European
Historical
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EHES WORKING PAPERS IN ECONOMIC HISTORY | NO. 125

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FEBRUARY 2018

EHES Working Paper | No. 125|February 2018

'Getting to Denmark': the Role of Elites for Development*

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Abstract

We explore the role of elites for development and in particular for the spread of cooperative creameries in Denmark in the 1880s, which was a major factor behind that country's rapid economic catch-up. We demonstrate empirically that the location of early proto-modern dairies, so-called hollænderier, introduced onto traditional landed estates as part of the Holstein System of agriculture by landowning elites from the Duchies of Schleswig and Holstein in the eighteenth century, can explain the location of cooperative creameries in 1890, more than a century later, after controlling for other relevant determinants. We interpret this as evidence that areas close to estates which adopted the Holstein System witnessed a gradual spread of modern ideas from the estates to the peasantry. Moreover, we identify a causal relationship by utilizing the nature of the spread of the Holstein System around Denmark, and the distance to the first estate to introduce it, Sofiendal. These results are supported by evidence from a wealth of contemporary sources and are robust to a variety of alternative specifications.

JEL classification: N53, O13, Q13

Keywords: Institutions, technology, cooperatives, dairying

[1] We would like to thank Philipp Ager, Sascha Becker, Per Boje, David de la Croix, Carl-Johan Dalgaard, Jeremiah Dittmar, Alice Fabre, Giovanni Federico, James Fenske, Nicola Gennaioli, Ingrid Henriksen, Anton Howes, Pablo Martinelli, Joel Mokyr, Nathan Nunn, Cecilia Garcia Penalosa, Jared Rubin, and James Simpson for helpful comments and suggestions. Moreover, we would like to thank conference and workshop participants at the 2017 World Congress of Cliometrics in Strasbourg, the Agricliometrics II in Zaragoza, the CAGE/CEPR Economic History Conference in Abu Dhabi, the 2016 Social Science History Association meeting in Chicago, the CREA 2016 workshop in Luxembourg, the MEHR end of semester workshop 2016 at Copenhagen University, Simposio de la Asociación Española de Economía 2015 in Girona, the 2017 Economic History Society Conference, the 2017 workshop on 'Elite human capital and the role of modernity: The East versus the West' in Marseille, as well as seminar participants at the University of Santiago, the Catholic University of Chile, the Central Bank of Chile, Lund University, George Mason University, Remnin University, the Central University of Finance and Economics (Beijing), the University of South Australia, the London School of Economics, the University of Duisburg-Essen, the University of Bonn, and the University of Siena. Finally, we would also like to thank Dorte Kook Lyngholm from the Dansk Center for Herregårdsforskning (Danish Research Center for Manorial Studies) for sending us some of the data on the estates. Markus Lampe acknowledges funding from Fundación Ramón Areces, and Paul Sharp gratefully acknowledges funding from the Danish Council for Independent Research: this paper is part of his Sapere Aude grant no. DFF-6109-00123.

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1. Introduction

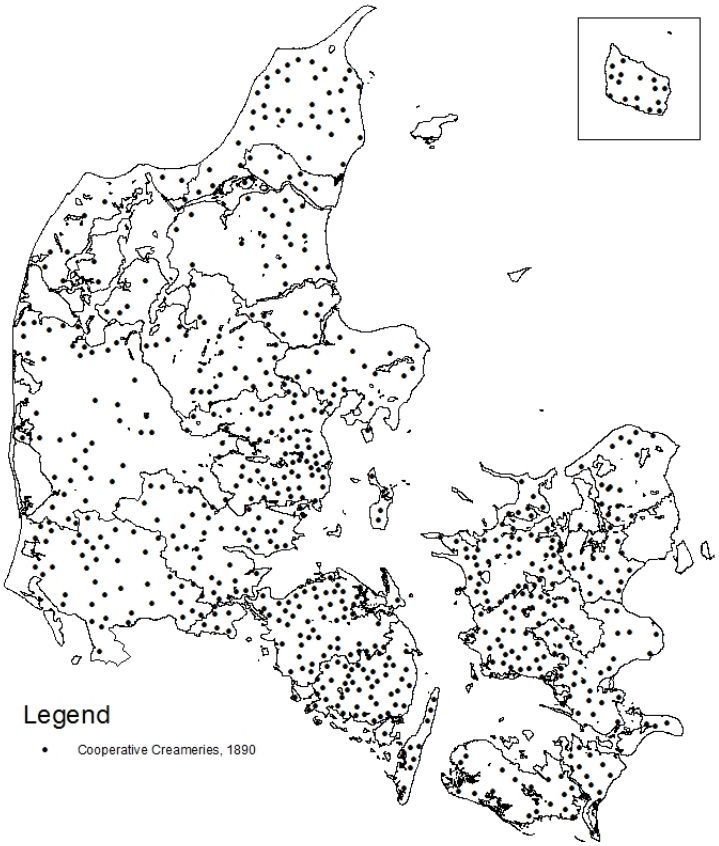
A substantial literature in economics examines the impact of elites on the growth trajectories of societies across time and space through various channels. While the impact on economic and political institutions is well-established, the role of elites for knowledge diffusion is not as well understood. In this paper, we shed new light on how elites may foster growth through this channel. We focus on a specific example centered on the Kingdom of Denmark, and the emergence of a modern dairy industry based on a new technology, the automatic cream separator (a steam-powered centrifuge), and a new institution, the cooperative creamery, which propelled the country towards prosperity in the last decades of the nineteenth century (for a brief account, see Henriksen 1993). After the foundation of the first cooperative creamery in 1882, hundreds of cooperative creameries spread throughout the whole country within a decade. Massive increases in productivity followed, production boomed, Denmark captured a large share of the important UK market for butter and other agricultural products, and witnessed rapid economic catch up with the leading economies of the day, as traditional suppliers of agricultural goods such as Ireland and the Netherlands lost market share. An important point motivating the present work is the rapidity with which the cooperatives spread, with the first wave over by 1890; see figure 1.

In a light-hearted manner, Francis Fukuyama (2011) has described the issue facing developing countries as the problem of 'getting to Denmark', a metaphor for a society characterized by wealth, the rule of law, good governance, and related virtues. But how did Denmark get to Denmark? For economic historians, the rise of the cooperatives is usually considered to be a turning point, but this is questioned in a recent book on the subject (Lampe and Sharp 2018), where we argued that it was rather the end result of a long period of agricultural enlightenment, as a modern, scientific form of agriculture spread into and throughout the country, propelled initially by a group of elites[1] on landed estates one hundred years earlier. The intermediate steps are described in detail in the book, and are summarized in the present work, which constitutes a reduced form test of their hypothesis. Lampe and Sharp's (2018) account is a significant revision of our understanding of the Danish development path, with important policy implications, largely due to the role Denmark often plays as a poster boy for the idea that countries can develop through cooperation in the countryside, as is perhaps best exemplified by the classic account commissioned by the Food and Agricultural Organization of the United Nations after the Second World War (Skrubbeltrang 1953). However, the idea that a country with a large number of peasants and cows (for example Ireland at the turn of the twentieth century, or India after the Second World War) could simply cooperate its way out of underdevelopment has been severely criticized by

[1] Or at least their administrators, tenants and/or skilled dairy workers, the latter mostly women, who traditionally dominated that sector.

Lampe and Sharp (2018) for exactly the reason presented here, that successful cooperatives stood on the shoulders of at least a century of accumulated improvements in agricultural theory, practice, and teaching.

Figure 1: Location of Cooperative Creameries in 1890



Source: Own work, based on Bjørn (1988).

Beyond the policy implications, it is certainly useful to understand what allowed Denmark to grow rapidly from some point in the second half of the nineteenth century[2], eventually to become one of the richest countries in the world, with many other desirable socioeconomic characteristics (low inequality, high levels of 'happiness', etc. – see Lampe and Sharp 2018). The discussion among Danish historians has largely focused on whether agriculture can be seen as the leading sector in this process, creating demand and growth in other sectors, such as industry (supplying the centrifuges and refrigerators used in dairying for example) and services[3]. Revisionists

[2] Reliable GDP/capita data for Denmark do not unfortunately exist for this period. See however the work on real wages by Khaustova and Sharp 2016.

[3] In particular transportation, where the Danish shipping giant Mærsk is a direct descendent of the firms that carried the agricultural exports to the UK.

argue that the developments in agriculture were simply part of a wider process of development which touched all sectors of the economy (see for example Boje 2016).

Whatever the case, the success of Danish agriculture was extraordinary. Within a few years at the end of the nineteenth century, Denmark captured a significant share of the important UK market for animal foodstuffs. By around 1900, over ninety percent of Denmark's total production of butter and pork went to the UK. This was also significant from the UK side. Danish exports made up an increasingly large share of total imports, increasing from around 15 percent in the 1870s to over 43 percent before the First World War for butter, from under 1 percent to almost 50 percent over the same period for bacon, and from under four percent to almost one fourth for eggs (Henriksen 1993, p. 156). This Danish success is usually set within the context of the American 'grain invasion' from the 1870s (O'Rourke 1997), when cheap exports of American grain flooded Europe, promoting a backlash of protectionism. Denmark, like the UK, chose to remain open, however, and successfully exploited its comparative advantages, using the cheap grain as fodder for increased animal production, and outcompeting traditional suppliers of the UK market, such as the Irish.[4]

Danish agricultural products (Lurpak butter and Danish bacon) still today constitute important components of the English breakfast, although Denmark is no longer so dependent on the UK market, and Danish agricultural products can be found all over the world. Denmark's current status as an 'agricultural superpower'[5], dominated by massive firms such as Arla (a dairy cooperative) and Danish Crown (a food, especially meat, processing firm previously also a cooperative until 2010), is usually traced back to the aforementioned developments in the 1880s. As we will discuss in more detail below, at this point a new technology, the steam-powered automatic cream separator made it possible to use milk which had been transported over long distances to be processed in a central production facility, and the voluntary associations of Danish peasants, the cooperatives, sprang up to take advantage of this possibility. Thus, modern Denmark emerged based on a democratic, cooperative countryside, providing something of a role model to other agricultural countries around the world.

As attractive as this narrative might appear, it begs the obvious question as to why other countries could not so easily follow similar strategies. As noted above, it also remains to be explained how hundreds of butter factories could spring up in a few years in the 1880s, and how dominance in agricultural exports could be so rapidly consolidated. The existing literature (basically Henriksen 1999, inspired by Ó Gráda 1977) has attributed the rapid diffusion of the cooperative dairy movement in Denmark mostly to pre-existing cow densities. In other

[4] Thus, however, as Boserup (1992, p. 57) noted long ago, this development was crucially dependent on Britain's decision to remain a free trader, which allowed this process to happen in a way which is perhaps inconceivable for developing countries today, which are constrained by the protectionist policies of the US and the EU in particular.

[5] *Economist*, January 4, 2014 'Bringing home the bacon: Tiny Denmark is an agricultural superpower'.

country-commodity specific studies, the scale of production prior to the introduction of cooperatives has also been highlighted, apart from other product-specific factors and access to transportation networks. Recent internationally comparative studies (Fernández 2014) have highlighted the importance of social capital (or trust) proxied by a variety of variables, especially (low land) inequality and (protestant) religion. This follows important work by O'Rourke (2006, 2007), who argued that it was the absence of conflicts and the egalitarianism of the Danish population which distinguished it from Ireland, where cooperation emerged later and less successfully. This homogeneity can in turn be traced back to more secure property rights in Denmark, due to the centralization of government and land reforms in the eighteenth century, which made it more difficult for the elites to exploit the peasantry, who also enjoyed more secure assets, with the consequence that violent conflict was less likely, and networks and social capital could form more easily. While religion and social fractionalization have proven to be important in other countries, this can arguably not explain the adoption pattern within Denmark given the extremely homogenous population.

