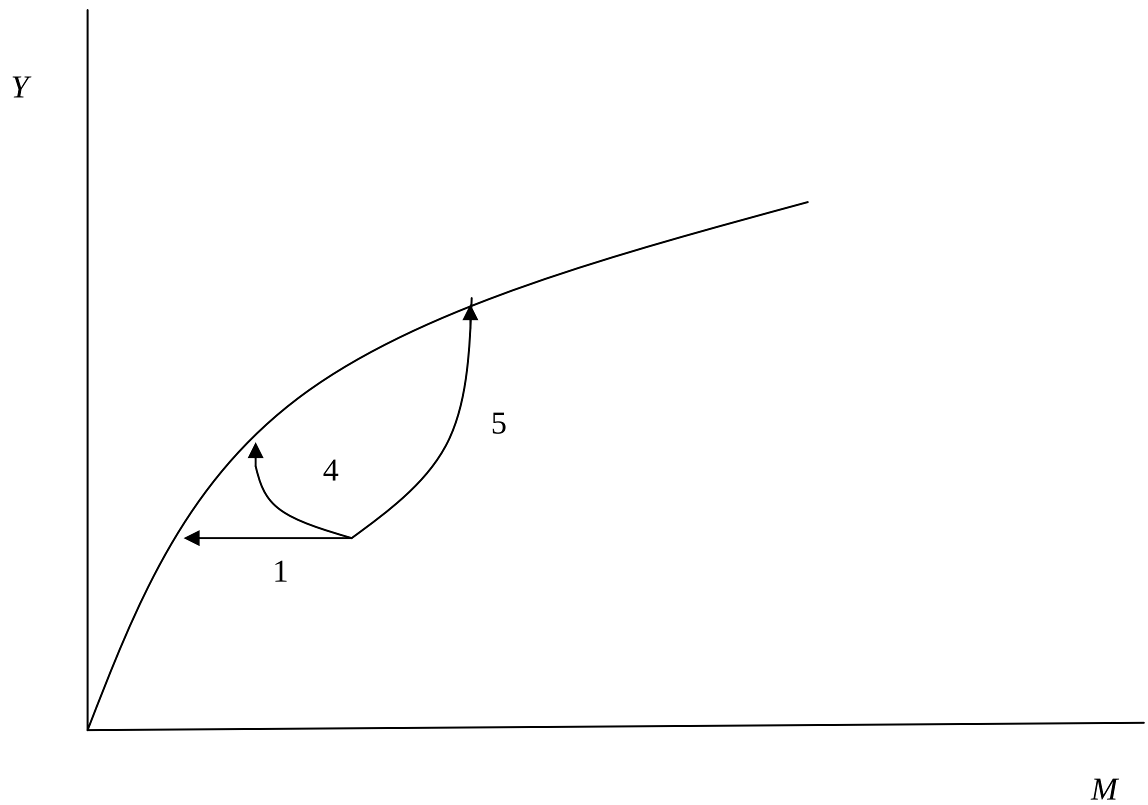
$$\begin{aligned}
&\max_{\vartheta,\lambda}\left\{\psi : (\psi y^{i}) \in P(\lambda^{-1}x^{i}; \lambda^{-1}m^{i})\ \right\}\\
&s.t:\\
&-\psi y^{i} + Y\lambda \geq 0\\
&\psi^{-1}m^{i} - M\lambda \geq 0\\
&\psi^{-1}x^{i} - X\lambda \geq 0\\
&N1'\lambda = 1\\
&\lambda \geq 0
\end{aligned} \qquad (4)$$

The technical efficiency in which inputs (*x*) are contracted and both output (*y*) and raw material (*m*) are simultaneously expanded is measured in model 5 and illustrated in Figure1 with line (5). The technical efficiency is expected to be higher for cooperatives.

$$\begin{aligned}
&\max_{\vartheta,\lambda}\left\{\vartheta : (\vartheta y^{i}; \vartheta m^{i}) \in P(\lambda^{-1}x^{i})\ \right\}\\
&s.t:\\
&-\vartheta y^{i} + Y\lambda \geq 0\\
&-\vartheta m^{i} + M\lambda \geq 0\\
&\vartheta^{-1}x^{i} - X\lambda \geq 0\\
&N1'\lambda = 1\\
&\lambda \geq 0
\end{aligned} \qquad (5)$$

