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‘Rational’ Farmers and the Emergence of Modern Accounting  
in Danish Dairying

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Danish Dairying<sup>1</sup>

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**Abstract**

We argue that Danish agriculture provides an ideal opportunity to understand how and why modern accounting emerged. Denmark underwent an unusually rapid and successful agricultural transformation in the second half of the nineteenth century, largely based on dairying, for which we present unique ‘real time’ data on the process of the development of accounting. We observe that economic actors first argued for the introduction of modern accounting at a time of crisis during the Napoleonic Wars and immediately after, when the proscriptive arguments offered failed to take hold. Then, in the 1850s and 1860s, a group of ‘rational farmers’ – owners and administrators of landed estates – made a second attempt. During this latter period, they succeeded in spreading their ideas: initially to their peers, but later even to the peasantry through the cooperative movement, thus transforming agricultural practice in their wake. We analyze this within a theoretical framework borrowed from the international relations literature, and see the rational farmers as an example of the creation of an ‘epistemic community’: they emerged during a period of uncertainty, offered interpretations based on their normative understanding of reality, and finally institutionalized praxis through for example scientific journals and schooling.

JEL classification: M41, N53

Keywords: Accounting, bookkeeping, dairies, Denmark

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## 1. Introduction

Is accounting shaped by external needs or shaping its own environment? How does modern accounting emerge, and more specifically, what environment needs to be present for this to happen? We argue that nineteenth century Danish agriculture provides an ideal opportunity to shed light on these questions. This is partly because it offers unique ‘real time’ data on the process of the development of accounting, and because it can be demonstrated that this was of great importance for the development of the country, which underwent an unusually rapid and successful agricultural transformation in the second half of the nineteenth century. Moreover, we observe that economic actors argued for the introduction of modern accounting to agriculture in two waves. The first came during the Napoleonic Wars and immediately after, a period which ushered in a profound period of crisis and a postwar national economic depression. The proscriptive arguments offered failed to take hold at this time. We then observe a second wave, as a group of ‘rational farmers’ – owners and administrators of landed estates of both noble and bourgeois origin – worked on developing accounting techniques for agriculture in the 1850s and 1860s. During this period, they succeeded in spreading their ideas: initially to their peers, but later even to the peasantry through the cooperative movement, thus transforming agricultural practice in their wake. We analyze this within a theoretical framework borrowed from the international relations literature on the creation of ‘epistemic communities’ (Haas 1992). This allows us to understand the emergence and success of the rational farmers through the particular environment they were confronted with in the mid-nineteenth century. We thus also demonstrate that accounting in this context was both shaped by external needs, and fundamental to shaping the environment.

The Danish rational farmers sought through accounting to describe and understand the internal flows involved in managing cattle with the goal of maximizing output and income from animal husbandry, initially with a focus on obtaining natural fertilizer, manure, *the* key ingredient for sustainable premodern agriculture, in the most efficient way. This same technique was then refined to cover an ever wider range of potential production decisions regarding by-products (for example pigs raised on waste dairy products for bacon production), additional inputs (such as fertilizer not produced on

the farm) and production technology choices (for example whether to use milk to produce cheese or butter). Eventually, those techniques diffused through the Danish agricultural sector, became standard curriculum at the Royal Agricultural and Veterinary College and agricultural schools, and led to annually published dairy survey tables of feeding, production and revenue that individual farms could benchmark their results against. All this took place in the context of the unprecedented rise of the Danish dairy industry, which came to dominate the important British market for butter and bacon from the last decade of the nineteenth century both in quantity and quality of produce.

What distinguishes the present paper from most other contributions on accounting history of this period of transformation, and especially agricultural accounting history, is that we have comprehensive documentation of contemporary discussions involving actual accounts being directly interpreted by their authors and appreciated and contested by others, so that both the calculative practices we present and the lessons drawn from them are by contemporaries.<sup>2</sup> We thus provide much needed evidence to close the gap between historically observed accounting practice and the 'supposition that it was key support for optimal decisions'<sup>3</sup>, while maintaining that as much as the actual decision-making, the use of the account to justify and legitimize these decisions was key.

A well-known narrative depicts the origins of modern cost and management accounting as a rational response to the development of the modern firm as an ever more complex organism with a myriad of internal material flows and different tasks

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<sup>2</sup> Probably due to the main reliance on British sources and the wide-spread system of tenancy after the late Middle Ages which mostly left records regarding stewardship and tenant and tax payments (e.g., Dobie 2015, pp. 50-51, 58-59), most of agricultural accounting history has to rely on aggregate accounts, textbooks or piecemeal evidence from scattered published accounts (see, for example, Parker 1997, Scorgie 1997, Bryer 2000b, Toms 2010, Edwards 2011, cf. Turner et al 2001 and Tribe 1978, p. 71). Even works as detailed as Oldroyd (2007) have detailed accounts mostly for non-farming, enterprise activities on estates, in his case coal mining. In the case of Denmark, similar limitations appear. Surviving accounts from before the 1840s are from estates except for some very peculiar examples of outstanding 'accounting peasants' (see Lampe and Sharp forthcoming for the former and Schousboe 1978-79 for the latter). The literature on Danish dairying (e.g. Bjørn 1982a) has also noted the importance of modern accounting practices, but without investigating this in depth.

<sup>3</sup> Such is the criticism of the Chandler's (1977) account, that modern cost accounting evolved from the increasing complexity of capitalist firms in the United States, in the review article by Luft (1997, 176-180, quote on p. 178). See also Vollmer (2003, 359).

that required an advance in accounting techniques in order to maintain the integration of its organizational structure.<sup>4</sup> More sophisticated techniques thus followed from demands for more information and led to a better structuring and more efficient processing allowing for the management of these larger quantities of information. Better decision making and increased efficiency in processing of inputs would in turn enhance economic growth at a firm, industry, national and world level (Chandler 1977, Johnson and Kaplan 1987). Skeptics argue, however, that in practice the evidence linking the introduction of sophisticated accounting techniques to efficient decision-making is thin, and that what actually happened was that a desire to measure, quantify and monitor was being imposed on the firm by interested parties (Miller and O'Leary 1994).

The imposition of accounting might have been for the sake of class interests and profit maximization and the appropriation of surplus generated by labor (Bryer 2000a, 2006b, 2006c), or, denying the primacy of economic forces, it might have been due to mechanisms aiming at disciplining workers and managers so that they became 'responsible' (Hoskin and Macve 1994). Thus, the promise of 'efficiency', whether or not this materialized, and the implementation of accounting techniques would, deliberately or not, shape the organizational form of the firm and the social relations in it, and as such the entire economic process and even the way society sees itself as 'rational' (Miller and Napier 1993, p. 641, Miller 1994, Carruthers and Espeland 1991, March 1987, Burchell et al 1980). Accounting deployed its 'transformative capacity' (Miller 1994, p. 1) in this process, vastly extending the range, precision and system of quantification in the economy and at the same time giving power to those who controlled the calculation of the 'relevant' figures. These new protagonists could therefore conclusively argue that the application of the lessons their techniques implied was rationalizing production, and thus accounting and benchmarking spread ever wider, transforming the way in which societies organized and saw themselves (Burchell et al 1980, pp. 5-6, 19-21; Miller and O'Leary 1994, p. 99). Accounting was

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<sup>4</sup> With a tragic twist: Eventually, accounting would focus on financial figures required by external reporting but providing figures of dubious value for managerial decision-making. This is, of course, the well-known argument by Johnson and Kaplan (1987). See also Previt and Murwanto (2003).

therefore not simply an innocent technique, but a 'technology of government' (Miller 2001, pp. 381-382, 394).

For the most part, the setting for this debate is industrial firms: the factories and corporations born during industrial revolutions. Agriculture would play only a secondary role as a rather traditional declining sector, since most farms were not sophisticated organizations, and neither were their cultivators held to be of a particularly calculative mentality. Nevertheless, a certain category of farms, the great landed estates, did receive attention especially in the Marxist interpretation of the process, where estate-owners – often not themselves involved in cultivating the land – took part in the general process of bourgeoisification, aiming to maximize rates of return on capital invested instead of simply extracting feudalist rents, and thus also motivating them to implement changes in accounting practices (Bryer 2000a, 2006a). While in most cases this involved investment monitoring for estates that were leased to tenants or operated by stewards, in some instances, including those we discuss below, changes to accounting techniques involved tracing the actual production process and the efficiency of internal resource use on the farm in a manner not so different from the accounting systems used in industrial enterprises.<sup>5</sup>

In agriculture, however, it was not costing decisions in multi-product firms and a managerial grip on ever-growing organizations that was the key problem, but rather how to adapt a growing body of knowledge about local conditions of soil, climate and market access in a way that gave the possibility of profiting more from the increasing national and international market integration which took place from at least the 1840s, with the resultant increased access to international markets for inputs and outputs. Contrary to what is described as having taken place in industry (Johnson and Kaplan 1987, pp. 19-23), in the case of agriculture few external transactions were internalized. Rather, decisions had to be taken as to whether primary products (such as grains) were better sold directly or processed on the farm (by feeding to cows or bulls to obtain

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<sup>5</sup> Such as the double-entry accounting system devised by the agronomist Albrecht Thaer (1806) in Prussia, according to its author motivated by empirical scientific interest as well as managerial concerns (Lampe and Sharp forthcoming). See also Tribe (1978, pp. 64-79), who traces the change from a moral economy behind farm cultivation to a logic of 'production units' especially through the writings of Arthur Young.

manure, milk, butter and meat), how to increase the value added and to improve the production of the land (through better fertilizing, more grain output, etc.), and whether buying and incorporating external resources ('artificial fertilizers' such as guano and feed concentrates for example) and technologies made sense.