Lampe and Sharp (2018) argue, in contrast to the traditional accounts, that the cream separators and cooperatives marked the end of the story of the modernization of Danish dairying, where the former was the final piece of the jigsaw, allowing the latter to form – an unintended end-result of something which happened over a century earlier, as elites moved into Denmark. This can be traced to developments following Denmark's rather numerous military defeats at the hands of Sweden[6], which led to a considerable loss of territory, and financial difficulties for the Crown and the privatization of almost all the crown estates by 1740 in order to raise revenue. A rather inconclusive debate about how to take advantage of this situation in order to introduce reforms and modernize agriculture ensued, but with the ultimate result that many were sold to enterprising Danish and German nobles, merchants, and others. A well-functioning market for land meant that this process also spread to other estates, beyond the former crown estates. Many were bought up by elites from Schleswig and Holstein, who saw opportunities for vastly improving the productivity of the Danish countryside. They brought with them the relatively sophisticated agricultural system they knew from home, the Holstein System, which importantly for the emergence of the cooperatives introduced the idea of centralizing dairy production in a central facility. This in turn set in motion an early 'enlightened' approach to agriculture, including modern standards of bookkeeping and accounting (important for science and for discovering what is most profitable to produce); the establishment of knowledge institutions: apprenticeships, agricultural schooling, extension, etc.; and experimentation both on the estates as well as at specialist research institutions – in fact the first centrifuge in Denmark was trialed on one of the estates. Importantly, however, the estate owners of the 1880s did not

[6] In fact, Denmark and Sweden hold the record for having fought the largest number of wars.

support the cooperatives directly, seeing them as competition, and even actively campaigned against them. Nevertheless, Lampe and Sharp (2018) argue that it was a trickle down of ideas from the elites in the 1700s that allowed the cooperatives to emerge so successfully a century later. In our reduced form of their hypothesis, we exploit that not all parts of the country were equally influenced by the elites, which in turn explains the specific spatial pattern of the cooperatives.

We thus demonstrate econometrically that the pattern of adoption of cooperative creameries in Denmark followed the introduction of proto-modern dairies by agricultural elites on estate farms. In the Duchies of Schleswig and Holstein, ruled by the King of Denmark in personal union until 1864 when they were lost to Prussia, an intensified crop rotation system with an important dairy component was developed on the large manorial estates known as *Koppelwirtschaft* in German, or *kobbelbrug* in Danish. It became the dominant field system in the Duchies in the 1700s, and included unprecedentedly large herds of milch cows and the invention of an innovative new centralized system of butter production, the *hollænderi*, with unparalleled standards of hygiene and equipment (Porskrog Rasmussen 2010a). These innovations – collectively known as the above mentioned 'Holstein System' when the crop-rotation was combined with the dairy unit – came relatively late to Denmark, but when they did they gradually transformed Danish agriculture. We show how the specific organizational and technological innovation of estate dairy production came to Denmark in the 1760s and quickly increased in importance, although this adoption was unequal across the country, and led to an uneven spread of emulation by common farmers in the following decades, a common pattern for the diffusion of innovations in early modern societies, as highlighted by Mokyr (2009) for the British 'agricultural enlightenment'. Hence, the main alternative use of the same resources, cattle-fattening, within the production system of *Koppelwirtschaft*, was still discussed and seen as viable in the run-up to the spread of dairy cooperatives. Subsequent scientific debate led to further advances, including accurate bookkeeping, better breeds of cows, and better feed. Agricultural societies, schools, and journals were established. More generally, it became firmly established that Denmark's comparative advantage lay in dairying, and butter production in particular. As we will discuss, and summarize below, we have previously (Lampe and Sharp 2018) established a narrative account – based on substantial use of primary archival and other sources – of how this innovation spread and trickled down to the peasantry through general and specific education, research, diffusion of examples of best practice and the establishment of channels of marketing.

Our econometric analysis relies on a novel database for which we have collected a substantial amount of data from a combination of primary and secondary sources. For the most part we have this data on the grid level, and we divide Denmark into 38,370 1x1km grid cells. Controlling for a large number of other relevant determinants

of cooperation, including indicators of land quality and suitability for dairying, we find that each grid cell's exposure to cooperative creameries in 1890 (measured as the sum of the inverse distance to every cooperative from that location) correlates with that cell's treatment by the elites, measured by the sum of the (tax assessed land quality adjusted) sizes of all estates with *hollænderier* (and thus the Holstein System) in 1782 weighted by their distance to the grid cell. Then, we demonstrate causality using the fact that the Holstein System spread throughout the country in a particular way, starting with the first, which was established on an estate called Sofiendal, the distance to which we use as an instrument. The use of distance as an instrument follows studies on the spread of ideas such as Dittmar (2011) on the diffusion of the printing press and Becker and Woessmann (2009) and Akçomak et al. (2016) on the spread of religious practices that favor literacy. Our results are not just statistically but also highly economically significant, implying that an increase of one standard deviation in the elite influence increases the cooperative exposure 42 percent of the mean exposure in one of our preferred specifications. They are also robust to a variety of alternative specifications, including using data on the parish level and using the estates (with vs. without the Holstein System) as the unit of analysis.

In contrast to much other similar research, the intermediate steps during the century between the elites establishing the *hollænderier* by 1782 and the end of the initial spread of the cooperatives in 1890 are not a black box, and we discuss them briefly in this paper, although a full account is provided by Lampe and Sharp (2018). Certainly, however, an important prerequisite to the rapid establishment of cooperative creameries was through an increasing interest in dairying by the peasantry, which we are able to measure thanks to occasional agricultural censuses taken during the nineteenth century. Thus, we are also able to demonstrate that one channel through which the elite influence trickled down to the peasantry was via increased cattle densities in areas which had been treated more by the elites. Thus we conclude that the early and rapid spread of the cooperative creameries, which in turn are often considered to have propelled Denmark toward modernity, and were an important precursor of the country's agricultural success today, was due to the accumulation and spread of knowledge over a century. Developments on the Danish estates are in this way put in their rightful place as the starting point of the Danish agricultural revolution, which was to change Denmark forever.

Besides the literature on the role of elites for development, on agricultural cooperation, and on the development of Denmark, the present work is also closely connected to recent studies that show the long-run impact of the adoption of agriculture (Olsson and Hibbs 2005; Putterman 2008; Comin et al. 2010, Cook 2014a) and major productivity improving implements like the (heavy mouldboard) plough (Andersen et al. 2016), as well as complementing the emerging literature on the effects of new crops on productivity, population and

economic growth, and political stability (e.g. Nunn and Qian 2011, Cook 2014a, Cook 2014b, Dall et al. 2014, Chen and Kung 2016, Jia 2014, Bustos et al. 2016).[7]

The following section provides a brief review of the relevant literature on the role of elites for development. Section 3 describes the Holstein System as it emerged in Schleswig and Holstein, and considers its spread into and throughout Denmark. Section 4 provides an empirical analysis of the impact of this for the emergence of the cooperatives more than a century later. Section 5 tests the robustness of the results, and finally Section 6 concludes.

2. A brief literature review on the role of elites for development

A long running theme in growth and development is how elites influence the long run economic trajectories of societies (Amsden, DiCaprio and Robinson 2012). It is undeniable that elites exert disproportionate influence on how institutions are designed and factor endowments are used, but it is less well known how their actions feed into the development process. For the case of agricultural elites, the existing literature has provided conflicting views on the role of large landowners in economic development. On the one hand, the concentration of agricultural resources in the hands of large landowners and accompanying high levels of land inequality are often seen as an impediment to development. Engerman and Sokoloff (2002) stress the interaction between factor endowments and the resulting impact of land inequality and how higher land inequality leads to agricultural elites who favor slavery and extractive institutions, which produces poor economic outcomes, see also Acemoglu, Johnson and Robinson (2001) ad Bannerje and Iyer (2005). Galor, Moav and Vollrath (2009), Baten and Juif (2014) and Cinnirella and Hornung (2016) demonstrate that high land inequality causes elites to block investment in human capital. Others have stressed that high land inequality limits the scope for agricultural cooperation both through lower social capital (Fernández 2014) and through direct crowding-out (Henriksen 1999). On the other hand, in contexts in which property rights are poorly defined, large landowners can 'shelter' dependent peasants from extractive state institutions (Dell 2010) and effectively lobby for better provision of collective goods and infrastructure than politically weak peasant communities (Dell 2010, Dell 2012).[8]

[7] In addition, our work connects to literatures such as the role of immigration for technology and knowledge transfer, the significance of local knowledge spillovers from large to small firms, and to 'new new' trade theory, which suggests that firms that export are more productive, and that more productive firms export more.

[8] In Denmark, during the nineteenth century, the property rights of peasant farmers became increasingly more secure through enclosure and formation of inheritable property. Hence we do not believe – and find no evidence – that estates *per se* should have had a necessary

By contrast, we stress that agricultural elites may spread knowledge, which then subsequently aids development in the agricultural sector. In other words, our work suggests that agricultural elites may also be knowledge elites, who facilitate later development. Recent work by Squicciarini and Voigtländer (2016) demonstrates that knowledge elites played a significant role in the industrialization of France by e.g. running businesses themselves or exchanging knowledge with entrepreneurs. Our work emphasizes the importance of knowledge spill-overs and agricultural enlightenment (Mokyr 2009, ch. 9), and shares some similarities with Hornung's (2014) work on high-skilled immigration of Huguenots into Prussia. He shows that this led to higher productivity in the textile sector and interprets this as evidence of an effect of diffusion of technology. We focus on agricultural elites and their impact on the part of the agricultural sector that led to an economy-wide take-off.

3. The evolution of modern dairying and its spread to Denmark

In this section, we provide the argument that we set out to test. We first explore the origin of the Holstein System. We next describe how it spread into and across Denmark. As will become clear in Section 4, we will apply our knowledge of the spread across Denmark to identify the causal effect of early elites on the spread of cooperative creameries. We finally discuss how the spread of proto-modern dairying eventually propelled the spread of cooperatives.

The origin of the Holstein System and Koppelwirtschaft

The Holstein System and *Koppelwirtschaft* more generally was a 'collective invention' by estate owners and their administrators in sixteenth-century Holstein and Schleswig, the German-speaking part of the Danish monarchy, in order to overcome the fundamental problem of intensified organic agriculture, i.e. how to sustain production and yields in the long run by obtaining sufficient fertilizer from animal husbandry. This challenge was met in different parts of Europe in different ways, especially in modern-day Belgium, Northern France, the Netherlands and Britain, where 'convertible husbandry' systems developed (Mokyr 2009, p. 173; Jones 2016). The Holstein model consisted of changing the traditional three-field rotation with outlying pasture areas into an eleven-field rotation, thus alternating the use of individual fields between pasture and grain cultivation over eleven years.[9] This way, extensively used grazing areas (pastures) were included in the crop rotation by changing the traditional design of fields and the crop rotation itself in a way that allowed for sustained grain yields and

facilitating function for the establishment of cooperatives. On the other hand, while large landowners in Denmark might have been interested in blocking education and other rights for peasants between the 1780s and the 1880s, as evidenced by the short-lived second serfdom in the late eighteenth century, effectively, the centralization and professionalization of government and the Constitution of 1849 reduced the scope for such action. However, since long-term effects of elite blockage might have persistent outcomes, we control for the share of land under the direct control of estates (demesnes).

[9] For more details on alternative systems see Lampe and Sharp (2018) and the references provided there.

sufficient fodder for the animals, normally in the form of summer pasture and winter hay – all this at the same time as production surpluses were exported from rural areas in order to sustain growing urban populations. This system was relatively more focused on animal production than alternative systems, in part because soils were particularly suited for fertile grasslands in Holstein and Schleswig, which in the sixteenth-century had focused on oxen fattening and horse breeding. In part, the evolution of *Koppelwirtschaft* in the seventeenth and eighteenth centuries seems to be the reaction of estate owners to an improvement in the relative prices of dairy products versus grain and oxen (Porskrog Rasmussen 2010a, p. 180), which led to intensified collaboration with available specialized immigrants from the Netherlands and their descendants so as to develop a strong dairy sector (Porskrog Rasmussen 2003, p. 447). Since these specialists originated from Holland, the tenants involved in dairying became known as *hollænder* (and their dairies as *hollænderier*), even if they were not of Dutch descent.[10]

Koppelwirtschaft was introduced in the *demesne* farming of large manorial estates, and not in peasant agriculture, because these were the most commercially oriented agricultural units, the most likely to be able to sustain the considerable capital investments and labor efforts (via *corvée* or hired labor) required for reorganizing the fields, and also the ones with the largest freedom to act under the institutional framework of the time. Many manorial estates were managed by relatively professional staff (Porskrog Rasmussen 2010a, p. 182), and dairying became a professionalized subset of demesne farming activities, in which specialist *hollænder* managed specialized dairy equipment under a regime of well-specified dairy lease contracts (Drejer 1925-33, p. 181-2; Iversen 1992, p. 76-77; Porskrog Rasmussen 1987, pp. 63-65 and Lampe and Sharp 2018). *Hollændere* were normally a couple, with the woman in charge of dairy production and the man supervising the feeding of the cows and the transportation of raw materials and produce to and from the dairy (Hansen 2006). Moreover, the Holstein system implied a proto-modern dairy with a centralized production facility for separation of cream from milk and production of butter much like the cooperative creameries a century later.[11] Under the Holstein System, many estates in Holstein and Schleswig came to have very large herds of several hundred cows, even exceeding herd sizes in Holland (Porskrog Rasmussen 2010a, pp. 181-2).

