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by

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'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 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. 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. Finally, we demonstrate that areas with cooperatives also enjoyed higher levels of income.

Keywords: Institutions, technology, knowledge spillovers, landowning elites, cooperatives, Denmark

JEL codes: N53, O13, Q13

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1. Introduction

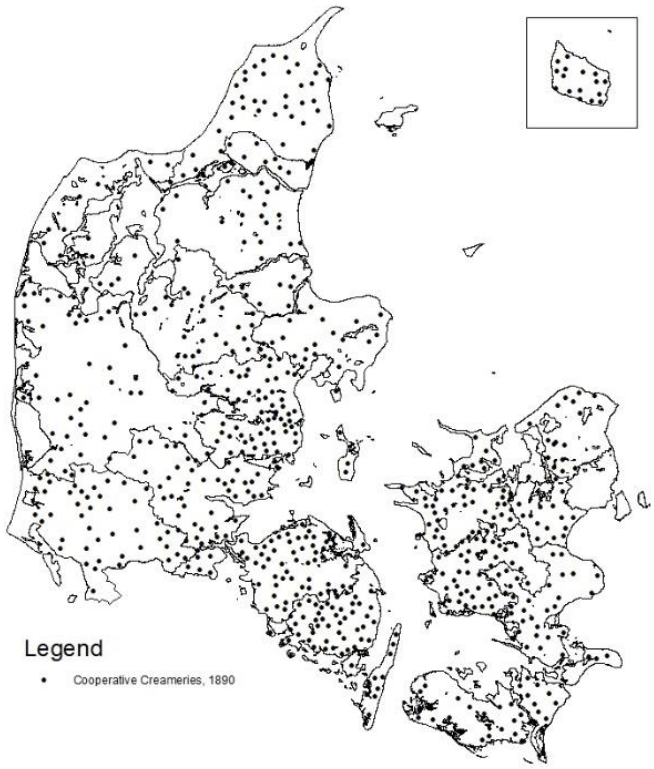
A substantial literature in economics examines the impact of elites on the growth trajectories of societies across time and space through various channels. Their impact on economic and political institutions is well-established[1], and in this literature, agricultural elites are only very occasionally good for development, usually because they can lobby the government to the benefit of citizens (see for example Bates 1974 and Dell 2010). Less well-understood however is how elites may foster growth through knowledge diffusion, and in this paper we shed new light on this channel in an agricultural setting. We exploit a specific example centered on the Kingdom of Denmark[2], 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 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[3] for butter and other agricultural products, and witnessed rapid economic catch up with the leading economies of the day[4], 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? The rise of the cooperatives is often considered a prominent part of the answer, but, following an argument first laid out by Lampe and Sharp (2018), we demonstrate that elites[5] facilitated this. This was despite the fact that these were elites in the traditional sense of the word, being large, often aristocratic landowners, and like elites elsewhere they were jealous of their status and were not always supportive of economic progress for the wider population. These elites were however also 'knowledge elites', transferring technology, in particular through the introduction of new agricultural methods including the idea of centralizing the production of dairy products. This latter also means that their presence is easy to measure since the locations of their proto-modern dairies, so-called *hollænderier*, are well documented.

[1] See for example Meltzer and Richard (1981), Acemoglu and Robinson (2000, 2005).
[2] The present borders of Denmark include from 1920 the northern part of the former Duchy of Schleswig which was ruled by the King of Denmark until it was lost to Prussia in 1864. The empirical basis of this analysis is based on the pre-1920 borders of the Kingdom of Denmark. See also below.
[3] 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.
[4] 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.
[5] Or at least their administrators, tenants and/or skilled dairy workers, the latter mostly women, who traditionally dominated that sector.

Most importantly for the present work, however, these were enlightened elites, providing inspiration, education, and enlightenment thought in general to local agriculture, and we do indeed find that their presence is a major factor behind the spread of the cooperatives a century later, and is associated with greater local incomes. This represents 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 Lampe and Sharp (2018) for exactly the reason presented here, that cooperatives stood on the shoulders of at least a century of accumulated improvements first introduced by elites.

Figure 1: Location of Cooperative Creameries in 1890



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

Our findings also contribute in other important ways. Cooperation is often seen as something which is facilitated by or promotes social capital (see for example Valentinov 2004), which in turn is often given as one of the reasons for other 'typically' Danish features such as the development of a large welfare state and inclusive democracy. Recently, the Danish social compact between the government, employers and workers has often been looked favorably upon, and has again been emphasized in relation to plans for protecting the economy during the COVID-19 outbreak[6]. Thus, this study contributes in the broadest terms to our understanding of what made Denmark Denmark. Moreover, Denmark's current status as an 'agricultural superpower'[7], 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. 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 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.[8]

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

[6] *New York Times*, March 28, 2020 'The Nordic Way to Economic Rescure'.
[7] *Economist,* January 4, 2014 'Bringing home the bacon: Tiny Denmark is an agricultural superpower'.
[8] 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). 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.

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* in 1782 weighted by their distance to the grid cell. Then, we demonstrate causality using the fact that these 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.[9] 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 by 42 percent of the mean exposure in one of our preferred specifications. They are also robust to a variety of alternative specifications. Moreover, we provide suggestive evidence that the location of cooperatives is associated with differences in local incomes (as measured by income tax payments) by the turn of the twentieth century.

