Cooperative Formation and European Immigration: The Case of Cow-Testing Associations in the United States Dairy Industry

Ziad Sabbah Alian[12] and Jared Hutchins[3]

[1] University of Illinois Urbana-Champaign, Department of Economics
[2] Cairo University, Faculty of Economics and Political Science
[3] University of Illinois Urbana-Champaign,
Department of Agricultural and Consumer Economics

United States of America
Email - jhtchns2@illinois.edu

Abstract

We study how European immigrants to the United States influenced the formation of productivity-enhancing cooperatives – the cow-testing associations (CTAs) – which were imported to the US by a Danish immigrant. We hypothesize that Danish immigrant communities were important to their formation by transferring knowledge of the cooperative to dairy farming communities. Using novel data on CTAs, we find evidence that counties with higher influxes of Danes between 1880 and 1900 were more likely to form CTAs. While other immigrant groups were familiar with cooperatives, we only find Danish immigrants to be important, suggesting that familiarity with this specific institution was important to formation.

Acknowledgements: The authors would like to acknowledge the helpful feedback from our seminar participants at the Agricultural and Applied Economics Association (AAEA) Annual Meeting 2025 as well as Adam Osman and Paul McNamara. The work was funded by the University of Illinois Campus Research Board Award RB24035.

1 Introduction

One of the main reasons why some economies fare better than others is the quality of institutions (North, 1990; Acemoglu et al., 2001, 2002, 2005; Rodrik et al., 2004). Historically, institutions in agriculture have played a key role in advancing innovation (Hutchins and Hueth, 2023; Andrews, 2021; Kantor and Whalley, 2019), farm electrification (Kitchens and Fishback, 2015), and crop productivity (Hutchins, 2023; Kantor and Whalley, 2019), among others. Yet, why and how certain institutions form is still a matter of debate, with previous studies exploring factors such as culture (Tabellini, 2010; Alesina and Giuliano, 2015; Henriksen et al., 2015), legal systems (Guinnane, 1994; Henriksen et al., 2015), and geography (Easterly and Levine, 2003; Rodrik et al., 2004).

We focus on the formation of a pervasive and influential form of institution in agriculture: the cooperative. Cooperatives are often theorized to form where investor-owned firms cannot adequately operate due to coordination or monitoring problems (Hueth, 2014; Henriksen et al., 2011). Previous literature also finds that legal and market structures play a crucial role in determining the success of cooperatives. For instance, cooperative creameries in the dairy sector successfully formed in Denmark but not in Ireland, seemingly due to differences in the legal system (McLaughlin and Sharp, 2021; Henriksen et al., 2015). Yet, social cohesion and immigration patterns are also hypothesized as important factors in the formation of cooperative creameries in Denmark and the US (Henriksen et al., 2012; Boberg-Fazlić and Sharp, 2024).

We study the impact of European immigration on the formation of a producer cooperative in the United States dairy industry: the cow testing association (CTA). CTAs are member-owned organizations made up of dairy farmers that hire a milk tester to measure the butterfat percentage of each cow's milk in the members' herds. This information became valuable to dairy farmers after creameries began using the Babcock butterfat test, invented in 1890, to pay farmers for their butterfat percentage instead of using the weight of their milk. Knowing the butterfat production of each cow helps dairy farmers breed highly productive

cows and cull unproductive ones from their herd, thereby increasing the overall efficiency of their operations (Pirtle, 1926; Rabild, 1911). The CTAs, later renamed to dairy herd-improvement associations, now test about 40% of the US dairy herd and provide crucial data for genetic testing and research for the entire US dairy industry (Voelker, 1981; Hutchins and Hueth, 2023).

The idea of a cooperative organization that pools resources from farmers to hire their own professional milk tester was first implemented in Denmark in 1895 and grew to over 400 associations by 1905 (Rabild, 1911). The first CTA in the US was introduced by a Danish immigrant, Helmer Rabild, in 1905 in Fremont, Michigan. Despite having Babcock testing in creameries, testing at the farm level was encouraged due to disputes between creameries and farmers over the correct interpretation of the test (Sinclair, 1912; Bulletin, 1897). Yet, farmers conducting their own tests accurately also proved difficult and had low adoption by farmers (Kansas State Board of Agriculture, 1903; Michigan Dairymen's Association, 1906). The CTA provided a way for farmers to hire their own tester to produce accurate data for use on their farms.

We hypothesize that Danish immigrant communities helped catalyze the formation of CTAs by transferring knowledge about the cooperatives from Denmark to US dairy farming communities. We test this hypothesis by testing whether Danish immigration flows between 1880 and 1900, a period when CTA formation in Denmark was active, had an effect on CTA formation in the US in 1910 and 1920. In addition to being more familiar with CTAs, Danish immigrants possessed expertise in dairying and familiarity with cooperative organizations in general which may have helped catalyze their formation. To isolate the effect of having knowledge specific to CTAs, we also test the impact of Dutch immigration, a group that had similar dairying expertise and experience with cooperatives but very little exposure to CTAs (Rabild, 1911; National Farm and Home Hour, 1939).

We find that increases in the Danish-born population share between 1880 and 1900 had a positive impact on CTA formation. A one percentage point increase in the *change* in the

share of Danish immigrants between 1880 and 1900 is associated with a seven percentage point increase in the likelihood of a CTA forming. Alternatively, a one standard deviation increase in the change in share of our immigration variable leads to a 4.25 percentage point rise in the probability of the formation of a CTA. We also find some evidence that CTAs formed in response to a general trend of industrialization in the dairy industry. Proximity to creameries and cheese factories has a statistically significant relationship to the formation of CTAs. We find no significant impact for Dutch immigration or similar immigrant groups: Germans, Swedes, Norwegians, and Finns. In a robustness check, we also find that the impact of Danish immigration is significant in counties where Danes were a higher percentage of the immigrant population, suggesting that Danish immigrants could have spread CTAs easier in counties with a large number of foreign-born individuals.

Our paper contributes to two main areas of literature. First, our paper contributes to the literature on the role of immigration in technological and institutional development. Previous work has documented positive impacts of immigration on patents (Moser et al., 2014; Hunt and Gauthier-Loiselle, 2010; Chellaraj et al., 2008), and technology adoption (Hornung, 2014; Chander and Thangavelu, 2004) since immigrants often bring new ideas and human capital to their host countries. Our paper instead deals with the case of immigrants bringing ideas about institutions and organization to their host countries. Danker (1968) is an early example of work which noted a positive correlation between Scandinavian immigrants and the presence of cooperatives in the Midwestern US. Similarly, it has been hypothesized that Japanese immigrants were an important factor in the formation of cooperatives in the Brazilian agricultural frontier in the early 20th century (Makabe, 1999). Our paper considers that immigration may impact *institutional* innovation in the host country, a possibility seldom discussed in this literature and rarely examined econometrically.

Most relevant to our work is Boberg-Fazlić and Sharp (2024), who elucidate the significant role that Danish immigrants played in the US dairy industry. They hypothesize that existing Danish migrant communities played a critical role in the adoption of creamery tech-

nology and find that counties with more Danish immigrants were more likely to specialize in dairy farming. Yet, creamery technology was not the only advantage that Denmark had in dairy farming. At the time that CTAs were forming, Denmark's cooperatives were of special interest to US policymakers (Sinclair, 1912; Pearson, 1914; Christensen, 1924) and US policymakers were taking trips to Europe to understand whether such cooperatives could be replicated in the US (United States and Fletcher, 1914; Turvey, 2017). We provide evidence of yet another way that knowledge in Denmark may have spilled over to the US dairy industry through immigration.

Our work also contributes to the literature exploring the factors conducive to the success of agricultural cooperatives (Danker, 1968; van Zanden, 1991; Beltrán Tapia, 2012). Studies have sought to understand the factors behind the formation of dairy cooperatives in Denmark (Henriksen et al., 2011, 2012) and the factors which led to the failure of similar cooperative businesses in Ireland (McLaughlin and Sharp, 2021; Guinnane, 1994). Despite the relative prevalence of cooperatives in US agriculture (Kitchens and Fishback, 2015; Hutchins and Hueth, 2023), fewer studies have explored the US experience with forming cooperatives. Our work studies one case in which cooperative development in Europe, in this case Denmark, may have spilled over to the US through immigration flows, much like the European credit cooperatives influenced the formation of the Farm Credit System (Turvey, 2017; Morman, 1915). The CTA was stated to be a copy of the association in Denmark and we test whether Danish communities were one element in their success by providing specific knowledge and expertise concerning the CTAs (Michigan Dairymen's Association, 1906).

The rest of this paper is organized as follows. Section 2 reviews the historical background of our study and the rationale for studying Danish immigration. Section 3 details our data sources and the trends uncovered from our digitized historical records. Section 4 presents the empirical models, and Section 5 describes the results of our analysis. Section 6 discusses our results and concludes.

2 Historical Background

The US dairy sector underwent significant structural changes in the late 19th century. In addition to the modernization of creamery technology (Boberg-Fazlić and Sharp, 2024), the invention of the Babcock butterfat test in 1890 incentivized creameries to switch from paying dairy farms on the weight of their milk to paying them for the amount of butterfat in their milk (Monrad, 1891). Under butterfat testing, dairy farmers were no longer incentivized to adulterate their milk to increase their income, at the time a semi-common occurrence (Olmstead and Rhode, 2008). To increase their payments from the creamery, dairy farmers were now incentivized to remove cows that produced too little butterfat and breed cows that had milk rich in butterfat.

