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Abstract: The thesis advanced in this paper holds that any transaction cost explanation of the diffusion of a particular organizational form requires an evolutionary analysis of differential performance of competing organizational forms over time. Using data on 1141 dairy factories in The Netherlands, we find evidence that cooperative factories performed significantly better than private factories, which can be explained by cooperatives' lower transaction costs. However, superior performance is observed only in the Northern part, while cooperatives were more dominant in the Southern part. This suggests that entry conditions for cooperative factories in the South were more favourable than in the North.

Key words:
transaction cost economics, survival analysis, industry lifecycle, dairy industry, cooperatives

1. Introduction

In several European countries (Denmark, Ireland, The Netherlands), the industrialisation of the dairy sector at the end of the nineteenth century involved the emergence of cooperative organisational structures, which came to dominate in the twentieth century. With the introduction of centrifugal separation technology around the 1880s, the optimal scale of milk processing rapidly increased. As a result, many farmers started to transport their milk to nearby factories. The early factories, which were predominantly privately own and run, faced a problem of asymmetric information regarding the quality of the milk supplied. At the same time, due to high costs of transport and conservation, farmers were forced to deliver their milk to the nearest factory, which allowed private factories to set monopsonic prices. To overcome the resulting incentive problems, farmers set up their own cooperatives, which allowed them to reap the full benefits of milk processing (O'Grada, 1977; Van Zanden, 1994; Henriksen, 1999; Bijman, 2000).

In the field of economic history, the dairy industry has been extensively studied because no other agricultural sector has shown such a rapid and wide diffusion of cooperatives (O'Grada, 1977; Van Zanden, 1994; Henriksen, 1999; O'Rourke, 2006). Among historians, consensus has been growing that the success of cooperatives can be attributed to their capability to solve 'transactional' problems among farmers and factory owners (Williamson, 1985). Though the explanation for the rise of cooperatives in the dairy industry is widely shared among historians, *the question remains whether cooperative factories were indeed more efficient*. According to transaction cost theory, the cooperative factory would diffuse at the expense of the private factories due the superior efficiency of cooperative factories in reducing transaction costs. Evidence presented hitherto, however, has been circumstantial: after an initial period during which private enterprise dominated, cooperatives quickly became the dominant organizational form in the dairy industry, be it in Ireland (O'Grada, 1977; O'Rourke, 2006), Denmark (Henriksen, 1999; O'Rourke, 2006) or The Netherlands (Van Zanden, 1994). However, from diffusion studies, showing the dominance of cooperatives, one cannot derive the relative efficiency of cooperatives, because the dominance of cooperatives may also be due to more favourable entry

conditions for cooperatives compared to private factories. This is why we analyse, below, the performance rather than the diffusion of different organisational forms.

The thesis advanced in this paper holds that any argument based on the relative efficiency of a particular organizational form in reducing transaction costs requires an evolutionary analysis of differential performance of competing organizational forms over time. In the words of Williamson (1981: 574): *"the transaction cost approach relies – in a somewhat informal, background, and long-run way – on the operation of natural selection forces"*. In the following, we adopt an evolutionary approach by analysing the survival probabilities of cooperative and private dairy factories. At the national level, our analysis shows indeed the superior performance of cooperative factories compared to privately owned factories. Yet, and surprisingly so, cooperative factories performed better only in the Northern regions in which the cooperative form was *less* dominant, while the cooperative factories performed equally well as private factories in the Southern regions in which the cooperative form was much *more* dominant. This suggests that the dominance in the latter regions is to be explained by more favourable entry conditions for cooperative factories compared to private factories.

Further analysis shows that the superior performance of cooperative factories is intimately related to the early introduction of steam engine technology in the Northern regions, which increased the scale of operation. We argue that cooperatives became more efficient than private factories only with the increase in scale, which increased the optimal number of milk suppliers and the importance of stable and reliable milk supplies. From transaction cost economics, we expect that cooperative factories handle both aspects in a better manner than private factories.

The paper is structured as follows. In section 2 we present a short history of the Dutch dairy industry discussing the rise of the cooperative form, the regional differentiation herein and the interdependence between organizational form and processing scale. In this section we will also derive three hypotheses. Section 3 discusses the research design, which is based on survival analysis. In section 4 we present the empirical results and section 5 concludes.

