Immigration and Knowledge Spillovers: Danish-Americans and the Development of the Dairy Industry in the United States*

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Abstract

We exploit the example of Danish migration to the United States during the late nineteenth century to examine the hypothesis of knowledge spillovers through migration. Modern cooperatively-owned butter factories spread around Denmark within a decade after 1882, and by 1890 Denmark had established itself as a world-leading dairy producer characterized by institutional, technological and scientific innovation. We hypothesize that despite being few in number, Danish-Americans helped spread this knowledge to the US and thus played a central role for the growth and modernization of American dairying. Supported by a narrative based on historical evidence, we test our hypothesis using a difference-in-differences strategy, using data taken mainly from the US census. We find that counties with more Danes up to 1880 (before the transformation of Danish agriculture) do not appear to have enjoyed advantages in dairying compared to other parts of the country. Subsequently, however, they both specialized in dairying, and used more modern practices. This example illustrates the importance that even a small number of migrants can have on relative development.

JEL classification: 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 (2018b); Jensen et al. (2018)) has demonstrated that this rested on developments since the eighteenth century, when an agricultural elite from north-

[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.

ern Germany[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% of the population in Sweden and almost 39% of the population in Norway (Hvidt, 1960). Part of this was due to Denmark's aforementioned agricultural leadership. This attracted migrants to Denmark who found work in the agricultural sector, such that it was actually a country of immigration while the rest of Scandinavia and beyond experienced massive emigration during the 'first era of globalization'. 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

[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.

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 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,

[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).

and have been proposed by for example both US and UK politicians.[9] Another popular bone 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 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 the 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

[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).

[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.

to religion (Furer, 1972, p. 45).

Emigration from Denmark increased from the late 1860s, with around 158,000 leaving 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 to build new tracks and then finance the 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 of all 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 Swedish.[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 number of emigrants from Denmark with an occupation related to dairying (left panel) as well as their destination (right panel) by year.[16] Especially for Danes with a dairy-related occupation, immigration numbers are very

[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.

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 occupation, for men in particular.

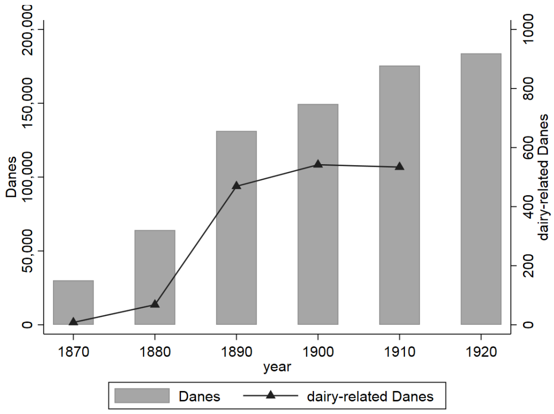


Figure 1: Stock of Danish immigrants and flow of Danish immigrants with a dairy-related occupation.

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. 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.

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 (2018b), 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 (2018b) 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 (2018a), 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.[17] 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',[18] 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 produced 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

[17] Interestingly, Hvidt (1960) notes that many Danish migrants came from areas with more of the large farms Lampe and Sharp (2018a) 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.

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

mention Olmstead and Rhode (2008)[19] make of possible Danish influence is that the world's 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.[20] 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),[21] but there is certainly no doubt that Den-

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

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

[21]The extent to which Alvord neglects the contributions of dairy scientists in Europe is apparent from the

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.[22]

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 (2018b), 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,[23] 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

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

[22]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.

[23]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).

there were no less than 630 (Edwards, 1938, p. 157).

By far the most comprehensive coverage of notable Danish-Americans and their impact on American dairying is provided by Sørensen (1908).[24] 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.[25] 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 US was in the Danish settlement of Fredsville, Iowa.[26] 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 through correspondence with his father, Jeppe Slifsgaard (a merchant in southern Jutland) about developments in Denmark and in particular the use of centrifuges, who eventually decided to go to the US with a Burmeister & Wain automatic cream separator[27] together with Niels Blom, a *mejerist*. 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.[28] Jeppe and Truels Slifsgaard then established 'The Danish Creamery' with Niels Blom as *mejerist* in 1883 at the place where Fredsville later grew up.[29] 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

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

[25]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.

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

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

[28]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)).

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

just over 100 miles away from Fredsville), where a creamery was established in 1874-75 as 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[30]), 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 Cow Testing 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 Cow Testing 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,

[30] 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.

when it was established by Viggo F. Jensen from Southern Jutland in 1900, the Continental Creamery Company in Topeka, Kansas was the largest creamery in the world.[31]

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.[32] 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*,[33] 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, 2018b,a) 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.

[31]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 possible 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 (and we exclude it in robustness checks below). 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.

[32]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).

[33]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 on county level for the years 1870, 1880, 1890, 1900, 1910, and 1920 compiled by Haines (2010). The census gives us information on the number of individuals born in Denmark in each county. Thus, our measure of Danes includes people born in Denmark, not their descendants. In addition, we use data from the agricultural census, 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 a cow 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 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 state level. In order to calculate the total amount of butter produced in a state one has to add the amount of industrial butter from the industrial census to the amount of butter produced on farms from the agricultural census. We show results for the amount of butter produced in factories versus farms on the state level from the year 1880.