To accomplish this, dairy farmers needed a way to use the Babcock test to test the milk of each of their cows. While creameries could, in theory, test samples from each of their cows, dairy farmers often clashed with creameries over the correct reading of the test, sometimes claiming that the creameries were underpaying them (Bulletin, 1897; Wisconsin Dairymen's Association, 1900; Indiana State Dairy Association, 1909). Yet, dairy farmers conducting their own tests also proved difficult, as they found them inaccurate and often too burdensome (Sinclair, 1912; Michigan Dairymen's Association, 1906). As a result, farmers doing their own Babcock tests failed to become widespread despite encouragement from several state officials (Michigan Dairymen's Association, 1906; Kansas State Board of Agriculture, 1903).

Helmer Rabild, a Danish immigrant working for the Michigan Department of Agriculture, introduced the cow-testing association (CTA) as a solution. A cow-testing association is a member-owned cooperative that pools resources from dairy farmers to hire a tester to periodically test the butterfat content of each farmer's cows. Rabild brought this idea from his native Denmark, the country which had formed their first CTA in 1895, the first of its kind recorded in Europe (Rabild, 1911; International Institute of Agriculture and Fjelstad, 1925). As evidenced in Figure 1, the movement grew rapidly in Denmark before growing in

Sweden and Norway.[1] By the time Rabild formed the first CTA in Michigan in 1905, there were more than 400 associations in Denmark.

[Figure 1 about here.]

CTAs were cooperatives to the extent that they were designed as member-owned organizations with an elected board of directors and monthly meetings, similar to the Farm Credit System (Turvey, 2017). Originally, farmers were to pay a $0.25 annual membership fee and $1 per cow annually to pay for the staff and equipment, primarily the salary of the milk tester and their equipment (Rabild, 1911). The tester would test every farm's cows once a month, and members were responsible for the tester's room and board as they stayed on the farm to conduct the test (Bureau of Dairying, 1925). The results of the test for each cow would be recorded in a herd book kept by the farmer and also summarized by the association each year for the farmer.

The first CTA was met with enough enthusiasm that Rabild was hired by the USDA in 1908 to begin forming them nationwide. The work of organizing the associations was first under the supervision of the state departments of agriculture and land grant universities. After the passage of the Smith-Lever Act in 1914, the formation of CTAs started to fall under the umbrella of state and federal extension programs. The number of CTAs grew to 40 in 1910 and 468 in 1920, first spreading to the Northeastern states and then becoming present in almost all states by 1920 (Hutchins and Hueth, 2023).

There is suggestive evidence that membership in a CTA increased the productivity of dairy farms. According to calculations made by Voelker (1981) for 1906, a cow part of an association produced 98 kilograms/year of butterfat on average, while the average cow in the US produced a lower value of 66 kilograms/year in 1906. This margin widened to 103 kg/year and 68 kg/year, respectively, in 1910. Similarly, Hutchins and Hueth (2023) notes

[1]The number of associations does not necessarily reflect the participation of dairy farms. While the number of cows enrolled in the associations as a percentage of total cattle would be a better measure of adoption, Rabild (1911) is one of the few sources providing these data across years and countries and only details the number of associations.

that increased enrollment in CTAs at the national level closely follows milk yield growth from 1920 to 1980.

Our analysis focuses on the role of Danish immigrant communities in the formation of the CTAs. Unlike the cooperative creameries, Denmark did not contribute specific technology that made CTAs possible. The Danish had used two butterfat testing methods, Fjord's centrifugal cream tester from 1878 and the Gerber method from 1892, and neither of them were ever adopted in the US (Farrington, 1913). Instead, Denmark appeared to contribute an organizational model that made widespread butterfat testing possible on farms. This is evidenced by the number of government reports that studied Denmark as a model for successful agricultural cooperatives. Reports such as Sinclair (1912), Howe (1921) and Christensen (1924) study and laud the agricultural cooperatives in Denmark as examples to emulate, even in agricultural sectors other than dairy.

We hypothesize that Danish immigrant communities specifically aided the formation of CTAs in the US by transferring knowledge and experience with CTAs. We test this hypothesis by focusing on Danish immigrants who came between 1880 and 1900, a period where CTAs were forming fast in Denmark but not in any other European country (see Figure 1). Yet, there are other reasons that Danish immigrants may have been instrumental in forming CTAs apart from their direct experience. For one, Danish immigrants could have had considerably more experience with forming cooperatives than their host communities. In Michigan Dairymen's Association (1906), the president of the first CTA, Henry Rozema, specifical praises the cooperative principles he felt that Denmark embodied. Danish immigrants may have also helped form CTAs due to their superior dairying expertise, which allowed them to recognize the value of forming a CTA more readily than their host communities.

To discern the difference between these mechanisms of influence, we consider the case of Dutch immigrants as a point of comparison. Like Denmark, the Netherlands had many agricultural cooperatives and had expertise in dairying (Bieleman, 2005; Bijman, 2018). Rabild himself picked the location of the first CTA because of the presence of a creamery

and Dutch farmers. Specifically, he noted that they were "progressive," that is willing to adopt new techniques, and "comitted to the cooperative enterprise" (National Farm and Home Hour, 1939).

The key difference between Danish and Dutch farmers is that Dutch farmers had far less exposure to CTAs. By the time Rabild had formed the first CTA in Michigan, there were more than 400 CTAs in Denmark and very few reported in the Netherlands.[2] Thus, if knowledge of CTAs is the key mechanism by which Danish immigrants spread the CTAs, we should see Danish immigration patterns impacting CTA formation but not Dutch immigration. Conversely, we would see similar impacts of Dutch immigration on CTA formation if dairying expertise and cultural values of cooperation were the main mechanisms.

A related consideration for understanding the efficacy of spreading CTAs is the density of Danish networks. The spread of ideas and technology in such cases can depend on the closeness of social ties and existing social capital (Beltrán Tapia, 2012; Burlig and Stevens, 2024; Satyanath et al., 2017). For a CTA to form, a critical mass of farmers would needed to have been achieved, which (Michigan Dairymen's Association, 1906) estimates as about 26 farmers. Thus, the strength of the impact of Danish immigration on CTA formation could depend on factors related to the social networks Danish immigrant are already involved in. Our study lacks specific data to test this hypothesis rigorously, but an indirect way to explore the influence of networks on the effect is by exploring the effect of Danish immigration as a percentage of the immigrant community. If Danish immigrants found it easier to communicate the idea to other European or Scandinavian immigrants, we might find this factor predicting CTA formation even better than using the share of the entire population.

[2]While International Institute of Agriculture and Fjelstad (1925) claims the first CTA formed in the Netherlands in 1896, there is no reliable data showing growth in the Netherlands in this same period. (Rabild, 1911) notes that 36 associations had been formed in the Netherlands before 1904, making the growth rate much lower than in other countries.

3 Data Description

To study the formation of the CTAs in the US, we digitize archived CTA directories compiled by the Dairy Division/Bureau of Dairying of the United States Department of Agriculture (USDA). The available reports were for the following years: 1916-18, 1921-23, and 1925. In the constitution and by-laws of the cow-testing associations, the association name was suggested to be the county or the nearest town name (Bureau of Dairying, 1925). We convert the data to be county-level (instead of association-level) by using the names of the associations to match the town or county of operation. The directories also include the number of cows and herds operating within the association.

To understand which cow-testing associations were present in 1910, we use the 1916 report, which notes the year the associations first started operations. However, since it shows only associations active in 1916, some associations may have formed and disbanded by 1910 while we only know about associations that survived until 1916. Similarly, we use the list of active associations in 1921 to proxy for the distribution in 1920. In Figure 2, the distribution of cow-testing associations in our sample of Midwestern states is shown for 1910 and 1920. The maps show a more widespread distribution of the cooperatives in 1920 among Midwestern states, especially in Wisconsin, the state with the highest number of cow-testing associations in the country. Between 1910 and 1920, 11 counties had CTAs that closed, or roughly 2% of the total counties.[3]

[Figure 2 about here.]

Figure 3 plots the number of cow-testing associations per 100 cows in the six states in our analysis: Illinois, Indiana, Iowa, Michigan, Minnesota, and Wisconsin. We normalize these figures by the number of dairy cattle in each state from the 1910 agricultural census. In Figure 4, we also show the "percentage" of cows under test by dividing the number of

[3]We explore the factors behind the closing of these CTAs in Appendix A6.

tested cows by the total number of dairy cows in 1910 (Haines et al., 2018).[4] The state of Wisconsin emerges as having the most cows under test, as well as the most CTAs per 100 cows, in almost every year. Over time, the next states that show the strongest growth in CTA involvement are Michigan and Minnesota.

[Figure 3 about here.]

[Figure 4 about here.]

An important factor in the formation of associations is the existence of creameries and cheese factories in each county since they paid for milk based on butterfat (Kent, 1902; Rabild, 1911). Like creameries, cheese factories also paid for milk based on butterfat tests. The presence of either creameries or cheese factories would generate demand for a CTA as dairy farmers seek ways to improve the quality of their milk. We digitize reports from six states which report the number of creameries and cheese factories in each county: Illinois (University of Illinois Agricultural Experiment Station, 1900), Indiana (Indiana State Dairy Association., 1903), Iowa (Iowa. State Dairy Commissioner, 1900), Michigan (Michigan Office of Dairy and Food Commissioner, 1900), Minnesota (Minnesota Dairy and Food Department, 1901), and Wisconsin (Commissioner, 1901). While we have CTA data for the whole country, the rarity of creamery and cheese factory data restricts our sample to just these six states. The creamery and cheese factory locations are for the year 1900, except for Indiana (1903) and Minnesota (1899). Figure 5 plots the distribution of creameries in our sample. Their distribution is very similar to that of cow-testing associations in 1920, suggesting a relationship between CTA formation and creamery activity.

[Figure 5 about here.]

[4]Note that for these figures there is no data for 1919, 1920, and 1924 as the cow-testing associations' reports were not available for these years. The year 1910 is used since agricultural censuses during that time were decennial.