[10] Bieleman (1996) gives an account of the sophisticated dairy sector in the Low Countries during the Dutch 'Golden Age'.
[11] The *hollænderi* would also have practical independent rooms, a strong focus on hygiene, cows milked at particular times (and milked dry), control of the temperature of the cream, so it could be skimmed and churned at the right time, and care would be exerted at all times from milking to packaging.

Within Holstein, Schleswig, and subsequently Denmark,[12] the Holstein system thus led to a model of production with advances on the estates in different parts of agriculture and thus the opening of a gap in quality between estate and peasant producers emerged in the extent to which produce was regularly marketed (Lampe and Sharp 2015a) and in terms of grain yields, butter quality, etc. (Bjørn 1988, p. 159; see also Lampe and Sharp 2014, 2015b). In the Kingdom of Denmark itself, from the Middle Ages until the seventeenth century, estates as well as peasant farms typically only had as many cows as they needed to feed the household, and more sophisticated dairy products were imported from Holland (Appel and Bredkjær 1924-33, pp. 279-80).[13] Even for the latter half of the 1700s, scholars often highlight the low proportion of cows (and bulls) relative to horses in the use of pasture in Denmark. Hertel (1920, 149-51) for example, estimates the cattle to horse ratio at only 1.4:1 in the 1770s[14], much less than the 4:1 in 1914.

The introduction of the Holstein System to Denmark

An important prerequisite to the introduction of the Holstein System was the redistribution of land throughout the eighteenth century. In the 1600s Denmark consisted of a large number of Crown Estates, under the direct administration of the monarch, smaller estates owned by the nobility, as well as many medium sized subordinate farms belonging to estates (Porskrog Rasmussen 2003, p. 8). From the 1600s and into the 1700s, the bad finances of the crown, largely as a result of continuous wars against Sweden until 1721, meant that monarchs were forced to sell off more and more land, until by the 1740s almost all the crown estates were privatized (Frandsen 2005, p. 58, 74-76), with a final touch of privatizations in around 1770. At the same time, the introduction of absolutism in Denmark in 1660 had weakened the privileges of the traditional nobility and opened up the possibility of estate ownership to non-nobles (Lampe and Sharp 2018, Linvald 1912). This situation encouraged discussions, also in the government, on how to introduce reforms and a general modernization of agriculture (Jensen 1998, p. 37-8; Feldbæk 1988, p. 19).

The introduction of *Koppelwirtschaft* was to be the result of this debate, although most saw it simply as a means to increase grain yields. This is best illustrated by a famous quote by Adam Gottlob Moltke, effectively prime minister from 1746 to 1766 and generally credited with introducing the Holstein System to Denmark (Jensen

[12] *Koppelwirtschaft* and *hollænderier* also spread to the east to Mecklenburg in the eighteenth century, but relatively little research is available on this, apart from Schröder-Lembke (1978, 65-67), who portrays the troubled figure of Mecklenburg *Koppelwirtschaft* pioneer Joachim Friedrich von der Lühe and his Panzow estate. See also Jones (2016, pp. 95-97).

[13] The word *hollænderi* entered the Danish language apparently from the eighteenth century with the spread of *Koppelwirtschaft* into Denmark (Drejer 1925-33, p. 138). Some prior examples of larger dairy units, managed by *hollænder* from Holstein or the Netherlands have been mentioned in the literature, but with little sustained impact (Drejer 1925-33, pp. 140-143; Skrubbeltrang 1978, p. 120; Frandsen 2005, pp. 46-47, 146).

[14] When, however, cattle pests had done much to reduce cattle stocks.

1998, p. 92), from a plan devised in 1746 for King Frederik V: 'Agriculture in these lands seems to be still very backward. I keep myself assured that, if the soil here would be worked as is custom in other countries, especially in Holstein, the land could yield twice as much as it has produced hitherto.' (quoted from Porskrog Rasmussen 2010b, p. 9 and note 1). In the context of his ascent to Lord Chamberlain for Frederik V in 1746, Moltke also received the large estate of Bregentved in Southern Zealand, and up to 1751 bought four more nearby estates: Turebyholm, Juellinge, Tryggevælden and Aslev (Porskrog Rasmussen 2010b, p. 11).[15] In 1759, he came, under fortuitous circumstances, to own the estate of Niendorf near Lübeck in Holstein, on which the Holstein System was firmly established. He sold it two years later with a large profit (Porskrog Rasmussen 2010b, p. 19-21) and took the former leaseholder of Niendorf, Johann Matthias Völckers, to his estates on Zealand to become his administrator and agricultural reorganizer there. Völckers started on the newly established farm of Stenkelstrup (later named Sofiendal after Moltke's second wife) to implement an exact copy of Holstein *Koppelwirtschaft* with the layout of the eleven fields, the original crop rotation and a *hollænderi*, and finished this in 1766. He then continued to reform Moltke's estates of Alslev, Turebyholm and the Bregentved main estate up to 1767 and Juellinge in the early 1770s. Most of Moltke's reorganized estates were then, as before, leased in auctions to interested leaseholders, including Völckers himself (Jensen 1998, p. 49-51, Porskrog Rasmussen 2010b). In reports he wrote for the king in the 1780s to highlight his role as a reformer, Moltke claimed that the value of his lease contracts in 1787 had increased by more than 200 percent since the introduction of the Holstein System in comparison to the 1740s, although modern research has qualified this somewhat since estate leases had generally increased over the period (Porskrog Rasmussen 2010b, p. 26-7). There is, however, no doubt that Moltke's reorganization increased the capitalized value of his estates, and his descendants are in fact still the largest noble landowners in Denmark[16], according to a list published by the Danish public broadcaster, DR, in relation to a recent debate on lowering inheritance taxes for family-owned businesses.

Moltke was imitated by his neighbors. For example, the Løvenborg estate was reorganized in 1767 with Völckers as expert, and the Gisselfeld estate, adjacent to Bregentved, in 1768 (Porskorg Rasmussen 2010b, 27; Jensen 1998, 52). In 1769 the estate of the Vemmetofte Jomfruekloster was reorganized, with Völckers as consultant to its administrator (Linvald 1905-08, p. 250; Prange 1971, p. 552). Gradually Moltke's example was followed in other parts of Denmark, and by 1800 most demesnes were using *Koppelwirtschaft* (although not necessarily

[15] During the next decades, Moltke would own estates in all parts of Denmark as well as in Schleswig and Holstein and become the largest landowner in the Monarchy (see the map in Porskrog Rasmussen 2010b, p. 14). His cultivation reforms in Denmark were centered mostly on the aforementioned estates on Zealand and the ones he bought between 1763-5 on Funen.

[16] The net worth of the Moltke family (still based in Bregentved) was almost 1 billion Danish kroner (around 150 million US dollars) in April 2017. DR, 'Grafik: De største adelige godsejere i Danmark', https://www.dr.dk/nyheder/penge/grafik-de-stoerste-adelige-godsejere-i-danmark, retrieved December 8, 2017.

with the dairy unit), while peasant agriculture still largely relied on the medieval three-field system (Falbe Hansen 1889, p. 10; Bjørn 1988a, p. 35; Frandsen 2005, p. 90).[17] In fact, the list of estates having a *hollænderi* in 1782 reads like something of a who's who of nobility: old, new, high, low, Danish and foreign, and includes some of the leading reformers of the time.[18]

Over the subsequent decades, despite a general economic and agricultural crisis as a consequence of the Napoleonic Wars and state bankruptcy, *Koppelwirtschaft* continued to spread across Denmark. Lampe and Sharp (2018) provide a detailed account of this, based on a large number of primary and secondary sources, principally for the first half of the nineteenth century a series of books by Begtrup (1803, 1806, 1808) and a series of reports on the state of agriculture in each county commissioned by the Royal Agricultural Society and published between 1826 and 1844 (Dalgas 1826), the latter of which reveal for example that by the late 1830s or 1840s good dairy practices were spreading to the peasantry in the south of the island of Zealand close to where Moltke first introduced the Holstein system in 1766, and that estates further west adopted the Holstein System more slowly, thus supporting our narrative that both the adoption of the Holstein System by estates, and the early spread of good practices to the peasantry, was more frequent closer to Sofiendal.

In fact, by the 1840s, the transformation of Denmark was already well underway, decades before the first cooperative. Thus, the prominent German travel writer Johann Georg Kohl observed that the Holstein System had spread throughout the country, even to the opposite end of the country in Northern Jutland, where he noted that many farms had switched from oxen-raising to dairying. He was impressed by the scientific nature of this progress, and noted that important articles on dairying from the Duchies were reprinted all over Denmark. In conclusion, he stated his belief that Denmark would eventually converge on the Duchies, and that they would finally integrate completely with the Kingdom to become a land 'not of milk and honey, but of milk and butter' (Kohl 1846, pp. 58-60). Other foreigners, even from the UK, marveled at the scale of the operations, such as the British writer, Samuel Laing, who wondered at the 'regularity, arrangement, cleanliness and the vast scale of all

[17] In the late 1760s, he and Völckers also developed a version of *Koppelwirtschaft* for the villages dependent on his estates which respected traditional common land rights (*fællesskab*) (Porskorg Rasmussen 2010b, 30-35). It did, however, not spread as fast and widely as its estate demesne counterpart.

[18] Apart from Moltke and his son Joachim Godske Moltke with nine different estates, there was also for example the famous reformer Christian Ditlev Frederik Reventlow, as well as Christian von Benzon, Christine Sophie Friis and her husband Erhard Wedel-Friis, and Frederik Siegfried Christiansen Rantzau, all with three estates; as well as many others with one or two estates, including Theodor Adeler, Sigfred Victor Raben-Levetzau, Lorentz Christian Ernst Cederfeld de Simonsen, Jørgen Wichmand Wichfeld, Hans Henrik von Eickstedt, Godske Hans von Krogh, Frederik Ludvig Christian Beenfeldt, Christian Ahlefeldt-Laurvig, and members of the Rosenkrantz, Gyldencrone, Hardenberg, Holstein, Lüttichau, Stampe, Raben (the family of Moltke's wife), Juel and Finneke(-Blixen) families etc. However, among them we also find parish priests (Niels Frederiksen Amager, whose widow owned Gedsergård), merchants (Hans Bergeshagen Hincheldey of Valnæsgård), apparently a pharmacist (Henrik Schmidt of Haraldskær), and the son of an estate tenant who started as an estate tenant himself (Jens Lange of Løjtved).

the operations [which] give the impression rather of a great manufactory of butter and cheese than of a farm' (Laing 1852, p. 124).

The spread of knowledge and cooperative creameries

In the next section, we demonstrate empirically that the estate creameries had a trickle-down effect on the peasantry, consistent with the historical narrative. Lampe and Sharp (2018)[19] provide a detailed account of the chain of events and the developments which connect the two end points of the reduced form analysis presented in this paper: the establishment of the elite-owned estate creameries in the late eighteenth century, and the emergence of the peasant-owned cooperative creameries from 1882. Thus, we describe in detail the developments which were initiated by the elites since the establishment of the Holstein System, and document the links that emerged between the estates and the peasantry. Here, we provide a concise, self-contained summary.