Figure 1 illustrates the three models (the traditional and the two alternative ones). For simplification, we use two dimensions: output (*y*) and materials (*m*). Line (1), in Figure 1, illustrates the traditional situation where material is contracted while output is held fixed. Lines (4) and (5) illustrate the two hyperbolic models, where line (4), in Figure 1, presents the situation where materials is contracted while output is expanded, while line (5), in Figure1, presents the situation where material and output are expanded. Given the assumed objective of CFs to pay a high price for inputs delivered by their members (materials), the cooperatives are expected to be located further to the right corner, while IOFs are expected to be located left upper corner in Figure 1.

Figure 1: The Direction of the different Models.



2.3 Bootstrap Method

The bootstrap method is an established statistical resampling method used to perform inference in complex problems. If the data generating process (DGP) characterises the true data generation well and is mimicked in the resampling simulation, then the bootstrap method is well-performed in validating statistical inference. The bootstrap is mainly to approximate the sampling distribution of the estimator (in this study: input-oriented, hyperbolic and scale efficiencies). To approximate this sampling distribution we use the empirical distribution of the resampled estimate, which is obtained from the Monte Carlo resampling distribution of the estimation procedure (in this case the DEA). Repeated re-samples are obtained from an estimate of the DGP are used in the estimation procedure to produce repeated estimates (Lothgren and Tambour, 1999).

In this study, we use the bootstrapping method suggested by Simar and Wilson (2007) to avoid sample biases of the technical and hyperbolic efficiency measures, and we use the bootstrapping approach in Lothgren and Tambour (1999) to correct for data biases when measuring scale efficiencies. We use *Hall percentile intervals* based on differences to construct 95% confidence interval for input-oriented and hyperbolic technical efficiency and scale efficiency.

3. Data

Data on dairy processing firms in six European countries (Belgium, Denmark, France, Germany, Ireland and the Netherlands) covering the year 2004 come from AMADEUS[2]. The data set used for estimation consists of 133 firms among which 90 are IOFs and 43 are CFs.

The model distinguishes one output (total turnover) and three inputs (fixed assets, material cost, and employment cost). The outputs and inputs are expressed in Euros of 1996 (base year) by deflating the monetary values with their Tornqvist price indexes (Coelli et al., 2005).

The dairy plants in these countries are typically producing more than one product. However, the only relevant output available in the data set is total turnover. Total turnover represents the total operating revenue from selling all products produced by the processing company. Turnover (output) is deflated using the countries harmonized index of consumer prices for milk, cheese and egg.

Fixed asset is measured as the value of physical land, buildings, machinery, and the non-physical fixed assets: such as the goodwill, patents, brands, and market shares. The value was deflated using the average value

[2] AMADEUS is a European financial data base prepared by Bureau van Dijk and contains more than 5 million private, cooperative and public companies. The data-base is collected from reports produced by the chamber of commerce of the different European countries. AMADEUS unified the figures of the financial statements of the different countries.

of the prices index of the agricultural gross fixed capital formation and the price index of the agricultural machinery and equipment per country.

The AMADEUS data base includes material cost, reflecting the cost of purchasing the input materials before the processing operation starts. This input mainly consists of raw milk purchased by the dairy plant. We used the deflated EC-index of producer prices of the cows' milk per country as the deflator for the material cost. Labor cost is deflated using the nominal value of the labor cost index in total industries (excluding public administration).

The price indexes vary over the years and the different countries but not over the firms or over their type, implying differences in the composition of inputs and output or quality differences are reflected in the quantity (Cox and Wohlgenant, 1986). Additionally, the quantities also reflect differences in prices of the production factors between the two types of firms; a higher the milk payment implies a higher quantity of materials.

Table 1 provides the means and standard deviations of turnover, fixed assets, raw material, labor and prices. It shows that CFs have, on average, a higher average value of the output and the three inputs than IOFs.

