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Abstract

Despite the growing literature on the impact of immigration, little is known about the role existing migrant settlements can play for knowledge transmission. We present a case which can illustrate this important mechanism and hypothesize that nineteenth century Danish-American communities helped spread knowledge on modern dairying to rural America. From around 1880, Denmark developed rapidly and by 1890 it was a world-leading dairy producer. Using a difference-in-differences strategy, and data taken from the US census and Danish emigration archives, we find that counties with more Danes in 1880 subsequently both specialized in dairying and used more modern practices.

JEL Codes: F22, J61, N11, N31, N51, O33, Q16

Keywords: Dairying, immigration, knowledge spillovers, technology

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1 Introduction

In what way can established immigrant communities serve to promote economic development? A number of recent works have demonstrated that high-skilled immigrants can promote knowledge and technology transfer (Hornung, 2014), improve human capital (Kerr and Lincoln, 2010; Hunt and Gauthier-Loiselle, 2010; Moser et al., 2014; Rocha et al., 2017),[1] and impact on growth more generally through patenting (Akcigit et al., 2017b,a).[2] None of these studies have however touched on the impact an existing migrant community can have on the adoption of technology in the wake of significant developments in their country of origin. The present work presents just such an example, where the small Danish settlements established in the United States before 1880 came to play an important role for spreading information on subsequent radical changes that were taking place in Danish agriculture, and dairying in particular. Our hypothesis is that Danish communities in the United States facilitated the spread of information on the revolutionary changes in dairying that were taking place at home. We find that the areas 'treated' with more Danes are associated with both a greater specialization in dairying, and the use of more advanced technologies before the First World War. In fact, the association between these areas (largely in the Midwest) and dairying can even be detected after the Second World War.[3]

Thus, our work is closely related to and yet contrasts with that of Hornung (2014), who demonstrates how high-skilled immigration of Huguenots to Prussia led to a diffusion of technology and higher productivity in the textile sector of that country.[4] In our case, this was not a story of expert migrants bringing benefits to their destination country, but rather an example of how existing migrant communities can play an important role for the spread of knowledge and technology from abroad, although they certainly later also attracted skilled labor from home. Moreover, we can safely assume that the original location of the Danish communities before 1882 was not determined by any prior knowledge of changes which were only to come after that date.

Danish agriculture developed rapidly from the 1880s with the emergence of a modern dairy industry, which many consider to have been a decisive factor in that country's catch up with the richest countries of the time (for a brief account, see Henriksen (1993)). Previous work (Lampe and Sharp (2019); Jensen et al. (2018)) has demonstrated that this rested on developments since the eighteenth century, when an agricultural elite from northern Ger-

[1] Although they might also displace domestic knowledge producers (Borjas and Doran, 2012)

[2] Somewhat related to this, Hunt and Gauthier-Loiselle (2010) show that immigration can have a positive effect on economic growth by fostering innovation.

[3] Rauch and Trindade (2002) and Ammon and Baiardi (2018) provide another example of unanticipated economic gains from migration decades after arrival. These studies demonstrate that countries with ethnic Chinese communities see an important impact on trade with each other, something which in the context of the present work is especially interesting given the importance of trade with China today, and the fact that Chinese were the first ethnic group to be specifically discriminated against in the United States under the Chinese Exclusion Act of 1882.

[4] See also Fourie and von Fintel (2014) on the effects of Huguenot migration on wine production in South Africa and Frost (2002), who finds a beneficial effect of Chinese immigrants on Australian agriculture between 1850 and 1920, also for European farmers.

many[5] introduced both new methods, including centralized butter making facilities, and a new 'enlightened' way of thinking to the landed estates of Denmark. They argue that this was first able to be adopted by the peasantry with the invention of a new technology, the automatic cream separator (a steam-powered centrifuge), which allowed for centralization of production under a new institution, the cooperative creamery.[6] The first of these was founded in 1882, followed by hundreds of others around the whole country within a decade, although adoption rates differed according to differences in the prior treatment by the aforementioned elites. Massive increases in productivity followed, production boomed, and Denmark captured a large share of the important UK market for butter and other agricultural products. This success is usually set within the context of the American 'grain invasion' from the 1870s (O'Rourke, 1997), when cheap exports of largely US grain flooded Europe, promoting a backlash of protectionism. Denmark, like the UK, chose to remain open, however, and successfully exploited its comparative advantages (created or discovered by the elites in the previous century), using the cheap grain as fodder for increased animal production.

In the context of migration, Denmark is also an exceptionally interesting case to study, but not due to its large outmigration. Denmark is and was of course a small country, with little obvious opportunity for its emigrants to make a large impact on the US, with a population of less than two million around 1880. Moreover, in contrast to its Scandinavian neighbors, Norway and Sweden, which witnessed massive outmigration in the nineteenth century, Danish emigration was relatively modest. Between 1840 and 1914 only 309,000 Danes emigrated, approximately 16% of the population compared to 24% in Sweden and almost 39% in Norway (Hvidt, 1960). Part of this was due to Denmark's aforementioned agricultural leadership. We argue that this highly productive and innovative agricultural sector also meant that, despite few in number, emigrants from Denmark transfered knowledge which potentially boosted economic growth in the host country. Thus, as Denmark had benefited from openness to ideas from Germany in the 1700s, the United States then in turn benefited from the 1880s once modern dairying had spread to the Danish peasantry, who transmitted their knowledge of new production processes and technologies through preexisting emigrant communities, and through new migration.

We thus examine the effect of relatively modest numbers of Danish immigrants on economic development in the US, and for the dairy industry in particular. Theory suggests that technological progress is one of the most important drivers of economic growth (Galor and Weil (2000); Howitt (2000)). If immigrants shift the technological frontier by bringing in new knowledge and ideas, immigration can boost economic growth and thereby be beneficial for regional development. Empirically, however, technological progress is often just the residual as it is difficult to measure. Moreover, the link between immigration and technological progress and ultimately economic growth is not well established, mainly due to a lack of

[5]Specifically the Duchies of Holstein and Schleswig, which until 1864 were joined in personal union to Denmark under the Danish king.

[6]The reason why Denmark so successfully adopted cooperatives is explored in a number of works, most notably perhaps by O'Rourke (2006, 2007), who contrasts with Ireland.

data. Thus, although the research on the economic consequences of migration has advanced greatly in recent years (see for example Longhi et al. (2005) and Kerr and Kerr (2011) for surveys), it has as yet failed to reach a consensus. The empirical evidence on the short-run link is mixed. Peri (2012) finds short-run productivity gains upon immigration, but other authors find negative effects (e.g. Ortega and Peri (2009)) or no effect (e.g. Quispe-Agnoli and Zavodny (2002)). As for the long-run, Hatton (2010) summarizes much of the cliometric literature on international migration for the period 1850-1940 and mostly for Europeans moving to the New World. His survey divides the literature into a number of themes including the forces driving migration, over time and across space; the assimilation of migrants and their effects on wages and income distribution in source and destination countries; and the evolution of immigration policy.[7] A number of papers have demonstrated the links between coethnic networks and international trade[8] (which might be an obvious channel for technology transfer). Buchardi and Hassan (2013) find that West German regions where more households had maintained social ties with East Germany in 1989 experienced higher growth after the fall of the Berlin Wall due to the ability of entrepreneurs better to exploit opportunities in the East. Likewise, Buchardi et al. (2017) use 130 years of data on historical migrations to the United States to demonstrate a causal effect of the ancestry composition of US counties on foreign direct investment (FDI) sent and received by local firms. More recently, Sequeira et al. (2019) have found that locations in the US with more historical immigration have today higher incomes, less poverty, less unemployment, higher rates of urbanization, and greater educational attainment, which they attribute to the persistence of considerable short-run benefits, including greater industrialization, increased agricultural productivity, and more innovation.

Otherwise, 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 (2014b)) and major productivity improving implements like the heavy 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); Bustos et al. (2016); Cook (2014b,a); Dall et al. (2014); Chen and Kung (2016); Jia (2014)).

Our findings have significant policy implications. Along with the rise of populist movements, there has been increasing adoption or encouragement of various measures to combat immigration. One popular suggestion is so-called 'point systems', whereby potential immigrants are assessed based on a number of criteria, including for example age, educational attainment, language, etc. Such systems have already been adopted in Australia and Canada, and have been proposed by for example both US and UK politicians.[9] Another popular bone

[7] See also the survey for the United States by Abramitzky and Boustan (2016).

[8] See for example Greif (1989, 1993) and Gould (1994) as well as Rauch and Trindade (2002) and Ammon and Baiardi (2018).

[9] See for example 'How to earn "points" to come to the US under Trump's immigration plan', CNN (https://edition.cnn.com/2017/08/02/politics/cotton-perdue-trump-bill-point-system-merit-based/index.html, retrieved March 23, 2018).

of contention has been so-called 'chain migration', i.e. immigrants coming to a country due to family connections, which in the US constitute a far larger proportion of total immigration than those entering on green cards.[10] Similar concerns were of course also present in the past. Ironically, in a report by Cance (1925) which came out in the wake of the Emergency Quota Act of 1921, which established quotas by nationality, the author (unwittingly) underlines the point about how it is difficult to know which migrants are 'desirable'. He falls into the trap of assuming that previous generations of migrants were the 'right' migrants, specifically mentioning the large number of Scandinavians in agriculture, and concluding that 'some of the very best of our farmers are immigrants of the first and second generation'. He concludes however with a warning against importing cheap labor to the countryside, since he believed this would hurt rural living standards and delay the process of assimilation, without seemingly realizing that discriminating against poor rural migrants would have meant that the Scandinavians he praises would not have arrived in the first place.

In the remainder of this paper, we first provide a literature review, which also provides more detail on the historical background to our story. In section 3, we discuss the data used in the analysis and the empirical strategy employed. In section 4, we present our results along with a number of robustness checks. Section 5 provides the conclusion as well as a discussion of possible policy implications.

2 Historical Background

2.1 The History of Danish Emigration to the United States

There are a number of studies of Danish migration to the United States. The most detailed is that by Hvidt (1960),[11] who, as is common in the literature, divides the reasons for migrating into 'push' and 'pull' factors.[12] He bases his account on Danish police records, and this section draws heavily on his work. Relatively few Danes migrated to the US before 1866: only 14,000 between 1820 and 1866, of whom many were Mormons. From this point the numbers increased somewhat, and emigrants were relatively evenly spread according to population from different parts of the country (Hvidt, 1960, p. 100). Many left northern Schleswig after Denmark lost the Duchies of Schleswig and Holstein to Prussia in 1864 and others migrated from 1865 on, as the Danish government became less liberal with respect to religion (Furer, 1972, p. 45).