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. Finally, we also use information from income taxes to demonstrate that the presence of cooperatives in turn increased local incomes. We thus 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.

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 Section 6 presents

[9] 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. As a robustness check, we also however demonstrate that our main results hold with an alternative instrument, where we utilize the fact that the new methods implemented by the elites were more likely to be implemented in areas which had previously used a particular crop rotation system.

tentative evidence for the relationship between the cooperatives and local economic development. Section 7 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) and 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).

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 (2015, 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 spillovers 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

The origins of modern dairying in Denmark begin in the Duchies of Schleswig and Holstein, ruled by the King of Denmark in personal union until 1864 when they were lost to Prussia. There, an intensified crop rotation system with an important dairy component, known as *Koppelwirtschaft* in German, or *kobbelbrug* in Danish, was developed on the large manorial estates. 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). The Holstein System and *Koppelwirtschaft* more generally was a 'collective invention' by estate owners and their administrators in sixteenth-century Holstein and Schleswig 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.[10] Thus, 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 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).

Koppelwirtschaft was introduced to 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,

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

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*[11] 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 et. al. 1987, pp. 63-65 and Lampe and Sharp 2018). 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.[12] 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).

These innovations came to Denmark in the 1760s and quickly increased in importance, although the adoption was unequal across the country, a common pattern for the diffusion of innovations in early modern societies, as highlighted by Mokyr (2009) for the British 'agricultural enlightenment'. 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. The defining moment came with the ascent of Adam Gottlob Moltke to Lord Chamberlain for Frederik V in 1746. Moltke sold his estate of Niendorf near Lübeck in Holstein, on which the Holstein System was firmly established and took the former leaseholder, 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. There is 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, according to a list published by the Danish public broadcaster, DR, in relation to a recent debate on lowering

[11] 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. Bieleman (1996) gives an account of the sophisticated dairy sector in the Low Countries during the Dutch 'Golden Age'.
[12] 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.

inheritance taxes for family-owned businesses.[13] Moltke was imitated by his neighbors, and Lampe and Sharp (2018) describe how this established a particular pattern around Denmark, with greater concentrations of estates using the Holstein System closer to Sofiendal. 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 with the dairy unit), while peasant agriculture still largely relied on the medieval three-field system (Falbe Hansen 1889, p. 10; Bjørn 1988, p. 35; Frandsen 2005, p. 90).[14] 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.[15]

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. Nevertheless, *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). In short, these sources reveal two things: first, that estates in the western part of Denmark (i.e. further away from Sofiendal) developed slower than in the east, and second, the peasantry began the period as relatively backward, but had an early advantage in the

[13] 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.

[14] 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.

[15] 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).

east, where 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. This supports 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.

The elites who introduced the system, however, continued to innovate beyond the pure transfer of technology from the Duchies. By the 1820s, many leading farmers in Denmark were from Holstein (Bjørn 1988, p. 24), one of the most famous examples being Adolph Valentiner, who took over his father's estate in 1831, and proved a great innovator and contributor to dairy science, publishing the first of many articles in the Danish agricultural journal *Tidsskrift for Landøkonomi* in 1837, in which he amongst other things highlighted the primacy of profit motives, and published his accounts (Andresen 1992, pp. 7-8). The success of Gjeddesdal from 1853 made it an attractive place for young farmers to visit and learn their trade, and it was the site of numerous experiments by the Royal Danish Agricultural Society, the members of which were estate owners, from the 1860s (Andresen 1992, pp. 8-10). Another energetic promoter of dairying was another Holsteiner, Edward Tesdorpf, who took over the estate of Orupgaard on the island of Falster in 1839. He bought in angler cattle from eastern Schleswig in 1841, and his whole herd changed in 1845 (Bjørn 1988, pp. 152-3). He was an active writer in the scientific press and promoted many valuable innovations. More generally, Lampe and Sharp (2018) argue that their main contribution 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, providing an important human capital channel. Between 1837 and 1875, when this role passed to the agricultural colleges, the Royal Danish Agricultural Society organized apprenticeships on its members' estates, including Gjeddesdal. At its height, around 300 were placed, thus again demonstrating the importance of the estates for spreading modern dairying across the country (Hertel 1920, p. 358).

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, in particular among the peasantry, although this proved difficult until the invention of the automatic cream separator in the late 1870s.[16] With this innovation, it became possible 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.[17] 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. Nevertheless, the cooperatives spread rapidly through the 1880s, and it has been suggested that this led to rapid development in the countryside, something we provide more evidence of below.

In short, this narrative relies on three things: 1) That the Holstein System spread around Denmark in a particular pattern, beginning with its point of introduction in Sofiendal; 2) The landowners who introduced the system intentionally or unintentionally transferred knowledge and specialization in dairying to the peasantry; 3) the areas which enjoyed greater treatment by these elites witnessed a more rapid adoption of cooperation after the invention of the automatic cream separator; and finally 4) The cooperatives stimulated growth in income in the local area. We take this to the data in the following section.

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

[16] 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).

[17] One might ask what the peasants did with the milk they produced before the centrifuge. They mostly produced poor quality butter and cheese, which they consumed locally or sold to merchants for local consumption. Their produce was rarely if ever exported. (Henriksen et al 2012).

estates of the elites and be able to account for potential cofounding factors at a very detailed level.[18] In practice, we calculate measures of the degree to which a cell is near *hollænderier* and cooperative creameries.