Table1: Description of the Data.

Variable	Dimension	Mean (n)		Standard deviation	
Type		IOFs (90)	CFs (43)	IOFs	CFs
Quantities					
Output (turnover)	10^6 Euros	14.37	49.04	47.21	110.39
Fixed assets	10^6 Euros	2.40	9.67	5.80	27.36
Materials	10^6 Euros	9.64	34.64	4.97	94.92
Labor	10^6 Euros	0.28	1.05	0.66	1,52
Prices					
Output (turnover)	1996=100	91.83			
Fixed assets	1996=100	87.54		--	
Materials	1996=100	128.59		--	
Labor	1996=100	113.14		--	

4. Results

The results of the DEA models and the bootstrapping measures all were obtained using the package FEAR (Wilson, 2008). Section 4.1 presents the results of the traditional approach and Section 4.2 presents the alterative approach of the two hyperbolic models.

4.1 The Results of the Traditional approach

Results in Table 2 show that IOFs, on average, are more technically, scale and allocative efficient than CFs, hence, more overall efficient. The CFs are technically less efficient when compared to IOFs, CFs are slightly less scale efficient than IOFs, and CFs are less allocatively efficient than IOFs. Using the traditional approach, in which firms are considered to minimize cost (and contract the quantity of materials), CFs are out-performed by IOFs in their technical, scale and allocative efficiencies. Treating the material as an input, which has to be minimized, provides us with an expected lower performance of the CFs. On average, the input oriented technical efficiency of the IOFs is more than 50 percent higher than the one of the CFs. The results of the technical efficiency also reflect differences in for example prices paid for raw materials between CFs and the IOFs, where CFs is expected to pay higher total price. On average, the scale efficiency of the IOFs, using the traditional approach, is 10 percent higher than the one of the CFs. This difference in scale efficiency suggests that CFs are operating on a less optimal size than IOFs. This finding may be due to the fact that CFs are more restricted in choosing their optimal size due to their obligation to process all what members provide to the CFs. On average, the allocative efficiency of the IOFs is 20 percent higher than the one of the CFs. This difference of the allocative efficiency suggests that the CFs are less successful in minimizing costs than IOFs (as assumed to be more of profit oriented firms). The latter finding suggests that CFs may have another objective rather than minimizing costs, CFs may be more interested in paying a high milk price to their farmers.

These results do confirm the hypothetical expectations of the CFs performance when compared to the IOFs. The difference of the technical and scale efficiencies between the CFs and IOFs are statistically significant as their confidence intervals do not overlap. Therefore, the overall performance of the CFs using the traditional model is lower than the IOFs over all efficiency.

Table 2: Overall efficiency and its decomposition for CFs and IOFs (95% confidence interval in parentheses)

	Technical efficiency	Scale efficiency	Allocative efficiency	Overall efficiency
CFs	0.428 (0.29-0.54)	0.769 (0.71-0.77)	0.416	0.137
IOFs	0.642 (0.52-0.71)	0.849 (0.79-0.85)	0.582	0.317

4.2 The results of the alternative approach

Table 3 presents the results of the two hyperbolic efficiency models (model 4 and model 5). Model 4 expands outputs and contracts materials along with other inputs, whereas model 5 expands outputs and materials and contracts the use of other inputs.

Results of model 4 in Table 3 show that CFs score, on average, 1.659 in the first hyperbolic model (model 4) which says that CFs can increase their output with 65.9 percent contract their inputs (including materials) by ($(1-\frac{1}{1.659})$ *100 =)39.7 percent. The IOFs, on the other hand, scored on average 1.430 in the first hyperbolic model (model 4), which says that the IOFs can expand their output with 43 percent and contract their inputs with 30.1 percent.