We also use data from the US agricultural censuses for the years 1900, 1910, and 1920 (Haines et al., 2018). They contain data on the number of dairy cows and butter production on farms, factors we believe could influence the establishment of CTAs. For data on immigration patterns, we use the (full-count) individual-level micro-censuses published by the Integrated Public Use Microdata Series (IPUMS) to get the number of foreign-born by country of origin in 1880 and 1900 (Ruggles et al., 2024). Figure 6 shows the distribution of the shares of Danish and Dutch immigrants of the population in the US in 1900. As shown on the figure, Danes had generally higher shares in Iowa and the Dutch in Michigan. Both, however, did not make up a particularly large share of the population.

[Figure 6 about here.]

Mass migration from Denmark to the US had begun by 1870. According to Brøndal (2013), a strong driver for migration during this period was family and chain migration. In addition, Boberg-Fazlić and Sharp (2024) explains how Danish immigrants were so-called negatively selected. The authors state that Danish newcomers were mainly from the Tyender class – a kind of domestic servants – looking to obtain more land. Newly arrived Danes preferred to settle in the Midwest, where they made up a large share of the Danish diaspora in the country (Christensen, 1927, 1928). As for Dutch immigrants, their main motivations for their departure were economic, as farm work became automated and large supplies of grains muted prices in their home country. They also concentrated in Midwestern states: Michigan, Iowa, Illinois, and Wisconsin, among others (Schoone-Jongen, 2013). Thus, while our sample is limited to the Midwest, it is an appropriate region for testing our hypothesis.

Following Boberg-Fazlić and Sharp (2024), we use geographical variables to account for land characteristics that may affect their choice of settlement area. We use a pasture suitability index called suitability of global land area for pasture (FGGD) published by FAO (2005b). We also include a suitability index for low-input rainfed wheat, also released by FAO (2005a). We use GTOPO30, a digital elevation map, to calculate average elevation in each county (Survey, 2018). Lastly, we use the boundaries of the 1900 counties' shapefile,

provided by NHGIS, to calculate all the geographical features mentioned above. Table 1 shows summary statistics for all of the variables used in our study.

[Table 1 about here.]

4 Methodology

Our goal is to determine whether counties with higher concentrations of Danish immigrants were more likely to form CTAs. The first cow-testing association was formed in Denmark in 1895 (see Figure 1) and we expect that only immigrants who came following that year knew or experienced their operations firsthand. We also expect that Danish immigrants who arrived before 1900 did not anticipate that CTAs would be forming in the areas they chose to settle in. That is, we assume that these immigrants did not make the choice of living in the areas they did because they thought that CTAs would form there. Hence, we analyze the lagged effects of immigrant shares on forming CTAs in 1910 and 1920.

We test two specifications: one using the share of immigrants in 1900, the other with the change in share between 1880 and 1900. In the first specification, we use the shares of Danish and Dutch in 1900 to explain CTA formation in 1910 and 1920 using 1900 as the base period:

$$CTA_{i,t} = \sum_{t=1900}^{1920} \beta_t Danes_i^{1900} \times \gamma_t + \sum_{t=1900}^{1920} \alpha_t Dutch_i^{1900} \times \gamma_t + \theta_i + \gamma_t + \lambda X_{i,t} + \gamma_{C_{i,t}} + \varepsilon_{i,t}. \quad (1)$$

$CTA_{i,t}$ is an indicator variable for whether county i is served by a cow-testing association in year $t \in \{1900, 1910, 1920\}$; $Danes_i^{1900}$ is the share of Danish immigrants living in county i in 1900; $Dutch_i^{1900}$ is the same but for Dutch immigrants, acting as our point of comparison; γ_t are year fixed effects where 1900 is the reference year; θ_i are county-level fixed effects that absorb all time-invariant effects for county i; $X_{i,t}$ includes data on the number of dairy cows and butter production on farms from the agricultural census of year t; and $\gamma_{C_{i,t}}$ is a set

of time-invariant variables interacted with year fixed effects. These include the number of creameries and cheese factories in each county in the year 1900, distance to the nearest land-grant university, the share of people working in industrial dairying in 1900, and geographical controls (share of county area with high pasture suitability, share of county area with high wheat suitability, and average elevation).

We include time-invariant variables interacted with time fixed effects to control for "pre-treatment" differences in these covariates (Hornbeck, 2012; Kantor and Whalley, 2019). It is important to use levels of these variables before the CTAs were introduced so that the formation of the CTAs does not impact the levels of these covariates in later periods (Callaway and Sant'Anna, 2021; Karim and Webb, 2025). In all specifications, we use standard errors that are robust to correlation between errors at the county level.

Our second specification tests Danish immigrants arriving during the boom of CTAs in Denmark explain CTA formation in the US:

$$CTA_{i,t} = \sum_{t=1900}^{1920} \beta_t \Delta Danes_i \times \gamma_t + \sum_{t=1900}^{1920} \alpha_t \Delta Dutch_i \times \gamma_t + \theta_i + \gamma_t + \lambda X_{i,t} + \gamma_{C_{i,t}} + \varepsilon_{i,t} \quad (2)$$

where $\Delta Danes_i$ is the difference in the share of Danish immigrants living in county i between 1880 and 1900; similarly, $\Delta Dutch_i$ is the change in the share of Dutch immigrants in this period. All the other variables are defined as in equation 1. The coefficients of interest in both specifications are β_t and α_t, which will show the lagged effects of the share of Danish and Dutch immigrants (and their changes) in 1900 on the formation of cooperatives in 1910 and 1920, compared to a reference year of 1900, when no associations were operational.

To interpret the coefficients of interest as causal, our model requires exogeneity ($E(\varepsilon_{i,t}|\text{Danes}_i^{1900}) = 0$ for the first specification and $E(\varepsilon_{i,t}|\Delta\text{Danes}_i) = 0$ for the second), which is satisfied when there are no omitted variables causing bias. Omitted variables that would violate this assumption are likely to be in two categories. First, there could be factors related to dairy sector success that would help the formation of CTAs but would also lead

Danish immigrants to select into these areas. We follow Boberg-Fazlić and Sharp (2024) and include several geographical controls that could be correlated with Europeans' preferences for areas of residence (average elevation, share of county area with high pasture suitability, and share of county area with high wheat suitability). We also include the number of dairy cows, the number of creameries/cheese factories, and the presence of industrial dairying to control for this potential selection.

Second, factors related to cooperative formation would have lead to CTA formation and might have been culturally attractive to Danish immigrants. Previous Danish immigration which may have helped cooperative formation and attracted more Danish immigrants is captured in our second specification by using the change in Danish immigrants between 1880 and 1900 instead of the stock of immigrants in 1900. Other county-level factors such as legal institutions and regulations that may have helped cooperatives are very likely to be fixed in our period and would then be controlled for in the county-level fixed effects. Further, changes in legal institutions or broad economic conditions common to all of our states are captured in year fixed effects.

However, one omitted variable that we do not have data on is the placement of cooperative creameries. Assuming that, given their popularity in Denmark, Danish immigration would be positively correlated with cooperative creameries, we could see a downward or upward bias in its coefficient depending on how it affects CTAs. We know that in some cases distrust between creameries and dairy farmers motivated some butterfat testing at the farm level (Wisconsin Dairymen's Association, 1900; Bulletin, 1897). If cooperative creameries garnered greater trust with farmers than investor-owned creameries, this might be a disincentive to adopt a CTA and would lead to a downward bias on the impact of Danish immigration. On the other hand, cooperative creameries may have held expertise in forming cooperatives that would have helped the formation of CTAs. In this case, we would see an upward bias on the impact of Danish immigration. Understanding the relationship between cooperative creameries and the formation of the CTAs is a subject for future research that requires more data than is

available in this analysis.[5]

5 Results

Table 2 shows the results of our two specifications. While we see positive coefficients for most of the 1900 shares, none of the coefficients are statistically significant. The second column of Table 2 presents results using the change in share between 1880 and 1900. We find that the change in the share of Dutch immigrants between 1880 and 1900 had a positive but statistically insignificant effect on CTA formation in 1910. For Danish immigrants, we see that their change in share had a positive, although statistically insignificant, effect in 1910 and a sizable, statistically significant effect in 1920. This is evidence that the group of Danish immigrants who came between 1880 and 1900 may have helped catalyze the adoption of CTAs while similar groups of Dutch immigrants had no measurable impact on CTA formation.

[Table 2 about here.]

[Table 3 about here.]

Since we are also interested in what other factors influenced adoption of CTAs, we report the results of the other covariates in Table 3. As expected, the number of dairy cows in a county is a very important factor for the formation of cow-testing associations, though that was not the case for butter production. For 1920, the agricultural census documentation clearly states that butter production numbers refer to those produced on farms, excluding butter made in creameries. We believe it might be reasonable to assume that creameries would demand higher standards for milk quality as compared to local farms that produce butter.

[5] Of the states in our study, Minnesota keeps the best data on cooperatives (Durand and Robotka, 1917). In other states, the exact ownership structure of creameries is not recorded and cannot reliably be determined from the name.

The results show that creameries had a positive effect on forming CTAs in 1920. The significance of this factor confirms that the commercialization and modernization of the dairy industry are also key components to the formation of CTAs. There is also evidence that the elevation and the wheat suitability index are important to the establishment of CTAs. The coefficients are as expected for 1920. Elevation had a negative effect as areas suitable for dairying – and consequently for CTAs – are generally flatter (i.e., less elevation). Similarly, areas with a higher share of land fit for growing wheat would also be suitable for dairy farming as they provide feed for livestock. We would expect that areas with higher proportion of land suitable for pasture would be more likely to have these cooperatives, but it seems that they had no effect. Finally, we expect negative coefficients for the distance to nearest land-grant university variable, but see no specific pattern in the coefficients.