2. The evolution of the Dutch dairy industry

Dairy factories emerged when farmers recognised that they could realise scale economies when merging their supplies of milk to be processed centrally. In particular, the advent of centrifugal separation machines increased the level of scale economies substantially. This technology made it possible to produce butter on a continuous basis and with a much higher return of butter for each litre of milk supplied compared to butter production at the farm. The scale advantages were further reinforced with the widespread adoption of steam powered separator technologies around the turn of the century (Van Zanden, 1994).

Before the introduction of centrifugal separation technology in the 1880s, dairy products were made at the farm. In The Netherlands, the production of dairy products at farms concerned mainly butter and cheese. Geographically, dairy production concentrated in the West (Holland) and the North (Friesland) of the country, both areas with fertile grasslands. Part of the dairy production was exported to England (mainly butter from Friesland) and to Germany, Belgium and France (mainly cheese from Holland) (Van Bers, 1994). In the sandy soils in the Eastern and Southern parts of The Netherlands, dairy products were produced at lower qualities and quantities for local markets. Cows were held mainly to fertilize the land. However, with the rapid fall of grain prices from 1870s onwards[1] and the advent of artificial fertilizer, farmers in the Eastern and Southern parts became more prone to engage in dairy production as a core activity. This explains why the spread of dairy factories from 1871 onwards did not only concern the traditional grassland area in the West and the North, but also involved the Eastern and Southern provinces (Van Zanden, 1994).

Although the advent of the dairy industry is primarily made possible by the invention of centrifugal separation technologies in the early 1870s, its rapid development is also to be understood from a

[1] Prices dropped forty percent between 1877 and 1897 (Van Zanden and Van Riel, 2004).

market perspective (Van Bers, 1994; Van Zanden, 1994). Dutch butter exports to England had dropped rapidly due to the competition of high-quality butter from Denmark and Normandy produced using the new separator technology. By contrast, the average quality of Dutch butter deteriorated due to fraud with "illegal" adding of substances by both farmers and merchants. Lacking governmental institutions to regulate quality, farmers were advised to set up their own cooperatives in a report issued by de government committee for agriculture[2] in 1886 (Roosen, 1993). The advent of margarine butter by Dutch companies even reinforced the need for regulated quality to distinguish "real" butter from margarine and to avoid that margarine was mixed with butter to reduce costs. Another market-pull factor concerned increased inland consumption of dairy products due to rising income and changing consumption patterns. During the 1860s and 1870s, the percentage of household budgets spent on dairy products almost doubled (Van Zanden and Van Riel, 2004).

The rapid proliferation of dairy factories in The Netherlands is clear from Figure 1 in which the total number of factories is plotted for the period 1871-2005 as well as the annual number of entries and exits. The data shown are based on records on 1141 factories out of a known 1475 factories found by Willemsens and De Wit (1995). For the remaining 334 factories entry and/or exit years are lacking and cannot be included in our analysis. The evolution of the number of factories shows a clear industry lifecycle pattern with rapid entry in the early period of the industry and eventual concentration of the industry into an oligopoly (Klepper and Simons, 1997; Klepper, 2002). The process of concentration reflects a continuous rise in the minimum efficient scale of operation resulting from a series of process innovations in milk processing as well as in transport and conservation technology.[3]

[2] This committee was called *Staatscommissie voor de Landbouw* in Dutch.

[3] Interestingly, the "shake out" of the industry leading to an oligopoly took much longer than observed in manufacturing industries (Klepper and Simons, 1997). This can be understood from the fact that dairy factories have always been dependent on regional suppliers of fresh milk. This dependence implies that increases in the scale of the dairy industry are more severely constrained by transport costs than its manufacturing counterpart resulting in a more gradual process of concentration.