CFs score slightly higher in the second hyperbolic model (model 5) than the first hyperbolic model with 1.638, which says that CFs can on average expand output and materials by 63,8 percent and decrease the use of inputs (excluding materials) by ($(1-\frac{1}{1.638})$ *100 =) 39.0 percent efficient in contracting their input (excluding materials). The IOFs score worse in the second hyperbolic model (model 5) rather than in the first hyperbolic model with 1,647, which implies a potential for expansion of outputs and materials by 64,7 percent their and a 39.3 percent contraction of inputs (excluding materials). When moving from model 4 to model 5, the scale efficiency has also improved for the CFs (from 1.21 to 1.10) while it has worsened marginally for the IOFs (from 1.09 to 1.10).

The results of the bootstrapping show that all differences in technical and scale between CFs and the IOFs are not significant at the critical 5% level in model 4 and model 5. In the first hyperbolic model (model 4), the hyperbolic technical and scale efficiencies of the cooperative (1.659) and (1,21) lie within the confidence interval of the hyperbolic technical and scale efficiencies of the IOFs [1,14-1,74] and [0,89- 1,97], respectively. The situation is similar for the hyperbolic technical and scale efficiencies of the IOFs (1,430) and (1,091) which are also located within the CFs confidence interval for both measures [1,21-1,92] and [0,88-1,47], respectively. The bootstrapping results of the second hyperbolic model (model 5) are similar to the results of the first model in terms of location within the confidence intervals. The hyperbolic technical and scale efficiencies of CFs (1.638) and (1,10) lie within the confidence interval of the hyperbolic technical and scale efficiencies of the IOFs [1,03-1,97] and [0,73- 1,43], respectively. The situation is similar for the hyperbolic technical and scale efficiencies of the IOFs (1,647) and (1,10) which are also located within the CFs confidence interval for both measures [1,09-2,61] and [0,73-1,43], respectively.

Table 3: Hyperbolic Technical and Scale Efficiencies for CFs and IOFs (95% confidence interval in parentheses)

	Model (4): Contract Materials		Model (5): Expand Materials	
	Technical Efficiency	Scale Efficiency	Technical Efficiency	Scale Efficiency
CFs	1.659 (1,21-1,92)	1,21 (0.88-1,47)	1.638 (1.09-2,61)	1,10 (0,73-1,43)
IOFs	1.430 (1,14-1,74)	1,091 (0,89-1,43)	1.647 (1,03-1,97)	1,10 (0.89-1,48)

Although the difference of the measure between the two is not significant at the critical 5% level, it shows that the performance of the CFs improved by 8 percent while the IOFs performance is worsened by 17 percent when moving from a model that contracts materials to a model that expands materials. This change of the performances between the two models, suggest that CFs are more oriented to increasing material costs (e.g. through a higher price), whereas IOFs are more focused on decreasing material costs. Additionally, the difference of the scale efficiency between the CFs and the IOFs reduced to zero in the second model, which implies that CFs are more scale efficient when materials and output are expanded rather than when the CFs expand only the output while contracting materials and other inputs.

4.3 The performance of the largest CFs and IOFs

In Appendix A, we present the results of the ten largest CFs and IOFs in terms of turnover. Arla and Friesland are the only two CFs which are technically efficient using the traditional and both alternative approaches. Campina and Glanbia are only technically efficient using model 1, while Nordmilch is technically efficient in both hyperbolic models (model 4 and 5).

Results in Appendix A show that scale efficiency of the largest CFs is rather poor in both model 1 and model 4, and improved significantly using model 5. Nordmilch and Arla are the only two CFs that are scale efficient in the second hyperbolic model (model 5). However, Friesland and Campina are the least scale efficient using the traditional mdoel and the first hyperbolic model (model 4). The average improvement of the scale efficiency from model 4 to model 5 is 19 percent for the ten largest cooperatives and only three percent for the ten largest IOFs.

The allocative efficiency of the CFs is generally very low, which suggests that the objective of large CFs differs from the objective of large IOFs. Among the ten largest IOFs, there are five IOFs technically efficient using model 1. The number of technically efficient IOFs drops dramatically (to only two IOFs) when measured using model 5; this drop in the number of efficient IOFs in model 5 is in line with the finding in section 3.2 which showed that IOFs perform worse in model 5 rather than model 1 and 4. More details can be viewed from the Appendix.