Emigration from Denmark increased from the late 1860s, with around 158,000 leaving

[10] 'What is "chain migration" and how could it disrupt a DACA deal?', CNN (https://edition.cnn.com/2017/09/15/politics/chain-migration-daca-trump-tweet/index.html, retrieved April 4, 2018).

[11] Although see also Christensen (1924, 1927, 1928) for accounts of Danes who migrated to Iowa, Minnesota and Wisconsin respectively and Brøndal (2013) and Pedersen (1992) for a more general account.

[12] See Lee (1966) for the original theoretical approach to migration.

for the US between 1868 and 1900. Hvidt (1960) demonstrates that two-thirds of these knew exactly where they wanted to go (state, county and settlement), and just one-third had a ticket to New York, from where they either stayed or moved on. Of the roughly 88,800 emigrants who knew where they would go, Hvidt (1960) argues that they were probably pulled to the US by personal contacts (through a job opening or letters from earlier emigrants) or by railroad companies selling land through agents in Denmark. Railroad companies would buy large areas of land in the US and then finance construction by selling off plots along the planned tracks, thereby also ensuring future customers. Danish statistics cannot really tell us about the number of emigrants returning, but Hvidt (1960) believes there were relatively few, perhaps around 10 percent. The greatest extent of Danish immigration was reached in 1882, when 11,000 Danes arrived in a single year, many of whom were small farmers and laborers who sought land and jobs in the interior areas of America (Furer, 1972, p. 56). Much of the writing on Danish immigrants concerns the conflict between rival religious factions, specifically those supporting the Danish state Lutheran Church, and those supporting *Indre Mission*, a rather radical evangelical movement: a conflict which also played out in parts of Denmark (see for example Kjær and Larsen (1972)).

In an attempt to gain more control of the process of emigration and to prevent fraud by emigration agents, a law was passed in 1868 requiring every emigrant to sign a contract with an emigration agent, which then had to be approved by the police.[13] Although, the original contracts no longer exist, the police kept protocols all of which survived. These protocols were digitized by The Danish Emigration Archives (*Det Danske Udvandrerarkiv*) in collaboration with Aalborg City Archives (*Aalborg Stadsarkiv*) and comprise information on around 330,000 emigrants going from Denmark to the US between 1868 and 1908, the majority of them Danish but also including foreign emigrants travelling via Denmark, mainly Swedes.[14] The data include the name, birth place and date, the ship travelled on, and the destination of the emigrant.[15] Figure 1 below shows the total stock of Danish immigrants in the US (left panel) as well as the number of emigrants from Denmark with an occupation related to dairying (right panel) by year.[16] Especially for Danes with a dairy-related occupation, immigration numbers are very small before 1890. This pattern arises due to two factors: first, the total number of Danish immigrants was rather low before 1890, but second and probably more importantly, working in dairying was not initially considered to be a unique

[13] An exception were mormons who often chartered whole ships on their own. These are not included in the data for the years 1873-1894 but also represent a very different kind of emigration which is not relevant for the development of the dairy industry.

[14] The data was kindly provided to us by the *Danish Demographic Database*: Det Danske Udvandrerarkiv. Københavns Politis Udvandrerprotokoller (hosted at Danish Demographic Database, (delivery 12-02-2018))

[15] Not all information is always available. Occupation is surprisingly complete with only 103 missing entries, although also often recorded as 'child', 'housewife', or 'worker'.

[16] We include the following titles in dairy-related occupations: dairyman (*Mejerist* or *Mejerimand*), dairy manager (*Mejeribestyrer*), dairy owner (*Mejeriejer*), dairy consultant (*Mejerikonsulent*), dairy worker (*Mejeriarbejder*), dairy student (*Mejerielev*), dairy tenant (*Mejeriforpagter*), dairy apprentice (*Mejerilærling*), woman working in dairying (*Mejeripige* or *Mejerske*), dairy technician (*Mejeritekniker*). For lack of a better translation, we translate *mejerist* with dairyman although this may be misleading. In Denmark a mejerist was a person with a very long education and a high skill-level. Although the other occupations included in the figure do not represent the same level of education, they are all likely to have known about modern dairying techniques.

occupation, for men in particular.

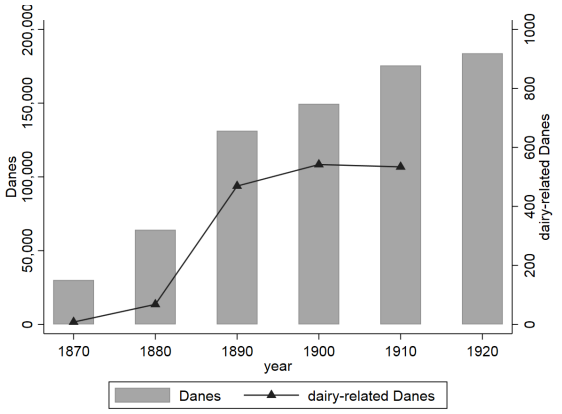

Figure 1: Stock of Danish immigrants and flow of Danish immigrants with a dairy-related occupation.

Although there is some evidence that Danish farmers earned more money in the US than they did back home (Mackintosh, 1992, 1993), Hvidt (1960) argues against the primary role of differences between economic conditions in Europe and the US for the decision to migrate, and for the importance of various push and pull factors.[17] Although earlier migration was determined by religious and political motives, the much greater emigration from the 1880s was the result of two factors: first, higher wages in Denmark, and second, lower costs of transportation, both meaning that more people could afford to emigrate. He argues that this was not sufficient, however, since potential migrants needed information about conditions in the US before they could make a decision. This came first through personal connections: migrant Danes sent generally positive letters back home, and sent money or purchased tickets for their friends and family. Second, shipping and railroad companies (sometimes in collaboration, or private companies acting on their behalf, or on behalf of firms looking for labor) advertised heavily, distributed pamphlets and sent previous migrants to be agents in Denmark. Finally, the US and State governments themselves advertised in Europe, and Hvidt cites an example from 1871 of 10,000 pamphlets which were printed in Copenhagen for distribution in Scandinavia. Moreover, there were special newspapers for emigrants with information on emigration and the US (e.g. *Den nye Verden* 1886-91, *Kors og Stjerne* 1889-), and Danish-American organizations such as *Dansk Folkesamfund* (the Danish People's Society) also played a role for the spread of information on the US, for example through the distribution of addresses of Danes in the US one could write to. Finally, returning emigrants also of course brought with them information.

[17] In an econometric analysis of the reasons for Danish migration to the US between 1870 and 1913, Larsen (1982) finds economic conditions (for example employment and wage differentials) in the US to be more important than those at home, where demographics played a negligible role. Thus there is no evidence of a stock or cohort effect.

2.2 The Modernization of Dairying in Denmark and the United States before the First World War

At the same time as some Danes were migrating to the United States, something quite remarkable was happening back in Denmark. As is explained by Lampe and Sharp (2019), Danish agriculture, and dairying in particular, had been developing strongly from at least the eighteenth century. Numerous military defeats at the hands of Sweden and substantial losses of territory had left the Crown bankrupt, and almost all crown estates were therefore privatized by 1740 in order to raise revenue. A well-functioning market for land meant that these as well as other estates were sold to a new set of elites, many of whom were from the Duchies of Holstein and Schleswig, which were ruled by the Danish king until they were lost to Prussia in 1864. The Duchies had already by the 1700s developed a relatively sophisticated agricultural system, the Holstein System, with large dairy herds and a central dairying facility. Lampe and Sharp (2019) argue that their migration to Denmark set in motion an early 'enlightened' approach to agriculture, including accurate record keeping in the form of bookkeeping and accounting, the establishment of apprenticeships, agricultural schooling, extension services, etc., and experimentation both on the estates and at specialist research institutions. At the same time, important innovations were made. Before the invention of the automatic cream separator (a centrifuge), important innovations included for example winter dairying, proved in 1887 but understood prior to that date and widely practiced on estate dairies by the 1860s, with the first exhibition of winter butter in Aarhus in 1868. This greatly increased the productivity of the cows, and allowed farmers to take advantage of the relatively high price of butter during the winter (see also Henriksen and O'Rourke (2005)). Other innovations included various improvements regarding feeding, in particular the use of concentrates, the breeding of cows, in particular the Danish red milk cow, and the artificial cooling of milk to speed the separation of cream.

As for the centrifuge itself, the principle that cream could be separated using centrifugal force was discovered in Germany in 1864, but important refinements were made in the Duchy of Holstein in 1876, and separators based on this design were then produced by rival Danish (Burmeister & Wain) and Swedish (Alfa Laval) firms in 1878/9 (Pedersen, 1999, p. 51). Up to and beyond this date, many important innovations came out of the work of docent Niels Johannes Fjord at the Royal Veterinary and Agricultural College in Frederiksberg, near Copenhagen. He presented the first results of his work with centrifuges in 1879, and established an Agricultural Economic Experimental Laboratory in 1883. Among important later innovations was Fjord's invention in 1887 of a control centrifuge for assessing the butterfat content of milk, which meant that it became possible to pay for milk by quality as well as quantity.

The centralization of production moved from the estates to the peasantry initially with the establishment of 'community creameries' from the 1860s, but it was to be the separator which was to allow for the widespread centralization of butter production. Jensen et al.

(2018), in a test of Lampe and Sharp (2018), demonstrate that the differential uptake of the cooperative institution and the new technology which they embodied can be traced to a trickle down from the elites who had brought the Holstein System over a century earlier.[18] Using the distance to the first estate to adopt the Holstein System as an instrument, they find a causal impact of the distribution of estates using the Holstein System in 1782 on the location of cooperatives established by 1890, as well as cow densities prior to the first cooperative, which they interpret as a measure of specialization by the peasantry in dairying. The centrifuge meant that it was possible to use milk which had been transported over longer distances to be processed in a central production facility, and led to massive productivity gains. Voluntary associations of Danish peasants, the cooperatives, sprang up to take advantage of this possibility. Danish agriculture witnessed extraordinary success, outcompeting traditional leaders in the sector such as the Dutch and the Irish. Within a few years, Denmark had captured a significant share of the important UK market for animal foodstuffs, for example almost fifty percent of butter imports by the First World War (Henriksen, 1993, p. 156). In fact, Denmark is still considered an 'agricultural superpower',[19] and dairy production is still dominated by a massive Danish-Swedish cooperative, Arla, which traces its roots back to the developments of the 1880s.