Figure 1: Number of dairy factories and annual number of entries and exits, 1871-2005 *(source: Willemsens and De Wit, 1995)*

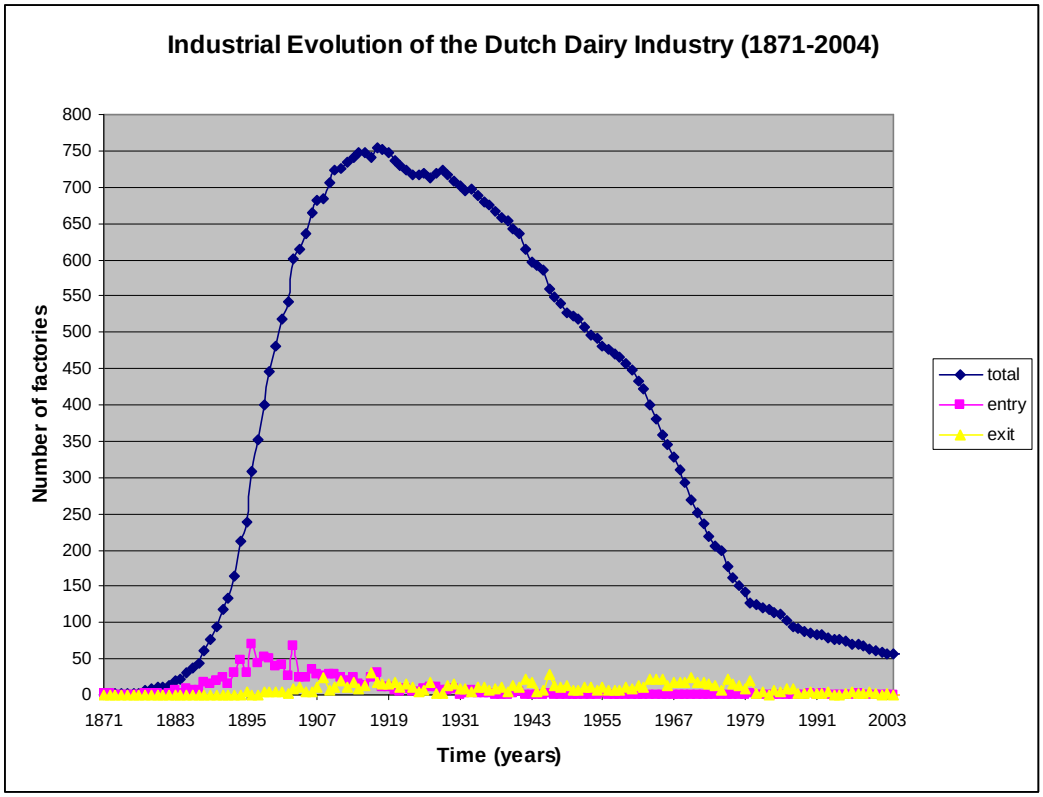
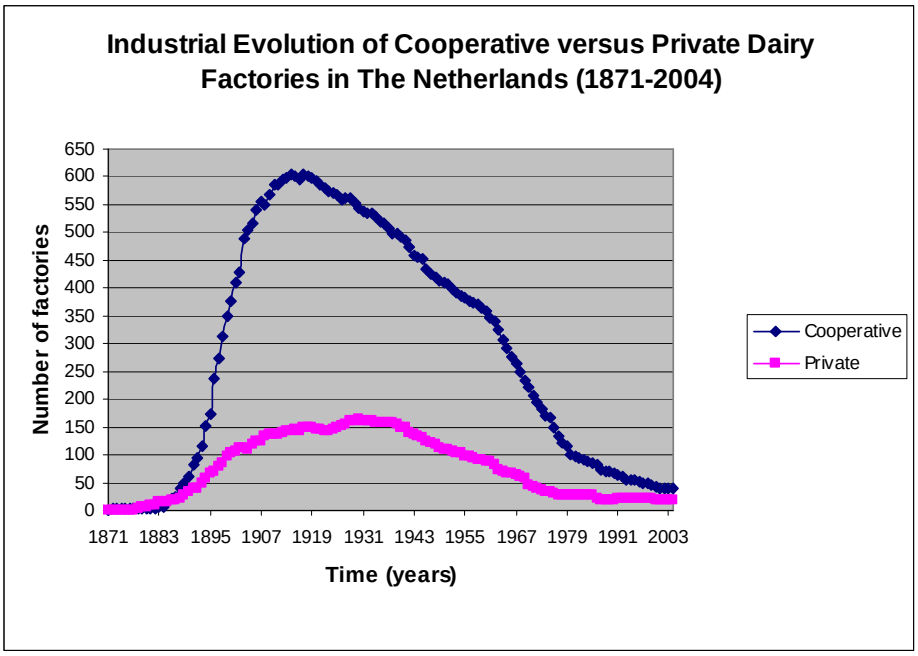