As mentioned earlier, many of the early Danish migrants were Mormons. As these were very different from the Danish settlers, we use the number of mormon organizations in the county from the 1870 census to control for these very different types of settlements.

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 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 well as the number of people working in the textile industry for a placebo test. 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 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).[34] 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.

The main analysis is conducted on the county level. Of course county boundaries were changing over time, 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 2,181 counties.[35] Table A1 in the appendix provides summary statistics on the main variables.

3.2 Empirical strategy

In order to identify the effect of Danes immigrating to the US on the local dairy industry we implement a difference-in-differences analysis.[36] We compare the development of the dairy industry in counties that received many Danes with those that did not or received 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

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

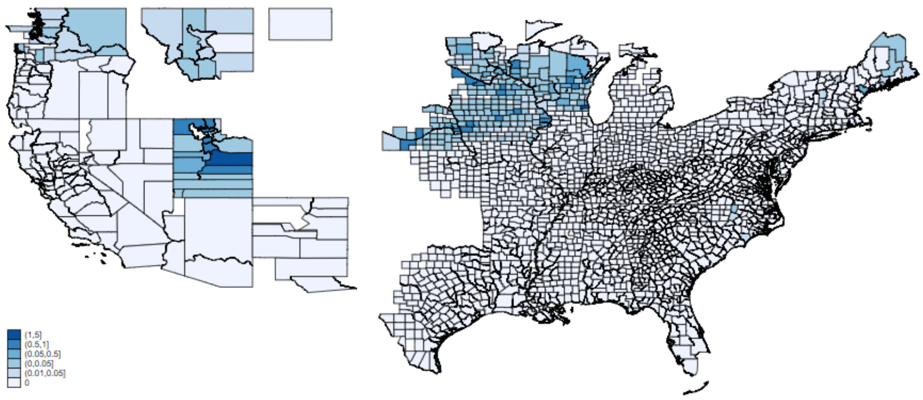
[35]Using the 1870 counties implies that we do not include territories that only acquired statehood after this date, although see Rogers (1978) on 'Creamery Fever' among Scandinavians in Grant County, South Dakota before the First World War.

[36]We also present results from an instrumental variable estimation in section 4.4.1 using the shift-share approach (see Bartik (1991))

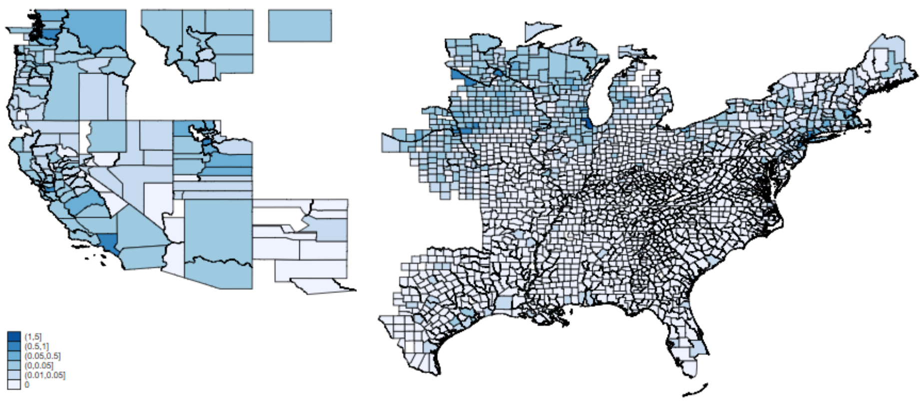
we use the amount of industrial versus farm butter produced in the county. Along with our hypothesis that areas which received Danes conducted more modern dairying, we expect a positive effect on the amount of industrial butter produced and no effect or possibly even a negative effect on the amount of butter produced on farms.

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 are taking place during the 1880s: the 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.[37] Figure 2 below 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. Comparing the 1880 to 1910, it is evident that, in line with the findings of Hvidt (1960), earlier migrants settled mainly in rural areas whereas later migrants often settled in urban centres such as Chicago and New York.

[37] We prefer the specification in logarithms as the distribution of Danes in 1880 is highly skewed to the left. Section 4.4 shows that the results are robust to alternative functional forms.



(a) 1880



(b) 1910

Figure 2: Concentration of Danes (county share of national total) in 1880 and 1910

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 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 both a flexible difference-in-differences model, including dummy variables for each year, and a standard difference-in-differences model including a dummy variable taking the value one for the years 1890 and after. In the flexible estimation we use 1880 as the baseline year. The flexible model allows us to test the common trend assumption, which can only hold if there is no effect of Danes prior to the treatment year.

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)). We also include the natural logarithm of the initial level of dairy cows (year 1870) interacted with time fixed effects to rule out that Danes just settled in areas that were already specializing in dairying. 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. Lastly, we control for the per capita number of mormon organizations as of 1870. 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 estimate the following (non-flexible) difference-in-differences models to determine the average treatment effect:

$$
\begin{aligned}
Y_{it} = & \, \beta \, ln(Danes_{1880i}) \times D_{post1890} \\
& + \delta \times D_{post1890} + \sum_{j=1870}^{1920} X_i \times I_t^j \Gamma_j + \mu_i + \lambda_t + \eta_{rt} + \epsilon_{it}
\end{aligned} \tag{2}
$$

where Y_{it} is one of our outcome variables $ln(DairyCows_{it})$ or $ln(DairyIndustry_{it})$ for county i at time t. $D_{post1890}$ is an indicator variable which takes the value zero before 1890 and one for 1890 and after. The rest is defined as above. Our main parameter of interest is β, the average treatment effect.