As our evidence only concerns a limited part of the total farm operations, it is probably not suitable for testing the Marxist interpretation of the rise of modern accounting practices. When examining the evidence, we will pay as close attention as possible to the question of whether accounting is primarily used to take 'objective' comparisons between alternatives that would encourage an 'economic rationalist' view of the accounts, or whether they are more likely used as persuasion tools that eventually imposed control, discipline and 'self-responsibility' in Danish dairying beyond the economic 'need' for accounting, in a Foucauldian sense. We find evidence for both interpretations, which we do not see as entirely exclusive: The 'rational farmers', fueled by enlightenment ideas, do indeed seem to have been swimming in a similar current as the West Point connection in US railway accounting (Hoskin and Macve 1994, p. 80-81), and they advocated a rather rigid regime of measurement and control. On the other hand, from the very beginning, this was largely focused on management decisions for the production process. Moreover, at least in dairying, the regime of measurement and control, while it was largely required to be performed by – mostly female – workers, was not directed at labor, but at the central capital product in the production process, the cows.<sup>6</sup> In fact, even the individual cow does not seem to have been as much the center of attention as the practices of feeding and breeding at the herd level.

It would therefore be tempting to tell the story of the development of agricultural accounting in Denmark as the rise of 'rational farming': one in which bookkeeping and accounting were used to steer a cluster of 'modern' estates towards productive efficiency and, thus, excellence, developing techniques that would ultimately lead the whole country through the turmoil of the great transformation and specialization that characterizes the nineteenth century, while at the same time establishing the main

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<sup>6</sup> But compare the interpretation by Nimmo (2008) of similar, but government imposed, recording requirements in Britain half a century later.



actors as a (re)new(ed) elite of Danish agriculture. Such a teleological perspective, in which the protagonists seem to have foreseen perfectly the trial and error path of learning that was necessary for success would, however, have an undeniably Whiggish taste (Luft 1997, p. 164, 180). Thus, instead of stressing the eventual outcome, we are more interested in analyzing what we perceive to be the formation of an 'epistemic community' of self-styled rational-accounting practical farmers.

In the standard definition by Haas (1992, p. 2), epistemic communities are groups of academic scholars with a common policy enterprise who share normative beliefs, beliefs about cause-effect relationships, and have the same 'notions of validity' for conclusions. Both denomination and description are closely linked to conceptions developed by Foucault (*The order of things*, 1973) about the creation of a common mindset and the cohesion of discourse. While international relations is primarily interested in the effects of the transnational variety of epistemic community in international organizations and institutions, they can of course also form and act at a national level and, as in our case, in the blurry area between science and practice (Cross 2013, pp. 154-159). We transfer this concept to accounting history because scholars of international relations have been able to isolate the key condition under which epistemic communities gain importance in wider society, namely uncertainty: 'The causal logic of epistemic policy coordination is simple. The major dynamics are uncertainty, interpretation and institutionalization' (Haas 1992, p. 3; also Cross 2013, pp. 144, 151-153).

Uncertainty, in the form of a crisis or a major shock, is a key condition because it unsettles established ways of decision making, and increases the demand for credible specialist knowledge. Such specialist knowledge, a.k.a. scientific rationality, is what epistemic communities share and provide, if they manage to form a cohesive and persuasive discourse (Haas 1992, pp. 7-8, 23; Cross 2013, pp. 147-151). If the issue dominated by the epistemic community in question is salient enough, and the dominance of the group is sufficiently strong, knowledge can translate into power (Cross 2013) and eventually contest and occupy space left by formerly established, 'traditional' elites, a topic that has recently gained interest within accounting history directed at the proper field of accounting (Edwards et al 2013). Moreover, of course,

the use of accounting to achieve group cohesion, to legitimize beliefs, to direct the focus of attention and to consolidate power is at the center of critical accounting theory and history (Funnell et al 2016, 741-2; Roberts and Scapens 1985, 448).<sup>7</sup> Within this framework, we examine below the role of the Danish rational farmers and their presentation and discussion of methods of internal accounting in the three dimensions highlighted by scholars of epistemic communities: uncertainty, interpretation and institutionalization.

Thus, the next section outlines the three-dimensional great transformation of the social context and resultant *uncertainty* which occurred between roughly 1750 and 1850 in most of Europe with links to large parts of the world (cf. Bayly 2004), with a clear focus on rural Denmark: 1. the dissolution of feudalism, 2. the spread of Enlightenment ideas and the rise of quantification and improved measurement in science, public administration and agriculture, and 3. the ‘great transformation’ (Polanyi 1944/2001) from communal, rather isolated production to a national market economy and the emergence of the first globalization, during which agricultural producers fought to supply the growing industrial cities in the United Kingdom in particular. Each of these dimensions were of course intimately linked and created together a renewed need for orientation after the spatial reorganization of Danish villages as a consequence of enclosures of de-communalized farmland, the accompanying social separation and the abolition of old ties of obligations and tenancy between formerly bonded farmers and their former landlords. On top of this came a profound economic and agricultural crisis in the wake of the Napoleonic Wars with falling prices of products and assets.

In section 3 we then present the *interpretation* of the new possibilities developed by a group of ‘rational farmers’ in Denmark from within a broader rural elite, presented through interpretations of their accounts and the solutions and prescriptions they developed. For this we have a particular focus on two major agricultural journals of the

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<sup>7</sup> In the history of agricultural accounting, a similar view of ‘rational farmers’ especially in early nineteenth century France has been taken recently by Depecker and Joly (2015, p. 78), but the evidence examined there is much less specific to accounting than that presented here.

time. First, the publication outlet of the estate-owner dominated Royal Agricultural Society of Denmark, *Tidsskrift for Landøkonomi* (Journal of Agricultural Economics), henceforth abbreviated as *TfL* (Kærgård 2007, Lampe and Sharp 2014), and second, the less elitist, broader-based *Ugeskrift for Landmænd* (Farmers' Weekly, *UfL*). The latter in particular provides evidence of the ever more marginalized dissenting voices regarding practices and the interpretation of figures.

Finally, in section 4, we show how this interpretation became *institutionalized* through accounting guides, teaching programs and periodical surveys of farm accounts in a common format. This marked the spread of what was argued to be 'best practice' by large and small non-estate farmers, in particular through the cooperative creameries as modern dairying spread from the realm of the estates to the medium and small farmer. Section 5 concludes.

## **2. Uncertainty: The great transformation and the need for orientation**

### *The agricultural reforms and the birth of the freehold farmer*

Between the 1760s and the early 1800s, relationships of power and property in the Danish countryside were transformed substantially. In legal terms, this period witnessed greater mobility as peasant bondage to estates was dissolved; the conversion of a system based predominantly on leasehold for most farmers into one of freehold with full-property rights; and peasants also largely freed themselves of labor services to be performed on the demesne as part of rent payments under the traditional system of production and social order. At the same time, demographic growth, and an institutional setting favorable to those now owning middle-size farms in freehold, led to the increase of a class of day-laborers and cottagers working both on estates and for the emancipated farmers (Kjærgaard 1994, pp. 174-177). At the level of the government, estate owners were stripped of their traditional functions as public administrators, tax collectors, military recruiters, and appointees of local judges, teachers and priests. Thus the centralization of government converted the (mostly

noble) estate owners from 'local vice-regents'<sup>8</sup> into large landowners. These developments, mirrored to a certain extent in many parts of north-western Europe, eventually led to a three-tiered distribution of farms: large estates, middle sized farms, and small cottages, the latter of which were only seldom sufficient to make a living from their lands alone.

This period also witnessed economic changes in the countryside, as the large estates introduced new crop rotation systems, which they combined with more labor intensive animal husbandry in order to produce manure and to diversify production (see Jensen et al 2016), probably as a reaction to demographic growth and an ecological crisis in the first half of the eighteenth century (Kjærgaard 1994, pp. 159-61). These improvements were part of a process of bourgeoisification of the large landowners: traditional, quasi-public manors were converted into private villas, the traditional aristocratic style of living receded and estates were transformed into large commercial enterprises. Many landowners converted themselves from public figures involved in politics to something more like private businessmen (Kjærgaard 1994, pp. 231-235), or they were replaced by a new class of merchant-farmers on their estates. Such bourgeoisification occurred all over Europe, and has been linked to the direct cultural impact of enlightenment philosophy (Kjærgaard 1994, p. 235), to the political transformations brought about by the French Revolution and the Revolutionary and Napoleonic Wars (Frie 2007, p. 415), to a fundamental change in the role of the aristocracy as an administrative elite, again tied to the enlightenment (Mokyr 2009), or to new possibilities for monitoring and organizing public administration due to better measurement and monitoring techniques (Allen 2012, p. 77).

Large estates evolved into centers of commercial agriculture and thus became the sort of places where new crop rotations and management techniques could be tested and put into practice both by enterprising landowners themselves, or by 'professional' administrators or tenants (Bayly 2004, p. 427; Schiller 2003, p. 64, 477-495, 504; Mokyr 2009, pp. 183, 191-192). This process could be observed both in the latter decades of the eighteenth century, and, after widespread agricultural crisis in the 1810s and 1820s, again from the 1830s. From these developments in the estate sector,

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<sup>8</sup> Kjærgaard (1994), p. 205, citing Jensen (1936), p. 16.

the goal of providing support for the advancement of all agriculture would emanate<sup>9</sup>, and it at the same time provoked a retreat from politics, since being at the forefront of modern agriculture required a certain dedication, thus leading to the emergence of a 'rational' elite farmer group seeking to provide the recipes for others to follow.