Figure 2: Number of private and cooperative dairy factories, 1871-2005

(source: Willemsens and De Wit, 1995)



2.1 The rise of the cooperative form

Figure 2 shows the total number of cooperative or private factories present in the Netherlands per year following the classification by Willemsens and De Wit (1995). This figure is based on 1130 factories as 11 out of the 1141 factories changed organizational form in an unknown year (eight factories changed from private to cooperative form and three factories changed from cooperative to private form). Clearly, the cooperative form became rapidly dominant in The Netherlands.[4]

The early factories were predominantly privately own and run. Yet, as a reaction to the transactional problems mentioned earlier, and learning from successful cooperative practices in Denmark, many farmers preferred to deliver their milk to cooperative factories. In this way, they were able to reap the full benefits of milk processing, while, at the same token, the factory profited from higher certainty regarding milk supply and its quality (O'Grada, 1977; Van Zanden 1994; Henriksen 1999; Bijman, 2000). Our first hypothesis thus holds:

Hypothesis 1: Cooperative dairy factories have a higher performance than private dairy factories.

Though the advantages of cooperative milk processing became apparent to farmers throughout the 1880s and 1890s, private factories did not disappear and even continued to increase in absolute numbers. Some of these factories remained in business for many years. This suggests that private factories found ways to face the competition of cooperative factories. One common way has probably been to adjust prices for milk supplies upwards to levels paid by cooperatives. Thus, as suggested by O'Grada (1977, p. 295) in his study on Ireland, even though private factories had a *de facto* monopsony position, they can be expected to have paid acceptable prices under the threat of farmers

[4] However, a caveat applies. From the 334 factories with unknown entry and exit dates, the majority is of the private form. Probably, most of these private factories were short-lived as we reckon that the more successful private factories are archived more often. Still, the dominance in number of cooperative factories versus private factories is probably slightly less so than suggested by Figure 2.

setting up their own cooperatives or supplying their milk to nearby cooperatives. Put differently, the market was more or less 'contestable'. However, lacking price data, we cannot further pursue this line of reasoning empirically.

2.2 Regional differences

An aspect of the history of the Dutch dairy industry, which remains to be understood more systematically, is the co-existence of private and cooperative factories in the Northern regions. This phenomenon has been noted in studies on Ireland (O'Grada, 1977), Denmark (Henriksen, 1999) and The Netherlands (Van Zanden, 1994). In the Dutch case, the co-existence of private and cooperative factories, however, has not been universal but restricted to the provinces north of the Rhine, where almost 30 percent of all factories that ever existed were private. In this grassland area with a tradition dairy export, many merchants with experience in dairy trade started private factories in the early stage of the industry (Van Zanden, 1994). By contrast, in the sandy soils area of the Southern provinces Limburg and Northern Brabant, dairy production had always been for local consumption only. Here, private enterprise was reluctant to start commercial factories, which explain the relative dominance of the cooperative form. Based on the data provided by Willemsens and De Wit (1995), we could derive that from all factories that ever started in Limburg and Northern Brabant, less than 10 percent has been privately owned.[5]

One can expect that the continued presence of private factories in the Upper Rhine area is due to first-mover advantages of early entrants (O'Grada 1977). There are several reasons to expect that early entrants perform better than later entrants. First, following O'Grada (1977), having the first pick, early entrants were strategically well located in villages and towns with a tradition in milk and butter. Second, following Klepper (2002), early entrants gained experience before local competition between factories took off. The continued presence of private factories in grassland areas may thus be

[5] The Catholic Church also played an important role in Southern provinces in supporting farmers financially and administratively in setting up their cooperatives (Willemsens and De Wit, 1995).

understandable from the fact that many early entrants were private factories combined with higher survival rates for any early entrant.

Hypothesis 2: The earlier a dairy factory started, the higher its performance.