4 Results

4.1 Specialization

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. [38]

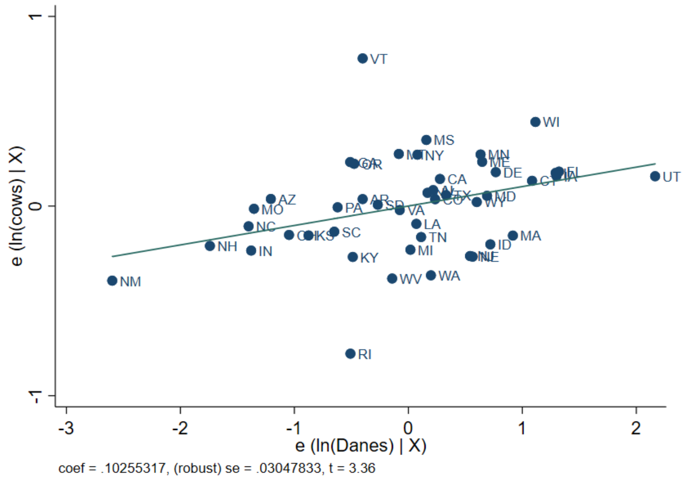


Figure 3: Partial regression plot between ln(Danes) and ln(cows). State level, year 1900.

Clearly, a positive relation emerges. Of course this result can by no means be interpreted as a causal relationship. Therefore, we now present results from the flexible and the non-flexible difference-in-difference model giving the average treatment effect of Danes on the number of dairy cows. The results can be found in table 2.

[38]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)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)	(5) ln(cows)
year_1=1870 × ln(Danes1880)	-0.035*** (0.011)	-0.025** (0.010)	-0.013 (0.008)	-0.006 (0.005)	-0.007 (0.005)
year_1=1890 × ln(Danes1880)	0.022*** (0.005)	0.021*** (0.005)	0.018*** (0.006)	0.018*** (0.006)	0.017*** (0.005)
year_1=1900 × ln(Danes1880)	0.021*** (0.005)	0.020*** (0.005)	0.016*** (0.005)	0.016*** (0.005)	0.016*** (0.005)
year_1=1910 × ln(Danes1880)	0.028*** (0.005)	0.029*** (0.005)	0.024*** (0.005)	0.024*** (0.005)	0.025*** (0.005)
year_1=1920 × ln(Danes1880)	0.033*** (0.005)	0.034*** (0.006)	0.030*** (0.005)	0.029*** (0.005)	0.031*** (0.005)
Controls	as below	as below	as below	as below	as below
Observations	13,086	13,086	13,086	13,086	13,086
Number of counties	2,181	2,181	2,181	2,181	2,181
post1890=1 × ln(Danes1880)	0.043*** (0.006)	0.038*** (0.006)	0.028*** (0.004)	0.025*** (0.003)	0.026*** (0.003)
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	N	Y	Y	Y	Y
ln(pop1870) x year FE	N	N	Y	Y	Y
ln(cows1870) x year FE	N	N	N	Y	Y
mormon x year FE	N	N	N	N	Y
Observations	13,086	13,086	13,086	13,086	13,086
Number of counties	2,181	2,181	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 2: Difference-in-differences estimation for dairy cow density

The upper panel shows results from the flexible estimation, the lower panel the average treatment effect. Our baseline specification (column (1) in table 2) includes only county, year and region by year fixed effects. Additional controls are added over the following columns. There is a strong positive effect of Danes on dairy cows after 1890. In the baseline specification, counties receiving Danes in 1880 do in fact have lower numbers of dairy cows than counties not receiving Danes before this date. When adding additional controls however, this effect becomes insignificant and there is no pre-trend. The effect of Danes stays rather constant across the period, and the average treatment effect is therefore also in line with the estimates of the flexible model.

Focusing on the standard DiD - specification with the full set of controls, our average treatment effect is an elasticity of 0.025. This means that one percent more Danes lead to 0.025 percent more dairy cows after 1890. This effect is not negligible, as the average number of dairy cows is almost 400 times the average number of Danes in the county before 1890 and still more than 100 times after 1890. 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. 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.

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 2 including the full set of controls (column 5). 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 significantly positive and even increases in the later years. We thus find strong persistence in dairy specialization: areas that started to specialize in the very early days of dairying still seem to do so today. The fact that the coefficient actually increases could be due to consolidation of the industry, especially in the later years. Today, only a few states produce large amounts of dairy products. Thus, in particular areas in the Midwest are strong dairy producers, which is exactly where also many Danes settled originally. In the long-run, states receiving more Danes in 1880 still specialize in dairying almost 100 years later.

4.3 Modernization

The above showed that areas where Danes settled specialized in dairying after 1890, measured by the number of dairy cows. Next, we look at whether this specialization went hand in hand with a more modern approach to dairying, which we would expect through the technological knowledge Danes brought in. We therefore use the number of people working in industrial dairying as the outcome variable in the following. As this figure is only available from 1880, we are not able to test for pre-trends and only present the standard difference-in-differences estimation giving the average treatment effect. Table 3 shows the results. Clearly, areas with more Danes exhibit more industrial dairying.