A program of agricultural reforms went alongside the spread of the Holstein System in the late eighteenth century, with the end result that for example serfdom (or 'adscription') was abolished and land enclosures were put in place, firmly establishing private property rights in the countryside. The completion of these reforms by the first years of the nineteenth century coincided however with the Napoleonic Wars, which were particularly devastating for Denmark. Copenhagen was almost completely destroyed in a British bombardment in 1807, and the Danish fleet was captured, and in the terms of the peace Denmark lost Norway to Sweden in 1814. The Danish state went bankrupt, and a profound period of uncertainty followed, although a second wave of elites (again, often from Holstein and Schleswig) began to establish themselves in Denmark from the 1820s, and built on the reforms of the eighteenth century. Of particular importance was the early introduction of an 'enlightened' approach to dairying and agriculture more generally, involving accurate measuring and recordkeeping, combined with sophisticated bookkeeping and accounting. This allowed first of all for a scientific and experimental approach to agriculture, answering questions such as how best to feed, breed, and milk cows. Second, accounting allowed for a better idea of profitability, allowing for profit-maximizing behavior and for example the discovery that specialization in dairying was the best strategy. Lively debates on methodology and the implications of the findings made played out in the Danish agricultural press in particular from the mid-nineteenth century. We argue that the knowledge built up in this process laid the foundation for the rapid spread of smallholder dairying later on, in particular because – apart from the example of specialization – it was increasingly taught through specialized agricultural schooling and apprenticeship programs.

[19] In part based on previously published articles: Henriksen, Lampe and Sharp (2011, 2012), Lampe and Sharp (2014, 2015a)

The Danish estates owners were also joined from the second half of the nineteenth century by a new set of elites, merchants, who established the marketing channels necessary for taking advantage of markets abroad, especially in industrializing Britain, and encouraged quality improvements to obtain more marketable produce for export. This was in part by encouraging medium-sized farms and smallholders outside the realm of the estates to centralize production, initially through a model of privately owned so-called community creameries in the 1860s (Bjørn 1977, McLaughlin and Sharp 2015). Little information remain on these, however, since they were small-scale and suffered from the problem that peasant producers owned just a few cows, and their milk production could not easily be transported to a central production facility. This was solved, however, with the invention of the automatic cream separator in the late 1870s[20], which was able to separate the cream from transported milk using centrifugal force. The cream separator thus finally allowed peasants to enjoy the benefits of centralized production and marketing pioneered by the *hollænderier* more than a century before, this time largely in the form of cooperative creameries. They did not enjoy an easy start, however. The first coops in southwestern Jutland met with great skepticism from the agricultural establishment, that is, estate owners. Thus, the chairman of the dairy committee of the United Jutland Agricultural Associations (and member of the board of the Royal Agricultural Society of Denmark) commissioned an instructor from the agricultural college of Ladelundgaard to travel around eighteen of them in order to demonstrate their inferiority compared to the privately-owned community creameries which he had previously reported on (Petersen 1885; Henriksen 1999). Although his report reached the opposite conclusion to that which its commissioners had hoped for, there can be little doubt that the estates themselves were not promoting the cooperative form as such.

4. Persistency and the spread of the cooperatives

To test for the influence of the elites on the location of cooperative creameries a century later, we examine whether areas closer to estates using the Holstein System were more likely to have cooperative creameries nearby after the first wave of cooperatives ended around 1890. Specifically, we divide Denmark into 38,370 1 x 1 km grid cells to be able to pick up the very local geographical variation in the location of cooperative creameries and the estates of the elites and be able to account for potential cofounding factors at a very detailed level.[21] In practice, we calculate measures of the degree to which a cell is near *hollænderier* and cooperative creameries.

[20] In fact, it seems that the principle that cream could be separated using centrifugal force was discovered in Germany in 1864, but the crucial refinements were made in the Duchy of Holstein in 1876. Separators based on this design were then launched by rival Danish and Swedish firms in 1878/9 (Pedersen 1999, p. 51).

[21] Population and barley suitability are the only control variables that we cannot directly generate at the grid level and hence we attribute the parish level population counts to each cell within the parish and with FAO's more aggregated barley suitability rasters. We assume the suitability to be constant within FAO's 5 arc minute resolution which corresponds to approximately 9 x 5 km raster cells in Denmark.

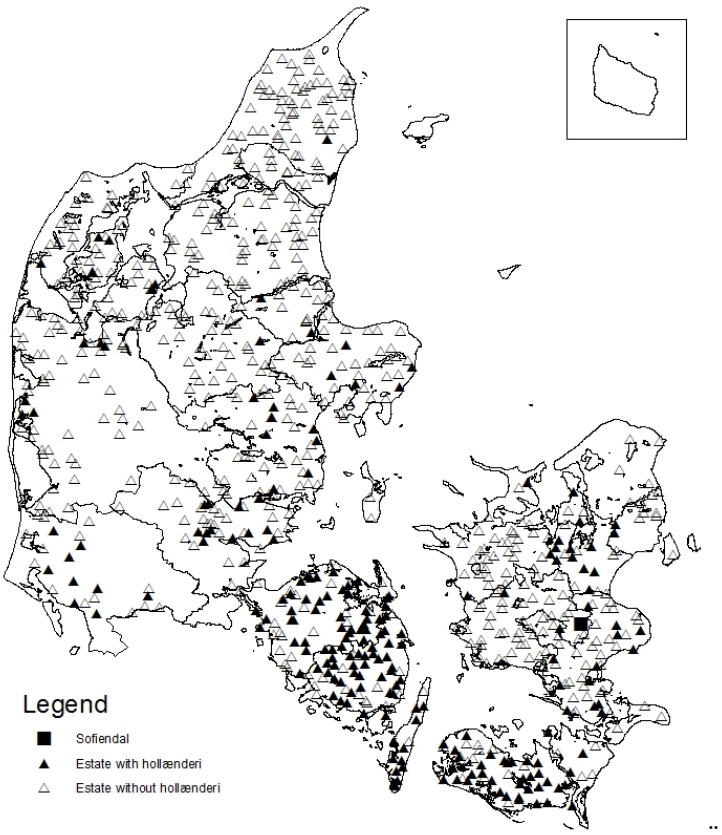
Our main proxy for the spillovers from elites to peasants is the variable *elites 1782*, constructed in the spirit of Harris' (1954) 'market potential' (mp) measure as the sum of the tax assessed land quality adjusted sizes of all estates with *hollænderier* weighted by their distance. We calculate this mp for all grid cells. The reasoning behind this strategy is that the influence of the elites increases with the estate size, but decreases with distance. In other words, the closer and larger the estates, the more influence they would have had in terms of knowledge spillovers. When assessing the relationship in this way, however, one needs to bear in mind that any surviving *hollænderier* on estates would have been competitors to the first cooperatives (see Henriksen 1999).[22] The estates with *hollænderier* are given in figure 3, together with all other estates in 1782. To measure the extent to which a grid cell is exposed to cooperative creameries, we also construct a market potential measure for dairies in a similar fashion and construct the variable *cooperative creamery exposure* as the sum of cooperative creameries weighted by the inverse distance from the grid cell to the cooperative.

Table 1 provides a brief description of the variables included in the regressions below, as well as summary statistics and sources. Apart from *cooperative creamery exposure* and *elites 1782*, we also construct several other variables, which might also contribute to explaining the location of cooperatives in 1890. The first is distance to the first cooperative creamery as the cooperatives might conceivably have spread from there. Second we control for the share of a grid cell that is occupied by estate demesnes (with or without *hollænderier*) in the late eighteenth century. Since this land was directly cultivated by estates, it is much less likely that (peasant) cooperatives would be founded there. We also control for the proximity of all estates to capture the general political and social effects of the presence of large landowners on peasant cooperation, which might be negative or positive, following the various results in the literature discussed above. We separately control for (pre-privatization) crown ownership of estates as these estates were typically larger and more centrally located and hence might have had an independent and perhaps stronger impact on the surrounding peasant society. Next we add controls for ideas in the half century leading up to the spread of the cooperative creameries in the form of proximity to a number of late innovators and to folk high schools. The former identifies estate owners who participated in a commission set up by the Danish Royal Agricultural Society in 1858 and were particularly influential. The latter controls for the impact of the folk high schools which traditionally have be seen as a main

[22] Unfortunately, data on which estate creameries survived until 1882/1890 are unavailable. As noted above, the agricultural establishment was initially hostile to the peasant cooperatives and as such surviving creameries work against our hypothesis making the results presented below conservative estimates.

driver of the cooperative movement due to their important role in educating peasants[23] and as they shared many of the same ideas and philosophies as those behind the cooperative movement.

Figure 3: Location of *hollænderier* among all estates in 1782



Source: Own work based on Andersen (1963)[24], Christensen (1886) and Roholt (2012).

One might further argue that the Holstein System was simply established in areas with previous dairy know-how and cow herds. We thus introduce a number of controls to take account of this possibility, including the presence of a grass field system in the seventeenth century, historical butter production, clover cultivation in 1805 and barley suitability[25], the latter of which captures the main alternate use of the land.[26] First, Frandsen

[23] The courses supplied by the folk high schools were decided by the head of each school but typically the peasants learned about hygiene in the production of milk, cultivation of plants and more general knowledge about democracy and how to participate in society.
[24] Andersen identifies the presence of *Hollænderier* based on 652 estate accountings ("amtsmandsindberetninger") from the Ministry of Finance ("Rentekammeret"), 1782. We match the estates with *Hollænderier* with the 1770 list of estates from the Danish Research Center for Manorial Studies, supplemented by the list from Christensen (1886, appendix B). The latter is a transcription of a manuscript without title, date or signature preserved in the Royal Library in Copenhagen (Univ. Mskr. Add. 230). Christensen dates it to around 1770. For more on this see the discussion by Linvald (1912, p. 150, fn. 1).
[25] Strictly speaking present day potential yields of rain-fed barley, from FAOs GAEZ database (2002). As shown by Andersen et al. (2016) present day potential barley yields correlates strongly with the level of barley tenant payments under the feudal system in 1662. As the

(1983) gives direct information on dairying, that is, the amount of in-kind rent payments in butter made by peasants in 1662 per unit of land.[27] Although this says little about demesne production of butter on estates, it might be positively related to the later establishment of cooperatives if there is persistency in dairying patterns among the peasantry (which *hollænderier* might just have taken advantage of). Second, Frandsen (1983) reports information on the prevalence of field-grass-systems in agriculture in the 1680s at the time of the large land quality (and use) assessment for a new land-based taxation system – this might be positively related to dairying, but it might more likely proxy for the use of cattle-raising. Third, as clover was an important part of *Koppelwirtschaft* and the whole Holstein system, we control for the share cultivated with clover in 1805 as a further control for pre-existing conditions for dairying. Finally, we add distance to the coast as a simple measure for openness in the form of market access given that the cooperatives were heavily export oriented.

To further control for market access we add distance to Copenhagen, parish level population density, proximity to market towns, distance to the rail road in 1890, and distance to the Ox Road, where the latter controls for proximity to the main export route for cattle which was the main alternative use of similar resources.

<< Table 1 around here >>

As a first step to disentangle whether the knowledge of the elites spread to the peasantry over time Table 2 provides baseline OLS results from estimating the following regression equation:

$$Cooperative\ creamery_i = \alpha + \beta elites1782_i + \boldsymbol{X'_i}\boldsymbol{\delta} + \epsilon_i. \quad (1)$$

where i is a grid cell, $Cooperative\ creamery$ is cooperative creamery exposure, $elites1782$ is our proxy for the influence of the elite on cell i as explained above, $\boldsymbol{X_i}$ is a vector of control variables described above, $\boldsymbol{\delta}$ is the associated vector of coefficients and ϵ_i is the error term. The standard errors are corrected for clustering at the parish level. We also compute and report Conley standard errors to account for potential spatial autocorrelation not captured with dependence within the parish. In most specifications, $\boldsymbol{X_i}$ contains region fixed effects.

historical data do not provide full coverage we use the measure of present day potential yields. All results are robust to using the subsample for which historical data are available.

[26] It might also potentially capture its availability as fodder. Under *Koppelwirtschaft* dairying and grain production can be considered to be complements, but the cooperatives also imported grain and concentrates from overseas.

[27] This information was collected by the government for several commodity payments in order to construct a proxy for land productivity as a basis of immediate taxation before the actual land survey was carried out.