From the 1780s, as the former tenant farms acquired full property rights, a simultaneous enclosure movement took hold, leading to a completely new settlement pattern in most villages as farmers moved out of villages into farmsteads on their newly consolidated holdings. This change from communal systems of open-field cultivation created considerable uncertainty for farmers, who initially struggled to find adequate cultivation systems which might translate their newly acquired property rights into efficiency gains. Some have criticized the farmer class of being more interested in speculation in the liberalized land market than in cultivation (e.g. Kjærgaard 1994, p. 248-249), while others have highlighted the challenges that came with the freedom and responsibility to decide one's own preferred cultivation system in times of rapidly changing markets and eventual crisis (Jensen 2007, p. 148; Frandsen 1983, pp. 255-258), but there is common ground to assume that the productivity of land and labor on the privatized farms grew very little or even receded in the initial phase after the agricultural reforms, and one might even go so far as to style them polemically as a 'millstone around Denmark's neck' (Kjærgaard 1994, p. 251). Making sense of their new freedoms and responsibilities forced farmers to look for orientation and models to follow and adapt to their own lands.

### *The spread of enlightenment ideas and the rise of quantification and a scientific approach*

As noted above, enlightenment philosophy was a major influence on cultural life and self-perception among elites in Europe, and it has been linked directly to the economic transformation of the eighteenth and early nineteenth century. Thus, Mokyr (2009, p. 8) called the British version of Enlightenment 'the mother of all institutional changes',

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<sup>9</sup> In the 1760s, in France, a deliberate program by the physiocratic movement aiming to professionalize agriculture had still failed to find adopters among the dominant landowner class (Girardeau 2010, pp. 228-231).

forming 'meta-institutions' that propelled new ideologies and beliefs into practice in areas as different as politics, science, industry, agriculture and public service: 'the essence of the Enlightenment's impact on the economy was the drive to expand the accumulation of useful knowledge and direct it toward practical use.' (ibid., p. 10). In this, the Enlightenment was not a movement for general and democratic reform, but 'an elite movement, and [...] much of its thinking served class interests. It was an ideology designed to protect private property from the masses and create the conditions for it to expand.' (ibid, p. 39). However, by doing so, it created a set of beliefs aimed at improving society as a whole, following the 'Baconian program' of increasing applicable knowledge and fomenting its application in production. This process was driven by a belief in rationality and efficiency that implied extensive description and quantification of all sorts of social phenomena, to a degree that later raised the suspicions of scholars as regards the underlying mental framework (ibid., p. 44).

The Enlightenment thus led, in Britain and beyond, to an increased effort to collect, organize and systematize existing knowledge, for economic and other purposes. This involved a scientific movement with the aim of greatly improving accuracy and reliability in the measurement of all sorts of phenomena (Mokyr 2009, p. 43; Heilbron 1990a). Allen (2012, p. 8) even claims that the vastly improved quality of measurement between 1750 and 1850 was the actual driver of the whole complex of socio-economic and political transformations, because it led to a different quality of accountability, and thereby made traditional institutional arrangements based on patronage and trust redundant, and a new world of meritocracy and efficiency possible. In such a process, bookkeeping and accounting would, of course, acquire a new social function, and gave those who mastered and determined it a much more central position in society, although neither Mokyr nor Allen prominently mention it.<sup>10</sup> However, most scholars would probably agree with Mokyr that Allen's focus on more precise and comprehensive measurement is too reductionist to explain social change (Mokyr and Espín-Sánchez 2013), and that the rise of quantification and measurement was part of a wider process and met with considerable resistance from vested interests and all

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<sup>10</sup> But, for a detailed historical account in a specific case, see Oldroyd (2007, pp. 188-189, 198).

those not immediately interested in increased efficiency at the cost of old habits (Heilbron 1990b).

Importantly in our context, this involved the idea that politics could benefit from the use of empirical knowledge, in the form of figures or detailed political comparative descriptions and surveys, something that came to be known as ‘political arithmetic’ in eighteenth century Britain and as stat[e]istics in Continental Europe, including Denmark, evolving in the 1820s and 1830s into ‘statistics’ as an enterprise with the purpose of extracting ‘laws’ and ‘lessons’ for politics from numbers (Porter 1986, pp. 18-27; Cullen 1975, pp. 1-15; Westergaard 1932, pp. 136-171, esp. 139). This would eventually converge with developments in other disciplines, including astronomy and applied mathematics into the academic field of statistics we know today, in around 1890 (Porter 1986; Westergaard 1932). The evolution of statistics in the older sense was to a large extent driven by questions of demography and public health, but this was only one branch of ‘what was later to be called “useful knowledge”’ (Cullen 1975, p. 6). It was connected both to scientific quantification in natural sciences, where it sharpened a spirit of diligence, precision and objectivity, but also territorial surveys of geography, customs and population up to the taking of the first censuses in late eighteenth century Denmark and much of the rest of Western Europe from the early nineteenth century (Westergaard 1932, pp. 61, 86; Cullen 1975, p. 12; Porter 1986; Hoppit 1996; Power 2004).

However, accounts of the eighteenth century as well as for the ‘age of enthusiasm’ of the ‘statistical movement’ in Britain and France in the 1830s and 1840s highlight that the link between quantitative ‘evidence’ and the conclusions presented was often rather loose and in no way impartial. Hoppit (1996, p. 531) writes about the rise of political arithmetic in the second half of the eighteenth century: ‘Such debate was, of course, often self-interested and the numbers employed were unreliable if not downright lies – the point is simply to stress the evident willingness, which existed to employ quantification as one weapon in the arsenal of the politician, commentator, lobbyist and projector. It was a valued weapon if not a decisive one.’ Moreover, Cullen (1975, e.g., p. 144) highlights that for the British statistical movement of the 1830s and 1840s, despite the stated non-partisan approach of the Statistical Society of London,

the spearhead of the British statistical movement, the statisticians often disguised their personal agendas and propaganda as facts, and that they did so because they stood in competition with other interest groups in their 'particular bid for control of the dominant value system', although they eventually failed in achieving such dominance (ibid., pp. 147-148).<sup>11</sup>

In Denmark, statistics in its descriptive and its numerical variant was well developed by the early nineteenth century and played a vital role in the process described in the preceding section whereby the central government increased its grip on power at all levels (Kjærgaard 1994, p. 229). In 1760, Pontoppidan published a multi-volume detailed description of the realm, comprising, among other things, topography, geography, estates and agricultural conditions. Population censuses were taken in 1769, 1788, 1801 and regularly from the 1830s after the creation of a 'Tabulation Commission' in 1834 and of the Statistical Bureau in 1850 (Westergaard 1932, p. 139).

In terms of agriculture, Gregers Begtrup, from 1801 extraordinary professor lecturing on agriculture at the University in Copenhagen, published in 1808 a detailed 'statistical' survey of agriculture in Denmark (Begtrup 1808, Boje 2014, p. 152), and subsequently the Royal Agricultural Society commissioned and published a detailed description of agriculture in all counties of the kingdom between 1826 and 1844. Local correspondents were to answer a set of 29 questions (see for example Dalgas 1826 on the county of Vejle), often framed in a way that asked for the relative suitability and profitability of alternative uses of similar agricultural resources. For example, question 18 asked whether milk cows or cattle for fattening were more advantageous, and has to be seen in context with questions 5 and 6, which asked for the prevalent crop rotation, the extension of grassland in comparison to arable and the local conditions regarding barn feeding of cows (with fodder crops). The early nineteenth century also saw the birth of publication outlets for 'enlightened' discussions of all sorts. In the context of agriculture, the main forum was the journal of the Royal Agricultural Society, *TfL*, first published in 1814. From the very beginning, this was the main outlet for a group of intellectual farmers who were dedicated followers of the leaders of

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<sup>11</sup> Cullen (1975, p. 146) cites, as a salient example of this bid for discursive hegemony, a statement from the Fourth Annual Report of the Statistical Society of London: 'Statistical data must constitute the raw material for all true systems of economy and legislation, local and national.'



‘rational farming’, especially Albrecht Thaer in Germany and Arthur Young in Britain. They advocated the most progressive cultivation systems, the variety of Flemish and Norfolk systems with summer barn feeding of cattle described as ‘best’ by Thaer in his works on rational farming.<sup>12</sup>

In fact, already in 1808 the first comprehensive manual on agricultural bookkeeping and accounting was published in Denmark by Carl Frederik Gyllembourg after it had been recognized by the Royal Agricultural Society as ‘the scientific arable farming’s *non plus ultra*’ (Krusius-Ahrenberg 1947, 328-330; Lampe and Sharp forthcoming). Thus, from the very center of the agricultural elite of Denmark ideas of ‘rational farming’ were spread while the agricultural transformation process described above was underway. Nevertheless, their prescriptions only had very limited acceptance among both estate-owners, who preferred the less intensive rotation system of *Koppelwirtschaft* introduced into Denmark from the 1760s (Jensen et al 2016), and among the peasantry, who seem to have largely followed traditional three-field rotations until well into the nineteenth century.