2.3 Physical geography, size and technology

The dairy industry did not developed evenly in all areas due to regional differences in physical geography. As explained, in the fertile grassland area in the Western and Northern part of the country, the industry developed at an earlier stage. And, because of higher cow density and larger markets, factories operated at a larger scale than their counterparts outside the grassland area. Not surprisingly, the use of steam engines also started in these fertile areas, as the adoption of the steam engine became profitable only when above a certain size threshold (Van Zanden, 1994).

There has been one area in which the land was fertile, yet factories remained small. This notable exception concerns the cheese factories in North-Holland north of Amsterdam, which were generally small cooperatives using manual separator technology, which allowed them to control the quality in a better manner.

We expect the relative success of cooperative dairy factories vis-à-vis private factories to be dependent on size. The cooperative organisational form is assumed to be more efficient in solving transactional problems between farmers and factory owners. These problems, in particular the incentive to cheat among farmers regarding the quality, were larger for factories that dependent on a large number of farmers, since monitoring costs rise with the number of farmers (Van Zanden, 1994). This implies that the cooperative organisational form is expected to be more efficient for larger factories.

Hypothesis 3: Larger cooperative dairy factories performed better than large private factories.

Since we lack data on size at the plant level, we will proxy size by assuming that factories on sandy soils are significantly smaller as well as the factories north of Amsterdam who specialised in cheese-making, which relies more on craftsmanship.[6] Even though the cooperative form was dominant in the areas were manual separators were the norm, we have no reason to assume that cooperatives were more efficient than private firms. Rather, we expect cooperatives to be more successful than private enterprise only in areas where the scale of operation was large.

3. Research design

The analysis of the efficiency of cooperative factories compared to private factories is highly demanding in terms of data. Unfortunately, systematic information on cost efficiency of processing plants is lacking, which implies that one cannot verify the claim that cooperatives were truly more efficient. An indirect measure of efficiency, however, is available by using survival rates of private and cooperative factories as a proxy, assuming that more efficient firms have lower hazard rates (Klepper, 2002).[7] Using survival as an indicator of performance, we will apply the Cox regression method to analyse the determinants of factory performance by examining which determinants affect the survival probability of dairy factories. We use Cox regressions (Audretsch and Mahmood, 1994) because this method makes use of the contribution of censored cases. This is necessary because some companies still existed in 2005.

[6] This classification also corresponds with data presented by Geluk (1925: 95).
[7] It can be argued that cooperatives have lower hazards than private organisations because their survival depends less on profits. Empirically, however, Pérotin (2006) recently found that the effect of the business cycle on exit is the same for cooperatives compared private companies.

The data are taken from an encyclopaedia by Willemsens and De Wit (1994) on 1475 dairy factories in The Netherlands starting from the first dairy factories starting in 1871 until 1994. We have updated the data from 1994 to 2005 using the information of the *Productschap Zuivel*, which is the national association of dairy factories (a period during which entries were absent). According to Willemsens en De Wit (1995) there were more dairy companies in the Netherlands than are in their data set. But they think their collected data contains at least 95% of the total Dutch dairy companies ever established. Therefore we assume the data are representative for the whole Dutch dairy industry.

The data contain the entry and exit years for most factories. The entry year is the first year, in which a company started producing dairy products commercially. The exit year is the last year of commercial production. For some companies the entry year and/or exit year were unknown. In these cases, the companies were left out of the analysis. These missing data reduced the dataset from 1475 companies until 1141 companies. Most entry or exit data are lacking on private companies. This is probably caused by the fact that private companies were not members of regional associations, the records of which are well kept.

The data also contains information on the organizational structure of each factory, that is, whether is concerns a private or cooperative factory, or a factory that changed organizational form from private to cooperative or vice versa. Finally, the data contain the name of municipality where the factory has been located.

To assess the differential impact of factory size on cooperative and private factories, we also require data on size. These data are not available at the plant level, but we have been able to proxy size at the regional level. We created a dummy variable LARGE to indicate all factories located in the area in which the average size is particularly large, which we proxy by taking by assuming that factories in sandy areas (the provinces of North-Brabant and Limburg) and in the area dominated by cheese makers (the area in North-Holland north of Amsterdam) are significantly smaller than elsewhere (Geluk 1925: 95; Van Zanden, 1994). Using this variable, we can test hypothesis 3 concerning the

complementarity between size and cooperative organisational form by regressing the interaction term of the COOPERATIVE dummy and the LARGE dummy.