As a robustness check, we run specification (2) using different European immigrants to see whether other groups of European immigrants were influential in the formation of cow-testing associations. We specifically examine nationalities that had cow-testing cooperatives in their countries by 1905: Germans, Swedes, Norwegians, and Finns. Yet, by 1900, there were very few CTAs in their countries, so we do not expect these groups to have direct experience with CTAs. By testing the influence of these groups, we are aiming to isolate knowledge of the CTAs, a unique resource provided by the Danish, from dairy knowledge and cooperative values that other groups may have shared.

These results are presented in Table 4. Generally, we do not see consistent effects for any of those immigrant group. Germans seemed to have had an effect in 1910, but that effect disappears when we run a "kitchen sink" regression in the last column, controlling for all immigrant groups. Finns had a negative effect for 1920, but it should be noted that Finland only had 2 CTAs in 1900, so they were not particularly successful by that time. Other than that, the only consistent effect we see is the effect of Danes in 1920.

[Table 4 about here.]

Finally, we estimate the model with different measures of the Danish concentration.

Specifically, we change the denominator of the Danish share to test differing definitions of the share of Danish immigrants. In Table 5, we divide the total Danish immigrants by the total immigrant population, the European immigrant population, and the Scandinavian immigrant population. Here, we define European immigrants as those in Table 4 and Scandinavian immigrants as Danish, Swedish, and Norwegian. This slight change in the definition can provide insight into whether or not Danish immigrant groups were more influential in CTA formation in places with more foreign-born individuals. For all of these specifications, we use specification (2), meaning we use the change in share between 1880 and 1900.

Table 5 shows that, when measuring the Danish share as a percentage of more specific groups, the effect becomes significant in 1910. Yet, compared to the main model, the size of the effects are roughly similar. The effects of a one standard deviation increase in the probability of forming a CTA by 4.74%, 4.59%, 4.42%, or 2.5% when using any of the four definitions. The most important takeaway is that the Danish share has a significant relationship to CTA formation in both years when there are more Danes compared to other immigrant groups.

[Table 5 about here.]

We run more tests in the appendix to further examine our results. In sections A1-A3, we test the impact of 2nd generation immigrants (some effect), percentiles of Danish share (an effect detected in the upper percentiles), and levels of immigrants instead of shares (no effect). In section A4, we add some control variables, farmland value and value of dairy products, and see only marginal changes to our results. In section A5, we attempt to predict the closing of CTAs between 1910 and 1920 but find that none of the covariates used in this study are statistically significant.

6 Discussion and Conclusion

We find evidence of Danish immigrants catalyzing the adoption of the productivity-enhancing cow-testing associations in a sample of Midwestern states in the US. Particularly, we find that the change in the share of Danish immigrants between 1880 and 1900 was associated with a higher probability of the formation of the associations in 1920. We find that Dutch immigrants, despite having a similar expertise in dairying and experience with cooperatives in general, did not have the same impact as Danish immigrants. We interpret our result as suggestive evidence that Danish people transferred knowledge or experience with the associations from their home country and not only dairying expertise and familiarity with cooperatives. The fact that no other immigrant group mattered to their formation pinpoints that Danish immigration played a crucial role in the formation of these cooperatives. Our results are significant to the literature on both institution formation and immigration by pointing out a case in which institutions might form because of ideas and organizational forms introduced by immigrants from their home countries. Thus far, this has been an understudied mechanism by which institutions can form.

However, our results also show that CTA formation was partly influenced by the modernization of the US dairy sector in general. CTAs were likely to form where creameries and cheese factories had already provided the economic incentive to form. In fact, while our approach attempts to isolate whether knowledge transfer is the reason Danish immigrants helped CTAs form, it is still possible that Danish immigrants influenced CTA formation because of a more industrialized approach to dairying. Denmark was known at the time for bringing new technology for creameries and their familiarity with these ideas may have caused them to uptake CTAs at a higher rate even apart from their direct experience with CTAs.

Another limitation in this study is the small sample of states analyzed – only 6 Midwestern states. This is due to our data on creameries and cheese factories being constrained to this set of states only. Including more states could amplify or mute the effects found in our analysis.

One could argue that we also need time-varying data for their numbers. Currently, we only have them during a single "snapshot" (around 1900) and we interact it with time dummies to add a temporal dimension. However, we believe that the distribution of creameries in 1900 is likely to be autocorrelated with its distribution of 1910 and 1920, and that we will be avoiding reverse causality by not including concurrent number of creameries – for example, counties that have CTAs in 1910 might be more likely to form more creameries during that year.

In addition, we might be omitting some variables that affected Danish/Dutch immigrants' areas of settlement that would eventually form CTAs. If that is the case, we would be picking up the unobserved motivations of these immigrant groups for living in certain areas. However, we believe that it is reasonable to assume that immigrants who chose to reside in a certain area in 1900 did not anticipate CTAs forming there as CTAs did not exist in the US at the time. We also add county fixed effect to absorb any time-invariant effects of their regions of residence, and we include several geographical controls that we vary with time. We believe that these variables – average elevation, pasture suitability, and wheat suitability indexes – could be correlated with the residence preferences of Danish and Dutch immigrants.

There is extensive research conducted on the importance of institutions to the agricultural sector. We add to the literature by showing yet another way that European immigrants transmitted ideas about cooperatives to the US (Turvey, 2017; Boberg-Fazlić and Sharp, 2024). To understand the impact of immigration, it is essential to recognize how immigrant groups can introduce not only new technologies but also innovative ideas. In the case of cooperatives in the US, it has become more apparent that many of the cooperative forms of organization we see today may have been brought by immigrants rather than invented within the country's borders. In future research, more can be learned about the formation of institutions by paying more close attention to how ideas might cross borders for the betterment of the host country.

Data Availability

The data and code underlying this article can be made available by the authors upon request.

References

Acemoglu, D., Johnson, S., and Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review*, 91(5):1369–1401.

Acemoglu, D., Johnson, S., and Robinson, J. A. (2002). Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution*. *The Quarterly Journal of Economics*, 117(4):1231–1294.

Acemoglu, D., Johnson, S., and Robinson, J. A. (2005). Chapter 6 Institutions as a Fundamental Cause of Long-Run Growth. In Aghion, P. and Durlauf, S. N., editors, *Handbook of Economic Growth*, volume 1, pages 385–472. Elsevier.

Alesina, A. and Giuliano, P. (2015). Culture and Institutions. *Journal of Economic Literature*, 53(4):898–944.

Andrews, M. J. (2021). 4. Local Effects of Land Grant Colleges on Agricultural Innovation and Output. In Moser, P., editor, *Economics of Research and Innovation in Agriculture*, pages 139–178. University of Chicago Press. Section: Economics of Research and Innovation in Agriculture.

Beltrán Tapia, F. J. (2012). Commons, social capital, and the emergence of agricultural cooperatives in early twentieth century Spain. *European Review of Economic History*, 16(4):511–528.

Bieleman, J. (2005). Technological Innovation in Dutch Cattle Breeding and Dairy Farming, 1850–2000. *The Agricultural History Review*, 53(2):229–250. Publisher: British Agricultural History Society.

Bijman, J. (2018). Exploring the Sustainability of the Cooperative Model in Dairy: The Case of the Netherlands. *Sustainability*, 10(7):2498. Number: 7 Publisher: Multidisciplinary Digital Publishing Institute.

Boberg-Fazlić, N. and Sharp, P. (2024). Immigrant Communities and Knowledge Spillovers: Danish Americans and the Development of the Dairy Industry in the United States. *American Economic Journal: Macroeconomics*, 16(1):102–146.

Brøndal, J. (2013). Danes and Danish Americans, 1870–1940. In Barkan, E. R., editor, *Immigrants in American History: Arrival, Adaptation, and Integration*, pages 323–332. Bloomsbury Publishing.

Bulletin, T. J. (1897). Misuse of the Babcock. *The Jersey Bulletin and Dairy Farming*, page 147. Place: Indianapolis, Ind.

Bureau of Dairying (1925). Dairy Herd Improvement Letter. Technical Report Vol. 1, USDA.

Burlig, F. and Stevens, A. W. (2024). Social networks and technology adoption: Evidence from church mergers in the U.S. Midwest. *American Journal of Agricultural Economics*, 106(3):1141–1166.

Callaway, B. and Sant'Anna, P. H. C. (2021). Difference-in-Differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230.

Chander, P. and Thangavelu, S. M. (2004). Technology adoption, education and immigration policy. *Journal of Development Economics*, 75(1):79–94. Publisher: Elsevier.

Chellaraj, G., Maskus, K. E., and Mattoo, A. (2008). The Contribution of International Graduate Students to US Innovation. *Review of International Economics*, 16(3):444–462. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-9396.2007.00714.x.

Christensen, C. L. (1924). *Agricultural cooperation in Denmark*. Department bulletin / United States Department of Agriculture ;no. 1266. U.S. Dept. of Agriculture, Washington, D.C.

Christensen, T. P. (1927). Danish Settlement in Minnesota. *Minnesota History*, 8(4):363–385. Publisher: [Minnesota Historical Society Press, Minnesota Historical Society].

Christensen, T. P. (1928). Danish Settlement in Wisconsin. *The Wisconsin Magazine of History*, 12(1):19–40. Publisher: Wisconsin Historical Society.

Commissioner, W. S. D. a. F. (1901). Biennial report of the Dairy and Food Commissioner of Wisconsin for the years 1899-1900. Technical report, Wisconsin. State Dairy and Food Commissioner.

Danker, M. P. (1968). Factors Influencing the Use of Agricultural Cooperatives. *Illinois Agricultural Economics*, 8(1):20–26. Publisher: [Agricultural & Applied Economics Association, Oxford University Press].

Durand, E. D. and Robotka, F. (1917). *Cooperative Creameries and Cheese Factories in Minnesota, 1914*. Agricultural Experiment Station, University of Minnesota. Google-Books-ID: YwcnAQAAMAAJ.

Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development. *Journal of Monetary Economics*, 50(1):3–39.

FAO (2005a). Crop suitability index (class) for low input level rain-fed wheat. https://s3.eu-west-1.amazonaws.com/data.gaezdev.aws.fao.org/res05/NorESM1-M/rcp8p5/2080sH/sxHr0$_w$*he.tif*.

FAO (2005b). Suitability of global land area for pasture (FGGD).

Farrington, E. H. (1913). *Testing milk and its products*. Mendota Book Company.

Guinnane, T. W. (1994). A Failed Institutional Transplant: Raiffeisens Credit Cooperatives in Ireland, 1894-1914. *Explorations in Economic History*, 31(1):38–61.

Haines, M., Fishback, P., and Rhode, P. (2018). United States Agriculture Data, 1840 - 2012. https://www.icpsr.umich.edu/web/ICPSR/studies/35206/versions/V4.

Henriksen, I., Hviid, M., and Sharp, P. (2012). Law and Peace: Contracts and the Success of the Danish Dairy Cooperatives. *The Journal of Economic History*, 72(1):197–224. Publisher: Cambridge University Press.

Henriksen, I., Lampe, M., and Sharp, P. (2011). The role of technology and institutions for growth: Danish creameries in the late nineteenth century. *European Review of Economic History*, 15(3):475–493. Publisher: Oxford University Press.

Henriksen, I., McLaughlin, E., and Sharp, P. (2015). Contracts and cooperation: the relative failure of the Irish dairy industry in the late nineteenth century reconsidered1. *European Review of Economic History*, 19(4):412–431.

Hornbeck, R. (2012). The Enduring Impact of the American Dust Bowl: Short- and Long-Run Adjustments to Environmental Catastrophe. *American Economic Review*, 102(4):1477–1507.

Hornung, E. (2014). Immigration and the diffusion of technology: The Huguenot diaspora in Prussia. *American Economic Review*, 104(1):84–122. Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Howe, F. C. (1921). *Denmark: A Cooperative Commonwealth*. Harcourt, Brace. Google-Books-ID: 01oEAAAAMAAJ.

Hueth, B. (2014). Missing markets and the cooperative firm. In *Workshop on Producers' Organizations in Agricultural Markets*, volume 22.

Hunt, J. and Gauthier-Loiselle, M. (2010). How Much Does Immigration Boost Innovation? *American Economic Journal: Macroeconomics*, 2(2):31–56.

Hutchins, J. (2023). The US farm credit system and agricultural development: Evidence from an early expansion, 1920–1940. *American Journal of Agricultural Economics*, 105(1):3–26. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/ajae.12290.

Hutchins, J. and Hueth, B. (2023). 100 years of data sovereignty: Cooperative data governance and innovation in US dairy. *Applied Economic Perspectives and Policy*, 45(3):1551–1576. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/aepp.13339.

Indiana State Dairy Association. (1903). Annual report of the Indiana State Dairy Association. Technical Report Volume 13, Indiana State Dairy Association.

Indiana State Dairy Association (1909). *Nineteenth Annual Report of the Indiana State Dairy Association*. BJRT-Haywood Co., Lafayette, IN. Place: Indianapolis etc. Publisher: The Association.

International Institute of Agriculture and Fjelstad, M. A. (1925). *Dairy cow testing in different countries.* Contrôle des vaches laitières dans divers pays.English. Printing office of the International institute of agriculture, Rome.

Iowa. State Dairy Commissioner (1900). Annual report of the State Dairy Commissioner to the Governor of the State of Iowa. Technical Report Volume 14.

Kansas State Board of Agriculture (1903). Report of the Kansas State Board of Agriculture for the Quarter Ending September 30, 1903. XXII(87). Place: Topeka.

Kantor, S. and Whalley, A. (2019). Research Proximity and Productivity: Long-Term Evidence from Agriculture. *Journal of Political Economy*, 127(2):819–854. Publisher: The University of Chicago Press.

Karim, S. and Webb, M. D. (2025). Good Controls Gone Bad: Difference-in-Differences with Covariates. arXiv:2412.14447 [econ].

Kent, F. L. (1902). Testing milk and cream. Technical report, Oregon Agricultural Experiment Station.

Kitchens, C. and Fishback, P. (2015). Flip the Switch: The Impact of the Rural Electrification Administration 1935–1940. *The Journal of Economic History*, 75(4):1161–1195.

Makabe, T. (1999). Ethnic hegemony: the Japanese Brazilians in agriculture, 1908-1968. *Ethnic and Racial Studies*, 22(4):702–723. Publisher: Routledge _eprint: https://doi.org/10.1080/014198799329350.

McLaughlin, E. and Sharp, P. (2021). Competition between organisational forms in Danish and Irish dairying around the turn of the twentieth century1. *Business History*, 63(2):314–341. Publisher: Routledge _eprint: https://doi.org/10.1080/00076791.2019.1575366.

Michigan Dairymen's Association (1906). *Twenty-Second Annual Report of the Michigan Dairymen's Association*. Wynkoop Hellenbeck Crawford Company, State Printers, Lansing, Michigan. Place: Lansing, Mich. Publisher: R. Smith Printing Co., state printers.

Michigan Office of Dairy and Food Commissioner (1900). Annual report of the Dairy and Food Commissioner of the State of Michigan. Technical Report Volume 7, Office of the Dairy and Food Commissioner.

Minnesota Dairy and Food Department (1901). Biennial report of the Minnesota State Dairy and Food Commissioner: 1899–1900. Technical Report Volume 8, Minnesota. Dairy and Food Department.

Monrad, J. H. (1891). Milk Testing. *The Dairy Messenger*, 1(2). Place: Chicago Publisher: Libby & Sherwood Print. Co.

Morman, J. B. (1915). *The principles of rural credits as applied in Europe and as suggested for America*. The rural science series, ed. by L.H. Bailey. The Macmillan Company, New York.

Moser, P., Voena, A., and Waldinger, F. (2014). German Jewish émigrés and US invention. *American Economic Review*, 104(10):3222–3255. Publisher: American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

National Farm and Home Hour (1939). Old Newaygo Dairy Herd Improvement Association records, 1935–1944 (UA-28.9). *Michigan State Archives*.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Political Economy of Institutions and Decisions. Cambridge University Press, Cambridge.

Olmstead, A. L. and Rhode, P. W. (2008). *Creating Abundance*. Cambridge Books.

Pearson, R. A. (1914). *Agricultural organizations in European countries.* N.Y. St. Agric. Dept. Bulletin66. Albany.

Pirtle, T. R. (1926). *History of the Dairy Industry*. Mojonnier Bros. Company. Google-Books-ID: n9VfAAAAIAAJ.

Rabild, H. (1911). *Cow-testing associations*. Washington, G.P.O.

Rodrik, D., Subramanian, A., and Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development. *Journal of Economic Growth*, 9(2):131–165.

Ruggles, S., Nelson, M. A., Sobek, M., Fitch, C. A., Ronald, G., Hacker, J. D., Roberts, E., and Warren, J. R. (2024). IPUMS ancestry full count data: Version 4.0.

Satyanath, S., Voigtländer, N., and Voth, H.-J. (2017). Bowling for Fascism: Social Capital and the Rise of the Nazi Party. *Journal of Political Economy*, 125(2):478–526.

Schoone-Jongen, R. (2013). Dutch and Dutch Americans, 1870–1940. In Barkan, E. R., editor, *Immigrants in American History: Arrival, Adaptation, and Integration*, pages 333–342. Bloomsbury Publishing.

Sinclair, J. F. (1912). *Report Upon Co-operation and Marketing*. Democrat Printing Company, State printers. Google-Books-ID: J4Lh7f_zCrAC.

Survey, U. G. (2018). USGS EROS Archive - Digital Elevation - Global 30 Arc-Second Elevation (GTOPO30).

Tabellini, G. (2010). Culture and Institutions: Economic Development in the Regions of Europe. *Journal of the European Economic Association*, 8(4):677–716.

Turvey, C. G. (2017). Historical developments in agricultural finance and the genesis of america's farm credit system. *Agricultural Finance Review*, 77(1):4–21.

United States and Fletcher, D. U. (1914). *Agricultural credit ... Report of the United States commission to investigate and study in European countries cooperative land-mortgage banks, cooperative rural credit unions, and similar organizations and institutions devoting their attention to the promotion of agriculture and the betterment of rural conditions.* 63d Cong., 2d sess. Senate. Doc. 380. Govt. print. off., Washington.

University of Illinois Agricultural Experiment Station (1900). Circular No. 26. Technical report, University of Illinois.