Turning to the United States, that country also witnessed considerable progress in dairying before the First World War, although this was understandably less uniform than in Denmark. A useful account of the development of American agriculture in general is provided by Olmstead and Rhode (2008), who argue for an exceptionally dynamic development path founded in science and a stream of biological innovations. In terms of dairying, their story does not sound too different to that in Denmark. They describe a gradual increase in milk yields, mostly due to improvements in feed (especially during the winter months), shelter, new breeds, and a longer milking season, largely as the result of winter dairying. The Babcock test from 1890 which could measure the butterfat content of milk is highlighted both by them and other historians of American agriculture as an important innovation, but as demonstrated above this was preceded by a similar invention in Denmark.

Dairying in Europe and North America was clearly separated by long distances and, initially at least, the perishability of the products meant that Denmark had little to fear in terms of competition for the UK market from American producers. This does not mean to say, however, that ideas could not flow across the Atlantic, and indeed they did, as we will discuss more below in the next section. But this is not the impression one would get from reading many accounts of the history of American agriculture. For example, the only mention Olmstead and Rhode (2008)[20] make of possible Danish influence is that the world's

[18] Interestingly, Hvidt (1960) notes that many Danish migrants came from areas with more of the large farms Lampe and Sharp (2018) suggest were so important for facilitating the uptake of modern dairying in Denmark. He attributes this to the fact that estate owners from the 1880s began to grow sugar beet, and brought in immigrant labor in particular from Poland to help with this. This put the wages of laborers under pressure, making it difficult for Danish agricultural workers to find enough work, giving an incentive to emigrate.

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

[20] See also Bateman (1968) for an analysis of the determinants of increases in US milk yields over time.

first dairy herd improvement association was founded in Denmark, and that the Danish immigrant Helmer Ræbild (who we will return to below) helped found the first association in the United States in Newaygo county in Michigan in 1906.

Neither do histories of cooperation often suggest a significant role for Danish migrants.[21] For example, Knapp (1969), writing on the emergence of cooperatives in the United States, describes how they were first established in the insurance business and then went over to cooperative retail stores, which were inspired by the example of the Rochdale cooperative in England. More specifically to dairying, he describes how cooperative cheese factories were established first in New York State by 1860, and that cooperatives for cheese making and creameries were established before the Granger movement called for their introduction to all forms of agriculture. Olmstead and Rhode (2008) consider the introduction of the 'factory system' to dairying to be a major advance, since it disconnected the production of cheese and butter from milk and farms. The first cheese factory was established by Jesse William in Oneida County, New York, in 1851, who bought the milk from his neighbors. The first butter factory, or creamery, was founded by Alanson Slaughter in Orange County, New York, in 1861. This was more or less contemporaneous with the spread of similar so-called community creameries in Denmark (McLaughlin and Sharp, 2018), but clearly the idea of centralizing production at the estate level had been around for much longer in Europe, and besides, it was the centrifuge which was to make possible the central processing of milk for a much larger area, and here Denmark was far in advance. Drejer (1933) (p. 41, based on an article from the Danish agricultural journal *Ugeskrift for Landmænd*) reports that in 1881 there were already ninety separators in use in Denmark, and that by 1887, the number had risen to about 2,200. As we return to below, the first centrifuge in the United States was imported by Danes, and installed in a creamery in 1883.

Knapp describes how hundreds of cooperative creameries were founded in the Midwest, enthused by the promotional activity of the sellers of creamery equipment, but that these largely failed in the 1880s and 1890s, and Professor Theophilus Levi Haecker (the son of German migrants, and whose mother was an expert butter maker) in Minnesota is often given a key role in changing this and educating people in how to establish well-functioning creameries. Moreover, there was a general expansion of rural education. From 1890 the closing of the frontier meant an intensification of agriculture (see also Federico (2005, Table 8.1)), leading to more expensive farm supplies (fertilizer, insecticides, seed, feed), which together with the need for larger investments with new technology, and the need to market to the expanding urban population, gave greater incentives to cooperate.

Cooperatives are even described in some (extremely biased) historical accounts as the 'American System of Dairying' (Alvord, 1899),[22] but there is certainly no doubt that Den-

[21] Although see Danker (1968), who finds a correlation between areas with more Scandinavians and cooperation in agriculture.

[22] The extent to which Alvord neglects the contributions of dairy scientists in Europe is apparent from the following sentence: 'The world is indebted to Europe for [the centrifuge], at least as a dairy appliance. It is the only instance in which dairy invention abroad has been notably in advance of the United States' (Alvord,

mark both centralized production earlier, and that cooperatives earned a greater foothold in Denmark than in the US. In fact, also in productivity terms there is no mistaking the lead Denmark had over the US at an early date. As table 1 demonstrates, Danish milk yields were similar to those in the United States in 1860, although those on the landed estates (consistent with the story presented above) were already much higher. As the productivity of the cows owned by the peasantry converged on that of the estates, which also continued to increase, the United States was left far behind.[23]

Table 1: Milk yields in tons per cow

	1850	1860	1870	1880	1900
Denmark		1.1	1.5	1.8	2.5
Danish estates	1.3	1.7	1.8	2.0	2.5
United States	1.1	1.2	1.2	1.3	1.5

Source: Lampe and Sharp (2019), table 6.1.

In the following we present the work of others who have suggested that Denmark exported its knowledge and technology to the US, laying a large part of the basis for the successful dairy industry which emerged in the American Midwest in particular. We start with the work of the aforementioned Professor Haecker. Where did he for example get his inspiration from?

2.3 Danes and Dairying in the United States

Edwards (1938) describes how Haecker was active in the Granger movement, which advocated for cooperative agriculture, and took an early interest in cooperation, organizing a cooperative creamery in his community. But it was while working in 1892 on an extensive survey of dairying in Minnesota that he became familiar with the Danish community in Clarks Grove, where a cooperative creamery had been established in 1890 under the initiative of Hans Peter Jensen, who had been inspired by the cooperatives he had seen while visiting his homeland. According to a later interview with Haecker,[24] he was so impressed by this that he worked on promoting the Danish system of butter production around Minnesota, including through a press bulletin issued by the Minnesota Agricultural Experiment Station in March 1894 on 'Organizing Co-operative Creameries', and for over twenty years by direct contact with farmers by traveling between farms. The end result was that from just four cooperative creameries in Minnesota in 1892, by the time of his retirement in 1918 there were no less than 630 (Edwards, 1938, p. 157).

1899, p.394). Apart from the Danish contributions we mention here, others such as Louis Pasteur would no doubt beg to disagree.

[23]Leisner (2005) describes how American creameries also introduced pasteurization rather late compared to those in Denmark, largely due to an American demand for a 'strong flavor' which was not so easily obtainable using pasteurized milk, which also kept them from the UK market.

[24]Interview with Professor Haecker; *Hoard's Dairyman*, 69:14, 23 (January 16, 1925); *Farmer*, 39:1395, 1403, 43:35 (October 8, 1921, January 10, 1925) – cited by Edwards (1938).

By far the most comprehensive coverage of notable Danish-Americans and their impact on American dairying is provided by Sørensen (1908).[25] He explains how American agricultural magazines and bulletins contained frequent references to the Danish dairy sector, and how Danish scientific discoveries were quickly adopted in the US, for example the work of Bernhard Lauritz Frederik Bang at the Royal Veterinary and Agricultural College in Frederiksberg (near Copenhagen), whose method for testing for bovine tuberculosis was already widely used in Wisconsin in 1896, and later around the country.[26] But his main point is that the US 'did not simply receive Danish dairy ideas, but also Danish men' (Sørensen, 1908, pp. 267-8). The following in no way gives justice to the extensive survey he provides in his work.

In fact, the first creamery to use a centrifuge in the US was in the Danish settlement of Fredsville, Iowa.[27] Truels Slifsgaard from southern Jutland moved to the US in 1869, where he became a tenant on a farm in Grundy County, Iowa. There was already the cooperative Fairfield Creamery in Cedar Falls, but this was some distance away, and the skim milk he received back was sour and not very useful for feeding pigs, for example, which was the common practice among Danish farmers. He learned about developments in Denmark and in particular the use of centrifuges through correspondence with his father, Jeppe Slifsgaard (a merchant in southern Jutland), who eventually decided to go to the US with a Burmeister & Wain automatic cream separator[28] together with Niels Blom, a *mejerist*.[29] They arrived in Cedar Falls in the summer of 1882, but the machine was held up by customs in New York, because they did not know if it was made of iron or steel. They finally decided it was made of steel, charged $93 in duties, and this machine thus became the first separator in the US.[30] Jeppe and Truels Slifsgaard then established 'The Danish Creamery' with Niels Blom as *mejerist* in 1883 at the place where Fredsville later grew up.[31] There they used the B&W separator for 11 years, although it caused some difficulties, since it had to be sent back to Denmark for repairs. Other creameries were established using a similar model in the local area, and the Danish Creamery was eventually bought up by the farmers and became a cooperative (Sørensen, 1908; Christensen, 1957).

The 'Danish Creamery' in Fredsville was not the first Danish creamery in the US, however. That honor belongs to the aforementioned Clarks Grove, Minnesota (which is in fact only just over 100 miles away from Fredsville), where a creamery was established in 1874-75 as

[25] In a massive, comprehensive coverage of every aspect of Danish-American life published in two volumes and edited by Vig (1908, 1916).

[26] Bang is best known today for the discovery of *Brucella abortus* in 1897. This gave rise to the contagious Bang's disease (now known as Brucellosis), which causes pregnant cattle to abort and to undulant fever in humans.

[27] *Fred* is Danish for peace, so literally: 'village of peace'.

[28] The patent for the B&W centrifuge was later sold in America and they were marketed as 'Danish-Weston' and later 'Reid'.

[29] See footnote 16

[30] In fact, the first centrifugal separator in Canada was also imported from Denmark, and was installed in Sainte-Marie de Beauce, Québec (Fondation de technologie laitière du Québec 1985, p. 476). Apparently the first centrifuge in New Zealand was also imported by a Dane, John Henry Monrad (Sørensen (1908), see also Sundstrom (1986)).