4. Results

We start by testing the first hypothesis from plotting the survival curves using a Kaplan-Meier plot (figure 3). Clearly, the cooperative factories outperform the private factories with the exception of long-lived firms of 95 years and older (which are, of course, only few). From the plot, we can confirm hypothesis 1, though we still have to analyse whether the outcome is robust in a multivariate analysis.

The results are present in Table 1 and show that cooperatives perform indeed better than private factories (hypothesis 1), as suggested by the Kaplan-Meier plot in Figure 3. It must be reminded that we lack entry and exit data of 334 factories. The large majority of the missing data concern private factories. However, we expect that the reason the entry and exit data could not be collected is due, at least partly, to their short existence. Put differently, the mean lifetime of a private factory omitted is probably significantly shorter than the mean lifetime of those in the dataset, which suggests that the true difference in hazard between private and cooperative factories is probably even greater than our result indicates.

Figure 3: Kaplan-Meier plot of cooperative dairy factories (upper curve) and private dairy factories (lower curve)

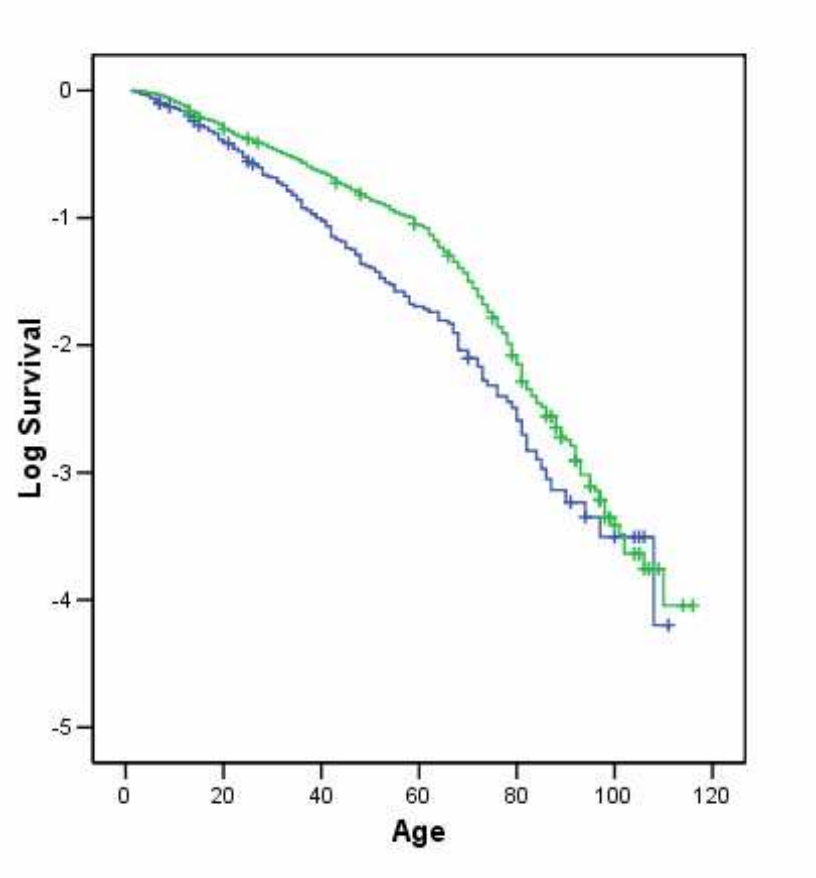


Table 1. Regression results (Cox)

	Model 1	Model 2	Model 3	Model 4	Model 5
COOPERATIVE	-0.308*** (0.072)	-0.303*** (0.072)	-0.299*** (0.072)	-0.438*** (0.074)	+0.101
PRIV->COOP		-1.267*** (0.384)			
COOP->PRIV		-0.836 (0.710)			
ENTRYYEAR			+0.008*** (0.002)	+0.006** (0.002)	+0.007** (0.002)
LARGE				-0.573*** (0.066)	+0.021 (0.175)
COOPERATIVE*LARGE					-0.713*** (0.189)
N	1130	1141	1130	1130	1130