<< Table 2 around here >>

In all specifications in Table 2, the coefficient on $elites1782$ is positive and statistically significant. This implies a positive effect on the likelihood that cooperative creameries were established in proximity to *hollænderier* established by elites. The introduction of regional fixed effects in column 2 has very little impact on the estimated coefficient.[28] In column 3, we control for the distance to the first cooperative creamery, and find that the coefficient is largely unchanged as compared to columns 1 and 2. As controls for estates without *hollænderier* and the presence of an estate demesne in the grid cell are included in column 4, the size of the effect is more than cut in half but is still highly significant. Controlling for crown estates, late innovators and the presence of folk high schools has little impact on the coefficient on $elites1782$ in column 5. The same is true when we include barley suitability, historical butter production, the share of the area growing clover, historical presence of the grass field system, and the distance to the coast in the set of control variables in column 6. Finally, when we add control variables for market access (Distance to Copenhagen, Population density, presence of a market town, Distance to the railway and Distance to the Ox road) in column 7, the estimated coefficient on $elites1782$ is reduced substantially, but remains strongly significant. The estimated coefficient in column 7 of Table 2 implies that an increase of one standard deviation in the elite influence increases the likelihood for a grid cell to be exposed to cooperative creameries by (0.00243*70,81)=0.17, or 9 percent of a standard deviation in the cooperative creamery exposure using the most conservative estimate. This indicates that the effect of the elites is not only statistically, but also economically, significant.

The results also produce some interesting findings for the control variables. Being closer to the first cooperative creamery is positively associated with the emergence of cooperatives as one might expect. The presence of estates or crown estates nearby is also positively associated with the emergence of cooperatives but not if the location is *on* an estate demesne. Further, the presence of folk high schools and late innovators are also positively associated with the presence of cooperative creameries as expected. All market access and geographical control variables enter with the expected signs except for distance to the coast and grass-field-system. Cooperatives were more intensely established further away from the coast and in areas without a grass-field-system in the 1680s. One potential explanation for the former is that the distance to the sea had become less important with the arrival of the railroad, which itself could have been an important locational determinant for many cooperatives. The result on grass-field-system may be interpreted as a legacy of the historical optimal

[28] The regional fixed effects are for 21 historical counties when we use the grid level data. For the much smaller parish and estate samples, we use fixed effects for 5 larger historical regions (Jutland, Funen, Zealand, Lolland-Falster and Bornholm). These fixed effects capture, among other things, that some regions historically were subject to serfdom longer than others.

use of land. In the seventeenth century those parts of the country that were most fertile were cultivated using the traditional three-field-system whereas the less fertile sandy soils especially found in western Jutland were primarily used for grazing. With the advent of the cooperative movement, the fertile parts of the country could support more cows and in turn more cooperative creameries.

Even though we include an extensive set of control variables, the concern that omitted variables determine both the location of *hollænderier* and cooperatives could remain. To address this, we propose an instrumental variable identification strategy, where we instrument $elites1782$ by the distance to Moltke's estate, Sofiendal, where the Holstein System was first established. This is consistent with our story that the system spread through Denmark inspired by Moltke (and his administrator, Völckers) as well as the historical literature cited above. Hence, we estimate the following instrumental variables model:

$$Cooperative\ creamery_i = \alpha + \beta elites1782_i + \boldsymbol{X'_i\delta} + \epsilon_i. \quad (2)$$

$$elites1782_i = \theta + \gamma DistanceSofiendal_i + \boldsymbol{X'_i\Gamma} + \mu_i. \quad (3)$$

where we include the great circle distance[29] to Sofiendal in our first stage (3) as our excluded instrument in (2).

In Table 3 we present the results of the first stage. The table follows the same structure as Table 2 and we control for the same variables as above. We notice that the coefficient on the distance to Sofiendal is always negative and strongly significant. Moreover, as shown at the bottom of Table 4, the F-test of instrument relevance is always well above 10, as per the usual rule of thumb. Thus, the instrument is highly relevant and there is no sign that distant to Sofiendal is a weak instrument. In column 4 in Table 3, It is seen that *hollænderier*, among other things, were established in places nearer estates in general but away from the estates of the late innovators. Proximity to crown estates does not influence the location of *hollænderier*. Higher suitability for barley production increases the likelihood of being close to *hollænderier* as do places further away from the coast and closer to the historical Ox Road as seen in columns 6 and 7. Importantly, the inclusion of the control variables does not change the statistical significance of the relation between the location of the *hollænderier* and Sofiendal.

<< Table 3 around here >>

[29] We have estimated all models using cost distance instead of great circle distance. Results are very similar in terms of significance as well as magnitude.

We present the instrumental variable (or two-stage-least-square) estimates of equation (2) in Table 4. Compared to Table 2, the coefficient on the $elites1782$ variable is now larger and more stable as control variables are added. Thus, when we rely on the plausibly, exogenous component of $elites1782$, we obtain large and significant effects that can be interpreted as the causal impact of the landed elites and the associated spread of knowledge on the emergence of the cooperative creamery movement. To a large extent the coefficients on the control variables are like those reported in Table 2. It is, however, worth noticing that when using the instrumental variable strategy $elites1782$ remain significant while other estates now have a negative impact and crown estates are only borderline significant.[30]

A potential threat to identification is the validity of the exclusion restriction of the instrument. Thus, even if we have included many control variables, there may still be remaining concerns about whether this restriction is violated. In order to further investigate the robustness of our results to this threat we use the 'plausibly exogenous' technique of Conley et al. (2012). In Figure C1 in the appendix, we apply this technique to gauge how large a potential direct effect of the instrument (Distance to Sofiendal) needs to be to render the IV estimate on $elites1782$ insignificant. The estimates suggest that some omitted variable that is also captured by *Distance to Sofiendal* needs to explain about 86 percent of the overall reduced form effect of the distance to Sofiendal to render the 2SLS estimate on $elites1782$ insignificant. As this is very high, we conclude that while it is possible that the direct effect is of this order of magnitude, this does not seem plausible (for further details see Appendix C).

<< Table 4 around here >>

To evaluate the importance of the elite based explanation relative to other potential explanations we calculate standardized coefficients in Table 5. When compared to all the potential cofounders, we see that $elites1782$ has much larger explanatory power. In fact, the beta coefficient on $elites1782$ explains more than all other the 16 covariates combined. In column 7, a one standard deviation increase in the $elites1782$ variable leads to a 1.73 standard deviation increase in the cooperative creamery exposure variable, or 1.73*2.00 = 3.46 which is 42% of the mean exposure. This is our preferred estimate as the instrumental variables estimate arguably measures the causal effect.

[30] We have also estimated models in which we control for calorie adjusted crop yields as constructed by Galor and Özak (2016) for the post 1500 period. This measure enters with a negative coefficient and has little impact on the estimated effect of $elites1782$.

<< Table 5 around here >>

If the presence of *hollænderier* had a persistent effect for a century before the first cooperatives, we would expect that this meant a gradual spread of the ideas used on the estates to the wider peasant population, due to the traditional links between the estates and the surrounding peasantry, and reflected by our reading of the contemporary literature. We can quantify this by considering the increase in the number of milch cows around the country in the intervening period. In 1760 there were 270,000 milch cows in Denmark, increasing to 335,000 in 1774, and 450,000 in 1810 (Drejer 1962, p. 22, Jensen 1998). Moreover, in 1837 we have parish level data from the first (surviving) animal census, which puts the total level at 578,000 in 1837. In 1861, there were 756,834 milch cows in the animal census. By 1881, the year before the first cooperative creamery was founded, there were 898,790. If we are to believe the persistency story, the local density of cows should have remained fairly constant before 1882. In fact, the correlation coefficients between the densities in 1837 and 1861 and 1881 are all around 0.9. It then remains to demonstrate that the location of the *hollænderier* also explains the pattern we observe in the cow densities. To do this, we employ the same empirical strategy as above, but with the cow densities in 1837 at the parish level as the outcome variable. Again, the relationship is very strong and robust – a greater influence from the elites implies greater cow densities (see Table 6). This result is consistent with the work of Henriksen (1999), who shows that the share of cows supplying a cooperative correlates with cow density, which implies that the peasantry was also turning to dairying in areas close to *hollænderier*, imitating the elites as the narrative above implies.

<< Table 6 around here >>

Looking across the table, we note that adding control variables does not change the significance of $elites1782$. Importantly, columns 6 and 7 show that the relationship between cow densities and $elites1782$ is not driven by past specialization in butter production by the peasantry.

5. Robustness

In this section, we investigate the robustness of our results in four ways. First, we show that the results are similar for the location of cooperatives in 1914. Second, we use alternative units of observation and find that the

results also hold at the parish and estate levels. Third, we test the relevance of our instrumental variable at the estate level and finally, we investigate whether our main results hold water in a model without the inclusion of fixed effects for regions.

We start by testing the robustness of our results in the temporal dimension. Hitherto we have focused on the time around the ending of the first wave of the cooperative creamery movement around 1890. One might argue that the results are sensitive to this specific year and therefore we select another point in time to test the hypothesis. Specifically, we select 1914, just before the First World War changed the landscape. Tables 7 and 8 present the results from this robustness test. Focusing on the standardized coefficients in Table 8 we see they are statistically significant, though slightly smaller than those for 1890, again emphasizing the persistence of the impact of the eighteenth century elites.

<< Tables 7 and 8 around here >>

Next, we show that the relationship between the elites and the cooperative movement is present also at the parish level. We use the parish level to demonstrate that results also hold when historical and larger units are used. Moreover, the parish level corresponds to the historical level at which population data were collected and hence we do not need to disaggregate these data. We use the same strategy as presented above but use parishes as the unit of observation instead of grid cells.[31] Table 9 shows the second stage results. We see that the results are robust to using parishes as the unit of observation. Reassuringly, the results are very similar to the grid level results in terms of both magnitude and significance.

<< Table 9 around here >>

Next we consider estates as an alternative unit of observation. We show that the relationship between the elites and the cooperative movement is also present if we apply a similar strategy at the estate level. Using the estate as the unit of observations confers the advantage that we now compare estates with estates which are likely to be more similar units than e.g. parishes. In this way, we reduce heterogeneity between the units of

[31] Parish level descriptive statistics can be found in Appendix B.

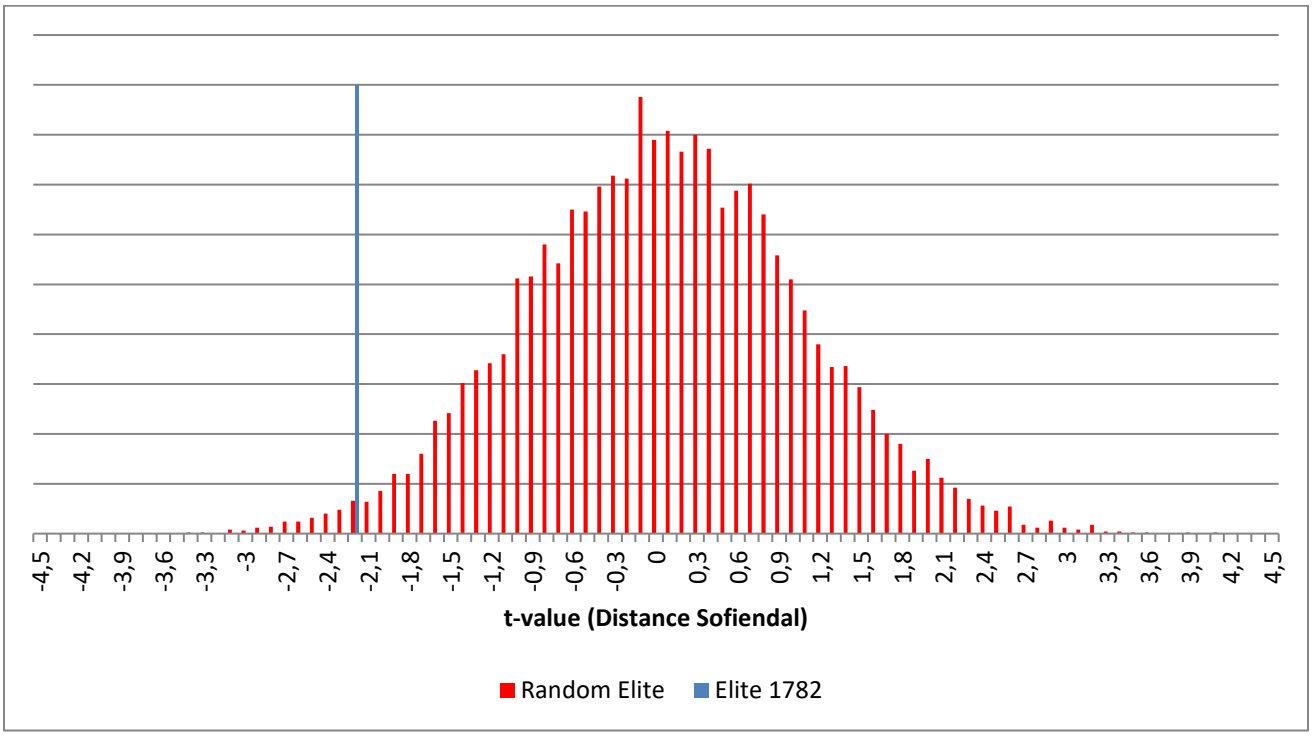
observations, but of course end up with fewer observations. We estimate the model using a similar outcome variable as before, but the distance to the cooperative creameries now being measured from each estate. We code a dummy for whether an estate used the Holstein System in 1782 and construct similar control variables as in the setups described above.[32] Thus, the variation comes from the plausibly exogenous component in the establishment of a *hollænderi* on an estate. Table 10 shows the second stage results. We see a positive and significant relation between the presence of a *hollænderi* on an estate and the proximity of cooperative creameries. In column 7, the significance level is only at the five percent level, whereas in other columns, significance is at the one percent level. Moreover, the F statistic is just above 5 in column 7 and thus below the conventional rule of thumb. However, as noted by Cameron and Trivedi (2005), an F statistic above 5 is also sometimes applied as a rule of thumb .