[31] Fredsville only got its Post Office in 1889.

part of a settlement which had its origins in a Danish Baptist colony, established in 1863, both founded by L. Jørgensen Hauge. The creamery struggled for years with low prices for butter, but things began to change when Hauge spent some time at Thorbygaard, Funen in Denmark, in the summer of 1887, where there were 200 cows, and a creamery with a centrifuge run on steam power. Hauge came back to Clarks Grove in 1889 and started giving his famous 'Butter Sermons', where he advocated for dairying on Danish principles, which has been considered to have had a strong impact on the development of cooperative dairying in Minnesota. Keillor (2000) argues, however, that this story is somewhat suspect, and that the role of the Danes has been somewhat exaggerated (also because they were well integrated[32]), although he does accept that the Clarks Grove creamery was the first successful cooperative creamery, although he thinks they adopted this from American antecedents.

Another notable Dane in the US was Johan Ditlev Frederiksen, who managed the American branch of the Danish producer of butter color, rennet, etc., Christian Hansen's Laboratory in Little Falls, NY, which sold its products to creameries and households around the US. It was at this factory that John Henry Monrad from 1885 was agent. After ten years he established his own office of the business in Chicago, from which he became an important figure in American dairying, through his regular contact with creameries, by writing for and editing the agricultural press, and even working for the Dairy Division of the USDA. Monrad was also instrumental for promoting the concept of dairy herd improvement associations, a system developed in Denmark whereby a group of farmers employed Control Assistants who traveled from farm to farm to observe the milking, weigh the milk and determine its fat content, supervise the feeding and determine whether the cost to benefit of the herd ratio was reasonable. He was supported in this by other Danes: the Dairy Inspector for Minnesota, H.T. Søndergaard and the aforementioned Helmer Ræbild, who was employed by the USDA to promote dairy herd improvement associations.

Another example is the pasteurization expert Julius Moldenhawer, who did important work on how to supply towns with clean and healthy milk, and there are many other examples. In sum, Sørensen (1908) argues that Danes were particularly successful in many aspects of dairying. Articles from Danish contributors were a frequent occurrence in American journals, many Danes won prizes at butter and cheese exhibitions, and Danish-educated *mejerister* (of which he argues there was an overproduction back in Denmark, although Hvidt (1960) describes this as a 'brain drain') had a relatively easy time finding work in American creameries. Many *mejerister* owned creameries, worked for the state as inspectors and consultants, and became teachers and professors. In addition, Danish migrants also produced successful offspring, educated in the US. He suggests, however, that in other branches of agriculture, although Danes were receptive to new ideas, they were more followers rather than innovators. But in US dairying, at the time Sørensen was writing, Danish migrants were extremely important, and not just for small scale cooperative agriculture. For example, when it was established by Viggo F. Jensen from Southern Jutland in 1900, the Continental

[32]Although see Jørgensen (1993), who argues that there were many examples of Danish settlements who preserved a strong Danish identity even with a relatively small population.

Creamery Company in Topeka, Kansas was the largest creamery in the world.[33]

A detailed study of the cross-cultural exchange between Americans and Danes is provided by Keillor (1993), arguing that despite Danish reservations about allowing their technological lead to be exported to the US, there was little they could do about the export of people, and with them ideas. He argues that, with some lag due to language, cultural and climatic differences to which the pure Danish system could not so easily adapt, Danish-Americans acted a 'brokers' spreading information between the two countries, something that was eventually institutionalized as Danes took important positions within American agriculture, government, and academia. This spread of knowledge was supported through various publications. For example, like other immigrants, the Danes established their own foreign language press.[34] A search in the *Digital Library of Danish American Newspapers and Journals* maintained by the Museum of Danish America provides plenty of evidence about the spread of information about dairying in Denmark and the progress of Danes in the US through the Danish-American agricultural press, as well as for example many advertisements for *mejerister*,[35] this latter demonstrating the endogeneity of the later movement of skilled dairymen to the US. An article from *Dannevirke* dated December 26, 1888 demonstrates, however, that progress was not always smooth:

> 'What we most need is a Danish dairy. We should really start with that in the spring. And it is probably best if we start from scratch. The reason is that a dairy was actually started a couple of years ago, and it is still waiting and freezing without a roof over its head.' (own translation)

There are even examples of Danish-American creameries in the United States publishing their accounts in the Danish agricultural press (see for example Jensen (1897)). Lampe and Sharp (2017, 2018, 2019) have argued that the development of bookkeeping and accounting practices and the sharing of results played an important role in the development of the dairying sector in Denmark. Thus, as Sørensen (1908) suggested, both Danish ideas and men flowed into the US, and although their importance has been disputed, the present work tests their influence.

[33] Another example mentioned by Sørensen is the Henningsen Produce Company, which at the time he was writing was apparently the largest supplier of dairy products in the Northwest, and possibly all of the US. Mackintosh (1990) considers Audubon and Shelby counties in Iowa, finding that around 1920, decades after the first Danish settlement, agriculture still reflected practices brought from Denmark (and Danish ethnic background dominated the influence of any other single factor). These counties contained however the Elk Horn settlement, which was the largest settlement of Danes anywhere in the US. She finds that Danish townships had on average smaller farms and a greater focus on livestock production, milk cows in particular, although the correlation is rather weak.

[34] The first Danish newspaper in the US was *Den Danske Pioneer*, founded in 1872, followed by *Bien*, from 1880; *Nordlyset*, published in New York from 1880; *Dansk Tidende*, published in Chicago from 1892; *Ugeblad*, published in Tyler, Minnesota; and *Lutheransk Ugeblad*, the official organ of the United Danish Lutheran Church, published in 1919 (Furer, 1972, p. 50).

[35] One of the earliest found can be read in *Dannevirke*, September 19, 1888, looking for a *mejerist* educated in Denmark.

3 Data and empirical strategy

3.1 Data

Our main source is US census data for the years 1870, 1880, 1890, 1900, 1910, and 1920. We use data from the agricultural census, compiled by Haines (2010), which collects information on the number of animals kept and the produce of each farm. The main variable used from this information is the number of dairy cows, defined as cows kept mainly for milk. As of the census of 1850 cattle were classified into three categories: working oxen, milk cows and other cattle. With increasingly different uses of cattle, this classification was changed to eight categories in 1900: calves under 1 year, steers between 1 and 2 years of age, steers between 2 and 3 years of age, steers 3 years and over, bulls 1 year and over, heifers between 1 and 2 years of age, cows kept for milk 2 years and over, cows and heifers not kept for milk 2 years and over. However, heifers between 1 and 2 years were generally counted as dairy cows and from 1920 counted as a separate category. Therefore, our measure of dairy cows includes 'milk cows' before 1900 and cows kept for milk 2 years and over, and dairy heifers between 1 and 2 years after 1900. Additionally, we use information on the number of bushels of wheat produced by county from the census. In 1870 this is divided into spring and winter wheat which we sum to give the total amount of wheat produced as reported for the other years.

The census data also includes information on the amount of butter produced. Before 1880 basically all butter was produced on farms and we thus only have this figure for the year 1870. After 1870 the industrial production of butter increased in importance and is included in the industrial census from the year 1880, although this is only available on the state level.

Additionally, we use micro data from the US censuses provided by IPUMS (Ruggles et al., 2018). The micro data for the years 1880, 1900, 1910, 1920 where full count data is available gives us information on the number of individuals born in Denmark (and other nationalities) in each county.[36] Thus, our measure of Danes includes people born in Denmark, not their descendants (although we consider second generation Danish immigrants in a robustness check). Additionally, the micro data includes information on the sector and, if in manufacturing, also the industry the individual is working in. We use this data to calculate the number of people working in the dairy industry (manufacturing) as a measure of modernity of the dairy sector. We calculate these figures on the county level. We also use the micro data from 1880 to examine whether Danes were different from other migrants or those born in the US.

We combine the census data with a number of geographical variables on the county

[36] Although note that we do not have the number of Danes in 1870, which would also have been extremely small.

level, which have been shown to be positively related to economic productivity. We use a measure of terrain ruggedness based on 'The Terrain Ruggedness Index' (in millimetres), which is provided by Nunn and Puga (2012).[37] Furthermore, we calculate average county elevation based on the data from GTOPO30 (US Geological Survey, 1996). In order to control for market accessibility we include the distance to the nearest canal or steamboat navigated river based on the maps provided by Atack (2015, 2017). Furthermore, we use the suitability index for pasture (suitability of global land area for pasture, FAO) provided by the Food and Agriculture Organization of the United Nations and the suitability index for wheat (Crop suitability index (class) for low input level rain-fed wheat, FAO) from the same source. In both cases we calculate the share of county area classified into high or very high suitability.

Finally, we also use the Danish police protocols on emigrants described earlier. These were provided by the Danish Emigration Archives and Aalborg City Archives (Det Danske Udvandrerarkiv, 2018).

The main analysis is conducted on the county level. Of course county boundaries were changing over time, as new counties were formed and others were abandoned. We use stable units of analysis by adjusting all county borders to the year 1870 using the procedure suggested by Hornbeck (2010). In the end we have data on all variables used in all years for a total number of 2,159 counties.[38] Table A1 in the appendix provides summary statistics on the main variables.

3.2 Empirical strategy

In order to identify the effect of Danish communities on the local dairy industry we implement a difference-in-differences analysis. We compare the development of the dairy industry in counties that received many Danes with those that received none or only few Danes. Further, we hypothesize that we would see this effect only after 1890. We measure the development of the dairy industry in two different ways. First, we look at whether an area specialized in dairying, by using the number of dairy cows (defined as described above) in the county as the outcome variable. Second, we investigate the state of modernization in the dairy sector. Here, we have two possible indicators of more modern dairying. As one indicator we use the number of people working in industrial dairying as the outcome variable. The more modern the dairy sector in an area, the more people should work in industrial dairying (as opposed to dairying conducted on farms). This outcome variable is only available from 1880, as industrial dairying was minimal prior to this date and we expect a positive effect of Danes on industrial dairying. As the second indicator for modern dairying we use the amount of farm butter produced in the county, with the expectation that this should be falling over

[37] Downloaded from: www.diegopuga.org/data/rugged/tri.zip

[38] Using the 1870 counties implies that we do not include territories that only acquired statehood after this date, although see Rogers (1978) on 'Creamery Fever' among Scandinavians in Grant County, South Dakota before the First World War.

time as production moved into the factories.