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).[19] The estates with *hollænderier* are given in Figure 2, 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.

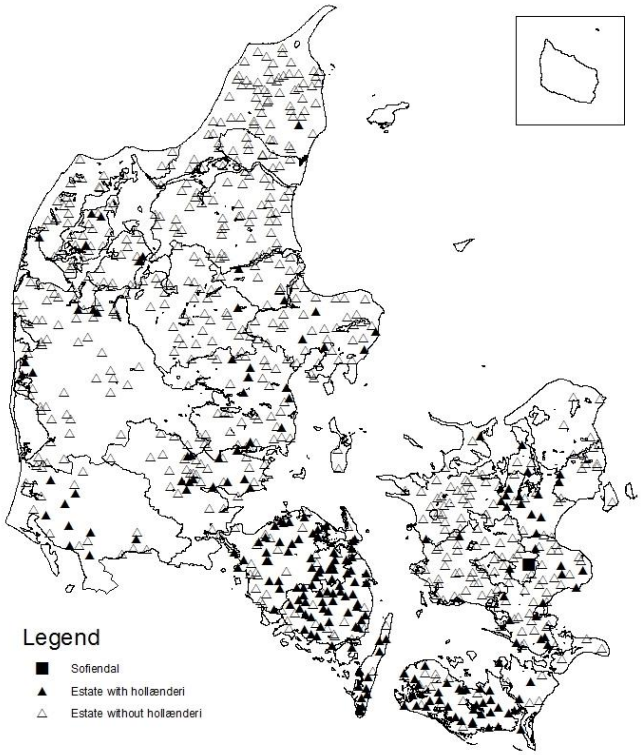
Table 1 provides a brief description of the variables included in the regressions below, as well as summary statistics and sources. Apart from *cooperative creamery exposure* and *elites 1782*, we also construct several other variables, which might also contribute to explaining the location of cooperatives in 1890. The first is distance to the first cooperative creamery as the cooperatives might conceivably have spread from there, and if that were the case we would expect a negative coefficient. 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 and hence we expect a negative coefficient. 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, so we expect a positive coefficient. 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 influential estates and to folk high schools. The former identifies estate owners who

[18] 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 grid cell within the parish. Regarding 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.

[19] 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.

participated in a commission set up by the Danish Royal Agricultural Society in 1858 and were particularly influential, so we might expect a positive coefficient. The latter controls for the impact of the folk high schools which traditionally have been seen as a main driver of the cooperative movement due to their important role in educating peasants[20] and as they shared many of the same ideas and philosophies as those behind the cooperative movement, so we might again expect a positive coefficient.

Figure 2: Location of *hollænderier* among all estates in 1782



Source: Own work based on Andersen (1963)[21], 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

[20] 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.

[21] 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 (Roholt 2012), 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).

barley suitability[22], the latter of which captures the main alternate use of the land.[23] First, Frandsen (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.[24] 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 making our expectation for the sign of the coefficient ambiguous. 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, although it is also used for feeding cattle, again making the expected sign ambiguous. Fourth, barley represents the main alternative use of the land, with an expectation that areas more suitable for cultivation of this crop might be associated with less dairying, and thus a negative coefficient. 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 and hence, we would expect a negative sign of the coefficient as the exporting potential would be lower for areas further from the coast.

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.[25]

<< 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:

[22] Strictly speaking present day potential yields of rain-fed barley, from the FAO/IIASA (2002) GAEZ database. 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 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.

[23] 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.

[24] 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.

[25] We expect distance to the railroad to have a negative coefficient due to a decreasing export potential the further away from the railroad. As the Ox Road was the main alternative use of similar resources, we expect coops to be concentrated further away from it, leading to a positive sign. For the three remaining controls expectations are ambiguous, on the one hand they all constitute a market potential but on the other hand they also take up land limiting the space for the fields necessary for the cooperatives.

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

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.

<< 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.[26] 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. This is perhaps not surprising, given that it is very unlikely that a cooperative would be located in or around such locations. 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.

[26] The regional fixed effects are for 21 historical counties when we use the grid level data. For the much smaller parish and estate samples that we apply as alternative units of observation below, 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.

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. Cooperatives were more intensely established further away from the coast. One potential explanation 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. Cooperatives were also more intensely established in areas without a grass-field-system in the 1680s. This result may be interpreted as a legacy of the historical optimal 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[27] 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 distance to Sofiendal is a weak instrument. In column 4 in Table 3, It is seen that *hollænderier*, among other things,

[27] 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.

were established in places nearer estates in general but away from the estates of the influential owners. 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 >>

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.[28]

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 as to whether this restriction is violated. In order to investigate further 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 any 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 >>

[28] 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 $elites1782$.

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.

<< 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 five 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.[29] Third, we test the relevance of our instrumental variable at the estate level. Fourth, we investigate whether our main results hold water in a model without the inclusion of fixed effects for regions. Finally, we demonstrate that the results are robust to the use of an alternative instrument.

First, we test 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 that 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

[29] Descriptive statistics are given in Appendices A1 and B1 respectively.

of observation instead of grid cells.[30] 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 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.[31] 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.