According to standard accounts of Danish agricultural history in the nineteenth century (Hertel 1891, p. 434; Drejer 1925-33, pp. 289-90), however, scientific, or ‘rational’ farming, and with it modern agricultural bookkeeping and accounting, came to Denmark only in the 1850s with Johannes Friis, owner of the small Lillerup Manor near Horsens in Jutland since 1859. Friis had travelled widely in Europe in order to educate himself, and, had visited Albrecht Thaer’s Agricultural Academy in Brandenburg among other agricultural schools, as highlighted in the university lectures of his old friend Thomas Riise Segelcke at the Royal Veterinary and Agricultural School (Segelcke 1891, pp. 64-65, 117, see also Hertel 1891) in the late nineteenth century, who is probably responsible for creating this retrospective accounting of his group’s history and changing role. Although Friis, born in 1832, was too young to have met Thaer (1752-1828) personally, and was not even formally enrolled at the Agricultural Academy, the link to the famous figure in continental ‘rational farming’ provided the story with credibility. It was reinforced by the fact that Friis had been in direct contact with one of

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<sup>12</sup> See Bjørn (1982a, 1982b) for a more detailed discussion of central early contributions to *TfL* such as Drewsen (1817). *TfL* was called *Landoeconomiske Tidender* for the first few years. For the wider context in Denmark see Christensen (1996) and for the European dimension cf. Depecker and Joly (2015).

Thaer's former students in Denmark, Niels Erik Hofman Bang of Hofmansgave, who had set up an agricultural school on his estate, where Friis taught in 1855.

According to Segelcke's lectures, in the first decades of the 1800s, farmers did not keep good accounts, but this changed when Friis acquired Lillerup Manor in 1859 and introduced precise measurement instruments and Italian double entry bookkeeping on his farm. As such, the 'official' story bypassed both the (failed) promotion of Thaer's preferred agricultural system in Denmark in the 1800s and 1810s, Gyllembourg's (1807) celebrated guide to agricultural bookkeeping, the statistical descriptions of Begtrup, a figure connected to Thaer's original circle (Lampe and Sharp forthcoming), and the Royal Agricultural Society's county descriptions led by Carl Dalgas, one of the first students at Thaer's Agricultural Academy in 1808/09. Perhaps the Napoleonic Wars and the subsequent economic chaos cast too long a shadow for many of these events to be remembered, or perhaps a certain inner circle at the Royal Agricultural Society wished to give the honor to one of their own. Nevertheless, we can say with certainty that Friis' innovations did not emerge in a vacuum, and we can also observe that the articles on agricultural accounting we discuss below, with seminal works from the mid-1850s, both pre-date Friis' purchase of Lillerup manor, and contain accounts which stretch back to the 1840s, giving the lie to the idea that he was the first to be interested in accurate accounting.

#### *Market integration, commercialization and the first globalization*

The late eighteenth and early nineteenth century also saw the rise of the market economy at both the national and international level. This happened in the context described above, i.e. the dissolution of communal methods of cultivation, and the decline of patron-client relationships towards a society guided by a laissez-faire ideology of full individual responsibility, and freedom of contracts and property rights (Polanyi 1944/2001). Such a great transformation again involves great uncertainty, in terms of individual living conditions, especially at the bottom of the income and property distribution, and in terms of how actually to use the unfettered resources on the market.

In the nineteenth century, probably the major challenge in a country as small as Denmark was how to integrate agricultural producers, large and small, into international markets. Before the major disruption of the Napoleonic Wars, incipient international market integration had taken place in Northwestern Europe (Lampe and Sharp 2015), but had probably not yet induced profound productive specialization. After 1815, widespread agricultural protection limited this integration process until the 1840s, when the British Corn Laws and many other barriers to international trade in agricultural produce fell (Federico 2012). Thus, from the 1840s there was a sustained increase in agricultural imports in countries increasingly specializing in the production of manufactures (such as Britain) and a corresponding increase in agricultural exports from countries like Denmark, Sweden and Prussia. The resultant market integration was reflected by an increase in the co-movement of prices at the international level, as domestic prices began to reflect less domestic supply and demand, and more world economic conditions (Uebele 2011).

The large Danish landowners noted rapidly that this market integration gave the opportunity to increase sales of agricultural products abroad, although it was less evident whether these should be barley,<sup>13</sup> other grains, or the products of animal husbandry, such as for example live cattle, whose exports had a century-long history but were experiencing decline over preceding decades (Appel and Bredkjær 1924-32, pp. 250-269, Hünninger 2010, p. 79; Drejer 1925-33, pp. 158-63), wool, or processed products such as butter, for which the neighboring Duchies of Schleswig and Holstein were acquiring a reputation on the British market, or cheese. Solid guidance as to what was most profitable to specialize in could potentially bring great benefits in economic terms and in terms of prestige and interpretative power in the countryside, both for individual farmers and for the whole economy.

The difficult decisions Danish farmers faced in the globalizing world of the nineteenth century mirror those that the development economists Hausmann and Rodrik (2003, p. 616) have highlighted for modern day developing countries. As they put it: 'Knowing that Bangladesh's comparative advantage lies in labor-intensive manufactures and not

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<sup>13</sup> Denmark's main export product in the early nineteenth century and up to the 1860s (see Lampe and Sharp 2011).

in high-tech machinery is useful for sure, but that leaves hundreds, if not thousands, of different types of activity up for grabs. The six-digit Harmonized Schedule (HS), which most countries use to assess customs duties, comprises around 5000 different commodity groups.’ They thus advocate a role for government intervention, since entrepreneurs alone are not able to guarantee that they can keep a successful market niche discovery for themselves and will therefore not invest, with the unfortunate consequence that the considerable social returns that might have resulted from successful national specialization might never materialize.

As we will see below, such concerns do not seem to have weighed heavily on the Danish rational farmers, who argued forcefully and publicly for an extreme level of specialization. This is probably because, for the rather rudimentary agriculture we deal with here, production units were rather small and economies of scale did not occur at the level of the individual farm, but rather at the level of the country. If farms were large enough for professional management, however, they could collectively establish a reputation on the national level (Olsen 1957, p. 141-144). In other words, due to the rather isolated location and limited production possibilities of individual farms, imitation by other producers would actually be desirable since it would provide a constant flow of similar products and hence regular market contacts, and give rise to a common reputation for quality. Thus, if a cluster of specialized professional producers of the same products evolved, all of them would benefit.<sup>14</sup>

Thus, for the pioneers, substantial gains in terms of reputation and influence could be gained by forming a specialized cluster of producers. However, it was first necessary to cohesively and credibly argue that the proposed productive specialization would actually be successful. For this, as for the (ultimately doomed) quest of the British statistical movement to gain control of social policy formation, legitimizing propositions in the most credible way was of primary importance. This was not always

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<sup>14</sup> This argument is directly related to one made for small and medium size producers in the case of the Danish cooperative dairies from the last decades of the nineteenth century by Henriksen (1999). There is little direct evidence that economies regarding transaction density motivated individual contributors in Denmark. Nevertheless, evidence from the duchies of Schleswig and Holstein, adjacent to Denmark and ruled by the King of Denmark until 1864, from the late eighteenth century at least, indicates that estate dairies were not afraid of competition on limited markets, but believed that the world market was much larger than could be satisfied by local estate production – see the discussion between Thær and the leading estate tenant Reiche in Thær (1799, pp. 196-7).

easy. For example, Depecker and Vatin (2016) have shown that in the management of cow feeding in France during the early nineteenth century, different currents, agronomic experimentation and chemical measurement, competed with each other. Likewise, we have demonstrated above that the prescriptions of the 'rational farmers' of the 1800s and 1810s in Denmark did not lead to widespread adoption despite influential institutional backing.

However, by the 1850s, the particular combination of circumstances described above had created a need for new orientation knowledge, and this was successfully met by a new generation of 'rational farmers' in Denmark, as shown in the next section. This allowed them eventually to influence the productive decisions of a large number of farmers, to establish themselves as decisive actors in the emergence of a new Denmark and even to influence the historiography of the period in question decisively.

### **3. Interpretation: Dairy accounting and productive decisions**

#### **3.1. Establishing the program of rational farming through accounting**

The new generation of rational farmers are in the traditional historiography somewhat embodied by the person of Edward Tesdorpf, the son of a Hamburg merchant, who purchased the Orupgaard estate on the island of Falster, south of Copenhagen, in 1840. He later became president of the Royal Agricultural Society, and was praised for his contributions in everything from agricultural science to organizing trading links with the UK (Lampe and Sharp 2015, p. 449). His accounts are no exception.

As mentioned above, Denmark had a vibrant scientific press, for agriculture most importantly the two journals *TfL* and *UfL*, and it is largely these which we turn to in order to trace the origins of accounting as a means of promoting production decisions, with a seminal contribution being an article reporting a speech by Tesdorpf at the annual meeting of the Maribo (Agricultural) Economic Society in 1856. In this he underlined, using data from his dairies, that early calving and feeding of cows through the winter was profitable in part through the production of pork as a byproduct.<sup>15</sup> This

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<sup>15</sup> In different contributions, Tesdorpf also contributed to a debate which had been emerging before 1860, as the relative prices of dairy products and bacon rose relative to that of wool, concerning

speech was published by the editors of *UfL*, who invited others to provide ‘similar valuable communications’ (Tesdorpf 1856, p. 85), leading first to a reaction by another estate owner, Adolph Valentiner (1856), who published some results of his dairy and comprehensive comments. Tesdorpf then provided some of the in-depth information requested by the editors of *UfL*, first with an article by his administrator, Buus (1858), who reported detailed information on Tesdorpf’s estate Gedsergaard for 1857-58. Tesdorpf (1861) himself then extended these to the production year 1859/60 for Gedsergaard and his main estate, Orupgaard, both situated on the island of Falster.<sup>16</sup>

It was *TfL*, however, and a couple of contributions by Frederik Sehested (1857, 1858), which took the discussion to a different level of exposition, shortly before Friis’ aforementioned purchase of Lillerup in 1859, the traditional beginning of modern agricultural accounting in Denmark. Sehested incorporated majestic tables that contributed two new insights: first, an exposition tracing the use of all the milk given by the c. 125 cows on his estate, Stamhuset Broholm near Svendborg on Funen, for 1856 and 1857, into all the direct uses on the farm through human consumption, feeding of animals and the production of butter, milk and cheese that were consumed and sold.<sup>17</sup> His motivation for so doing was stated clearly. His accounts gave ‘rise to various questions and give the possibility of various alternative configurations, in addition to those which are needed in order to make the following comparisons... This remark does not preclude the opinion that the accounts in several ways could have been better.’ (Sehested 1857, p. 143). He in this way describes the role which he believed accounting could play: his accounts could answer concrete questions, and they could also give rise to new questions. More important, however, accounting provided a flexible framework that could answer a multitude of other questions.