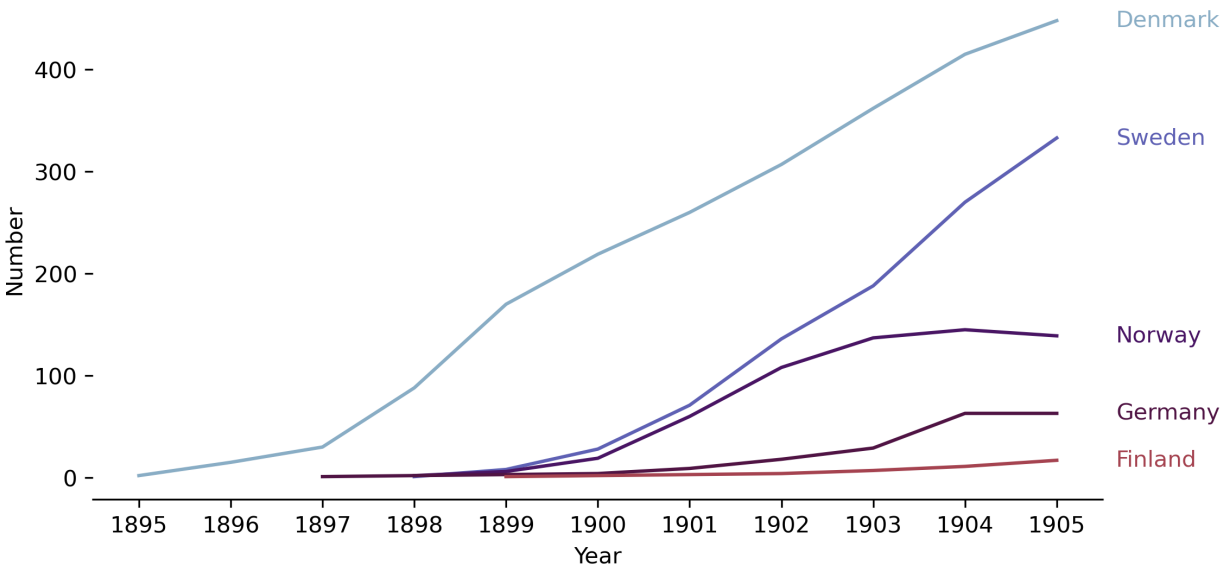
van Zanden, J. L. (1991). The First Green Revolution: The Growth of Production and Productivity in European Agriculture, 1870-1914. *The Economic History Review*, 44(2):215–239. Publisher: [Economic History Society, Wiley].

Voelker, D. E. (1981). Dairy Herd Improvement Associations. *Journal of Dairy Science*, 64(6):1269–1277.

Wisconsin Dairymen's Association (1900). *Twenty-Eighth Annual Report of the Wisconsin Dairymen's Association.* Democrat Printing Company, State Printers, Madison, WI. Place: Madison.

List of Figures

Figure 1: Cow-testing associations in European countries: 1895-1905

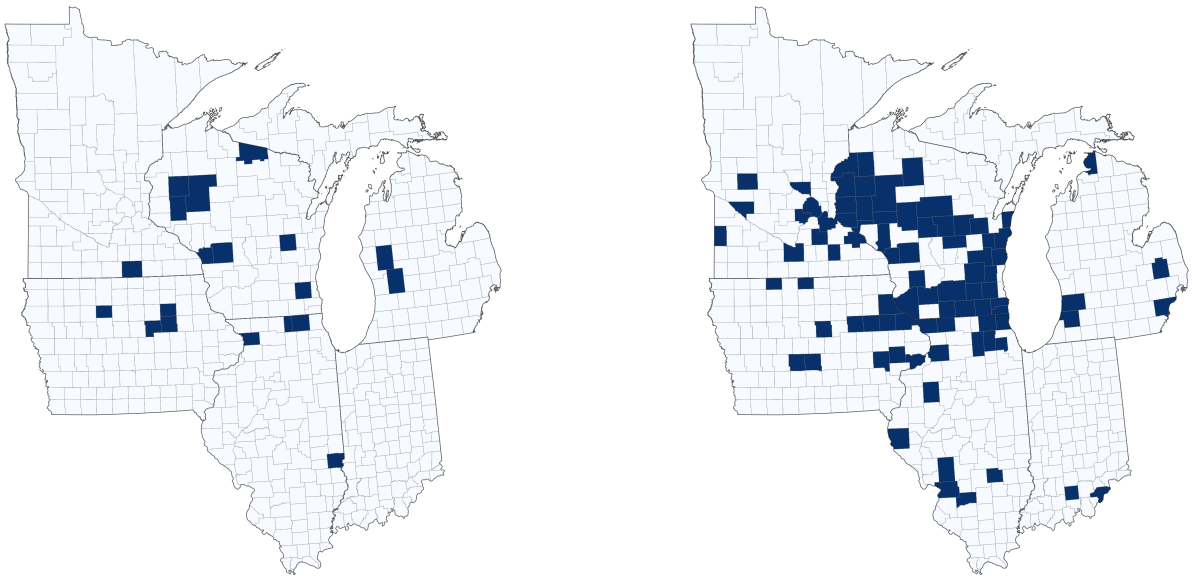


Source: Rabild (1911)