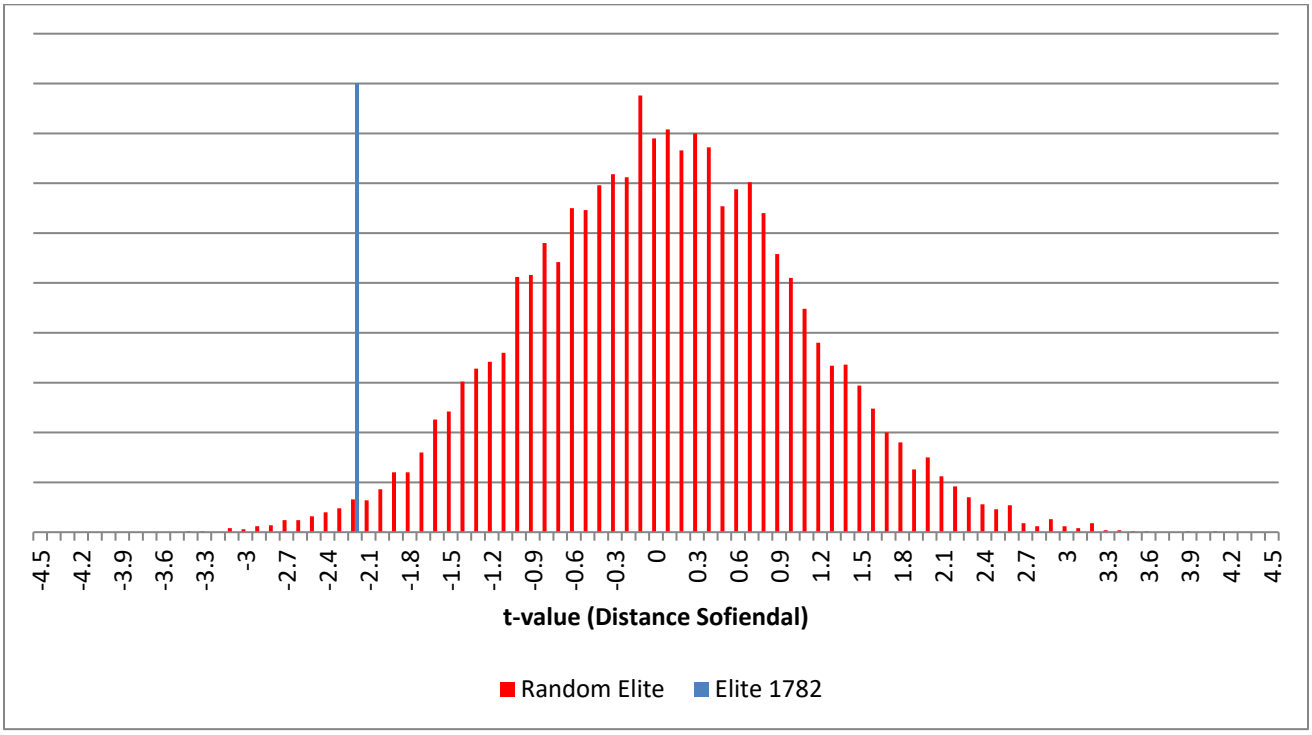
<< Table 10 around here >>

We found distance to 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

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

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 3 we plot the t-values of distance to Sofiendal from these 10,000 regressions. The figure shows that distance to 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.

Figure 3: 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).

Further, 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 >>

Finally, we have also considered an alternative instrument. Kjærgaard (1980) notes that *Koppelwirtschaft* was more likely to emerge in areas where the three-field crop rotation system was used. We digitize a map of historical field use (Frandsen 1983), which indicates the use of two-, three-, four- or five-field crop rotation in Denmark (see Figure D1 in the appendix). We then calculate the exposure of every grid cell to the use of three-field crop rotation by taking the sum of the inverse distances from the grid cell to every indicated use of the three-field system. We then employ this measure (*Threefield (mp)*) as an alternative instrument to the distance to Sofiendal. Table D1 in the appendix shows the first-stage results and Table D2 the second-stage results. The instrument is strong and confirms the positive effect on the emergence of cooperatives.

6. The cooperative creameries and (local) economic development

The historical narrative indicates that the cooperative creameries were an important factor in the growth trajectory of the Danish economy in the late nineteenth century. We have stressed above that the cooperative creameries were able to capture the UK market for butter, and the traditional narrative (e.g. Henriksen 1993; Hyldtoft 1999; O'Rourke 2006) also describes how agriculture stimulated demand for machinery for producing, among other things, centrifuges. Moreover, increasing demand from the peasantry as they became richer stimulated the development of a market for consumption goods. Services also benefitted due to increased demand for trade, transportation, and financial services. Finally, the cooperative creameries used physical capital, such as automatic cream separators and steam engines, and arguably built social capital as they required local cooperation, both of which are regarded as proximate causes of economic growth (e.g. Acemoglu et al., 2005). Thus, there are good reasons to believe that the cooperative creameries stimulated aggregate macroeconomic development in Denmark.