	(1) ln(ind.dairy)	(2) ln(ind.dairy)	(3) ln(ind.dairy)	(4) ln(ind.dairy)
post1890=1 × ln(Danes1880)	0.098*** (0.030)	0.088*** (0.030)	0.083*** (0.030)	0.083*** (0.031)
Year FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y
Geography x year FE	N	Y	Y	Y
ln(pop1870) x year FE	N	N	Y	Y
mormon x year FE	N	N	N	Y
Observations	8,724	8,724	8,724	8,724
Number of counties	2,181	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 3: Difference-in-differences estimation for industrial dairy workers

Finally, we might note that 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 (2018a) 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 A4 in the appendix.

4.4 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 the non-flexible difference-in-differences estimation (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 including the full set of controls (column (5) in table 2, lower panel). 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 A5 in the appendix. The significance of our results is not 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 adding a small value to the zeros, so that we can compare counties who received Danes to those that did not. Table A2 in the appendix shows that our results are robust to not adding a small value to the zeros (and thus excluding observations) and also to different small values. 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.[39] Table A3 in the appendix presents results when using the Danes by total population, Danes by area 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. When including all measures in a horserace specification (column (5)) only the logarithm of Danes and the population share of Danes remain positive. Although only the latter is significant, the coefficient on our preferred measure barely changes in size, which is reassuring as these measures are of course all highly correlated.

As is evident from figure 2, a large share of Danes emigrated to counties in the Midwest. This is also where many o the early dairy cooperatives started and where a large share of the 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 find almost the same result as in

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

the specification for the whole country - both in terms of size and significance of the effect. Estimation results can be found in column (5) in table A2 in the appendix. This means that also within an area receiving many Danes, counties which received more Danes specialized more in dairying than counties receiving fewer Danes.

4.4.1 IV

In the following we present another robustness check implementing an instrumental variable estimation using the shift-share approach first presented by Bartik (1991). Initially used in labour economics, this approach gained ground also in the migration and other literatures (see for example Card (2001); Nunn and Qian (2014); Autor et al. (2013)). The idea is to isolate the demand driven variation of local migration numbers in order to be able to estimate the effect of the 'exogenous' variation in local migration which is purely supply driven. The method has its drawbacks, discussed, for example, in Jaeger et al. (2018). General equilibrium adjustments in the outcome variable upon local shocks in combination with serial correlation in settlement choices makes the distinction between short- and long-run effects difficult, as general equilibrium adjustments from earlier immigrant flows will overlap with short-run effects stemming from current immigration. Also, very high correlation in settlements over time may lead to a violation of the exclusion restriction. In our context, the distinction between short- and long-run effects is not the focus of interest. In addition, our outcome variable is the number of cows in the county, which would naturally follow a very different process than wages. Moreover, as shown in table 4 below, the instrument is not very strong in the first stage (just meeting the conventional cut-off of 10 for the F-statistic), thereby weakening the concern of serial correlation in immigration streams in this case.

We proceed by applying the national growth rate in the number of Danes between different years to the distribution of Danes in 1880 in order to calculate the predicted (supply driven) number of Danes for the following years. The predicted number of Danes is then used as an instrument for the actual number of Danes for the years 1890 to 1920. Formally, we can write the estimation strategy as follows:

First-stage estimation:

$$\begin{aligned} ln(Danes_{it}) &= \alpha + \beta \times ln(predictedDanes_{it}) \\ &+ X_i' \times \gamma + \mu_s + \lambda_t + \eta_{rt} + \epsilon_{it} \end{aligned} \tag{3}$$

Second-stage estimation:

$$\begin{aligned} ln(Y_{it}) &= \alpha + \beta \times FittedValues_{it} \\ &+ X_i' \times \gamma + \mu_s + \lambda_t + \eta_{rt} + \epsilon_{it} \end{aligned} \tag{4}$$

where $ln(predictedDanes_{it})$ is the natural logarithm of the number of Danes predicted by the shift-share approach for county i in year t. Y_{it} is the number of dairy cows in county i at time t or the number of people working in industrial dairying. $FittedValues_{it}$ are the fitted values from equation 3, α is the constant term, not reported in the tables. X_i' is a vector of control variables at the county level including the same geographic controls as in the main estimations, the natural logarithm of initial (1870) population and number of dairy cows as well as the per capita number of mormon organizations. We further include state fixed effects μ_s, year fixed effects λ_t as well as region by year fixed effects η_{rt}. ϵ_{it} is the error term, clustered at the county level. Results are presented in table 4.

	(1) pooled OLS: ln(cows)	(2) 1st stage: ln(Danes)	(3) 2nd stage: ln(cows)	(4) pooled OLS: ln(ind.dairy)	(5) 1st stage: ln(Danes)	(6) 2nd stage: ln(ind.dairy)
ln(Danes)	0.016***		0.122***	0.207***		1.174***
	(0.002)		(0.011)	(0.014)		(0.106)
ln(pred_Danes)		0.222***			0.194***	
		(0.014)			(0.015)	
Year FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y
ln(pop1870)	Y	Y	Y	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y	Y	Y	Y
mormon	Y	Y	Y	Y	Y	Y
N	8,724	8,724	8,724	6,543	6,543	6,543
r2	0.424	0.470	.	0.505	0.482	.
Fstat			247.76			170.17

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 4: Instrumental variable estimation, shift-share approach

Columns (1) and (4) present simple pooled OLS estimations as a reference. The point estimates are both smaller than in the IV estimation, columns (3) and (6), indicating that it may be biased downwards due to endogeneity or omitted variable bias. The IV approach is presented in columns (2)-(5), where columns (2) and (3) present first and second stage results for dairy cows and columns (4) and (5) for industrial dairy workers. Note that the number of observations is different because we do not have the number of people working in industrial dairying for the year 1890. In the specification using dairy cows as the outcome variable, the F-statistic for the first stage meets the conventional cut-off of 10. In the second stage we estimate a significantly positive effect of Danes on dairy cows, in line with our earlier results.