In the difference-in-differences analysis, we use the distribution of Danes in 1880 as the treatment variable. The main innovations we are interested in took place during the 1880s: the first steam-powered cream separator was installed in 1878 in Denmark and the first cooperative creamery in Denmark was established in 1882. The first cream separator in the US was installed in the Danish cooperative creamery in Fredsville, Iowa in 1883. We use the distribution of Danes prior to these dates, i.e. the distribution in 1880, as this will ensure exogeneity with respect to these events. The developments in the Danish dairy sector happened rapidly over the course of just a few years. Danes emigrating before or in 1880 could not possibly know that Denmark would have an advantage in dairying just one decade later. Only by 1890 would Danes have learned about cooperatives and new technology in butter production by still keeping contact to their home country. Whether a county has resident Danes should thus only matter from 1890 and onwards where we expect to see an effect of Danes on the local dairy sector. As explained earlier, the absolute number of Danes coming to the US was small compared to other European countries, however it may not need many Danes to bring technological knowledge to an area. Technology spreads between people such that even one person with the right knowledge may have a great impact. We thus measure the pre-determined distribution of Danes by taking the natural logarithm to the number of Danes in the county in 1880.[39] Figure 2 presents a visualization of where Danes settled over time. In 1880, Danes are highly concentrated in the Midwest and Utah, where the latter are mormon colonies mentioned earlier.

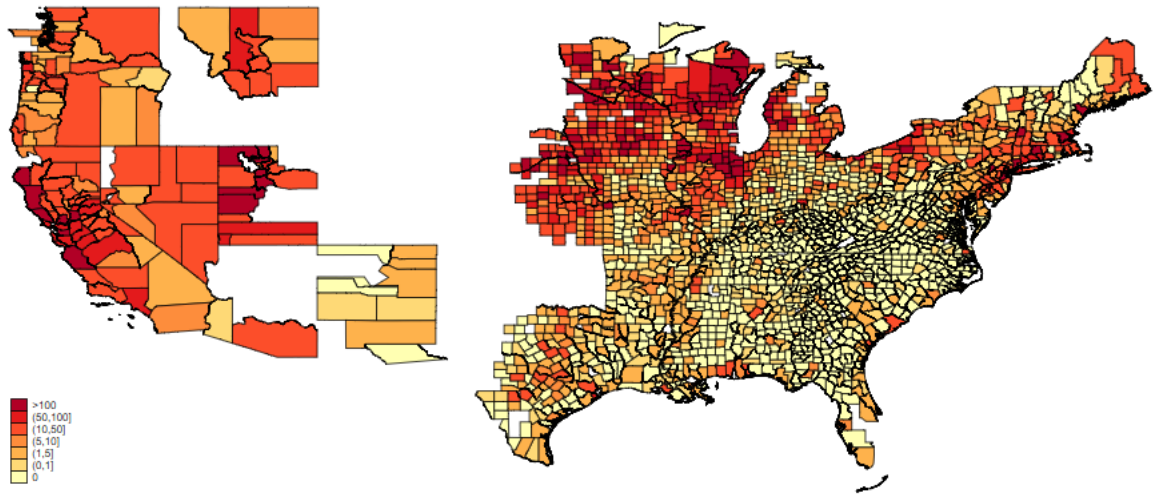

Figure 2: Number of Danes per county in 1880

One potential threat to our identification strategy is that Danes already before 1890 might have exhibited certain traits which would give them an advantage in dairying. Although they could not possibly know about modern dairying techniques, they could be better educated than others, for example. Based on the micro data from the 1880 census, figures A1 and A2

[39] We prefer the specification in logarithms as the distribution of Danes in 1880 is highly skewed to the left. Section 4.3 shows that the results are robust to alternative functional forms.

in the appendix show a comparison of several characteristics across different nationalities, to investigate whether Danish settlers in 1880 were different from other settlers at the time or from those born in the US. None of these variables show Danes to be particularly different from other immigrant groups or natives.

We estimate the following flexible difference-in-differences model, including dummy variables for each year, using 1880 as the baseline year. The flexible model allows us to investigate the common trend assumption, that the treated counties are not on a diverging path to more (modern) dairying prior to treatment. The flexible difference-in-difference model can be written as:

$$\begin{aligned} ln(DairyCows_{it}) = & \sum_{j=1870}^{1920} \beta_j \, ln(Danes_{1880i}) \times I_t^j \\ & + \sum_{j=1870}^{1920} X_i \times I_t^j \Gamma_j + \mu_i + \lambda_t + \eta_{rt} + \epsilon_{it} \end{aligned} \tag{1}$$

for county i at time t. The vector X_i represents time-invariant control variables interacted with year fixed effects. These include geographical controls (the share of county area with high or very high pasture suitability, share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the natural logarithm of the distance to a canal or steamboat navigable river). We include these variables to account for the possibility that it is not Danes having an effect on the dairy industry but that Danes may settle in areas with a geographical advantage for dairying or for industrial development in general (see also Nunn and Qian (2011)). Further, we include county fixed effects (μ_i), time fixed effects (λ_t), and region-by-year fixed effects (η_{rt}). ϵ_{it} is the error term, clustered at the county level.

We also estimate the following standard difference-in-differences models to determine the average treatment effect:

$$Y_{it} = \beta \, ln(Danes_{1880i}) \times D_{post1880} + \sum_{j=1870}^{1920} X_i \times I_t^j \Gamma_j + \mu_i + \lambda_t + \eta_{rt} + \epsilon_{it} \tag{2}$$

where Y_{it} is one of our outcome variables $ln(DairyCows_{it})$, $ln(DairyIndustry_{it})$, or $Butter_{it}$ for county/state i at time t. $D_{post1880}$ is an indicator variable which takes the value zero before 1880 and one after 1880. The rest is defined as above. Our main parameter of interest is β, the average treatment effect.

4 Results

4.1 Specialization and Modernization

We start with a simple pooled OLS estimation for the years 1890 to 1920. Figure 3, shows the partial correlation between the number of Danes and the number of dairy cows, including the full set of control variables.[40]

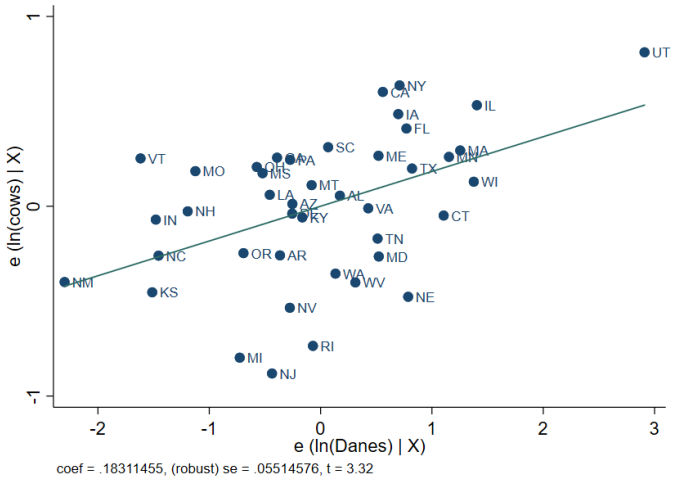

Figure 3: Partial regression plot between ln(Danes) and ln(cows). State level, year 1900.

Table A2 in the appendix also shows pooled OLS estimations regressing the number of Danes and the number of Danish immigrants recording an occupation related to dairying on the number of dairy cows. Clearly, a positive relation emerges in both cases. Of course this result can by no means be interpreted as a causal relationship. Therefore, we now present results from the flexible difference-in-difference model giving the effect of Danes on the number of dairy cows in each year. The results can be found in table 2.

[40]For the better visibility, we show this on state level and only for the year 1900, here. The same figure based on all datapoints, i.e. all counties for the years 1890-1920, can be found in figure A3 in the appendix.

	(1) ln(cows) all	(2) ln(cows) Danes1880> 3	(3) ln(cows) Danes1880> 10
year_1=1870 ×	-0.007***	-0.029	0.019
ln(Danes1880)	(0.002)	(0.018)	(0.029)
year_1=1890 ×	0.004***	0.025**	0.008
ln(Danes1880)	(0.001)	(0.011)	(0.016)
year_1=1900 ×	0.005***	0.046**	0.022
ln(Danes1880)	(0.001)	(0.020)	(0.030)
year_1=1910 ×	0.005***	0.058***	0.039
ln(Danes1880)	(0.002)	(0.019)	(0.027)
year_1=1920 ×	0.005**	0.046*	0.033
ln(Danes1880)	(0.002)	(0.026)	(0.037)
Year FE	Y	Y	Y
County FE	Y	Y	Y
Region x year FE	Y	Y	Y
Geography x year FE	Y	Y	Y
Observations	12,954	4,752	3,216
Number of counties	2,159	792	536

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 2: Difference-in-differences estimation

It is clear that there is a strong positive effect of Danes on dairy cows after 1880. In the baseline specification (column (1)), however, counties receiving Danes in 1880 do in fact have lower numbers of dairy cows than counties not receiving Danes before this date. This pre-trend might suggest a general pattern of convergence unrelated to the presence of Danes. We note, however, that roughly half the counties had no Danish population at all in 1880, and thus convergence of these, and other areas with almost no Danes, might be one explanation. This is confirmed in column (2), where we only consider the intensive margin of Danish treatment, for a 'significant' number of Danes (four or above). The pre-trend disappears, and the coefficient for the later years becomes even stronger. Column (3), however, shows that the effect we would like to capture is also highly dependent on comparing counties with no or very few Danes with those receiving more significant numbers of Danes as the positive effect after 1880 is insignificant when only comparing counties receiving more than 10 Danes - which represents the top 25% of the distribution in 1880. We therefore focus on the baseline specification and present the following results for all counties.

We estimate the average treatment effect for three different outcome variables, *ln(cows)*, *ln(ind.dairy)*, and *ln(farmbutter)*, presented in table 3.