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whether to keep sheep or cows, and concluding in favor of the latter (Larsen 1924-32, pp. 611-4) – an important first step on the road towards specialization in dairying. To keep the present article focused, we have to exclude such further strands of inquiry.

<sup>16</sup> Much of the information on physical outputs from the 1840s for Tesdorpf’s estates, especially Orupgård, is preserved in the regional archive for Zealand and surroundings, in part in handy time series (*Landsarkivet for Sjælland m.m., QA-257 Orupgård Gods, Statistik over høst, mejeridrift og fårehold 1849-1904*), where also further accounting documents for those estates and some others have been preserved.

<sup>17</sup> The handwritten manuscript versions of these tables are also preserved in the Danish National Archives (*Landsarkivet for Fyn, QB012, Stamhuset Broholm, 18/267, Diverse Mejeriregnskaber mv 1816-1887*).

Some detail will serve to illustrate the precocity of his work. Thus, in 1856, Sehested states that of 95,542 cans (of 1,92 liters) each of milk given by the cows, only 6,818 (7%) were consumed directly in the manorial household and by calves that were fattened for slaughtering and those raised as future cows in production. The rest was skimmed of its cream, which was consumed directly in the household and by animals (586.25 cans) and converted into 10,352 *pund* (of 0.5 kg) of butter, partially consumed in the household and by animals (23 percent) and mainly sold on the market at a price of 0.41 *Rigsdaler* per *pund*. The volume of the butter accounted for 3,268 cans, or 3.4 percent of the volume of milk produced. Therefore, in the process of skimming, 84,870 cans of liquid must have remained. 7,084 of them were buttermilk, left over after churning the cream into butter and fed to pigs. Logically, the rest must have been skim milk, although Sehested could only directly account for 74,354 of the theoretical 77,786 cans: 2,523 cans were used in the manorial household, 156 were given as donations, 558 were used in the manor's brick factory, 2,310 were given to calves to be used as future milk cows, 7,694 went to pigs, and 11,135 went to other animals. 46,955.5 cans were used for making (skim milk) cheese, leaving 38,833 cans of whey, which were again fed to the pigs. The 'missing' 10,516 cans of liquid entered his accounts as milk evaporated while waiting for the cream to separate before skimming, as a standard share of 4 percent (3,549 cans) and as 'other (of which no account can be given)' (6,967 cans), and for which he gives a long footnote with potential explanations, and whose share in total liquid he managed to bring down from 7.3 percent in 1856 to 5.2 percent in 1857 (Sehested 1858).

Sehested also provided a handy summary for the reader that omits some of the production concepts and focuses on the main products of the farm: of the volume contained in 100 cans of milk, 3 percent were embodied in butter; 9 percent in skim-milk cheese; 9 percent in buttermilk and 75 percent in whey (both fed to pigs); and the remaining 4 percent had evaporated. Since he knew the average values of the products sold (minus additional inputs used in pig feeding), he could calculate that 100 cans of milk brought him on average 7.73 *Rigsdaler*, of which 5.08 came from butter, 1.68 from skim milk cheese and 0.97 from the buttermilk and whey fed to pigs. He also calculates the value of the 16 calves that he fattened and sold alive and slaughtered in order to calculate the value of the 3,063 cans of full milk invested into cattle fattening,

arriving at a value of 0.047 per can of milk, significantly lower than the value obtained in dairying.

His main interest was to use his accounts to assess the effect of feeding concentrates on the milk and butter output of his cows as part of a wider discussion on 'strong feeding', that is, the use of grains (mainly barley), oilcakes, etc., to improve milk yields and the production of pork as a byproduct, mainly through the improvement of the cows' nutrition over the part of the year when outdoor grazing was not possible. To do this, he used the total values of income produced and deducted from his actual expenses for wages, energy and basic wear and tear, and calculatory expenses for feedstuffs he produced himself (Sehested 1857, pp. 131-133). This led him to a 'net earnings' figure, which he relates to the amount of land used by the cows for grazing in summer *tønde land* (0.55 ha), which can be understood as the land's contribution to production or the cows' contribution to the maintenance of the fertility of the grasslands as manure. Hence the 'net earnings' could also be calculated per cow, as the 'fertilizer-value of the cow'. This way of calculating implies that minimizing the deficit (and the manure price) of the cow could be achieved by maximizing the value of other outputs of cows, on which the subsequent discussion is centered.<sup>18</sup> The ultimate question was hence whether the additional cost of concentrates would lead to an at least equal increase in the output values of cows, thereby producing manure at lower costs. This logically required comparison to understand how additional feed translated into higher output and hence larger revenue – a question where comparative accounting could solve questions that chemists were struggling to solve convincingly (Depecker and Vatin 2016).

Sehested's contributions led to a reply by Valentiner (1858), who praised his way of obtaining calculatory values for products whose prices could not be observed, but criticized Sehested's principal interest in quantities of output. He argued that Danish farmers should not forget that, apart from maximizing total production, they would also need to be able to sell their produce at the best possible price. Thus he writes that

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<sup>18</sup> This is different from the accounting schemes presented by Thaer (1806), which introduce a separate pro-forma account for manure, which is valued at a 'natural cost-price' and credited as production to the cows. This reflects the different interests of Thaer and Sehested. While Thaer wanted to maximize fertilizer for grain production (see Lampe and Sharp forthcoming), Sehested seems much more interested in the marketable non-manure products obtained from milking the cows.



‘monetary return is the final and only result that can reveal a farmer’s profitability. We farmers have the task of first producing the greatest possible amount of the raw material, then making it into the best possible commercial product, and finally to sell this product in the best way possible; the man who does this best is the best farmer’ (Valentiner 1858, p. 349). In *UfL*, an anonymous contributor ‘m- e-’ (1859) also provided some additional calculations in order to ‘provoke a discussion’ on how to value milk via its marketable products. Thus, the final link in the accounting chain was made clear: Sehested had argued that accounting was necessary for decision making. Valentiner made it clear what decision needed to be prioritized: what later economists would present as the cornerstone of the rational economic behavior of firms, profit maximization. In so doing, he echoed the work of Gyllembourg half a century earlier. The difference this time was, however, that his arguments had tremendous traction. Thus, responding to Sehested’s request for others to submit their accounts, his contributions were followed by many more, in part to provide comparisons, although most of these do not allow for the detailed assessments pioneered by Sehested. Some of these contributions, however, contained figures reaching back into the 1840s, illustrating that records had been kept before and signaling participation in the emerging ‘accounting movement’ by a range of actors, an early example of which was posthumously provided by the forester Bjørnsen (1857, 1859), published by the editor because he believed it demonstrated ‘how large a return a small dairy can give if it is managed with expertise and skill’. Then, just one year later, the estate owner and politician Jørgen Henrik Theodor Hasle reacted to several accounts published in both *TfL* and *UfL*, ‘which more than I have read with great interest’. He requested permission to present the accounts in *UfL* from the Rosenlund estate on the island of Lolland, where he considered the tenant farmer to be particularly successful, and thus ‘it would please many to see an excerpt of his dairy accounts published’ (Hasle 1858, p. 585).

Of particular interest for revealing the link between dairying and science are a couple of articles published in *TfL* by Peter Berend Feilberg (1835-1925) who was (together with two others) the first to complete a two year education in agriculture and engineering at the College of Advanced Technology in Copenhagen (now the Technical

University of Denmark), which he followed with practical experience in Holstein, later becoming an expert in the drainage and cultivation of lakes (Pedersen 1979-84).<sup>19</sup>

Feilberg provided eloquent statements of the emerging paradigm, writing in his first contribution that one should strive to 'oppose damaging effects, to detect and correct mistakes, to record a simple new idea, and that the truth and interest in it that is awoken is in and of itself rich dividends' (Feilberg 1861, p. 321). This was almost an exact restatement of Thaer more than fifty years earlier (Thaer 1806, p. 623). Then, in his second article he noted that it is difficult to compare different dairy farms without 'detailed accounts', and that it is 'not enough that the farmer carefully notes how much butter and cheese that is sold; he ought also to demonstrate a similar accuracy in the entry of the material of which the sold items are produced, and what otherwise might have an influence on production. Praxis would then lay a foundation on which theory could be built, in that it would be possible through the volume of special observations to display ordinary experiences, link them to science, and thus find teachings, the application of which could be advantageous and successful in the practical life' (Feilberg 1862, p. 263). In a similar vein, Baron Zytphen-Adeler (1863), who had acquired his title by converting his lands around the medieval castle of Dragsholm into an entailed estate in 1843, explicitly stated that he hoped that by publishing his accounts others would find something they might wish to imitate, and that this might inspire them to publish 'which daily procedures and accounting they use, and thus by comparison obtain a better result' (Zytphen-Adeler 1863, p. 377).