In the specification using the number of people working in industrial dairying as the outcome variable the instrument is slightly weaker. This is due to the fact that we lack data for the year 1890. As Danish migration really took off only after 1890 many places will be assigned zero Danes although they received Danes in the years included in the estimation (1900 to 1920), and more so than in columns (2) and (3) where 1890 is included. The estimated effect of Danes on the number of people working in industrial dairying is therefore also not significant in the second stage, but it shows the expected positive sign.

4.5 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.[40] Furthermore, we hypothesize that all Danes are potential transmitters of knowledge. Along this line, we investigate whether the effect stems from Danes working in industrial dairying more than from 'regular' Danes, as we have information on the occupation from the micro data of the 1880 census. We extract all individuals recorded as being born in Denmark and working in the dairy industry and use this distribution as the treatment variable in the difference-in-differences setting. The last column of table A3 in the appendix presents results. The effect is positive, but insignificant. This indicates that the estimated effect in the main specification cannot be traced to Danes working in (industrial) dairying alone. It should, however, be noted that there are still very few people being employed in industrial dairying and even fewer of Danish descent (being born in Denmark) as most dairying in 1880 was still of agricultural type. We can also use the information from the micro data of the 1880 census in the IV setting and construct an instrument in the same way as in section 4.4.1, just using the 1880 distribution of Danes working in the dairy industry to predict the number of Danes working in the dairy industry in the years 1900, 1910, and 1920 instead of considering all Danes. The results are presented in table A6 in the appendix. The instrument is not very strong as indicated by the F-statistic. Still, the correlation in the first stage is positive and significant. The second stage, however, is insignificant in both specifications, i.e. both when using the number of dairy cows or the total number of people employed in the dairy industry as the outcome variable. These results indicate that the effect we find in the main specifications stems from the general Danish population, rather than dairy-related Danes. More generally, this also speaks against a transfer of people or human capital and in favour of a transfer of knowledge.

[40]This also speaks against a story of Danes simply increasing the demand for dairy products.

The effect seems to stem from the general Danish immigrant population rather than Danes related to industrial 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, Dutch, Germans, English, and Irish, interacted with time. We also use an aggregate measure of all foreign born, resembling **?**. 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 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, 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).

Combining the results above, we have evidence that the positive effect on the dairy industry stems from a transfer of knowledge rather than people and that this knowledge was transferred through the migration of ('ordinary') Danes. We suggest that the transfer of knowledge was specific to dairying, namely the knowledge of the centrifuge, which made it profitable to centralize production. However, it could be that Danes were just better at agriculture in general and would have the same effect for other types of agriculture. Column (1) in table A4 in the appendix therefore uses the amount of wheat produced in the county as the outcome variable. Wheat was one of the most important agricultural products at the time. So, if Danes had a general advantage in agriculture, we should also see this positive effect on wheat. On the contrary, however, Danes appear to have a negative effect on wheat production. This goes hand in hand with the fact that immigrating Danes tended to come from and settle again in agricultural areas, which in the earlier years mostly meant wheat producing areas. Over the next decades, these areas where Danes originally settled specialized more and more in dairying and we also saw that resources were diverted towards the industrial production of dairy products. In line with this, these same areas also turned away from wheat production such that we actually find a negative effect of Danes on wheat production. Instead of being good at agriculture it could also be that Danes were just more industrious than other immigrant groups or that areas where Danes settled were simply more industrial. Column (3) of table A4 presents a placebo regression in line with our analysis on modernization above, considering the important textile industry and the number of people working in it as a proxy for specialization. There is no significant effect of Danes on the textile industry.

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 present a similar estimation to above using other dairy-relevant immigrant groups, but now also including interaction terms between those immigrant groups and Danes.[41] 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 from immigration even decades after the first arrival.

[41] In 1880 there are no counties receiving Danes and Dutch. Therefore, Dutch are left out in this analysis.

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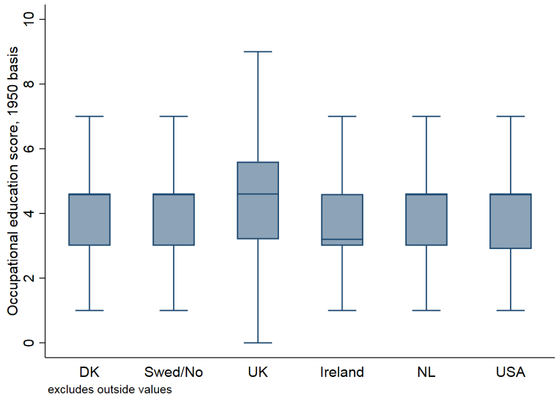
6 Appendix