*** = significant < .01, ** = significant < .05 * = significant < .10

An interesting detail in the data collected holds that we found out of a total of 1141 factories that 11 factories that could not be classified into either cooperative or private because these factories changed organizational form during their lifetime. We therefore constructed a dummy PRIV->COOP for factories that changed from a private into a cooperative form (eight cases) and COOP->PRIV for factories that changed from a cooperative into a private form (three cases). These dummies were included in model 2 jointly with the dummy COOP. Interesting, the dummy PRIV->COOP is highly significant and negative meaning that the eight factories that changed organisational form from private to cooperative have significantly lower hazard even compared to factories that started out as cooperatives. This finding reinforces our conclusion that cooperatives were the more efficient organizational form.

Early entry also increases life expectancy (hypothesis 2), measured as entry year in model 3. The positive sign here means that factories entering later in time performed less well than factories entering early in time. Given the fact that most entries in the first decade were private factories, this finding explains why many private factories continued to co-exist with cooperative factories. Even if the cooperative form can be assumed to have been more efficient, the first-mover advantages of early private firms allowed them to survive for a reasonable amount of time.

If we include LARGE as a dummy in model 4 to proxy the size of a factory, we observe that larger factories had higher survival probabilities. This is expected because survival is intimately related to a factory's scale of operation (Van Zanden, 1994; cf. Klepper 2002). However, using the interaction term in model 5 between large size and the cooperative form (COOPERATIVE*LARGE), there is no longer a statistically significant effect of being a cooperative factory *per se* (COOPERATIVE), nor of being a large factory *per se* (LARGE). The cooperative form proves to be superior only for larger factories. This result is in line with hypothesis 3, which stated that cooperative dairy factories perform better in areas where factories are large, because the advantages of cooperatives are especially strong

when factories draw their milk from many farmers. This outcome also suggests that the rise of the cooperative form can be seen as an example of co-evolution of technology and institutions, which have been mutually reinforcing (Nelson 1995). Technology allowed the scale of operation to increase, which reinforced the efficiency of the cooperative form, which in turn allowed a larger scale by drawing milk from more suppliers.

As explained, the dummy LARGE is defined as being located in the North. Thus, cooperative factories performed better only in the Northern regions in which the cooperative form was *less* dominant, while the cooperative factories perform equally well as private factories in the Southern regions in which the cooperative was much *more* dominant. This suggests that the dominance of the cooperative form in the latter regions is to be explained by more favourable entry conditions for cooperative factories compared to private factories rather than by the superior performance of cooperative compared to private factories. It has been suggested, for example, that the Catholic church, which constituted the dominant religion in the Southern provinces, was assisting the small farmers on the sandy soils in the South to set up a cooperative factory (Van Bers, 1994).[8] The exact reasons for differing entry conditions, however, are left for future research. More generally, the lesson to be learnt here is that one should never conclude from the relative dominance of an organisational form in a certain area that this form is also functioning better than alternative forms in this area.

5. Conclusion

We have argued that the relative efficiency of a particular organizational form in reducing transaction costs requires an evolutionary analysis regarding analysing the differential performance of competing organizational forms over time. Using survival analysis, we have been able to show the superior performance of cooperative factories compared to privately owned factories.

[8] Note that the facilitating role of the Catholic church is contrary to the thesis advanced in a study on Ireland that the cooperative form emerged more rapidly in protestant areas (O'Rourke, 2004).

Our analysis also showed that the superior performance of cooperative factories in the Northern part of The Netherlands is intimately related to the larger scale of operation. We have argued that cooperatives became more efficient than private factories only with up-scaling, which increased the optimal number of milk suppliers and the importance of stable and reliable milk supplies. Yet, and surprisingly so, cooperative factories were less dominant in the Northern regions compared to the Southern regions. This suggests that the dominance in the latter regions is to be explained by more favourable entry conditions for cooperative factories compared to private factories.

Though the history of the diary industry has been rather specific, the main argument and the survival methodology applied below are general enough to be applied to different case studies as well. We thus hope to show the value added of an evolutionary perspective, which combines institutional and technological change, and, as such, is viewed to be complementary to the transaction cost economics of vertical organisation and strategic behaviour.

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