	(1) ln(cows)	(2) ln(ind.dairy)	(3) ln(farmbutter)
post1880=1 × ln(Danes1880)	0.009*** (0.002)	0.076*** (0.021)	-0.007*** (0.002)
Year FE	Y	Y	Y
County FE	Y	Y	Y
Region x year FE	Y	Y	Y
Geography x year FE	Y	Y	Y
Observations	12,954	8,636	10,774
Number of counties	2,159	2,159	2,159

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 3: Difference-in-differences estimation

In line with table 2 we find a positive treatment effect on the number of dairy cows. We also find a positive effect on the number of people working in industrial dairying, indicating more modern dairying techniques. Another way to look at the state of modernization of the dairy sector is to look at the amount of butter produced and especially whether this butter is produced on farms (the traditional way) or in modern factories/creameries (industrial butter). Column (3) shows that Danes have a negative effect on the amount of butter produced on farms, which represents the more traditional method for producing butter. Ideally, we would like to contrast this with the amount of butter produced in industry, but unfortunately this information is not available on the county level. On the state level, however, this distinction is available. Table 4 shows the effect of Danes on the total amount of butter produced (column (1)), the amount of industrial butter (column (2)) and the amount of butter produced on farms (column (3)). Overall, we find an insignificant negative effect of Danes on total butter. When we split the butter numbers into modern and traditional production, however, we see that this is due to diverging effects between industrial butter and butter produced on farms. As industrial production was still rather limited (as are our number of observations, since this data is only available on the state level), it is not surprising that the coefficient in this specification is not significant. Nevertheless, the results indicate that areas with more Danes produced more industrial butter where they at the same time produced less butter on farms. This indicates that resources were diverted towards industrial production away from the more traditional methods in these areas.

Focusing on column (1) in table 3, our average treatment effect is an elasticity of 0.009. This means that one percent more Danes led to 0.009 percent more dairy cows after 1890. This effect is not negligible, as the average number of dairy cows is almost 200 times the average number of Danes in the county before 1890 and still more than 100 times after 1890.

Thus, one standard deviation more Danes above the mean translates to 3.3% more dairy cows. Moreover, the effect is most likely underestimated as we use the distribution of Danes in 1880 as our treatment variable. Danish migration first took off in the 1890's and we are thus assigning zero to many areas which later received Danes. Moreover, we demonstrated above that the effect was bigger on the intensive margin. Nevertheless, despite rather small Danish migration streams, we find a significant positive effect, thus demonstrating that areas with Danes specialized in dairying and kept a greater number of dairy cows.

	(1) ln(totalbutter)	(2) ln(ind.butter)	(3) ln(farmbutter)
post1880=1 × ln(Danes1880)	-0.080 (0.056)	0.841 (0.917)	-0.191*** (0.046)
Time FE	Y	Y	Y
State FE	Y	Y	Y
Region x year FE	Y	Y	Y
Geography x year FE	Y	Y	Y
Observations	210	210	210
Number of states	42	42	42

Geography controls include the natural logarithm of the share of state area with very high or high pasture suitability, the share of state area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of state area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the state level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 4: Difference-in-differences estimation for butter production (state level)

4.2 Persistence

We might wonder whether places where Danes originally settled are still relatively specialized in dairying. From Haines (2010) we also have data on the number of dairy cows for the years 1950, 1960, and 1970. We add these years to our preferred estimation from table 3 (column 1). Figure 4 shows the coefficients for the interaction between year dummies and the natural logarithm of Danes in 1880.

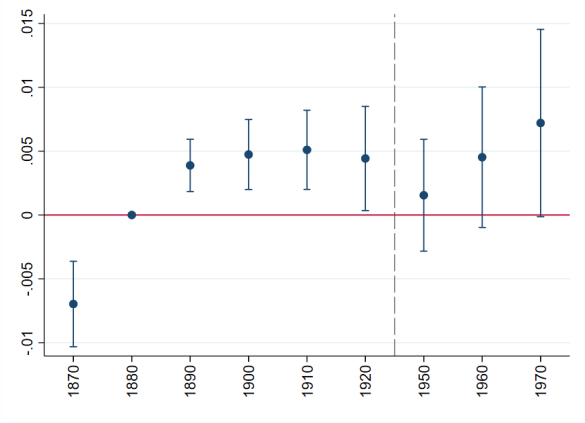

Figure 4: Coefficients on interaction between year dummies and ln(Danes1880), dependent variable: ln(cows).

The coefficient stays positive but becomes insignificant in the later years. Today, only a few states produce large amounts of dairy products, this might explain the very large standard errors on the estimates. Although this has tended to concentrate in the Midwest, where many Danes settled, thus maybe explaining the larger coefficient for the last period.

4.3 Robustness

The above has shown that areas which received more Danes specialized in dairying and also conducted more modern dairying. To test the empirical power of our treatment variable, the 1880 distribution of Danes, we randomize this distribution across counties. We repeat this exercise 10,000 times, and use each random distribution as the treatment variable in equation 2, instead of the true distribution. The t-values for the estimated treatment effects are presented in figure A4 in the Appendix. As a reference a line is added for the t-value from our preferred estimation (column (1) in table 3). Clearly, the true distribution of Danes in 1880 explains dairy cow numbers far better than any random draw. Moreover, the unit of analysis used here is the county, the borders of which are of course somewhat arbitrary. Also, as can be seen in figure 2 some counties are much larger than others. This may raise concerns about spatial correlation biasing our results. We therefore present estimates employing Conley standard errors using different cut-off points in table A3 in the appendix. The significance of our results is only marginally affected even by the largest cut-off of 500km.

One might of course also question our treatment variable. In the main specification we use the natural logarithm of the number of Danes by adding a small value to the zeros, so that we can compare counties who received Danes to those that did not. Table A4 in the appendix shows that our results are robust to not adding a small value to the zeros (and thus excluding observations), to different small values and to an inverse hyperbolic sine (IHS) transformation. As mentioned earlier, we prefer the specification in logarithms as the distribution of Danes in 1880 is highly skewed to the left. We could however also

use a different functional form for the measurement of Danes.[41] Table A5 in the appendix presents results when using the Danes by total population or an indicator variable for whether a county has Danes in 1880. When including each variable by itself we find a significantly positive effect of Danes on dairy cows in all specifications. We also include second generation Danes as an additional explanatory variable, although, only the first generation seems to matter. Jeppesen (2016), for example, notes that Danish migrants quickly integrated into American society. Thus, especially the first generation is expected to keep contact with the home country, which could explain why we only find an effect from first generation migrants. When including all measures in a horserace specification (column (4)) only the logarithm of Danes and the population share of Danes remain positive.

It could also be that Danes were just very good at agriculture, including dairying. Table A6 column(1) in the appendix, therefore presents a placebo regression using wheat as the outcome variable. We find no significant effect on the amount produced. Moreover, in Denmark, a specialization into pork production occurred along with the specialization in modern dairying. After separating the cream from the milk for butter production one was left with skim milk which was earlier used to make cheese of rather low quality. This was not a very efficient use of resources and it was soon realized that skim milk could be fed to pigs (see for example Lampe and Sharp (2018) or Bjørn (1982)). In line with this, we also find a positive effect of Danes on the number of pigs kept in a county, see column (2) of table A6 in the appendix – another indicator for the modernization of the dairy sector. As is evident from figure 2, a large share of Danes emigrated to counties in the Midwest. This is also where many of the early dairy cooperatives started and where a large share of dairy production still is located. For example, one of the largest dairy producers in the US today, the cooperative '*Land O'Lakes*', is based in Arden Hills in Minneapolis. We therefore check whether identification stems from the Midwest vs. the rest of the country receiving very few Danes or whether our results also hold true within the Midwest. When repeating our analysis for counties in the Midwest alone, in fact we also find a significantly positive effect of Danes, which is even larger than in the baseline specification. Our estimation results can be found in column (3) in table A6. This means that also within an area receiving many Danes, counties which received more Danes specialized more in dairying than counties receiving fewer Danes. Columns (4)-(6) in the same table include additional control variables. In column (4) we control for counties lying in the 'frontier'. It could be that our results simply stem from Danes settling in the frontier, which then catches up in terms of agriculture over the next decades. We therefore include a dummy variable for all counties lying in the frontier (or 'wilderness') in 1880 in column (4). Here, we use the contemporary definition of the frontier of the U.S. census bureau, defining areas with less than 2 inhabitants per square mile as 'wilderness' and between 3 and 6 inhabitants as 'frontier' (see also Turner (1920)). Our results are unchanged. As mentioned earlier, many of the early Danish migrants were Mormons. As these were very different from the Danish settlers, we use the per capita number of mormon organizations in the county from the 1870 census to control for these very different types of settlements in

[41] Although these do not fit the assumption of a linear relationship to the outcome variable *ln(cows)* very well.

column (5). Again, our main results are unaffected. Lastly, we include the natural logarithm of initial population (year 1870) interacted with time as it may be population in general rather than Danes fostering economic development in the area. In fact, the estimated effect of Danes increases in size and is unaffected in terms of sign and significance.

4.4 Mechanisms

We argue that we present a very specific example of knowledge transfer through migration, although it is of course impossible to actually measure this transfer. Nevertheless, we can investigate the mechanism further – considering in particular whether the effect is due to the transfer of knowledge or the transfer of people. Our hypothesis is that this was principally a transfer of knowledge. One reason for this is that the absolute number of Danes is simply too small for the people alone to have made a difference. Already by 1890 every single Dane in the country would have had to produce more than 1,000 pounds of industrial butter if our results were only due to the people arriving.[42] Furthermore, we hypothesize that all Danes are potential transmitters of knowledge.

Along this line, we investigate whether the effect stems from dairy-related Danes more than from 'regular' Danes, as we have information on the occupation from the Danish emigration data. We calculate the number of Danish immigrants with a dairy-related occupation[43] per county. This is possible as the majority of migrants record the exact settlement they travel to. In total we have information on 1,621 Danes working in dairying. As extremely few of them arrive before 1890, we can only use this variable in an OLS setting, and the results can be found in table A2 in the appendix. The emigration data only covers emigrants up to 1908, and thus columns (2)-(4) only include the years 1890-1910. There is also a positive correlation between the number of dairy-related Danes and the number of dairy cows but this does not alter the correlation between 'regular' Danes and dairy cows. Of course, these are pure correlations, which, nevertheless indicate that the estimated effect in the main specification cannot be traced to Danes working in dairying alone. More generally, this also speaks against a transfer of people or human capital and in favour of a transfer of knowledge.