Alongside this, over the 1860s, Tesdorpf (1861, 1867, 1868, 1871), who was by then president of the Royal Agricultural Society, continued to report and interpret data from mainly Orupgaard and Gedsergaard, going back to the early 1850s. Using this data, his administrators advanced the discussion in key articles motivating economic decisions, especially regarding the relative productivity of milk/butter production and cattle fattening/beef production in those years. Thus, Buus (1866c) contrasted two 100-animal herds specialized in dairying and beef production, respectively, which were

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<sup>19</sup> In later justifications of what was to emerge from this process as the 'modern training of agronomists', he was named by Segelcke (1867, p. 8), alongside Buus and two others, as an outstanding example of the benefit to be expected from such training, in defense against traditionalist critiques.

modeled on Tesdorpf's estates Gedsergaard and Frisenfeldt, respectively. He made various improvements to Sehested's early methodology, including 'amortization' of 6 percent per year on the inventory (instead of basic wear and tear), including stables for pigs and dairy equipment, and calculating an annualized value of the grassland. He also assumed that dairy cows are only 'in production' for ca. 4 years, so that each year 'capital reinvestment' in cows had to be made to keep the herd size constant.<sup>20</sup> Converting everything into fertilizer-value, he found that fertilizers from beef production were much more expensive than from dairy production. In 1873, Fenger (1873) returned to this issue, updating Buus' data, but again confirming that, at least on Falster, beef production was much less cost effective than dairying.

In a contribution to *UfL*, Tesdorpf himself (1866) incorporated new circumstances into the framework pioneered by Sehested, this time discussing the outcomes of five years of using 'artificial fertilizers' (guano and calcium phosphate from Chile saltpeter or crushed bones) on his estates, especially Orupgaard, on the output of grain, and the resulting higher milk and pork yields from the much increased grain feed for cows and pigs. He hence advocated the adoption of these new inputs. In the early 1870s, he (Tesdorpf 1874, 1875) used his accounts to examine the choice between the (then traditional) 'bøtte' system for cream separation in butter making, whereby large shallow bowls were used, and the emerging water dairy system (later superseded by the cream separator), which allowed for the cooling of the milk and a more rapid separation of the cream in taller containers which took up less space. He found evidence clearly favoring the new system, which was more expensive but yielded higher net revenues.

Thus, over a time span of less than twenty years, almost all important debates regarding the productive specialization in Danish dairying and other farm activities surrounding it were settled by examining the detailed accounts for material flows on landed estates. Farmers could learn that dairying was more profitable than meat production, that modern methods of cream separation were superior to traditional forms, and, above all, that recording, bookkeeping and accounting were the technologies necessary for understanding and transmitting what was happening on

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<sup>20</sup> Sehested had directly included the costs of feeding the calves to be used in production later on, apart from giving the newborn calves an initial value of 2 *Rigsdaler*.

individual farms. Thus a group of progressive estate owners advanced the program of 'rational farming' through accounting within the major publications of Danish agriculture. In fact, an interesting point about the later compared to the earlier contributions is that it seems that it was no longer necessary to argue for the importance of accounting, at least to the readers of the two journals, or to beg for others to send in their accounts. This had become the accepted norm.

### **3.2. Contesting contents, accepting rationales**

How this program succeeded in establishing accounting as a way to argue, and how consensus on the presentation of accounts was formed through discussion, can be seen through a discussion in *UfL* that involved an exchange between several estate and dairy tenants and leading experts in 1861, going back to the 'net revenue' figures published in the articles discussed in the previous section. The starting point was a piece by Niels Erik Hofman Bang (1861) on the conditions of tenants in Denmark which contributed to a more general discussion on the issue. Hofman Bang claimed that while estate owners could generate net earnings of about 70 *Rigsdaler* per cow, tenants often had to content themselves with much less, 20-25 *Rigsdaler* per cow, even in years with sufficient rain (and hence abundant grass). The published results of estate owners could thus, for different reasons discussed by Hofman Bang, not serve as the basis for rents payable by tenants.<sup>21</sup>

In response to Hofman Bang, an anonymous 'Forpagter K' [Tenant K] (1861) claimed that he had been able to obtain more than 42 *Rigsdaler* per cow, and was convinced that one could do even better, in the same way as grain yields with best practice were increasing constantly. One of the things he highlighted, apart from the dairy installations and the quality of the herd, was the positive impact of early calving on milk yields, an insight he obtained from his careful weekly records of milk yields. This

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<sup>21</sup> By this, Hofman Bang essentially provides a follow-up to a discussion that Thaer (1799, pp. 192-3) had had with one of Holstein's leading estate tenants, a Herr Reiche, who had decided to administer his dairy directly with a female dairyist in charge, instead of leasing it to a dairy tenant, as had been the case before. In the case of Reiche's Rundhof estate near Schleswig, net earnings per cow, as shown in Reiche's accounts for 1796, had increased to more than 21 *Rigsdaler* per cow, an increase of 80.4 percent in relation to the estate income from renting out cows at 12 *Rigsdaler* per cow. Reiche underlines that a dairy tenant could not have made the difference in profits due to a chain of incentive problems that created a worse equilibrium in terms of feeding, grazing and management of the herd, partly due to incomplete contracts and partly due to the limited duration of leases. Hofman Bang (1861) presents similar and additional arguments.

triggered a series of short, partly anonymous contributions, which in part doubted the accuracy of K's results, and in part asked for clarifications, which K quickly provided. A contributor named 'W.' (1862) found K's income from pork production (some 25 percent of gross earnings) to be very high, and also asked whether land for grazing and hay-making had been taken into account. Based on this 'm- e-' (1862a), inquired more on the general rotation and grass use of K, as well as milk to butter ratios and the assumptions behind K's feed grain and meslin price estimates, since the assumed wheat price seems to indicate very bad quality, to which K replied that mostly barley and oat meslin was fed to the cows.

In a second contribution (m- e- (1862b)) he used the results published by Tesdorpf (1856), himself (m- e- 1859) and data disclosed by K in the meantime to put K's pork production into comparison (without revising his overall calculations, since all figures had been included already in some form in K 1861). He showed that K's net earnings from pork production were considerable at 10.36 *Rigsdaler* (corrected by the editors in a note to 10.51), but still somewhat below those of m- e- (16.75) and Tesdorpf (12.35). More questions were posed by Dalgas (1862), and K's answers serve to teach about the milk yields of his cows in summer and winter, and to provide more details on feeding and the land at his disposition.

'En gammel Mejerimand' [An Old Dairyman] (1862) followed in a similar fashion. He added a few items which should have been taken into account as costs, such as taxes paid for grasslands, cows and dairy implements, and potential insurance premia for the latter two, heating and lighting of the dairy installations and the barn for feeding and milking in winter as well as salt and butter coloring. Taking these into account, the Old Dairyman stresses, he made never more than 26 *Rigsdaler* per cow. K (1862) once again replied to these comments, and defended his calculations. He highlighted that heating for example was provided from the hedges that enclosed the fields he used, and that taxes etc. are normally included in the lease rent and not separately given. He also highlights that he had not taken into account the additional manure produced thanks to feeding grain to his cows, and that some of his dairymaids also worked on the estate when not handling milk.

In a longer piece, Hofman Bang (1862) aimed to put the discussion into perspective. Although he expressed his approval of using accounting information to discuss

fundamental social and economic issues, he was not convinced that K's data disproved his initial claim. He countered by giving his own accounts from different leases of large dairy units (above 180 cows) in 1842-49 and for some years in the 1850s, which showed average net earnings of 10.60 *Rigsdaler* per cow in the 1840s and between 19 and 20 *Rigsdaler* in the mid-1850s (id., p. 224-5). His accounting practice, however, deviates somewhat from K's rudimentary accounts in that he explicitly includes changes in the appraisal value of the herd over the year into his accounts. He blames bad grazing, loss of cows, a bad barn, warm milk cellar and 'very simple' milk cows for the low results in the 1840s, and takes these numbers, in comparison to the good conditions underlined by K (1861), back to the general discussion on the situation of dairy tenants. Here he highlights that an outstanding profitability, even if revised downwards, does not disprove his point, since K seems to have been enjoying many of the favorable conditions whose general absence Hofman Bang (1861) aimed to address. He also underlined that the accounting information presented in the current discussion was highly biased, since few dairy tenants would go through the pains of consolidating their records into publishable summaries (Hofman Bang 1862, p. 227). This would lead to a double bias: records were probably better for more able tenants, and good results would be overrepresented. He thus called for more data, and also compared the average situation in Denmark to that in Mecklenburg, where often no tenants could be found due to unprofitability, and in England, where long-term leases had created much better average conditions which should serve as a model for Denmark.

Although the discussion remains inconclusive and highlights certain institutional problems in the estate dairy sector, it illustrates very well how not just leading dairymen, but wider circles took part passively or actively in the discussion, which also resonated in *TfL* and the Swedish *Tidskrift for svenska Landtbruken* (see notes to Dalgas 1862, p. 268) and thus transcended the pages of *UfL*. While the discussion was centered on the profitability of dairy leases, many authors give at least equal weight to other questions on individual aspects such as the profitability of pigs (m- e- 1862b) or the question of whether an additional amount of feed grain should better be given to cows to increase milk yields or to pigs to enhance the quantity of byproducts (Dalgas 1862). The shape of the discussion also reflects an increasing interest in comparison in

order to assess systematically the sources of high and low net earnings based on use of feed and grazing, length of leases, cow breeds and complementarity with other animals, mainly pigs and sheep, and beef production (Hofman Bang 1862). In this sense, the discussion contributed to shape the debate on acceptable ways of calculating net earnings and included a renewed call for publication of accounts of dairy units of various sizes and with varying practices under different institutional and geographical circumstances.