To further substantiate this, we have collected data on income and wealth tax revenue per capita (Statistics Denmark 1905). These taxes were introduced in 1903 and first collected in the tax year 1904/1905. The tax data have been matched to the parish level, and we present partial plots of the association between our indicator of the cooperative creameries and the tax revenue per capita variables. The income tax revenue reflects taxable

income, which was based on an allowance (which was higher in the market towns as compared to rural areas) and then a progressively increasing scale with the highest marginal tax being 2.5 percent (Philip 1955, p.56). The wealth tax was a flat rate of 0.6 per thousand without any allowance, but those earning below a certain threshold were exempt (Philip 1955, p. 209), implying that that taxable wealth is arguably closer to actual wealth, and in fact we note that wealth per capita performs stronger in terms of statistical significance. The association between cooperative creameries and income and wealth tax revenue per capita is displayed in Figures 4 and 5. Both figures show a positive and statistically significant association, and this remains if we control for region fixed effects and indicators of human capital and geographical factors, see Figures E1 and E2 in the online appendix.

Figure 4: The association between income tax revenue per capita and cooperative creameries

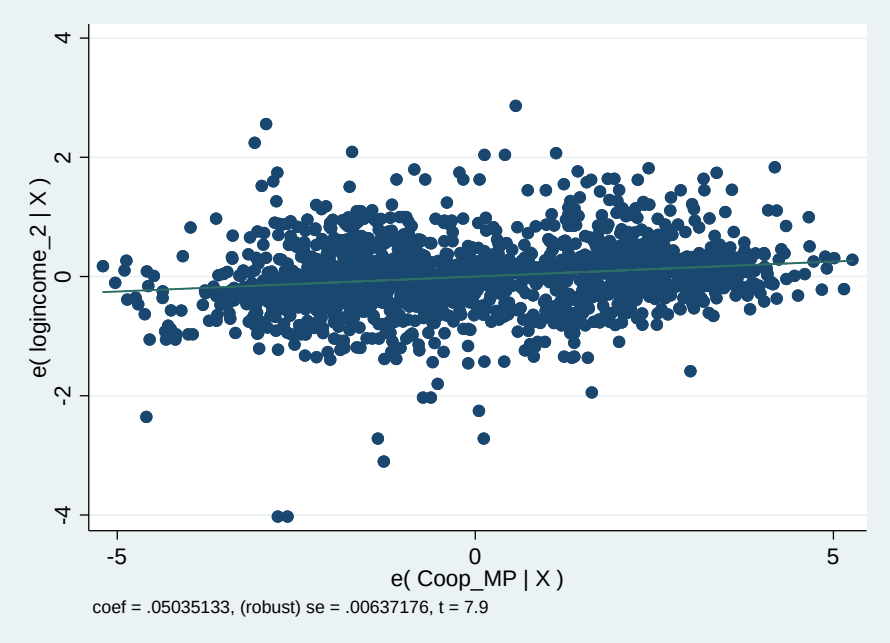
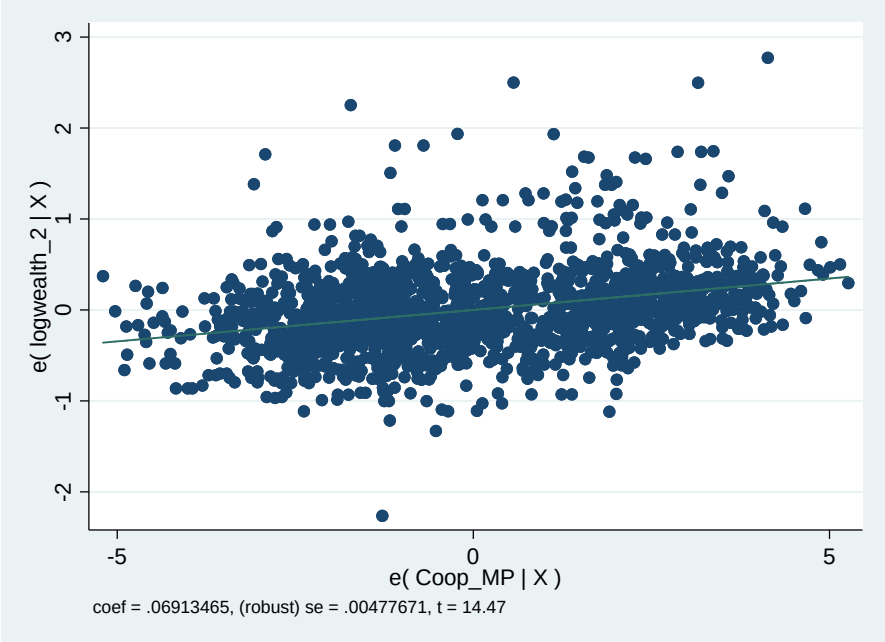


Figure 5: The association between wealth tax revenue per capita and cooperative creameries



Thus, as economic historians have long surmised, there is a strong association between the cooperatives and local economic development. The coefficient on the cooperative creamery market potential variable implies that log income per capita increases by 0.10 when the cooperative creamery variable increases by one standard deviation.

As the mean of log income is 0.10, this is arguably a large effect. The absolute effect for wealth is similar, but log wealth has a mean of 0.96.

7. 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 under a number of robustness tests. Moreover, there is a clear correlation between areas with more cooperatives and higher local incomes.