The effect seems to stem from the general Danish immigrant population rather than Danes related to dairying. Yet, it could be that it was not especially Danes who fostered development in the area, but immigrants in general or another group of immigrants which happens to correlate with Danes. We therefore include other (dairy-relevant) immigrant groups as of 1880, namely Swedish, Norwegians, Germans, English, and Irish, interacted with time. We also use an aggregate measure of all foreign born, resembling Sequeira et al. (2019). Results are presented in table A7 in the appendix. Several other immigrant groups have a positive effect on dairy cow numbers but the effect of Danes remains when including

[42] This also speaks against a story of Danes simply increasing the demand for dairy products.
[43] See footnote 16 for a list of occupations.

all immigrant groups in a horse race specification and is also the most important in terms of significance and magnitude. This is also true for the aggregate measure of foreign born residents. The result that also other immigrants have a positive effect is not very surprising. 1880 marks the period of mass migration to the United States, when thousands of settlers arrived from Europe and settlements expanded to the west. Due to the general settlement pattern, different immigrant groups will naturally correlate with each other. Moreover, people may choose to settle in the same region due to cultural similarity. Also, immigration agencies shaped the settlement patterns, with different agencies being active in different European countries. Often tickets were sold to a particular destination, and sometimes land was assigned/acquired before the journey. For example, as mentioned above, railroad companies bought large areas of land, built the railroad and then sold slots along the line to new settlers with the result that clusters of immigrants of different nationalities formed for those European countries in which the firms were active (Hvidt, 1960).

If it is not the flow of people but rather the flow of ideas we are measuring, others must have worked together with Danes or imitated the way Danes were conducting dairying. We therefore also present estimation results using other dairy-relevant immigrant groups, but now also including interaction terms between those immigrant groups and Danes.[44] We find a positive interaction effect with Swedes and Norwegians, which makes intuitive sense as these are all first generation immigrants and thus not likely to be proficient in English. Danes, Swedes and Norwegians would nevertheless understand each other and are also culturally closer to each other than other immigrant groups. It is thus likely that areas receiving both Danes and Swedes and Norwegians would benefit in terms of dairying activity from the interaction between them.

5 Conclusion

We have provided a wealth of evidence that Danish settlements established before 1880 significantly fostered the development of the dairy sector in the US: areas which had received more Danes both specialized in dairying and employed more modern production techniques. We have thus presented an example of knowledge transfer through migration in a rather unique setting: first, the story of Danes bringing in technological knowledge is based on an *existing* immigrant community. Second, these original immigrants were by no means 'economically desirable', and third, we were able to show how even a very small group of immigrants can have a positive impact on the local economy through spillover effects. This has important implications for the current debate on immigration, especially as it has often taken a rather negative stance recently. Our results show, however, that it is difficult to determine which immigrants are 'desirable' *ex ante* and that the host country may benefit

[44] We also estimate this specification including all fifteen pairwise interactions terms for the selected immigrant groups. Only the interactions between Scandinavian settlers turn out significantly positive and the effect of Danes by themselves remains. Results are not presented here but are available on request.

from immigration even decades after the first arrival.

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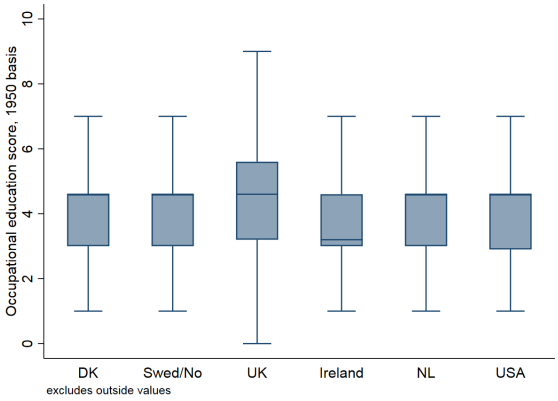
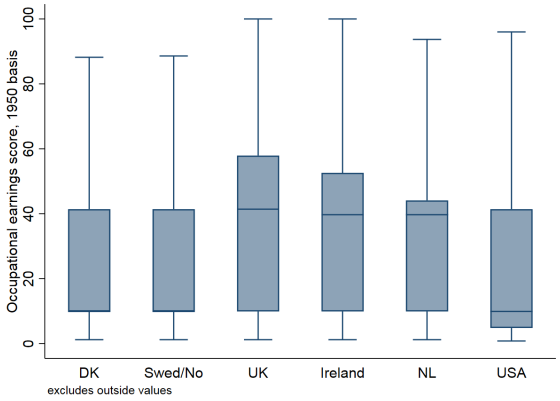
6 Appendix

1870-1880	*Obs.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*	*25%*	*50%*	*75%*	*90%*	*95%*	*99%*
Danes	2,159	27	126	0	3,095	0	1	10	51	103	537
cows	4,318	4,892	6,092	1	93,369	1,739	3,188	5,864	10,077	14,214	31,558
ind.dairy	2,159	3	17	0	251	0	0	0	3	12	82
wheat	4,318	170,140	302,542	0	4,297,840	6,102	46,897	196,060	521,039	742,123	1,456,544
pigs	4,318	16,740	17,243	0	152,975	5,471	11,819	22,273	36,659	50,155	86,250
total population	4,318	20,143	38,889	5	942,292	7,138	13,134	22,258	35,866	49,541	143,839
Swedish	2,159	84	452	0	15,344	0	3	25	145	169	1,615
Norwegian	2,159	75	424	0	10,422	0	0	6	56	319	1,669
Germans	2,159	866	4,486	0	98,024	12	87	496	1,704	2,873	9,053
UK	2,159	409	1,668	0	32,826	12	58	262	798	1,512	7,232
Irish	2,159	836	5,206	0	120,532	13	77	320	1,147	2,233	15,936
Slesvig	2,159	14	117	0	3,980	0	0	4	16	39	270
total butter (in 1,000 pounds)	46	17,500	24,900	45	121,000	1,404	8,208	19,200	60,200	69,700	121,000
ind. butter (in 1,000 pounds)	46	638	1,843	0	8,956	0	12	144	2,074	6,183	8,956
farmbutter (in 1,000 pounds)	46	16,900	23,500	45	112,000	1,356	8,098	19,200	53,700	67,600	112,000
post-1880											
Danes	8,636	62	325	0	12,090	0	2	22	117	259	1,098
cows	8,636	8,367	8,614	8	119,423	3,229	6,016	10,391	16,585	23,556	44,454
ind.dairy	6,477	9	25	0	489	0	1	6	23	42	130
wheat	8,636	219,501	650,904	0	31,400,000	3,028	45,607	236,749	621,876	966,749	1,852,127
pigs	8,636	25,632	26,060	4	252,139	8,414	17,549	32,081	59,095	81,826	122,102
total population	8,636	36,333	96,065	243	3,053,017	13,542	20,578	31,710	56,356	88,422	344,177
Swedish	8,636	231	1,593	0	68,736	1	6	58	373	925	3,855
Norwegian	8,636	120	755	0	25,891	0	1	14	156	510	2,270
Germans	8,636	1,005	5,902	0	201,930	13	96	547	1,676	3,161	11,362
UK	8,636	505	2,494	0	47,537	10	50	228	797	1,592	9,304
Irish	8,636	653	4,850	0	133,516	6	34	163	637	1,416	13,060
Slesvig	6,477	1	12	0	379	0	0	0	0	2	24
total butter (in 1,000 pounds)	184	31,700	34,800	86	167,000	5,292	18,100	49,300	82,700	111,000	139,000
ind. butter (in 1,000 pounds)	184	11,600	22,900	0	146,000	61	1,366	12,300	37,300	61,100	104,000
farmbutter (in 1,000 pounds)	184	20,000	20,200	86	98,200	3,520	14,300	29,500	48,500	61,800	79,600
Constant Variables											
foreign1880	2,159	2,967	13,189	0	290,641	61	474	2,277	5,779	9,187	46,729
pasture suitability	2,159	0.76	0.37	0	1	0.62	1	1	1	1	1
wheat suitability	2,159	0.29	0.39	0	1	0.00	0.00	0.59	1	1	1
average ruggedness	2,159	0.58	0.69	0	5	0.17	0.31	0.68	1.54	2.15	3.10
average elevation	2,159	289	307	1	2,408	123	238	337	492	749	1,825
distance river	2,159	58,566	80,908	2	774,147	13,793	31,850	68,630	143,521	200,404	441,126
area (in 1,000 squaremiles)	2,159	2,430,000	5,010,000	59,500	71,900,000	1,090,000	1,500,000	2,190,000	3,050,000	5,070,000	26,100,000
wildfrontier	2,159	0.14	0.35	0	1	0	0	0	1	1	1

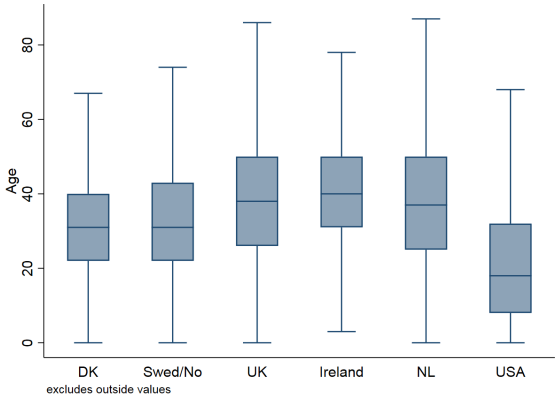
Table A1: Summary statistics



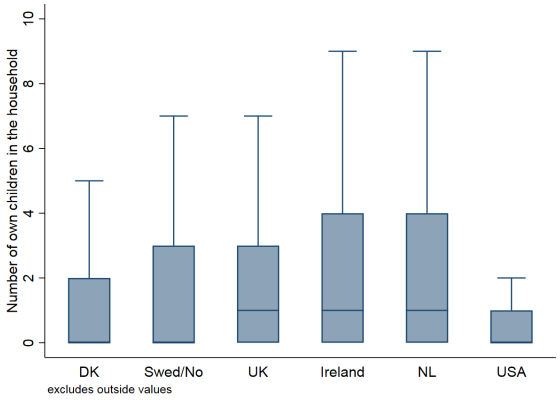
(a) education score (1950 basis)



(b) earnings score (1950 basis)



(c) age



(d) number of own children living in household

Figure A1: Comparison of Danes to other nationalities, 1880. Data source: IPUMS, 1880 census.