As can be expected, the discussion intensified and ramified even more in later years, both in *UfL* (Wassard 1864, C.I., 1864, Buus 1866a, Den Alsiske Landboforening 1866) and *TfL*. For example, a discussion in 1868/9 focused again on feed based on intensive exchange of accounting results (Ræder 1868a, 1868b, 1869a, 1869b, 1870, 'L.' 1868, '33' 1868, 'En Forpagter' 1868a, 1868b, Horsens Landbrugsforening og Thyrsting-Vrads Herreders Landboforening 1869, Schroll 1869, Fenger 1869), which had a follow up which directly addressed the role of accounting in agriculture and how to establish best practice (Ræder 1875a, 1875b, Schroll 1875, 'En Forpagter' 1875). And again, some tenants, administrators, estate owners and ordinary farmers published their dairy accounts to allow for comparison in all directions (Buus 1865, 1866b, K.H. 1865, H-- 1869).

#### **4. Institutionalization: Teaching accounting and providing benchmark surveys**

##### **4.1. Teaching accounting**

Parallel to the widening of the circle of participants in the public discussions on accounting, the aforementioned Thomas Riise Segelcke, who, after extensive studies in Denmark and around Europe, including a visit to the famous Rothamsted Experimental Station in the UK, and some practical experience in Denmark, had become the first official dairy consultant to the Royal Danish Agricultural Society in 1860, published a series of articles in *TfL* between 1862 and 1866. In these, the enthusiastic supporter of the importance of a scientific approach to agriculture explained how to produce good quality butter (Bjørn 1982a, p. 32). The most salient of these is probably his 3. *meddelelse om Mejerivæsenet* ('Third communication on dairying'), published in 1865, in which he argued for a reform of work practice in dairying. Like Friis, he stressed the importance of the use of scales and thermometers, and of keeping accurate records

(Drejer 1925-33, pp. 289-90). Despite some conservatism in his thinking,<sup>22</sup> his role in promoting good accounting practice is undeniable. Thus, in an article in *UfL* on 'The education of young farmers, as it is now and as it ought to be', provoked by a series of articles on the same topic, Segelcke railed against 'tradition, the power of habit' and argues for the importance of a theoretical approach to agriculture, including the use of accounting, blank books for which he provided for his students (Segelcke 1867).

In his later lectures at the Agricultural College (Segelcke 1891), by which time such discussions were long-settled, he again highlighted the practical importance of pre-prepared blank accounting books for the ordinary farmer, which they simply had to fill in, especially the *Prøvemælningsbog* ('Sample milking book') published in 1864 by *Kammeraad* Andersen, which contained one page for each cow per month (ibid., p. 60). In close cooperation with other reformers, Segelcke published several of these blank books from the 1860s, for example Tesdorpf and Segelcke (1862), who reproduced weekly accounting tables used on Tesdorpf's estates, and the *Mejeridagbog* ('Dairy Journal') and *Mejeritavler* ('Dairy Tables') he published jointly with Friis (Friis and Segelcke 1866, 1870-74), as well as Segelcke's *Mejerilærlingen* and *Optegnelsesbog*, a record book for dairy apprentices with introductory explanations (Segelcke 1872, Friis and Segelcke 1870). Other shorter versions were published by other authors (Segelcke 1891, pp. 64-65), and we found many of these reviewed in *UfL*, alongside more extensive accounting guides.<sup>23</sup>

In 1874 Segelcke became the first permanent lecturer in dairying and agricultural accounting at the Royal Veterinary and Agricultural School in Frederiksberg, close to Copenhagen, which had been established by law in 1856 as a continuation and expansion of the Veterinary School created in 1773. In 1892 he was promoted to professor. Through his lectures, he was in a key position to spread the message of accounting and rational decision-making to future generations of dairy managers as

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<sup>22</sup> Unlike Friis, he at least initially did not believe women were capable of keeping accurate accounts (Bjørn 1982a, p. 28).

<sup>23</sup> A selection is: *Praktisk Anviisning til Regnskabsføring for Landmænd* (*UfL* 1860/II, p.57). A.P., Bromander, *Bogholderi for Landbrug og Naeringsdrivende overhovedet* (originally in Swedish; *UfL* 1861/I, p. 145), and then in the 1870s: A. Svendsen and C. Christensen, *Mælkeri-Regnskab* (for teaching at Tune Agricultural School; *UfL* 1875/I, p. 287 and 1877/II, p. 575); L. Friis, *Tabel for Omsætning af Hvede, Byg, Rug, Havre og Smør, beregnet fra Kroner og Øre pr. 100 to til Kroner og Øre pr. Td.* (*UfL* 1875/II, p. 263); T.v.d. Goltz/C.G.V. Ræder, *Den landøkonomiske Bogføring* (*UfL* 1877/I, p. 660); S. Hansen, *Tabeller for Mejeri-Regnskab* (*UfL* 1877/II, p. 109); A. Svendsen, *Regnskabsbog til Optegnelser over Køernes og Svinenes Fodring* (*UfL* 1878/I, p. 674).



the sector grew quickly through the emergence of specialist creameries not just on the estates, but for a wider sector of the small- and medium-sized farms through the cooperative movement (Bjørn 1982a, Henriksen 1999).

Several versions of notes on his lectures on agricultural accounting have been preserved in the library of the former Royal Agricultural and Veterinary School, those taken by his student Niels Larsen in 1891 being probably the most readable and comprehensive (Segelcke 1891).<sup>24</sup> They extend to 143 pages that cover all aspects of accounting for agriculture such as its history abroad and in Denmark, theory and practice, establishing, as we noted above, the protagonism of Friis and the rest of his group in the process. This can for example be seen when he discusses some of the main contemporary issues, especially whether or not to use double-entry bookkeeping: According to Segelcke (1891, p. 92) Friis had promoted double-entry bookkeeping while Valentiner had printed books for promoting his version of single-entry bookkeeping (*ibid.*, p. 92) and Buus had advocated a combination of both (*ibid.*, pp. 96-100). Segelcke's personal opinion seems to have been that double-entry need not be too demanding, since it was even used in England and Sweden, where, in his words, they did not care so much about accounting (*ibid.*, p. 100). He also treated old discussions as to the difficulty of putting values on certain non-marketable inputs and outputs, such as hay and manure (*ibid.*, pp. 96, 111-12).

Under the guidance of Segelcke, the Royal Danish Agricultural Society's new dairy consultant from 1886, Bernhard Bøggild, who became Segelcke's successor as professor of dairying and agricultural accounting after his death in 1902, was to publish a series of books explaining to cooperative farmers how to apply this knowledge, including that on accounting, to their activities (Bøggild 1886, 1887, 1889, 1891). These books were reissued several times until well into the First World War. His advice regarding bookkeeping as a necessary part of an agricultural education became more specific over time, starting with a general statement that 'record keeping and accounting must of course be practiced from the beginning of the apprenticeship' (Bøggild 1886, p. 23) and explaining the importance of having not simply dairymen

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<sup>24</sup> Some of the materials Segelcke used to illustrate his lectures, including empty account books, have also been preserved at the library of the Royal Veterinary and Agricultural School, which is now the Frederiksberg campus of the Faculty of Natural and Health Sciences, University of Copenhagen. See Segelcke (1877).

competent in making butter, but also in bookkeeping (Bøggild 1887, p. 57), to explaining that apprentices should be taught accounting for two years (i.e. throughout their apprenticeship) and giving specific details as to how accounts should be kept (e.g. Bøggild 1889, 1899).

This focus on accounting also spread to other agricultural schools, such as Ladelund, founded in 1879, with the first education for dairymen in Denmark established in 1887. There, over 25 percent of the teaching was initially devoted to accounting, although this fell to around 14 percent in the early twentieth century (Bjørn 1982a, pp. 182-83).

#### **4.2. Providing guidance: Survey accounts and 'official' interpretations**

From the earliest contributions by Sehested (1857) or Hofman Bang (1862) it had become clear that accounting could only be really useful for farm management if some meaningful guidance existed as to when a result was good or bad, or which results could be expected under prevailing market and institutional conditions, with certain breeds of cows or under given practices of feeding and milk processing. From 1876, *TfL* started to publish a regular and standardized series of accounts from dairy units of different sizes all over Denmark. In the first attempt regional accounts were gathered and separately published for 1876 and 1877 for the regions of Zealand (Valentiner 1876, 10 farms), Funen (Schroll 1876, 12 farms; Schroll 1878, 17 farms), Lolland-Falster (Bockelmann 1877, 16 farms), Jutland (Winkel 1877, 15 farms; Winkel 1878, 24 farms) and northwest Jutland (Leegaard 1878, 9 farms). From 1879, this work became standardized and summarized for all of Denmark, initiating a regular series of articles called 'Mejeribruget i Danmark' with Winkel's (1880) survey of the accounts of 28 farms for the 1878-79 production year. Winkel also edited the report for 1880, after which Christian Sonne took over until the 1884 report published in 1885. From then, Bøggild was in charge of the report until well into the twentieth century.

Individual farms would keep similar accounts, for example via the blank books and similar forms promoted by Segelcke and others, and could thus compare their own decisions and accounts to those given there, and might be convinced to change their method of farming. For example, from 1878-79 we find printed tables in the archives of the Basnæs estate (located in West Zealand), which serve to record and consolidate annual records on dairying and assess productivity and efficiency in milk, butter,

cheese and pork production in a way that is compatible with the published tables in *TfL*.<sup>25</sup>

In a similar vein, the weekly journal of the association of dairy technicians, *Mælkeritidende*, founded in 1889, continued the tradition of publishing accounts on their pages, although initially in a much less systematic fashion.