Figure 2: Distribution of cow-testing associations

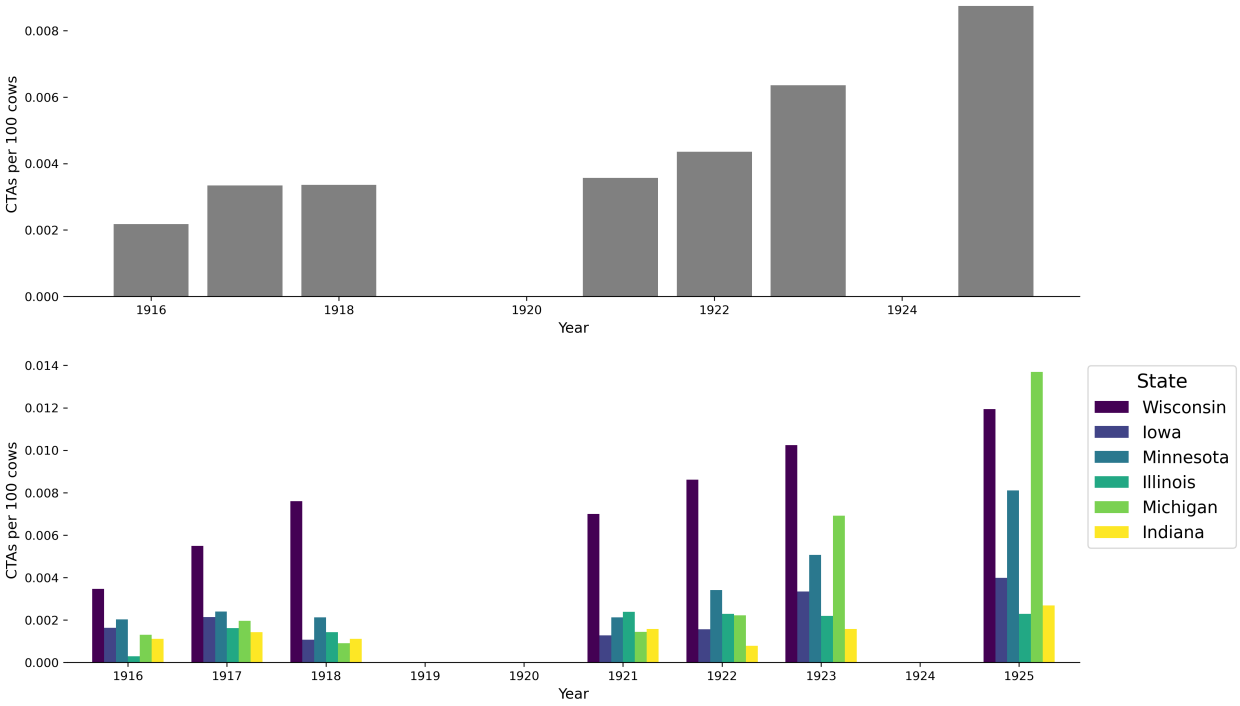
(a) Panel A: 1910

(b) Panel B: 1920



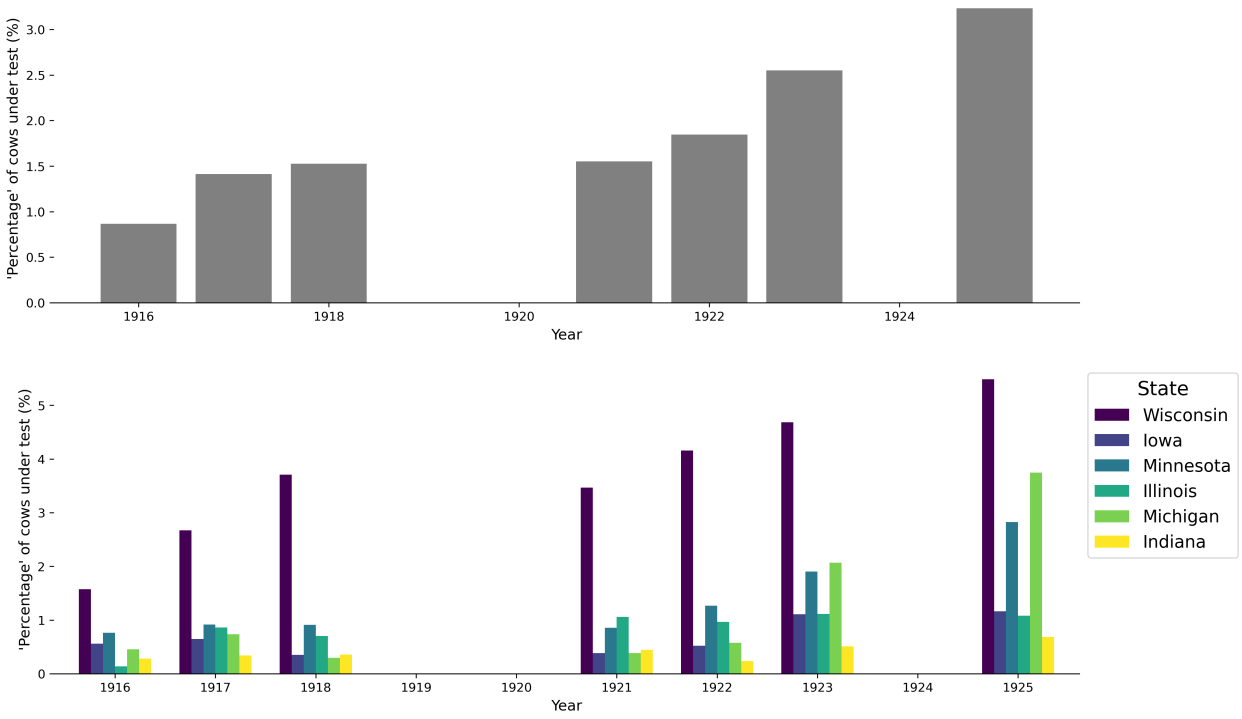
Source: Digitized reports of CTAs

Figure 3: Number of CTAs per 100 cows in our sample of states



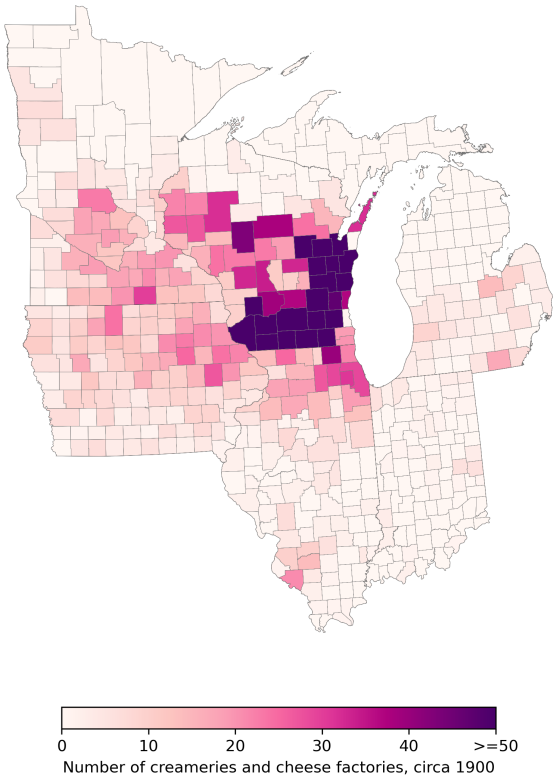
Source: Digitized reports of CTAs and agricultural censuses Haines et al. (2018). State bars are ordered descendingly according to the total number of cows in 1910.

Figure 4: No. of cows under test divided by no. of cows in 1910 in our sample of states



Source: Digitized reports of CTAs and agricultural censuses Haines et al. (2018) State bars are ordered descendingly according to the total number of cows in 1910.

Figure 5: Number of creameries and cheese factories in our sample of states

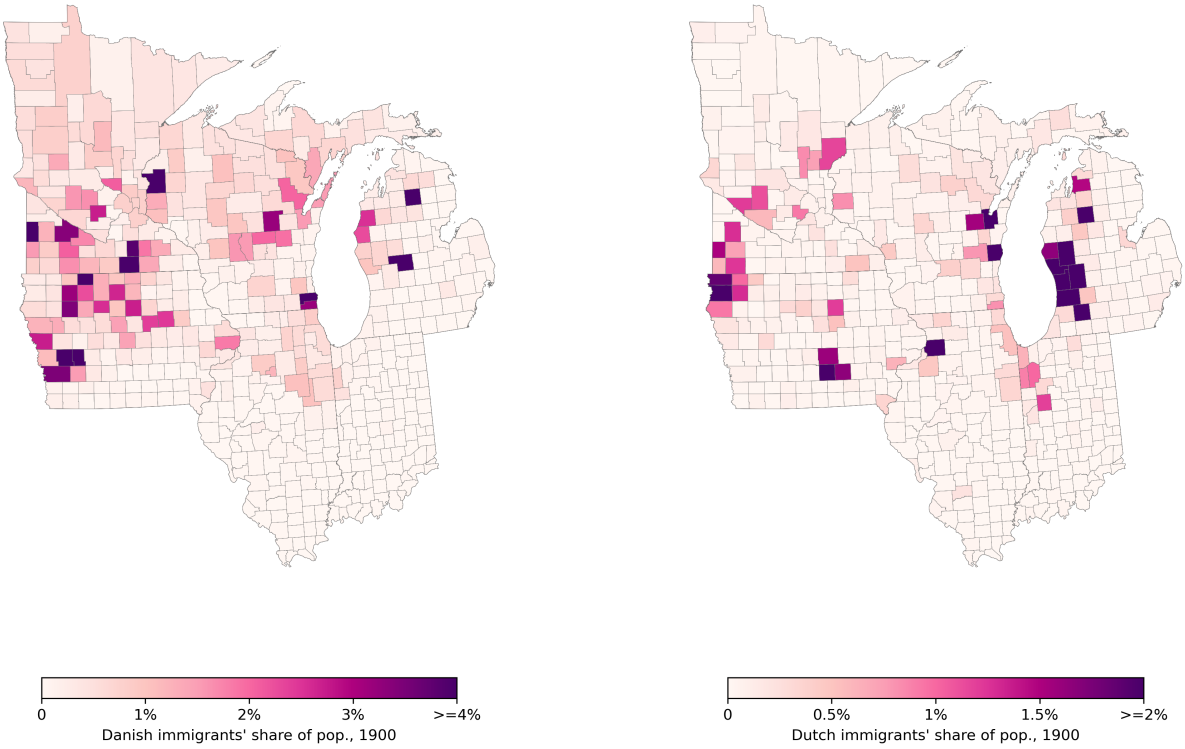


Source: Reports that include creamery and cheese factory locations (University of Illinois Agricultural Experiment Station, 1900; Indiana State Dairy Association., 1903; Iowa. State Dairy Commissioner, 1900; Michigan Office of Dairy and Food Commissioner, 1900; Minnesota Dairy and Food Department, 1901; Commissioner, 1901)

Figure 6: Danish and Dutch immigrants as a share of the county population

(a) Panel A: Danish immigrant share in 1900

(b) Panel B: Dutch immigrant share in 1900



Source: Full-count individual IPUMS micro-censuses (Ruggles et al., 2024)

List of Tables

Table 1: Summary statistics table

Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
Panel A: time-variant variables, 1900					
Number of CTAs operating	528	0.00	0.00	0	0
At least one CTA is present (0 or 1)	528	0.00	0.00	0	0
Number of dairy cattle	528	13303.30	9579.95	1	65608
Amount of butter produced on farms	528	589529.29	381371.86	1416	2132596
Panel B: time-variant variables, 1910					
Number of CTAs operating	528	0.04	0.20	0	2
At least one CTA is present (0 or 1)	528	0.04	0.19	0	1
Number of dairy cattle	528	12118.52	8909.23	61	65505
Amount of butter produced on farms	528	454316.38	283527.57	3566	1928492
Panel C: time-variant variables, 1920					
Number of CTAs operating	528	0.26	0.76	0	7
At least one CTA is present (0 or 1)	528	0.16	0.37	0	1
Number of dairy cattle	528	18974.74	15387.12	366	108667
Amount of butter produced on farms	528	232392.82	147364.93	8715	1007627
Panel D: 1880 immigration variables					
1st-generation Danish immigrants	509	61.92	195.85	0	3092
Share of 1st-generation Danish immigrants	509	0.00	0.01	0	0.07
1st-generation Dutch immigrants	509	70.33	410.12	0	5752
Share of 1st-generation Dutch immigrants	509	0.00	0.01	0	0.19
2nd-generation Danish immigrants	509	102.17	321.17	0	5239
Share of 2nd-generation Danish immigrants	509	0.01	0.01	0	0.11
2nd-generation Dutch immigrants	509	164.52	861.14	0	13158
Share of 2nd-generation Dutch immigrants	509	0.01	0.03	0	0.41
Panel E: 1900 immigration variables					
1st-generation Danish immigrants	528	136.10	538.33	0	10713
Share of 1st-generation Danish immigrants	528	0.01	0.01	0	0.10
1st-generation Dutch immigrants	528	118.63	825.35	0	13381
Share of 1st-generation Dutch immigrants	528	0.00	0.01	0	0.18
2nd-generation Danish immigrants	528	317.90	1143.43	0	22385
Share of 2nd-generation Danish immigrants	528	0.01	0.02	0	0.21
2nd-generation Dutch immigrants	528	304.66	1913.98	0	29630
Share of 2nd-generation Dutch immigrants	528	0.01	0.03	0	0.48
Panel F: miscellaneous variables					
Number of creameries	528	6.09	9.53	0	81
Difference in share of 1st-gen. Danish immigrants	509	0.00	0.01	-0.02	0.08
Difference in share of 1st-gen. Dutch immigrants	509	0.00	0.00	-0.04	0.03
Distance to land-grant university	528	151.33	94.63	0	575.75

Notes: All variables are at the county level. The 1880 immigration variables in Panel D have a smaller number of observations because there were counties that were formed by 1900 but were not formed by 1880. That is why the 'difference in shares' variables in Panel F also have a smaller number of observations.