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)
Threefield (mp)	38,370	22.93	13.84	7.94	57.23	C	Inverse distance weighted sum of three-field system use (mp)
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), H) own work based on Borup and Nørgaard (1939), I) own work based on Frandsen (1983), J) own work based on Kjærgaard (1994), K) own work based on FAO/IIASA (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***

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

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***

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

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 – Parish Level Descriptives

Table A1: 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 B – Estate Level Descriptives

Table B1: Summary Statistics and Variable Descriptions

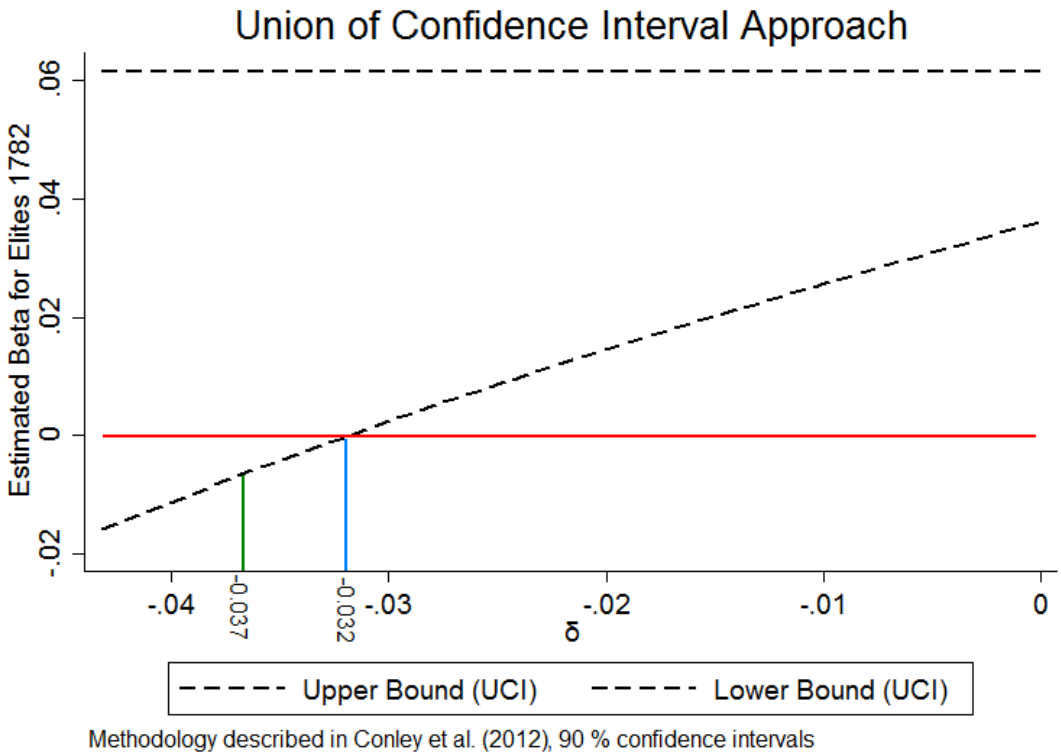
Variable	N	Mean	SD	Min	Max	Description
Cooperative creamery exposure, 1890	810	8.52	2.06	4.50	14.00	Inverse distance weighted sum of cooperative creameries, 1890 (mp)
Elites 1782	810	0.28	0.45	0.00	1.00	=1 if the estate had a hollænderi
Distance Sofiendal	810	147.48	82.67	0.00	285.80	Distance to the 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 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

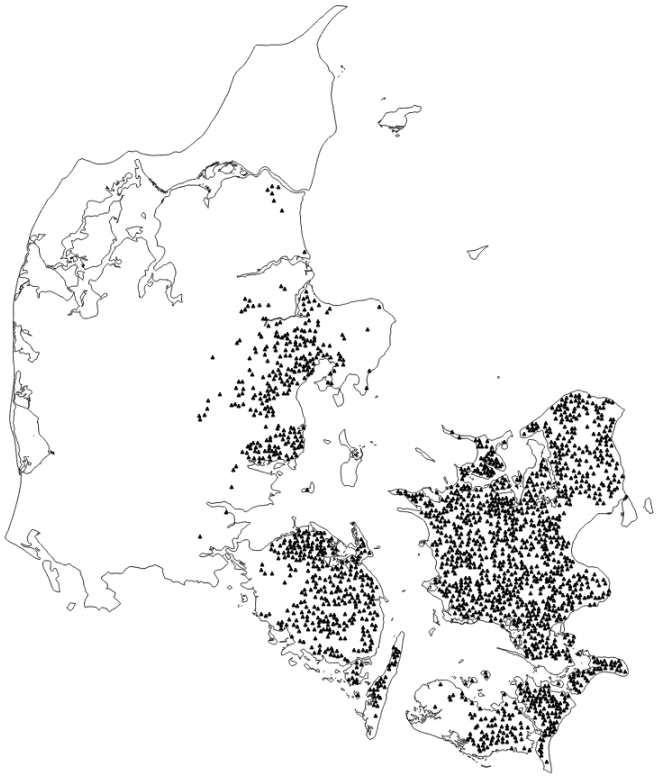


Methodology described in Conley et al. (2012), 90 % confidence intervals

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.

Appendix D – Three-field system as alternative instrument

Figure D1: Map of three-field crop rotation system



Source: Own work, based on Frandsen (1983). Every triangle represents three-field system in use in the village.