5. Conclusions

The raison d'etre of cooperatives differs from the one of IOFs. Therefore in order to evaluate the efficiency of the cooperatives, a different approach should be considered, i.e. an approach that takes into account the different objectives of the owners of the cooperative. Comparing the performance of CFs to the one of the IOFs using the same model imposes the same behavioral characteristic on either type of firm. CFs, as user-owned, user-controlled and user beneficiary firms are more restricted to members' interest in processing their own production and receiving the highest overall payment for their product which serves as the material to the cooperative. Therefore, materials have a different role for CFs rather than for IOFs. The role of material in CFs influences the choice of the input bundle by the cooperative firm to produce output, it restricts the choice of the optimal size, and implies a deviation from cost minimizing behavior.

Our empirical findings show that, on average, the CFs under-perform the IOFs in their input-oriented technical, scale, allocative efficiencies. However, the performance of the CFs in comparison to the IOFs improved when considering the model that expands the use of materials and output. Additionally, the differences in the scale efficiencies between CFs and IOFs disappear. The improvement of technical efficiency and the disappearance of the difference in scale efficiency suggest that materials have different roles in CFs and IOFs due to different objectives of the two firm types.

To provide a relevant comparison of the performance of the CFs with the IOFs' analysts should incorporate the interest of the owners of the firm. The overall conclusion is that CFs and IOFs need different tools to evaluate their performances, comparing the performance of the CFs to IOFs is not suitable if the same approach is used assuming same objectives to the two types of firms.

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Appendix A: The Results of the 10 Largest CFs and IOFs

	Traditional Models 1-3			Hyperbolic Model 4		Hyperbolic Model 5	
Name	**TE**	**SE**	**AE**	**TE**	**SE**	**TE**	**SE**
Coop							
ARLA FOODS AMBA	1.00	0.68	0.12	1.00	1.21	1.00	1.00
KONINKLIJKE FRIESLAND FOODS N.V.[3]	1.00	0.39	0.14	1.00	1.60	1.00	1.06
ZUIVELCOÖPERATIE CAMPINA U.A.	1.00	0.40	0.18	1.07	1.60	1.06	1.11
NORDMILCH EG	0.87	0.51	0.12	1.00	1.41	1.00	1.00
GLANBIA PUBLIC LIMITED COMPANY	1.00	0.61	0.55	1.55	1.33	1.59	1.18
CANDIA (CEDILAC)	0.44	0.45	0.75	1.48	1.53	2.04	1.20
BELGOMILK	0.31	0.65	0.64	1.73	1.30	1.87	1.16
3A SA	0.58	0.55	0.62	1.27	1.39	1.49	1.17
SODIAAL INTERNATIONAL	0.44	0.70	0.48	1.49	1.22	1.50	1.12
DRENTS OVERIJSSELSE COÖPERATIE KAAS BA.	0.24	0.68	0.51	1.91	1.29	1.88	1.13
IOF							
COGESAL MIKO	1.00	0.64	0.54	1.00	1.25	1.00	1.24
DANONE SA	0.39	0.27	0.74	1.00	1.93	1.59	1.33
SAS ENTREMONT ALLIANCE	1.00	0.46	0.49	1.00	1.47	1.25	1.41
NESTLE PRODUITS LAITIERS FRAIS	1.00	0.69	0.61	1.00	1.21	1.00	1.31
S,A, CORMAN	0.84	0.51	0.30	1.08	1.42	1.99	1.31
GOLDSTEIG KÄSEREIEN BAYERNWALD GMBH	0.74	0.69	0.24	1.13	1.23	1.21	1.36
SA INGREDIA	1.00	0.55	0.60	1.00	1.36	1.75	1.22
GLACES THIRIET	0.66	0.73	0.54	1.21	1.20	1.20	1.26
SAS LAITERIE DU VAL D'ANCENIS	0.71	0.64	0.63	1.14	1.30	1.47	1.22
MOLKEREI - LAITERIE WALHORN	1.00	0.81	0.77	1.00	1.11	1.02	1.17

[3] It is owned 100 percent by the cooperative Friesland.