<< Table 10 around here >>

We found distance Sofiendal to be a relevant instrument at the grid and parish levels above, so we think the weaker relation is likely due to a lower number of observations in column 7 of Table 10. To test the relevance or the predictive power of distance to Sofiendal in explaining the geographical distribution of *hollænderier* across estates we randomly allocate the 224 *hollænderier* to the 791 estates for which we have full data coverage. We repeat this procedure 10,000 times and regress the random allocation of *hollænderier* on distance to Sofiendal and the full set of covariates to check whether the true distribution of *hollænderier* is better explained by distance to Sofiendal than a given random allocation. In figure 4 we plot the t-values of distance Sofiendal from these 10,000 regressions. The figure shows that Distance Sofiendal does indeed explain the true location of *hollænderier* significantly better relative to the vast majority of the 10,000 random allocations. We see this as a further piece of evidence that the *hollænderier* did in fact spread in the way we suggest from Sofiendal to the rest of the country.

[32] Estate level descriptive statistics can be found in Appendix A.

Figure 4: Testing the relation between Distance Sofiendal and the distribution of *hollænderier*



Note: The red bars show frequencies of t-values of Distance Sofiendal from regressing (randomly allocated) $elites1782$ on Distance Sofiendal and the full set of covariates. The random allocation of the 224 *hollænderier* to the 791 estates was repeated 10,000 times. The vertical blue line indicates the t-value from the true distribution of *hollænderier* (t-value= -2.25).

Finally, we test the importance of regional fixed effects in our two stage least square estimates as they could potentially inflate the estimated effects. Hence, we re-estimate our main results in Table 4 but exclude regional level fixed effects in all specifications. Table 11 presents the results of this test. Panel A shows the results without fixed effects while Panel B repeats the results from Table 4 for convenience. We see that while there is a tendency for the fixed effects to inflate our estimates they are very stable as covariates are subsequently included and importantly, all results remain highly significant at conventional levels. Thus, we conclude that our instrumental variable results are not driven by the inclusion of fixed effects for regions.

<< Table 11 around here >>

6. Conclusion

How did Denmark 'get to Denmark'? To the extent that the country developed through agricultural cooperation, the present work suggests a striking answer, and one which is not particularly compatible with the usual narrative of hard working peasants and a democratic countryside. Thus, we have demonstrated that the reason for the extremely rapid spread of cooperative creameries in Denmark between 1882 and 1890 can be attributed to the spread of innovations, starting with the introduction of the Holstein System, by large landowning elites from Schleswig and Holstein over the preceding century. We have described based on the contemporary literature how these innovations spread throughout the country, and trickled-down to farmers beyond the large estates. Moreover, we have demonstrated empirically that areas with more *hollænderier* developed greater cow densities, revealing the spread of dairying around the country, and that the initial wave of cooperation was in areas which had been so treated. We also show that the historical persistence of the elites still played a role in 1914 and that our results are stable to a number of robustness tests.

On a less optimistic note, however, it should also be remembered that the process as a whole took well over a century. The institutions, technology, schools, etc. did not appear overnight, or within the first decade of cooperation. Farmers would not have known that their comparative advantage lay in dairying in the 1880s, and they would not even have had the cow densities for this to be the case, if the *hollænderier* had never existed. This has implications for understanding the reason why the attempt to transfer Danish-style cooperatives to other countries, such as Ireland in the 1890s (see e.g. Henriksen et al. 2015) and Iceland around the turn of the twentieth century (Jónsson 2012), as well as to developing countries more recently, were relative failures. For more than a century elites were initiating a whole package of reforms which eventually allowed the cooperatives to emerge and prosper. There has been a tendency to see cooperation as the solution to agricultural poverty, but this work suggests that this must be in combination with other reforms, which, at least initially, elites are probably better placed to implement than the peasants themselves.

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Table 1: Summary Statistics and Variable Descriptions

Variable	N	Mean	SD	Min	Max	Source*	Description
Cooperative creamery exposure , 1890	38,370	8.22	2.00	3.17	14.05	A	Inverse distance weighted sum of cooperative creameries, 1890 (mp)
Elites 1782	38,370	132.23	70.81	42.20	580.35	B	Inverse distance weighted sum of hollænderi estate hartkorn, 1782 (mp)
Distance Sofiendal	38,370	161.40	77.52	0.41	288.54	C	Distance from grid cell to the estate Sofiendal (km)
Distance first cooperative creamery	38,370	131.05	74.89	0.46	421.33	C	Distance from grid cell to the first cooperative creamery in Hjedding (km)
Estates (mp)	38,370	10.06	1.94	2.62	16.02	D	Inverse distance weighted sum of estates, 1770 (mp)
Demesne share, 1680s	38,370	0.12	0.28	0.00	1.00	E	Share of grid cell area owned by an estate (with or without a hollænderi), 1680s
Crown estates (mp)	38,370	2.25	0.86	0.71	6.37	F	Inverse distance weighted sum of crown estates (min 10 years, 1600-1800) (mp)
Late innovators (mp)	38,370	0.11	0.08	0.04	2.14	G	Inverse distance weighted sum of 'late innovator estates' (mp)
Folk high school (mp), 1890	38,370	0.75	0.24	0.26	3.55	H	Inverse distance weighted sum of folk high schools, 1890 (mp)
Butter production, 1662	38,370	1.18	4.89	0.00	73.21	I	Butter payments in 1662 - barrels per km2 land in the grid cell
Clover share, 1805	38,370	0.18	0.36	0.00	1.00	J	Share of grid cell area cultivated with clover, 1805
Barley suitability	38,370	57.02	17.53	0.00	92.50	K	Barley suitability from GAEZ, FAO (2002)
Field-grass-system, 1682	38,370	0.55	0.50	0.00	1.00	I	=1 if field-grass-system in 1682
Distance coast	38,370	9.45	9.46	0.00	48.67	E	Distance from grid cell to the nearest coast (km)
Distance Copenhagen	38,370	178.39	73.68	0.55	297.14	C	Distance from grid cell to Copenhagen (km)
Population density, 1787	38,010	21.58	96.17	0.00	7920.3	L	Parish population density in 1787
Market town (mp)	38,370	0.90	0.20	0.47	3.15	C	Inverse distance weighted sum of market towns (mp)
Distance rail, 1890	38,370	10.37	20.15	0.00	177.31	M	Distance from grid cell to the nearest rail road, 1890 (km)
Distance Ox Road	38,370	64.81	67.49	0.00	368.30	C	Distance from grid cell to the nearest Ox Road (km)

* Data sources: A) Own work, based on Bjørn (1988), B) own work, based on Andersen (1963), Christensen (1886), and Roholt (2012), C) own work, D) Christensen (1886), and Roholt (2012), E) own work, based on hiskis.dk, F) own work based on the Danish Center for Estate Research, G) own work based on Hertel (1920) – History of the Royal Danish Agricultural Society, the Royal Danish Agricultural Society , 1769-1868 H) own work based on Borup (1939) I) own work based on Frandsen (1983) J) own work based on Kjærgaard (1991), K) own work based on GAEZ, FAO (2002), L) Population count 1787, Statistics Denmark (1911) , M) own work based on Koed (1997)

Table 2: Main Results (OLS) – Cooperative Creamery Exposure 1890 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elites 1782	0.01743***	0.01710***	0.01624***	0.00639***	0.00458***	0.00469***	0.00243***
	(0.00064)	(0.00112)	(0.00112)	(0.00095)	(0.00095)	(0.00094)	(0.00086)
	[0.00316]	[0.00260]	[0.00272]	[0.00295]	[0.00260]	[0.00262]	[0.00243]
Distance first cooperative creamery			-0.01589***	-0.01280***	-0.01324***	-0.01065***	-0.01525***
			(0.00166)	(0.00147)	(0.00119)	(0.00121)	(0.00112)
Estates (mp)				0.43166***	0.30008***	0.30859***	0.26660***
				(0.02274)	(0.02172)	(0.02041)	(0.01951)
Demesne share, 1680s				-0.10556***	-0.09860***	-0.08036***	-0.04646**
				(0.02699)	(0.02494)	(0.02341)	(0.02035)
Crown estates (mp)					0.45723***	0.38210***	0.22579***
					(0.05187)	(0.05022)	(0.04701)
Late innovators (mp)					1.02982***	0.72001***	0.64265***
					(0.28510)	(0.24936)	(0.22324)
Folk high school (mp), 1890					0.76982***	0.67661***	0.39155***
					(0.09186)	(0.09058)	(0.08181)
Butter production, 1662						0.00083	0.00056
						(0.00078)	(0.00073)
Clover share, 1805						0.04172	0.01690
						(0.03484)	(0.03065)
Barley suitability						0.00293***	0.00550***
						(0.00097)	(0.00087)
Field-grass-system, 1682						-0.35827***	-0.36490***
						(0.06043)	(0.05080)
Distance coast						0.02696***	0.01487***
						(0.00251)	(0.00238)
Distance Copenhagen							-0.01688***
							(0.00113)
Population density, 1787							-0.00040***
							(0.00007)
Market town							0.04290
							(0.07866)
Distance rail, 1890							-0.01782***
							(0.00236)
Distance Ox Road							-0.01200***
							(0.00132)
Constant	5.91323***	3.33979***	9.82393***	7.82893***	7.42727***	6.16450***	18.25437***
	(0.08849)	(0.06521)	(0.69005)	(0.62739)	(0.51385)	(0.53036)	(0.88956)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
N	38370	38370	38370	38370	38370	38370	38010
Adj R^2	0.382	0.805	0.822	0.857	0.878	0.888	0.905

Parish level clustered standard errors in parentheses, Conley standard errors correcting for spatial autocorrelation within 50 km in squared brackets, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Main Results (IV, First stage) – Elites 1782 and Distance to Sofiendal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Elites 1782						
Distance Sofiendal	-0.6575***	-0.6473***	-0.6659***	-0.4206***	-0.4071***	-0.4719***	-0.7571***
	(0.0155)	(0.0366)	(0.0383)	(0.0295)	(0.0353)	(0.0332)	(0.1161)
Distance first cooperative creamery			-0.1969***	-0.0513	-0.0444	-0.1530***	-0.0998***
			(0.0419)	(0.0324)	(0.0323)	(0.0320)	(0.0384)
Estates (mp)				12.2277***	12.1003***	12.3435***	12.2350***
				(0.6724)	(0.7739)	(0.7327)	(0.7791)
Demesne share				3.1931***	3.2440***	2.8024***	3.1049***
				(0.7527)	(0.7460)	(0.7468)	(0.7391)
Crown estates (mp)					1.3574	-0.7378	-1.7443
					(1.7865)	(1.7960)	(1.8319)
Late innovators (mp)					-23.7641***	-20.6686***	-20.2987***
					(7.6383)	(7.5099)	(7.5279)
Folk high school (mp), 1890					1.9137	0.7805	2.5192
					(1.9618)	(1.8326)	(1.7879)
Butter production, 1662						0.0155	0.0133
						(0.0243)	(0.0242)
Clover share, 1805						0.2781	-0.0939
						(0.9960)	(1.0087)
Barley suitability						0.1256***	0.0882***
						(0.0252)	(0.0262)
Field-grass-system, 1682						-9.5859***	-9.2537***
						(1.4132)	(1.4260)
Distance coast						-0.4205***	-0.3408***
						(0.0552)	(0.0613)
Distance Copenhagen							0.3300***
							(0.1171)
Population density, 1787							-0.0044*
							(0.0023)
Market town							-0.1469
							(2.4761)
Distance rail, 1890							-0.0601
							(0.0787)
Distance Ox Road							0.0928**
							(0.0385)
Constant	238.3455***	166.4430***	249.7980***	110.2120***	103.5156***	153.3186***	111.5902***
	(3.5016)	(6.9252)	(17.6343)	(13.7017)	(15.1500)	(15.5743)	(29.1330)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
N	38370	38370	38370	38370	38370	38370	38010