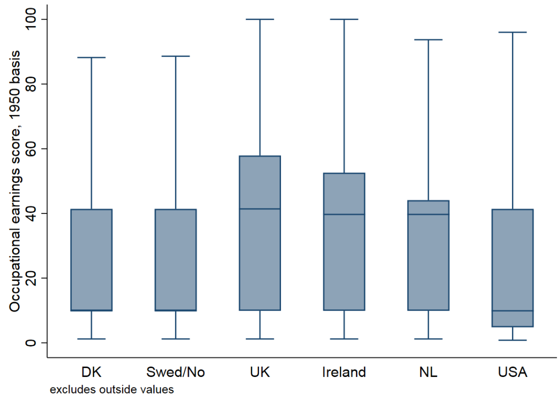
Variable	pre-1890 Obs	Mean	Std. Dev.	Min	Max	post-1890 Obs	Mean	Std. Dev.	Min	Max
Danes	4,362	13.15	85.03	0	2223	8,724	65.24	334.70	0	12226
dairy cows	4,362	4848.65	6077.27	0	93369	8,724	8338.04	8594.21	0	119423
wheat	4,362	169033.20	301774.80	0	4297840	8,724	222070.20	652849.20	0	31400000
ind. dairy	2,181	3.04	16.47	0	251	6,543	8.71	25.22	0	489
ind. textile	2,181	129.33	1103.86	0	23408	6,543	231.62	1784.28	0	53785
total population	4,362	19970.03	38732.54	5	942292	8,724	36125.17	95627.43	243	3053017
Germans	4,362	821.39	4596.50	0	151216	8,724	1056.27	6212.73	0	203315
SwedNor	4,362	126.69	646.21	0	25742	8,724	360.03	2262.66	0	94506
Dutch	4,362	15.10	181.92	0	5720	8,724	46.18	496.30	0	19691
EnglishUK	4,362	376.42	1562.00	0	32691	8,724	480.81	2401.57	0	47698
Irish	4,362	836.68	5529.50	0	201999	8,724	656.19	4894.11	0	131661

Variable	Constant Variables Obs	Mean	Std. Dev.	Min	Max
Slesvig1880	2,181	14.21	116.80	0	3980
suit_high	2,181	0.75	0.37	0	1
wheatsuit_high	2,181	0.29	0.39	0	1
mean_rug	2,181	0.58	0.69	0.00	5.14
mean_elev	2,181	292.73	313.00	1.02	2407.88
dist_anyRR	2,181	17593.95	28203.96	0.20	266455.30
dist_river	2,181	59805.70	82265.63	2.22	774147.30
area	2,181	2.56E+09	6.31E+09	5.95E+07	1.70E+11

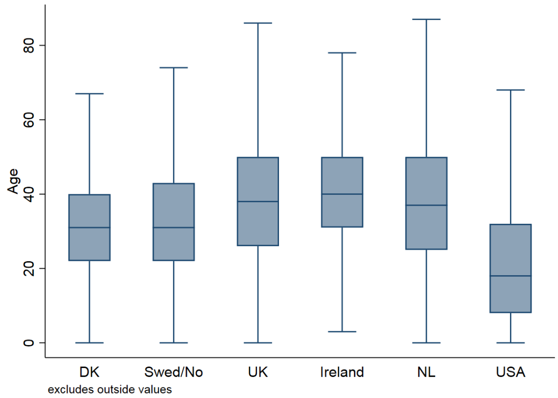
Table A1: Summary statistics



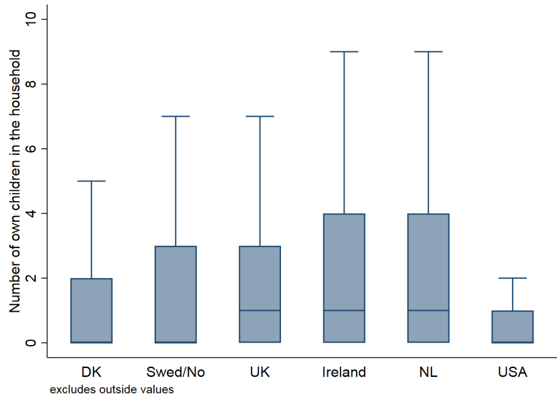
(a) education score (1950 basis)



(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.