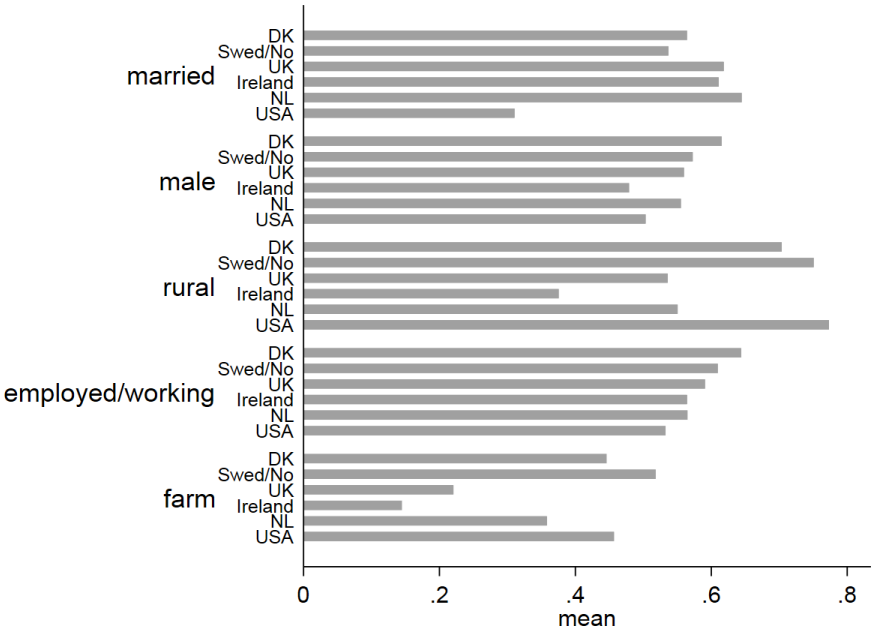


Figure A2: Comparison of Danes to other nationalities, 1880 (cont.). Data source: IPUMS, 1880 census.

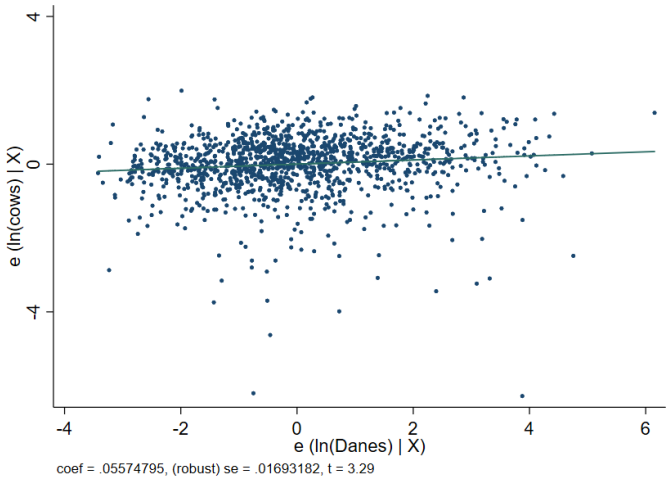


Figure A3: Partial regression plot between ln(Danes) and ln(cows). County level, years 1890-1920.

	(1) ln(cows)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)
ln(Danes)	0.022***	0.022***		0.021***
	(0.001)	(0.002)		(0.002)
ln(dairyDanes)			0.015***	0.011***
			(0.004)	(0.004)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y
Geography	Y	Y	Y	Y
Observations	8,636	6,477	6,477	6,477
Number of counties	2,159	2,159	2,159	2,159
R-Square	0.47	0.49	0.47	0.50

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A2: Pooled OLS estimation. Column (1): 1890-1920, columns (2)-(5): 1890-1910.

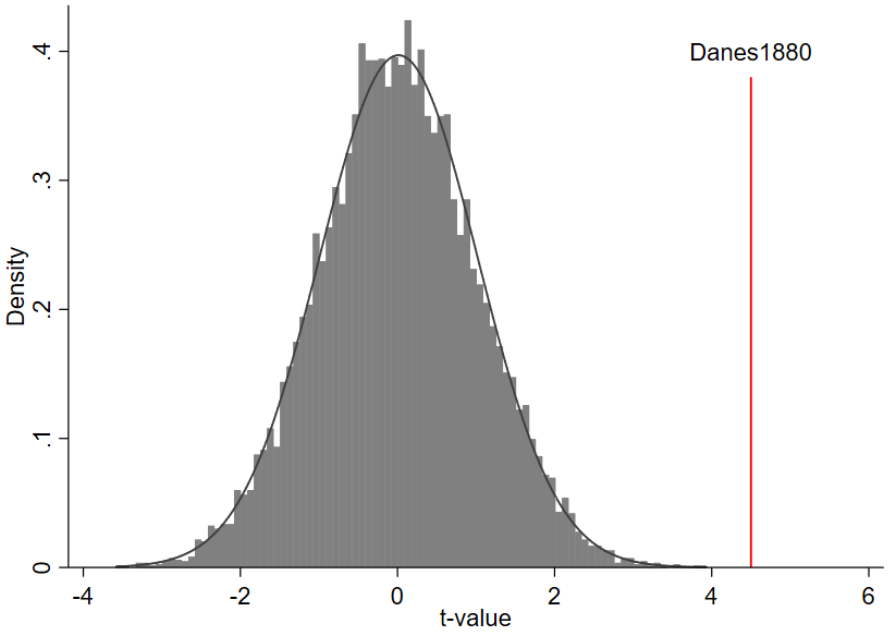


Figure A4: Histogram of t-values resulting from randomizing the distribution of Danes in equation 2

	(1) ln(cows) 50km	(2) ln(cows) 100km	(3) ln(cows) 200km	(4) ln(cows) 500km
post1880=1 × ln(Danes1880)	0.0085*** (0.0011)	0.0085*** (0.0013)	0.0085*** (0.0015)	0.0085*** (0.0017)
Year FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y
Observations	12,954	12,954	12,954	12,954

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A3: Conley standard errors for different cut-off points

	(1) ln(cows) $\varepsilon = 1e-08$	(2) ln(cows) $\varepsilon = 0$	(3) ln(cows) $\varepsilon = 1e-09$	(4) ln(cows) $\varepsilon = 1e-06$	(5) ln(cows) IHS
post1880=1 × ln(Danes1880)	0.009*** (0.002)				
post1880=1 × ln(Danes1880)		0.042*** (0.012)			
post1880=1 × ln(Danes1880)			0.008*** (0.001)		
post1880=1 × ln(Danes1880)				0.011*** (0.002)	
post1880=1 × Danes1880_ihs					0.063*** (0.011)
Year FE	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y	Y
Observations	12,954	7,764	12,954	12,954	12,954
Number of counties	2,159	1,294	2,159	2,159	2,159

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A4: Alternative transformation of *Danes1880*

	(1) ln(cows)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)	(5) ln(cows)
post1880=1 × ln(Danes1880)	0.009*** (0.002)			0.008*** (0.002)	0.034** (0.014)
post1880=1 × Daneshare1880		12.406*** (4.322)			9.219** (4.085)
Danes_present=1 × post1880=1			0.144*** (0.031)		-0.513* (0.266)
post1880=1 × ln(secondgen1880)				0.001 (0.002)	-0.003 (0.002)
Year FE	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y	Y
Observations	12,954	12,954	12,954	12,954	12,954
Number of counties	2,159	2,159	2,159	2,159	2,159

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A5: Alternative treatment variables

	(1) ln(wheat)	(2) ln(pigs)	(3) ln(cows) Midwest	(4) ln(cows) Frontier	(5) ln(cows) Mormon	(6) ln(cows) initial pop.
post1880=1 × ln(Danes1880)	0.009 (0.011)	0.008** (0.003)	0.020*** (0.005)	0.009*** (0.002)	0.009*** (0.002)	0.016*** (0.001)
Year FE	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y	Y	Y
frontier x year FE	N	N	N	Y	N	N
mormon x year FE	N	N	N	N	Y	N
ln(pop1870) x year FE	N	N	N	N	N	Y
Observations	12,954	12,954	4,596	12,954	12,954	12,954
Number of counties	2,159	2,159	766	2,159	2,159	2,159

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A6: Further robustness checks

	(1) ln(cows)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)	(5) ln(cows)	(6) ln(cows)	(7) ln(cows)	(8) ln(cows)	(9) ln(cows)	(10) ln(cows)	(11) ln(cows)
post1880=1 × ln(Danes1880)	0.009***							0.004**	0.050***		0.009***
	(0.002)							(0.002)	(0.006)		(0.002)
post1880=1 × ln(Germans1880)		-0.000						-0.001	-0.008		
		(0.002)						(0.003)	(0.011)		
post1880=1 × ln(UK1880)			-0.002					-0.007*	-0.041		
			(0.003)					(0.004)	(0.028)		
post1880=1 × ln(Irish1880)				-0.006				-0.014**	-0.074***		
				(0.005)				(0.006)	(0.024)		
post1880=1 × ln(Swedish1880)					0.008***			0.004**	0.011***		
					(0.001)			(0.002)	(0.003)		
post1880=1 × ln(Norwegian1880)						0.013***		0.013***	0.018***		
						(0.002)		(0.002)	(0.002)		
post1880=1 × ln(Slesvig1880)							0.003	-0.003	0.003		
							(0.002)	(0.002)	(0.002)		
post1880=1 × ln(Danes1880) × ln(Swedish1880)									0.001***		
									(0.000)		
post1880=1 × ln(Danes1880) × ln(Norwegian1880)									0.001***		
									(0.000)		
post1880=1 × ln(Danes1880) × ln(Germans1880)									-0.001		
									(0.001)		
post1880=1 × ln(Danes1880) × ln(UK1880)									-0.002		
									(0.002)		
post1880=1 × ln(Danes1880) × ln(Irish1880)									-0.004***		
									(0.001)		
post1880=1 × ln(Danes1880) × ln(Slesvig1880)									0.001***		
									(0.000)		
post1880=1 × ln(foreign1880)										0.007	-0.009
										(0.007)	(0.007)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	12,954	12,954	12,954	12,954	12,954	12,954	12,954	12,954	12,954	12,954	12,954
Number of counties	2,159	2,159	2,159	2,159	2,159	2,159	2,159	2,159	2,159	2,159	2,159

Geography controls include the natural logarithm of the share of county area with very high or high pasture suitability, the share of county area with high or very high wheat suitability, average elevation, average Terrain Ruggedness Index of county area (measured in millimetres), and the distance to a canal or steamboat navigable river. Robust standard errors in parentheses, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A7: Effect of other immigrant groups

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