Parish level clustered standard errors in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Table 4: Main Results (IV, Second stage) – Cooperative Creamery Exposure 1890 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elites 1782	0.0196***	0.0504***	0.0520***	0.0634***	0.0555***	0.0434***	0.0489***
	(0.0008)	(0.0030)	(0.0028)	(0.0051)	(0.0053)	(0.0037)	(0.0077)
	[0.00450]	[0.00942]	[0.00835]	[0.01448]	[0.01376]	[0.00951]	[0.01813]
Distance first cooperative creamery			-0.0110***	-0.0132***	-0.0137***	-0.0083***	-0.0046*
			(0.0020)	(0.0022)	(0.0019)	(0.0017)	(0.0026)
Estates (mp)				-0.3791***	-0.3340***	-0.1891***	-0.3401***
				(0.0831)	(0.0760)	(0.0564)	(0.1024)
Demesne share, 1680s				-0.2382***	-0.2218***	-0.1553***	-0.1687***
				(0.0572)	(0.0513)	(0.0414)	(0.0507)
Crown estates (mp)					0.0769	0.1569*	0.1858*
					(0.1096)	(0.0889)	(0.0973)
Late innovators (mp)					2.1067***	1.5142***	1.7044***
					(0.5448)	(0.4295)	(0.5047)
Folk high school (mp), 1890					0.3981***	0.4330***	0.3662***
					(0.1011)	(0.0837)	(0.0887)
Butter production, 1662						-0.0003	-0.0005
						(0.0013)	(0.0014)
Clover share, 1805						-0.0084	-0.0135
						(0.0538)	(0.0584)
Barley suitability						-0.0013	-0.0002
						(0.0013)	(0.0017)
Field-grass-system, 1682						0.1044	0.1382
						(0.0867)	(0.1165)
Distance coast						0.0337***	0.0331***
						(0.0032)	(0.0053)
Distance Copenhagen							0.0011
							(0.0036)
Population density, 1787							0.0000
							(0.0001)
Market town							-0.0459
							(0.1430)
Distance rail, 1890							-0.0154***
							(0.0042)
Distance Ox Road							-0.0147***
							(0.0023)
Constant	5.6289***	1.8447***	6.2341***	7.7170***	7.6630***	5.5294***	11.7066***
	(0.1053)	(0.1411)	(0.8812)	(0.8946)	(0.7859)	(0.7025)	(2.0592)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
N	38370	38370	38370	38370	38370	38370	38010
First stage F	1795.176	312.670	301.853	203.510	133.026	202.601	42.517

Parish level clustered standard errors in parentheses, Conley standard errors correcting for spatial autocorrelation within 50 km in squared brackets, * p < 0.1, ** p < 0.05, *** p < 0.01

Table 5: Main Results (IV, Second stage) – with Standardized Coefficients ("Beta Coefficients")

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elites 1782	.69400***	1.78643***	1.84322***	2.24516***	1.96617***	1.53697***	1.73159***
Distance first cooperative creamery			-.41233***	-.49572***	-.51324***	-.31204***	-.17426*
Estates (mp)				-.36723***	-.32353***	-.18324***	-.32897***
Demesne share,1680s				-.033161***	-.03088***	-.02163***	-.02347***
Crown estates (mp)					0.03304	0.06740*	.07995*
Late innovators (mp)					.08193***	.05889***	.06652***
Folk high school (mp), 1890					.09509***	.10342***	.08673***
Butter production, 1662						-.00083	-.00113
Clover share, 1805						-.00150	-.00241
Barley suitability						-.01160	-.00178
Field-grass-system, 1682						.02601	.03442
Distance coast						.15969***	.15612***
Distance Copenhagen							.03990
Population density, 1787							.00081
Market town							.00464
Distance rail, 1890							-.15589***
Distance Ox Road							-.49698***

Table 6: Channel (IV, Second stage) – Cow Density 1837 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cow Density, 1837						
Elites 1782	0.0921***	0.0867***	0.0942***	0.1119***	0.0689***	0.0672***	0.1015***
	(0.0040)	(0.0083)	(0.0090)	(0.0134)	(0.0146)	(0.0154)	(0.0353)
Distance first cooperative creamery			0.0320***	0.0365***	0.0265***	0.0145**	0.0296**
			(0.0060)	(0.0069)	(0.0063)	(0.0065)	(0.0142)
Estates, 1700 (mp)				-0.6554***	-0.7166***	-0.5747***	-1.4651***
				(0.2319)	(0.2054)	(0.2180)	(0.4486)
Demesne share, 1680s				-0.7471	0.1459	-0.1400	0.4266
				(1.1278)	(0.9920)	(0.9570)	(1.1934)
Crown estates (mp)					1.8101***	0.6153	0.7042
					(0.5386)	(0.5070)	(0.5671)
Late innovators (mp)					8.8885***	6.6957***	7.8451**
					(2.6674)	(2.5780)	(3.4008)
Folk high school, 1890					1.1100	1.1186	0.6832
					(0.8437)	(0.8003)	(0.9633)
Butter production, 1662						0.3354***	0.3493**
						(0.1270)	(0.1421)
Clover share, 1805						-0.9530	-0.8459
						(0.7885)	(0.8983)
Barley suitability						0.0596***	0.0622***
						(0.0110)	(0.0138)
Field-grass-system, 1682						-3.3601***	-2.5389**
						(0.8389)	(1.0082)
Distance coast						-0.1898***	-0.2223***
						(0.0275)	(0.0324)
Distance Copenhagen							-0.0013
							(0.0141)
Population density, 1787							-0.0011
							(0.0022)
Market town							-5.3662***
							(1.4821)
Distance rail road							-0.1032***
							(0.0343)
Distance Ox Road							-0.0659***
							(0.0155)
Constant	3.8554***	11.2005***	-2.1116	-2.9002	1.3891	3.0318	37.7817***
	(0.6344)	(2.1281)	(3.4101)	(3.6707)	(3.2781)	(3.3874)	(9.5380)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
Parishes (N)	1641	1641	1641	1641	1641	1641	1641
First stage F	906.398	341.133	306.667	164.838	103.898	84.817	20.103

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Robustness (IV, Second stage) – Cooperative Creamery Exposure 1914 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1914						
Elites 1782	0.0064***	0.0662***	0.0695***	0.0787***	0.0731***	0.0562***	0.0544***
	(0.0015)	(0.0049)	(0.0045)	(0.0080)	(0.0083)	(0.0057)	(0.0080)
Distance first cooperative creamery			-0.0230***	-0.0248***	-0.0253***	-0.0165***	-0.0102***
			(0.0029)	(0.0030)	(0.0028)	(0.0025)	(0.0029)
Estates (mp)				-0.3097**	-0.2743**	-0.0894	-0.2335**
				(0.1276)	(0.1228)	(0.0893)	(0.1106)
Demesne share, 1680s				-0.3217***	-0.3111***	-0.2190***	-0.2156***
				(0.0759)	(0.0716)	(0.0568)	(0.0587)
Crown estates (mp)					-0.1047	0.0556	0.0846
					(0.1465)	(0.1148)	(0.1075)
Late innovators (mp)					2.8477***	2.0542***	2.2468***
					(0.7730)	(0.6004)	(0.6231)
Folk high school (mp), 1890					0.4413***	0.5332***	0.2905***
					(0.1449)	(0.1182)	(0.1052)
Butter production, 1662						0.0002	0.0002
						(0.0017)	(0.0015)
Clover share, 1805						0.0215	0.0040
						(0.0730)	(0.0670)
Barley suitability						-0.0019	0.0040**
						(0.0019)	(0.0020)
Field-grass-system, 1682						0.5637***	0.4409***
						(0.1366)	(0.1376)
Distance coast						0.0482***	0.0397***
						(0.0043)	(0.0059)
Distance Copenhagen							-0.0047
							(0.0038)
Population density, 1787							0.0000
							(0.0001)
Market town							0.4416***
							(0.1688)
Distance rail, 1890							-0.0225***
							(0.0054)
Distance Ox Road							-0.0386***
							(0.0027)
Constant	14.9747***	3.4341***	12.6026***	13.8216***	13.8093***	10.2632***	25.5625***
	(0.2134)	(0.2244)	(1.2816)	(1.2318)	(1.1492)	(1.0190)	(2.3287)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
N	38370	38370	38370	38370	38370	38370	38010
First stage F	1795.176	312.670	301.853	203.510	133.026	202.601	42.517

Parish level clustered standard errors in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Table 8: Robustness (IV, Second stage) – with Standardized Coefficients ("beta coefficients")

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1914						
Elites 1782	0.1521***	1.5667***	1.6458***	1.8636***	1.7305***	1.33052***	1.2904***
Distance first cooperative creamery			-0.5754***	-0.6200***	-0.6342***	-0.4133***	-0.2552***
Estates (mp)				-0.2005**	-0.1775**	-0.0579	-0.1515**
Demesne share, 1680s				-0.0299***	-0.0289***	-0.0204***	-0.0201***
Crown estates (mp)					-0.0301	0.0160	0.0244
Late innovators (mp)					0.0740***	0.0534***	0.0588***
Folk high school (mp), 1890					0.0740***	0.0851***	0.0461***
Butter production, 1662						0.0003	0.0004
Clover share, 1805						0.0259	0.0005
Barley suitability						-0.0110	0.0235**
Field-grass-system, 1682						0.0938***	0.0736***
Distance coast						0.1526***	0.1256***
Distance Copenhagen							-0.1167
Population density, 1787							0.0004
Market town							0.0299***
Distance rail, 1890							-0.1521***
Distance Ox Road							-0.8748***

Table 9: Parish Level Results (IV, Second stage) – Cooperative Creamery Exposure 1890 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elites 1782	0.020***	0.053***	0.052***	0.048***	0.039***	0.032***	0.045***
	(0.001)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.009)
Distance first cooperative creamery			-0.004*	-0.004**	-0.006***	-0.006***	-0.001
			(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
Estates, 1770 (mp)				0.122*	0.100*	0.165***	-0.201*
				(0.067)	(0.057)	(0.053)	(0.116)
Demesne share, 1680s				-1.926***	-1.749***	-1.385***	-1.122***
				(0.332)	(0.282)	(0.238)	(0.344)
Crown estates (mp)					0.378**	0.278**	0.266
					(0.154)	(0.126)	(0.166)
Late innovators (mp)					2.212***	1.461**	2.237**
					(0.768)	(0.647)	(0.978)
Folk high school, 1890					-0.250	-0.224	-0.379
					(0.243)	(0.201)	(0.275)
Butter production, 1662						0.037	0.066
						(0.032)	(0.042)
Clover share, 1805						-0.344*	-0.454*
						(0.194)	(0.259)
Barley suitability						-0.001	0.004
						(0.003)	(0.004)
Field-grass-system, 1682						-0.856***	-0.501*
						(0.210)	(0.290)
Distance coast						0.051***	0.037***
						(0.007)	(0.009)
Distance Copenhagen							-0.004
							(0.004)
Population density, 1787							0.000
							(0.000)
Market town							-0.164
							(0.329)
Distance rail road							-0.005
							(0.010)
Distance Ox Road							-0.033***
							(0.004)
Constant	5.676***	1.815***	3.304***	3.429***	4.377***	4.529***	15.575***
	(0.140)	(0.672)	(1.117)	(1.051)	(0.911)	(0.830)	(2.797)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
Parishes (N)	1675	1675	1675	1675	1675	1675	1675
First stage F	932.554	348.808	312.922	170.219	108.669	88.848	25.552