Table D1: Robustness (IV, first stage), Three-field system

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Elites 1782						
Threefield (mp)	3.5874***	3.1378***	3.1712***	1.7169***	1.6505***	1.6465***	1.1190***
	(0.0988)	(0.1894)	(0.1816)	(0.1809)	(0.2082)	(0.2086)	(0.2343)
Distance first cooperative creamery			-0.1741***	-0.0493	-0.0413	-0.1168***	-0.2130***
			(0.0393)	(0.0347)	(0.0338)	(0.0323)	(0.0315)
Estates, 1700 (mp)				10.6702***	10.2312***	10.4791***	11.2734***
				(0.7602)	(0.7741)	(0.7505)	(0.7867)
Demesne share, 1680s				3.0789***	3.1784***	2.7207***	2.9956***
				(0.7566)	(0.7507)	(0.7565)	(0.7564)
Crown estates (mp)					1.9986	1.3116	-0.8562
					(1.9350)	(1.9242)	(1.9612)
Late innovators (mp)					-28.6070***	-25.6162***	-25.1894***
					(8.2259)	(8.0433)	(7.8056)
Folk high school, 1890					5.5903***	5.5199***	1.2920
					(1.8612)	(1.7923)	(1.9624)
Butter production, 1662						0.0213	0.0176
						(0.0249)	(0.0245)
Clover share, 1805						0.2460	0.1133
						(1.0421)	(1.0334)
Barley suitability						0.0639**	0.0957***
						(0.0252)	(0.0268)
Field-grass-system, 1682						-6.7266***	-7.5789***
						(1.5117)	(1.4872)
Distance coast						-0.3514***	-0.4758***
						(0.0621)	(0.0629)
Distance Copenhagen							-0.2907***
							(0.0362)
Population density, 1787							-0.0062**
							(0.0025)
Market town							1.2281
							(2.4981)
Distance rail road							-0.0203
							(0.0770)
Distance Ox Road							-0.0020
							(0.0402)
Constant	49.9560***	17.7095***	88.0416***	19.9168	13.3535	40.1737***	134.5937***
	(1.7743)	(1.6436)	(16.4606)	(14.4191)	(14.2177)	(13.1635)	(28.3291)
FE (Region)	No	Yes	Yes	Yes	Yes	Yes	Yes
Parishes	38370	38370	38370	38370	38370	38370	38010

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

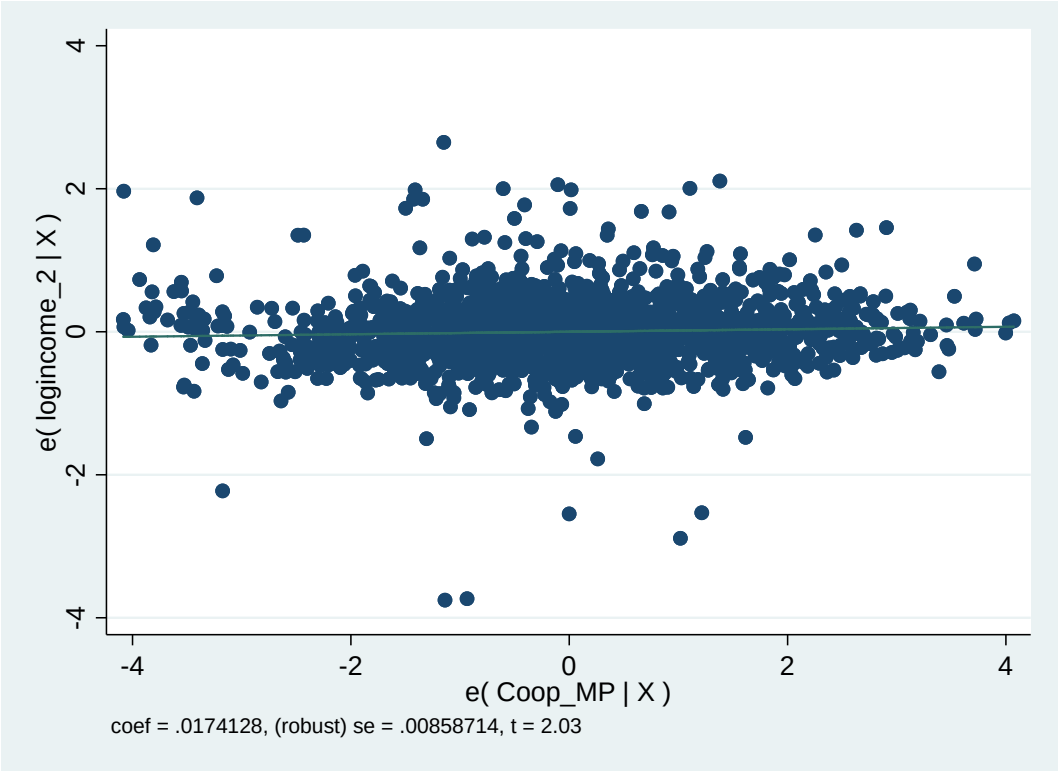
Table D2: Robustness (IV, second stage), Three-field system