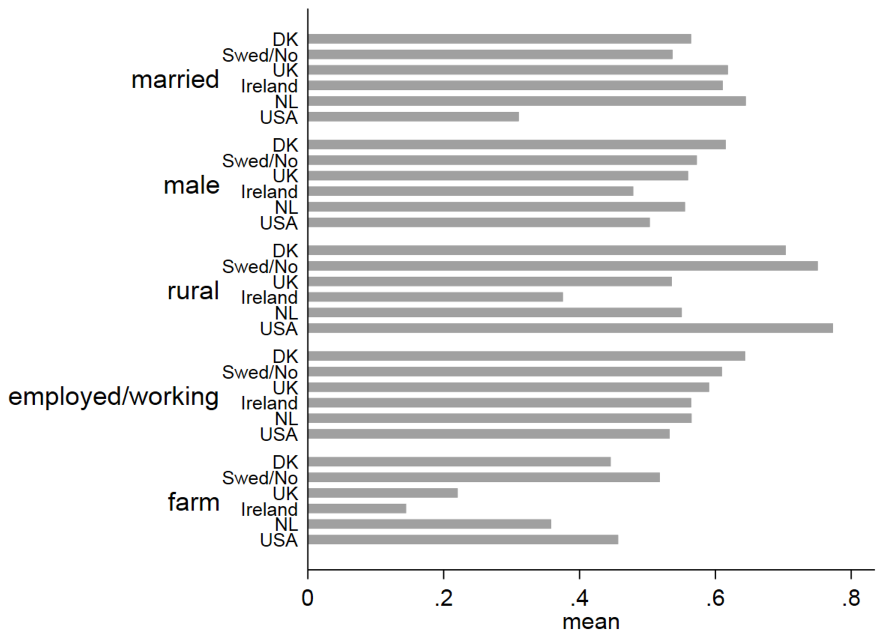


Figure A2: Comparison of Danes to other nationalities, 1880 (cont.). Data source: IPUMS, 1880 census.

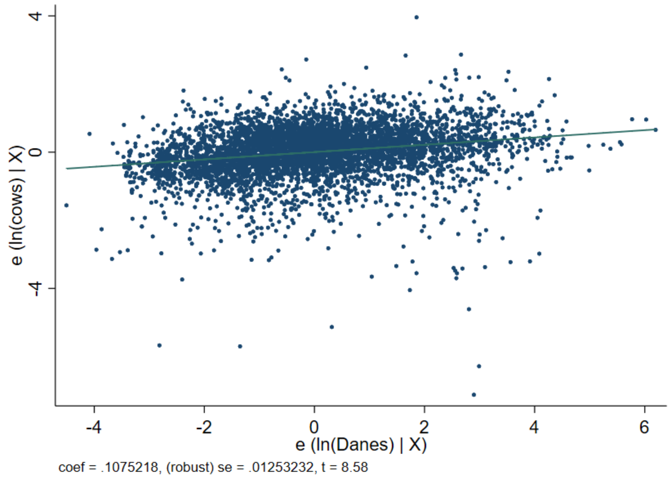


Figure A3: Partial regression plot between ln(Danes) and ln(cows). County level, years 1890-1920.

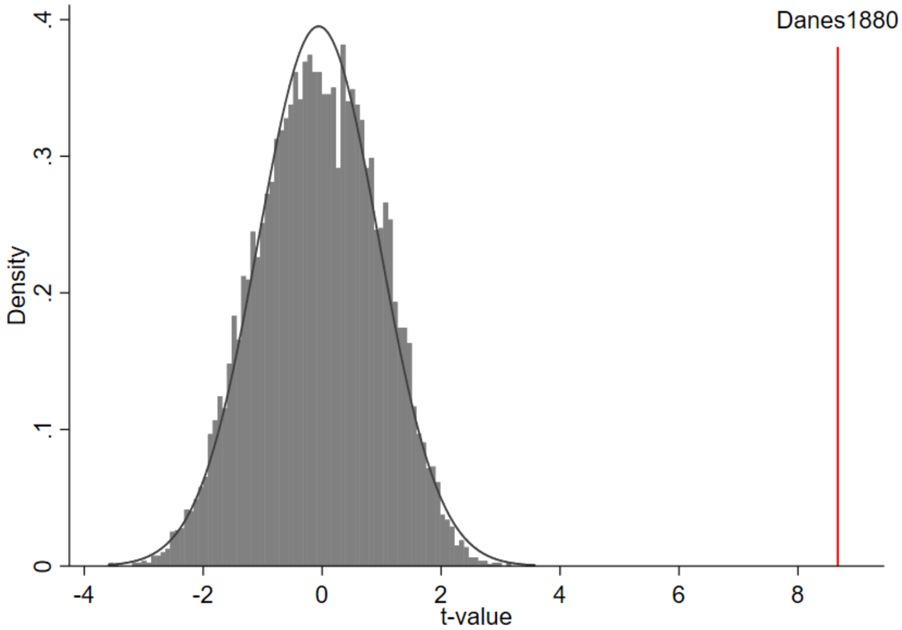


Figure A4: Histogram of t-values resulting from randomizing the distribution of Danes in equation 2

	(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) Midwest
post1890=1 × ln(Danes1880)	0.026*** (0.003)				0.022*** (0.003)
post1890=1 × ln(Danes1880)		0.035*** (0.013)			
post1890=1 × ln(Danes1880)			0.023*** (0.003)		
post1890=1 × ln(Danes1880)				0.032*** (0.003)	
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
ln(pop1870) x year FE	Y	Y	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y	Y	Y
mormon x year FE	Y	Y	Y	Y	Y
Observations	13,086	1,979	13,086	13,086	4,662
Number of counties	2,181	330	2,181	2,181	777

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A2: Alternative transformation of variables (columns (1)-(4)) and results for Midwest only (column (5))

	(1) ln(cows)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)	(5) ln(cows)	(6) ln(cows)
post1890=1 × ln(Danes1880)	0.026***				0.029	
	(0.003)				(0.031)	
post1890=1 × Danedensity1880		0.166***			-0.097**	
		(0.063)			(0.045)	
post1890=1 × Daneshare1880			10.632***		3.774**	
			(2.549)		(1.741)	
Danes_present=1 × post1890=1				0.545***	-0.080	
				(0.064)	(0.694)	
post1890=1 × ln(DKind.dairy1880)						0.011
						(0.013)
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
ln(pop1870) x year FE	Y	Y	Y	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y	Y	Y	Y
mormon x year FE	Y	Y	Y	Y	Y	Y
Observations	13,086	13,086	13,086	13,086	13,086	13,086
Number of counties	2,181	2,181	2,181	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A3: Alternative treatment variables