### 4.3. External validation

The care with which accounts were kept in Denmark was recognized by foreign observers as early as 1866, when John Wilson, Professor of Agriculture at the University of Edinburgh, reported on agriculture in Denmark in connection with the Agricultural Exhibition held in Aarhus that year (Wilson 1867), with a clear bias towards the epistemological community portrayed here. Wilson praised the accounts of Valentiner's Gjeddesdal estate as 'kept with scrupulous exactitude, even to the smallest details' (ibid., p. 63). 'Mr. Tesdorpf, like Mr. Valentin[sic, -er], believes in the importance and value of strictly-kept 'Farm Accounts,' and can turn to his 'ledger' and give the debtor and creditor statement in produce as well as in cash returns, of every department of his farming since he came into possession of the property.' (ibid., p. 65) '... [His] statement of the dairy returns... not only testifies to the care and exactitude with which the 'Farm Accounts' have been kept, but also gives an analysis of the dairy returns of a farm for a longer period, upon a large scale and with a greater minuteness of detail than has ever before been published' (ibid., p. 67).

Moreover, he poured scorn on the 'rule of thumb' used in the UK, comparing it with Denmark where 'a philosophic treatment, based on sound scientific principles, is the rule and not the exception'. He recounted an episode when Friis showed him his accounts, and he explained how he doubted dairy maids would be able to implement such a system in his country. Friis replied that:

'... on first showing it to his own head dairymaid she burst into tears, and continued in a very distressed state of mind for a full week afterwards. As she

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<sup>25</sup> *Landsarkivet for Sjælland, m.m., QA010, Basnæs Gods, Mejeriregnskabner 1878-1899*. Since none of the anonymous data surveyed by *TfL* in this or subsequent years matches with the archival information for Basnæs, we can assume that those accounts were not standardized just for *TfL*. In Henriksen et al. (2012) we could without problems incorporate the data for Basnæs into a comparative database based on the *TfL* sample.

regained her composure, a few figures were seen chalked on the board; these rapidly increased, until they reached the last column, when she acknowledged freely the value of the daily details, which testified to her own skill while recording her dairy returns, and declared that she would never take the management of any other dairy unless she had the comfort and protection of a similar arrangement. From that day the success of Messrs. Friis and Segelcke's 'Dairy Register' was assured, and it is now finding its way into all the best dairies of the country' (Wilson 1867, pp 75-76).

Later, a series of reports by H.M. Jenkins, the head of the Royal College of Agriculture in Cirencester, heaped similar praise on the standards of Danish dairy accounting. For example, that '[Tesdorpf's] books have been kept with scrupulous care and minuteness' (Jenkins 1876), and that the 'dairy records kept on three farms in the Island of Fyen... [illustrate] the care and accuracy with which the accounts are kept on Danish farms, and especially Danish dairies' (Jenkins 1882, p. 29). He also notes that it was common for the farmer's wife to keep the books, rather than paying clerks, as was apparently the norm in the UK (Jenkins 1882, p. 34), although his example was the rather remarkable Hanne Nielsen of Harvartigaard, who was in fact more the entrepreneur in an enterprise which invented many new types of cheese, finding a ready market in her little, royally endorsed, shop in Copenhagen.<sup>26</sup>

## 5. Conclusion

We have demonstrated how modern accounting emerged in Danish agriculture through the activities of a group around Tesdorpf, Valentiner, Friis, Buus and Segelcke<sup>27</sup> who, by the 1880s, had successfully spread their agenda of dairy accounting and 'rational' agriculture. This epistemic community took hold during a period of uncertainty generated by changes both at home and abroad, which provided a very different environment to that in which similar attempts had been made half a century earlier. They interpreted their accounts in order to provide prescriptions for others and solutions, which we observe in particular through the pages of the agricultural press,

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<sup>26</sup> Segelcke was so impressed with Hanne Nielsen's accounting, that he published a book for accounting based on her system, including of course a section for cheese (Segelcke 1870). He did, however, explicitly not endorse her (as a woman) to be admitted to the Royal Agricultural Society and asked her to stop applying (Fink 2009, p. 447).

<sup>27</sup> Sehested died in 1882.

thus establishing 'best practice'. Finally, they institutionalized this through accounting guides, educational establishments, and periodical surveys of farm accounts. Accounting was therefore both shaped by external needs, and instrumental in shaping its own environment.

In our analysis, we observe that through all the accounts by the rational farmers runs the conviction that record keeping and modern accounting practice was key to agricultural progress, whatever that meant at any point in time. The group was proud to spread their achievements within Denmark and abroad and to highlight how this helped to spread rational choice in general. As such, they presented themselves as creators of a modern dairy industry and as the embodiment of the reorientation of Danish agriculture in general.

The founding fathers were however to be eclipsed in later historical accounts by another group, since ironically nowadays nineteenth century Denmark is not really known for its rational farming estate owners, but for the cooperative movement that emerged from the 1880s and extended the commercial production of uniform high quality butter to the entire rural sector. The agricultural establishment, including Segelcke and Buus, was initially rather suspicious of this 'bottom-up' movement of farmers and had advocated a similar, more 'top-down' project of privately-owned 'community creameries'. Notoriously, the chairman of the dairy committee of the United Jutland Agricultural Associations (and member of the board of the Royal Agricultural Society) commissioned M.C. Pedersen, from the agricultural school Ladelundgaard, to travel around eighteen cooperatives in order to demonstrate their inferiority compared to the 'community creameries', which he had previously reported on.

The earliest cooperatives had of course taken onboard the importance of accounting, with the first cooperative in Hjedding (founded in 1882) devoting two paragraphs of its statutes to rules as to how they should be kept and audited,<sup>28</sup> and the Hjedding statutes were later to be taken as a model for other cooperative creameries. Thus Pedersen was able to compare the meticulous records from the cooperatives and the community creameries, finding that there was no competition (Pedersen 1885; see

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<sup>28</sup> 'Kontrakt for Hjedding Andelsmejeri 1882', <http://danmarkshistorien.dk/leksikon-og-kilder/vis/materiale/kontrakt-for-hjedding-andelsmejeri-1882/>, retrieved November 27, 2016.

also Drejer 1925-33, p. 352). His results then spread through the specialist and general press in Denmark and provided backing to the foundation of further cooperatives. Soon a true 'cooperative movement' developed and took over the position of Tesdopf, Segelcke and others in the future writings of Danish history.

Thus, when the Royal Agricultural Society set up a travel agency to guide the increasing inflow of foreigners interested in Danish agricultural practice, the standard tour featured the Royal Agricultural and Veterinary College, a farm on Funen and two different cooperative creameries (Keillor 1993, p. 76), instead of the estates that had been shown to Wilson and Jenkins. Thus, as other countries attempted to import the Danish cooperative system, they also imported Danish standards of accounting into agriculture, most famously perhaps in Ireland (O'Rourke 2006, 2007; Henriksen et al 2015), but also the United States (Keillor 1993). We cannot however provide a general explanation for the emergence of agricultural accounting, which no doubt developed independently in other countries, or was in this way imported together with the cooperative model.

Two distant shadows of the story provided here can nevertheless be found in the research by Nimmo (2008) on the campaign for and spread of milk registers (accounts of milk yields per cow) in Britain and by Walker (2014) on the imposition of accounting and record-keeping as a condition for rural rehabilitation loan programs in the United States during the Great Depression of the 1930s. In both cases it required uncertainty (*crises*) for existing tools to be spread and accepted, and it required interested parties, in this case government agencies, to convince people and press for adoption. Nimmo (2008) shows that, as in our example, initial efforts to spread milk registers as a tool to identify best practice (in feeding) and monitor cows (for breeding) were rather unsuccessful and limited to the agricultural elites trying to spread them. Only uncertainty in the interwar period and comprehensive government intervention in the 1930s and during the Second World War led to widespread adoption, and it took until the 1950s for ordinary farmers to accept their use in the much needed reshaping of dairy farming practice.<sup>29</sup> In the case of depressed American agriculture in the 1930s, accounting and the formulation of farm and household 'plans' was forced onto

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<sup>29</sup> This is backed by Hoyle's (2013, pp. 28-37) evidence that suggests that good accounting practice was not too widespread in British agriculture well into the twentieth century.

especially the poorer and credit constrained farmers who needed government help in order to remain in business. Walker (2014) argues that, although initially representing supervision and surveillance, these accounting prescriptions and their control by local supervisors led in the long run to the emancipation of many poor farmers from old habits and economic constraints, thus contributing to sustained poverty relief and better use of human and material resources in farming. Here, again, a crisis created momentum for a new sort of public policy that was eventually accepted as useful by a large share of the affected population, which previously had shown no signs of interest in adopting it. Whether these public policies are examples of the formation of domestic epistemic communities, or whether the 'best practice' and persuasion developed in Denmark in the previous century was behind this, is a matter for further research.

In Denmark, accounting remained an important technology after the specialization into butter produced using the automatic cream separator, and its associated byproduct, bacon, was complete by the 1890s. But it was then engineering and chemistry – whose epistemological basis had been greatly extended and systematized by the late nineteenth century – which took over as drivers of innovations and the adoption of new practices (cf. Depecker and Vatin 2016), as witnessed by for example the contributions of dairy scientists such as N.J. Fjord at the Royal Agricultural and Veterinary College in Denmark, and Louis Pasteur in France.

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