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Cooperative creamery exposure, 1890						
Elites 1782	0.0231***	0.0522***	0.0528***	0.0782***	0.0745***	0.0711***	0.1094***
	(0.0008)	(0.0029)	(0.0029)	(0.0082)	(0.0093)	(0.0089)	(0.0231)
Distance first cooperative creamery			-0.0109***	-0.0133***	-0.0139***	-0.0067**	0.0091
			(0.0020)	(0.0027)	(0.0025)	(0.0026)	(0.0065)
Estates, 1700 (mp)				-0.5900***	-0.5707***	-0.5454***	-1.1293***
				(0.1280)	(0.1233)	(0.1183)	(0.2954)
Demesne share, 1680s				-0.2727***	-0.2678***	-0.2090***	-0.3276***
				(0.0717)	(0.0702)	(0.0655)	(0.1187)
Crown estates (mp)					-0.0651	-0.0043	0.1337
					(0.1583)	(0.1479)	(0.2064)
Late innovators (mp)					2.5089***	2.0826***	3.0857***
					(0.7160)	(0.6600)	(1.0964)
Folk high school, 1890					0.2593*	0.2586**	0.3333*
					(0.1416)	(0.1277)	(0.2020)
Butter production, 1662						-0.0012	-0.0018
						(0.0019)	(0.0028)
Clover share, 1805						-0.0442	-0.0529
						(0.0783)	(0.1164)
Barley suitability						-0.0044**	-0.0076**
						(0.0020)	(0.0037)
Field-grass-system, 1682						0.4356***	0.7927***
						(0.1446)	(0.2798)
Distance coast						0.0385***	0.0568***
						(0.0051)	(0.0128)
Distance Copenhagen							0.0244***
							(0.0093)
Population density, 1787							0.0006*
							(0.0003)
Market town							-0.1614
							(0.2823)
Distance rail road							-0.0123
							(0.0088)
Distance Ox Road							-0.0183***
							(0.0045)
Constant	5.1650***	1.7659***	6.1519***	7.6878***	7.7511***	5.0747***	3.1890
	(0.1027)	(0.1365)	(0.8723)	(1.0937)	(1.0342)	(1.0474)	(4.8858)
FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Parishes	38370	38370	38370	38370	38370	38370	38010
F-Stat	888.178	610.555	559.225	313.480	314.919	351.806	200.921
First stage F	1318.806	274.539	304.916	90.063	62.837	62.310	22.804

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

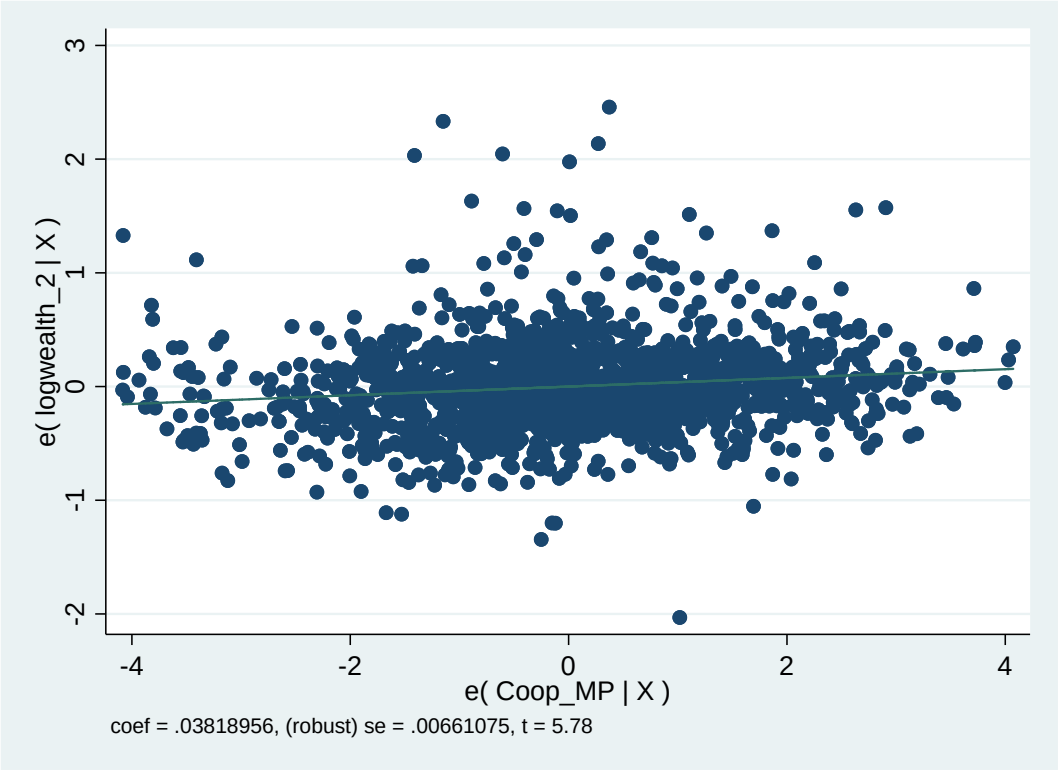
Appendix E – The association between tax revenue per capita and cooperative creameries

Figure E1: The association between income tax revenue per capita and cooperative creameries



Notes: The figure shows the partial association between log tax income per capita and cooperative creameries, controlling for region fixed effects, folk high schools, barley suitability, distance to Copenhagen, distance to Coast, distance to railways, and a dummy for market towns.

Figure E2: The association between wealth tax revenue per capita and cooperative creameries



Notes: The figure shows the partial association between log tax income per capita and cooperative creameries, controlling for region fixed effects, folk high schools, barley suitability, distance to Copenhagen, distance to Coast, distance to railways, and a dummy for market towns.