	(1) ln(wheat)	(2) ln(pigs)	(3) ln(ind.textile)
post1890=1 × ln(Danes1880)	-0.048*** (0.011)	0.029*** (0.006)	0.037 (0.029)
Year FE	Y	Y	Y
County FE	Y	Y	Y
Region x year FE	Y	Y	Y
Geography x year FE	Y	Y	Y
ln(pop1870) x year FE	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y
mormon x year FE	Y	Y	Y
Observations	13,086	13,086	8,724
Number of counties	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A4: Effect of Danes on other outcome variables

	(1) ln(cows) 50km	(2) ln(cows) 100km	(3) ln(cows) 200km	(4) ln(cows) 500km
ln(Danes1880)*post1890	0.0256*** (0.0034)	0.0256*** (0.0039)	0.0256*** (0.0046)	0.0256*** (0.0060)
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
ln(pop1870) x year FE	Y	Y	Y	Y
mormon x year FE	Y	Y	Y	Y
Observations	13,086	13,086	13,086	13,086

Geography controls include the share of county area with very high or 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. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A5: Conley standard errors for different cut-off points

	(1) 1st stage: ln(dairyDanes)	(2) 2nd stage: ln(cows)	(3) 1st stage: ln(dairyDanes)	(4) 2nd stage: ln(ind.dairy)
ln(pred_dairyDanes)	0.204***		0.158**	
	(0.061)		(0.066)	
ln(dairyDanes)		0.082		-0.152
		(0.115)		(0.399)
Year FE	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y
Geography	Y	Y	Y	Y
ln(pop1870)	Y	Y	Y	Y
ln(Y_initial)	Y	Y	Y	Y
mormon	Y	Y	Y	Y
N	6,543	6,543	6,543	6,543
r2	0.150	0.410	0.164	0.459
Fstat		11.05		5.78

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A6: Instrumental variable estimation using Danes in dairy industry, shift-share approach

	(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)
post1890=1 × ln(Danes1880)	0.026*** (0.003)							0.022*** (0.003)		0.024*** (0.003)
post1890=1 × ln(Germans1880)		0.018*** (0.003)						0.006** (0.003)		
post1890=1 × ln(Dutch1880)			-0.012*** (0.004)					-0.007** (0.003)		
post1890=1 × ln(EnglishUK1880)				0.020*** (0.003)				0.005 (0.003)		
post1890=1 × ln(Irish1880)					0.023*** (0.004)			0.009** (0.004)		
post1890=1 × ln(SwedNor1880)						0.014*** (0.002)		0.008*** (0.002)		
post1890=1 × ln(Slesvig1880)							0.007*** (0.002)	0.002 (0.002)		
post1890=1 × ln(foreign1880)									0.058*** (0.011)	0.042*** (0.010)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ln(pop1870) x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
mormon x year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	13,086	13,086	13,086	13,086	13,086	13,086	13,086	13,086	13,086	13,086
Number of counties	2,181	2,181	2,181	2,181	2,181	2,181	2,181	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A7: Effect of other immigrant groups

	(1) ln(cows)	(2) ln(cows)	(3) ln(cows)	(4) ln(cows)	(5) ln(cows)	(6) ln(cows)
post1890=1 × ln(Danes1880)	0.019***	0.017**	0.038***	0.031***	0.024***	0.044***
	(0.003)	(0.007)	(0.015)	(0.010)	(0.002)	(0.012)
post1890=1 × ln(SwedNor1880)	0.030***					0.045***
	(0.004)					(0.009)
post1890=1 × ln(Danes1880) × ln(SwedNor1880)	0.001***					0.002***
	(0.000)					(0.001)
post1890=1 × ln(Germans1880)		0.039**				0.068
		(0.018)				(0.042)
post1890=1 × ln(Danes1880) × ln(Germans1880)		0.001				0.003
		(0.001)				(0.002)
post1890=1 × ln(EnglishUK1880)			-0.030			-0.119*
			(0.043)			(0.065)
post1890=1 × ln(Danes1880) × ln(EnglishUK1880)			-0.003			-0.007*
			(0.002)			(0.004)
post1890=1 × ln(Irish1880)				-0.001		-0.039
				(0.027)		(0.036)
post1890=1 × ln(Danes1880) × ln(Irish1880)				-0.001		-0.003
				(0.001)		(0.002)
post1890=1 × ln(Slesvig1880)					0.003	-0.003
					(0.006)	(0.008)
post1890=1 × ln(Danes1880) × ln(Slesvig1880)					-0.000	-0.000
					(0.000)	(0.000)
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
ln(pop1870) x year FE	Y	Y	Y	Y	Y	Y
ln(cows1870) x year FE	Y	Y	Y	Y	Y	Y
mormon x year FE	Y	Y	Y	Y	Y	Y
Observations	13,086	13,086	13,086	13,086	13,086	13,086
Number of counties	2,181	2,181	2,181	2,181	2,181	2,181

Geography controls include the share of county area with very high or 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. Robust standard errors in parenthesis, clustered at the county level. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table A8: Effect of other immigrant groups