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Estate Level Results (IV, Second stage) – Cooperative Creamery Exposure 1890 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elite 1782	8.13652***	19.93444***	19.45107***	20.12016***	19.78238***	12.24757***	11.52997**
	(0.92323)	(4.70804)	(5.00953)	(5.31063)	(5.15796)	(3.41786)	(5.08719)
Distance first cooperative creamery			-0.00404	-0.00302	-0.00244	-0.00489	-0.00604
			(0.00744)	(0.00780)	(0.00777)	(0.00511)	(0.00657)
Estate size				-0.01377	-0.01296	-0.00469	-0.00346
				(0.00881)	(0.00859)	(0.00537)	(0.00492)
Crown estate					0.54374	0.34869	0.34582
					(0.66120)	(0.43188)	(0.43778)
Late innovator					3.22361	2.06005	2.09942
					(2.87729)	(1.82270)	(1.78802)
Folk high school, 1890					-1.72729	-1.18905	-1.12460
					(1.13602)	(0.72532)	(0.77846)
Butter production, 1662						0.23548*	0.22610*
						(0.13606)	(0.12765)
Pasture suitability						0.00026	0.00001
						(0.00021)	(0.00020)
Demesne clover share, 1805						-0.17802	-0.33733
						(0.61182)	(0.59273)
Barley suitability						-0.00010	0.00008
						(0.00014)	(0.00013)
Field-grass-system, 1682						-1.19250	-1.48014*
						(0.78098)	(0.78708)
Distance coast						0.11958***	0.07888***
						(0.02661)	(0.02917)
Distance Copenhagen							-0.01155
							(0.00810)
Population density, 1787							-0.00380
							(0.00803)
Distance Market town							-0.01540
							(0.03085)
Distance rail road, 1890							-0.00498
							(0.02893)
Distance Ox Road							-0.04698***
							(0.01153)
Constant	6.27175***	-3.69486	-2.82643	-2.83392	-2.64082	0.67929	6.85949
	(0.28624)	(3.48531)	(4.27626)	(4.41280)	(4.30145)	(2.96982)	(4.74731)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
Estates (N)	810	810	810	810	810	796	791
First stage F	88.009	18.391	15.525	14.711	15.031	13.194	5.079

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Main Results [T4] (IV, 2. stage) Without Fixed Effects – Cooperative Creamery Exposure 1890 and Elites 1782

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Panel A							
Elites 1782	0.0196***	0.0196***	0.0273***	0.0245***	0.0159***	0.0158***	0.0106***
	(0.0008)	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0009)
FE (Region)	No	No	No	No	No	No	No
First stage F	1795.176	1795.176	2799.355	2555.892	970.787	823.029	840.414
Panel B							
Elites 1782	0.0196***	0.0504***	0.0520***	0.0634***	0.0555***	0.0434***	0.0489***
	(0.0008)	(0.0030)	(0.0028)	(0.0051)	(0.0053)	(0.0037)	(0.0077)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
First stage F	1795.176	312.670	301.853	203.510	133.026	202.601	42.517
Full set of covariates (T4, Col 7)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	38370	38370	38370	38370	38370	38370	38010

Parish level clustered standard errors in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Appendix A – Estate Level Descriptives

Table A1: Summary Statistics and Variable Descriptions

Variable	N	Mean	SD	Min	Max	Description
Cooperative creamery exposure, 1890	810	8.52	2.06	4.50	14.00	Inverse distance weighted sum of cooperative creameries, 1890 (mp)
Elites 1782	810	0.28	0.45	0.00	1.00	=1 if the estate had a hollænderi
Distance Sofiendal	810	147.48	82.67	0.00	285.80	Distance to the estate of Sofiendal (km)
Distance first cooperative creamery	810	141.69	58.65	3.57	262.84	Distance to the first cooperative creamery in Hjedding (km)
Estate size	810	44.68	35.22	6.00	325.61	Historical measure of the value of the estate in 1770 (Domain size and soil suitability)
Crown estate	810	0.23	0.42	0	1	=1 if crown ownership at least 10 years during 1600-1800
Late innovator	810	0.01	0.09	0.00	1.00	=1 if the estate was one of the 'late innovators'
Folk high school, 1890	810	0.07	0.26	0.00	1.00	=1 if folk high school in the parish before 1890
Butter production, 1662	810	1.40	1.45	0.00	7.94	Butter payments in 1662 - barrels per km^2 land in the parish of the estate
Pasture suitability	810	63.17	12.70	26.80	77.70	Pasture suitability at the estate or the nearest geographical coverage of FAO
Demesne clover share, 1805	796	0.35	0.43	0.00	1.00	Share of grid cell area cultivated with clover, 1805
Barley suitability	810	60.04	19.56	15.00	92.50	Barley suitability at the estate or the nearest geographical coverage of FAO
Field-grass-system, 1682	810	0.46	0.48	0.00	1.00	Share of parish using field-grass-system in 1682
Distance coast	810	7.17	7.04	0.00	40.67	Distance to the nearest coast (km)
Distance Copenhagen	810	168.22	73.00	8.32	290.79	Distance to Copenhagen (km)
Population density, 1787	804	21.87	21.40	0.00	416.90	Parish level population density in 1787
Market town	810	11.36	5.66	0.03	37.14	Distance to the nearest market town (km)
Distance rail, 1890	810	6.85	6.23	0.01	37.59	Distance to the nearest rail road, 1890 (km)
Distance Ox Road	810	67.85	56.66	0.00	202.64	Distance to the Ox Road (km)

Appendix B – Parish Level Descriptives

Table B1: Summary Statistics and Variable Descriptions

Variable	N	Mean	SD	Min	Max	Description
Cooperative creamery exposure, 1890	1847	8.42	2.17	2.67	13.86	Inverse distance weighted sum of cooperative creameries, 1890 (mp)
Elites 1782	1847	147.14	88.31	42.07	1356.06	Inverse distance weighted sum of hollænderi estate hartkorn, 1782 (mp)
Cow density, 1837	1673	17.68	9.10	0.00	103.30	Number of cows per km^2, 1837
Distance Sofiendal	1847	148.64	78.04	2.80	287.88	Distance from parish center* to the estate Sofiendal (km)
Distance first cooperative creamery	1847	138.20	67.28	3.01	420.23	Distance from parish center to the first cooperative creamery in Hjedding (km)
Estates (mp) , 1770	1847	10.20	2.05	2.63	14.73	Inverse distance weighted sum of estates, 1770 (mp)
Demesne share, 1680s	1847	0.12	0.19	0.00	0.99	Share of parish owned by an estate (with or without a hollænderi), 1680s
Crown estates (mp)	1847	2.37	0.88	0.71	5.33	Inverse distance weighted sum of crown estates (min 10 years, 1600-1800) (mp)
Late innovators (mp)	1847	0.12	0.08	0.04	1.14	Inverse distance weighted sum of 'late innovator estates' (mp)
Folk high school (mp), 1890	1847	0.05	0.23	0.00	1.00	=1 if folk high school in parish before 1890
Butter production, 1662	1847	1.26	1.62	0.00	13.58	Butter payments in 1662 - barrels per km2 land in the parish
Clover share, 1805	1847	0.22	0.35	0.00	1.00	Share of parish cultivated with clover, 1805
Barley suitability	1808	56.77	20.85	0.00	92.50	Average parish barley suitability, GAEZ (FAO 2002)
Field-grass-system, 1682	1754	0.45	0.48	0.00	1.00	Share of parish with field-grass-system in 1682
Distance coast	1847	7.73	7.35	0.00	44.59	Distance from parish center to the nearest coast (km)
Distance Copenhagen	1847	168.40	74.04	1.79	295.12	Distance from parish center to Copenhagen (km)
Population density, 1787	1708	35.91	227.00	0.00	7920.25	Parish population density in 1787
Market town	1722	0.04	0.20	0.00	1.00	=1 if market town in parish
Distance rail, 1890	1847	8.44	18.61	0.01	176.80	Distance from parish center to the nearest rail road, 1890 (km)
Distance Ox Road	1847	69.67	66.33	0.01	367.28	Distance from parish center to the Ox Road (km)

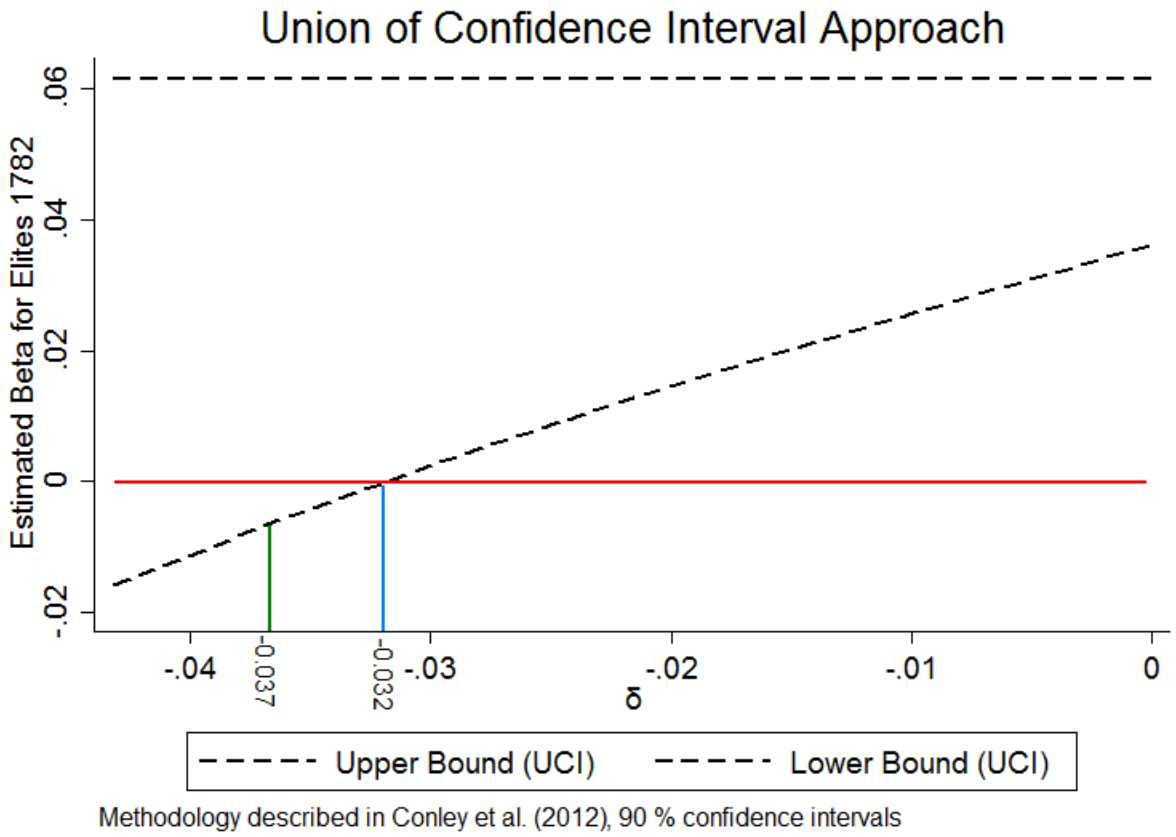
*: The parish center is defined as the location of the church. Some rural parishes located near a market town were served by the church in the market town and hence had no church. Hence, for such parishes with no church prior to the introduction of the first hollænderier in the 1760s we use the geographical center (centroid). For parishes with more than one church older than 1760 we use the location of oldest church as the parish center.

Appendix C – Plausibly exogenous

We test the exogeneity of our instrumental variable using the 'plausibly exogenous' framework of Conley et al. (2012). Instead of claiming complete exogeneity of instruments the framework tests the degree to which the instrument is endogenous and tests the 2SLS results given the potential level of endogeneity. In our case we test the degree to which our IV Distance Sofiendal directly explains the geographical distribution of cooperative creameries. If this degree is low we can arguable claim that our results are robust to the potential endogeneity.

We use the 'Union of Confidence Intervals' (UCI) approach and assume that the direct impact of our IV is somewhere between zero and the upper 95% confidence interval value from the reduced form estimate with the full set of controls ($\delta \in [-0.0433; 0]$).

Figure C1: Testing the plausible exogeneity



For the distance to Sofiendal to directly explain away our results delta would have to be -0.032 or below as indicated in the figure above (blue line). As the reduced form estimate of distance Sofiendal is -0.037 (green line) the direct channel should be 86% of the entire reduced form estimate. This seems highly unlikely and hence we trust our results to be robust to the potential level of endogeneity of our instrument.

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