Table 2: Results of specifications (1) and (2)

	CTA Operating (0 or 1)	
	Share in 1900	Share Diff, 1900 - 1880
Danish share × 1910	2.053	2.139
	(1.398)	(1.580)
Danish share × 1920	2.847	7.885***
	(1.786)	(2.799)
Dutch share × 1910	0.927	6.226
	(1.086)	(4.225)
Dutch share × 1920	-0.643	-2.636
	(0.452)	(3.447)
County and Year FE	Yes	Yes
Observations	1584	1527
Adjusted R^2	0.297	0.313

Notes: This table shows the results of running the regression for running specifications (1) and (2) for our main variables of interest. The dependent variable in both columns is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. For column (1), the Danish and Dutch shares variables measure the shares of the 2 immigrant groups out of the population in 1900. For column (2), these variables measure the change in the shares of the 2 immigrant groups between 1880 and 1900. Then, they are interacted with time dummies. County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

Table 3: Results of specifications (1) and (2), Control variables

	CTA Operating (0 or 1)	
	Specification (1)	Specification (2)
Dairy cattle	0.00001***	0.00001***
	(0.00000)	(0.00000)
Butter production	0.00000	0.00000
	(0.00000)	(0.00000)
Creameries × 1910	0.00001	0.00010
	(0.00120)	(0.00121)
Creameries × 1920	0.00551***	0.00528***
	(0.00170)	(0.00175)
Dairy occupation share × 1910	24.42870	27.66939
	(33.54255)	(35.16765)
Dairy occupation share × 1920	67.30496	68.56885
	(49.09347)	(50.14778)
Dist. to land grant uni × 1910	0.00010	0.00009
	(0.00012)	(0.00012)
Dist. to land grant uni × 1920	0.00054***	0.00054***
	(0.00018)	(0.00019)
Elevation mean × 1910	0.00003	-0.00004
	(0.00013)	(0.00010)
Elevation mean × 1920	-0.00049**	-0.00058***
	(0.00020)	(0.00022)
Pasture high share × 1910	0.02981	0.02273
	(0.03016)	(0.02957)
Pasture high share × 1920	-0.03601	-0.04327
	(0.05689)	(0.05685)
Wheat high share × 1910	-0.00858	0.00786
	(0.03075)	(0.02708)
Wheat high share × 1920	0.14281***	0.15501***
	(0.04986)	(0.05210)
County and time fixed effects	Yes	Yes
N	1584	1527
Adjusted R^2	0.297	0.313

Notes: This table shows the results of running the regression for running specifications (1) and (2) for our control variables. Dairy occupation share is the share of people working in industrial dairying in 1900. Distance to land grant university is the distance from each county's centroid to the state's land-grant university. Pasture and wheat high share are the share of county land that is highly suitable to pasture and wheat respectively according to FAO (2005a) and FAO (2005b). County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

Table 4: Regression of specification (2) with change in the share of other European immigrants

	CTA Operating (0 or 1)						
Danish share diff. × 1910	2.139	1.993	2.134	2.049	2.013	2.086	2.044
	(1.580)	(1.599)	(1.619)	(1.622)	(1.616)	(1.618)	(1.623)
Danish share diff. × 1920	7.885***	7.992***	8.018***	7.556***	7.679***	8.171***	7.638***
	(2.799)	(2.764)	(2.807)	(2.674)	(2.798)	(2.716)	(2.715)
Dutch share diff. × 1910	6.226						5.962
	(4.225)						(4.439)
Dutch share diff. × 1920	-2.636						-2.290
	(3.447)						(3.486)
German share diff. × 1910		0.475*					0.310
		(0.266)					(0.296)
German share diff. × 1920		-0.413					-0.488
		(0.588)					(0.630)
Swedish share diff. × 1910			-0.101				0.009
			(0.159)				(0.278)
Swedish share diff. × 1920			-0.923				-0.691
			(0.648)				(0.690)
Norwegian share diff. × 1910				-0.154			-0.002
				(0.353)			(0.427)
Norwegian share diff. × 1920				-0.786			-0.533
				(0.806)			(0.899)
Finnish share diff. × 1910					-0.706*		-0.456
					(0.398)		(0.362)
Finnish share diff. × 1920					-1.539**		-1.507**
					(0.604)		(0.619)
All immigrants' share diff. × 1910						0.027	-0.079
						(0.123)	(0.131)
All immigrants' share diff. × 1920						-0.397	-0.042
						(0.282)	(0.267)
County and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1527	1527	1527	1527	1527	1527	1527
Adjusted R^2	0.313	0.310	0.310	0.310	0.310	0.310	0.311

Notes: This table shows the results of running the regression in specification (2) but after replacing the share of Dutch immigrants with other European immigrants. The dependent variable for all columns is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. The Danish and other groups' difference in shares variables are the changes in the share of the 1st generation of immigrants for each group between 1900 and 1880. Then, they are interacted with time dummies. The same covariates used and shown in Table 2 are included here. County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

Table 5: Regression of specification (2) while differing the denominator of the Danish share

	Danish immigrants as a share of:			
	(1) Population	(2) Immigrants	(3) European Immigrants	(4) Scandinavian Immigrants
Danish Share Diff. × 1910	2.119	0.942*	0.536*	0.0602**
	(1.611)	(0.506)	(0.288)	(0.0238)
Danish Share Diff. × 1920	7.909***	1.638**	1.197***	0.129**
	(2.792)	(0.675)	(0.431)	(0.0535)
SD of Danish Share	0.006	0.028	0.037	0.196
County and Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	1527	1527	1527	1434
Adjusted R^2	0.309	0.307	0.307	0.300

Standard errors in parentheses

* p<.1, ** p<.05, *** p<.01

Notes: This table shows the results of running the regression in specification (2) while varying the definition of the Danish share. The dependent variable for all columns is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. European immigrants include the groups shown in Table 4. Scandinavians include Danish, Swedish, and Norwegian immigrants. The same covariates used and shown in Table 2 are included here. Some counties are not included in column 4 because of counties reporting zero Scandinavian immigrants. County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

Cooperative Formation and European Immigration: The Case of Cow-Testing Associations in the United States Dairy Industry

Supplementary Appendix

Ziad Sabbah Alian[12] and Jared Hutchins[3]

[1] University of Illinois Urbana-Champaign, Department of Economics
[2] Cairo University, Faculty of Economics and Political Science
[3] University of Illinois Urbana-Champaign,
Department of Agricltural and Consumer Economics

* Correspondence to be sent to:
Jared Hutchins, Ph.D.
1301 Gregory Drive
Mumford 312
Urbana, IL 61801
United States of America
Email - jhtchns2@illinois.edu

A Robustness Checks

A.1 Second Generation Immigrants

In Table A1, we run the specification (2) regression using 2nd generation immigrants. Experience and knowledge of institutions could be transferred from one generation to the next even though **?** found that only 1st generation Danish immigrants had a positive effect on agricultural outcomes in the US. We find that 2nd generation Danish immigrants had the same effect as their 1st generation counterparts although it is less precisely estimated.

Table A1: Results of specification (2) using 2nd generation immigrants

	CTA operating (0 or 1)	CTA operating (0 or 1)
Danish 2nd gen. share diff. × 1910	1.225	
	(0.815)	
Danish 2nd gen. share diff. × 1920	2.574**	
	(1.183)	
Dutch 2nd gen. share diff. × 1910	2.801	
	(1.924)	
Dutch 2nd gen. share diff. × 1920	-1.258	
	(1.122)	
Danish 1st+2nd gen. share diff. × 1910		0.829
		(0.561)
Danish 1st+2nd gen. share diff. × 1920		2.019**
		(0.847)
Dutch 1st+2nd gen. share diff. × 1910		2.149
		(1.410)
Dutch 1st+2nd gen. share diff. × 1920		-0.947
		(0.923)
County and time fixed effects	Yes	Yes
Controls	Yes	Yes
N	1527	1527
Adjusted R^2	0.311	0.312

Notes: This table shows the results of running the regression in specification (2). The dependent variable is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. The Danish and Dutch difference in shares variables are the changes in the share of the 2nd generation of immigrants for each group between 1900 and 1880. Then, they are interacted with time dummies. The bottom 4 rows are the same but with both 1st generation plus 2nd generation immigrants. The same covariates/controls used and shown in Table 3 are included here. County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

A.2 Percentiles of Change in Immigrants' Shares

In Table A2, we create dummy variables for the different percentiles in our main covariate of interest, change in the share of immigrants. There is some suggestive evidence that counties in the tail-end of the distribution drove our results.

Table A2: Regressions using dummy variables of percentiles the change in immigrants' shares

	10th percentile	25th percentile	50th percentile	75th percentile	90th percentile	95th percentile	99th percentile
Danish 'x'th percentile × 1910	0.005	0.007	0.027*	0.087***	0.055	0.093	-0.043***
	(0.029)	(0.017)	(0.016)	(0.030)	(0.041)	(0.065)	(0.016)
Danish 'x'th percentile × 1920	0.062	0.000	0.036	0.063	0.098*	0.049	0.535***
	(0.045)	(0.033)	(0.030)	(0.043)	(0.059)	(0.080)	(0.154)
Dutch 'x'th percentile × 1910	0.012	0.022	0.020	0.020	0.006	0.046	0.304
	(0.032)	(0.018)	(0.016)	(0.024)	(0.030)	(0.055)	(0.195)
Dutch 'x'th percentile × 1920	0.011	0.004	0.019	0.075**	0.028	-0.064	-0.101***
	(0.053)	(0.035)	(0.028)	(0.038)	(0.049)	(0.054)	(0.033)
County and time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1527	1527	1527	1527	1527	1527	1527
Adjusted R^2	0.300	0.299	0.300	0.307	0.302	0.302	0.326

Notes: The dependent variable in all columns is whether a CTA is operating in the county (0 or 1). First, we get the percentiles of the change in Danish and Dutch immigrants' shares between 1880 and 1900 for each county. Then, we create dummy variables that take 1 if the change in the share of immigrants lies in the 'x'th percentile. Each column shows what percentile the dummy variable is for in the regression. For example, in the '10th percentile' column, we run the regression with the above dependent variable and the Danish 'x'th percentile is a dummy variable that takes 1 if the change in the Danish immigrants' share lied in the 10th percentile. Other than that, all other covariates/controls in specification (2) are included and county and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

A.3 Levels of Immigrants

As an additional exercise, we also run the same regressions but using the levels of immigrants instead of their shares in Table A3. In specification (2), we find that Dutch immigrants had a positive effect in 1910. In both specifications – levels and change in levels –, we see no effect for Danish immigrants. However, we avoid interpreting this as our main result since the levels of immigrants could simply be proxies for population size (i.e., areas with a high number of immigrants might simply be more populous areas). Our use of shares is similar to the approach taken by **?** and **?**.

A.4 Land and Milk Prices as Controls

As a robustness check, we add two variables: farmland value and the total value of dairy products in the county. These controls may help control for additional selection of Danish immigrants into areas where CTAs would have been successful. However, it is also possible that they meet the definition of "bad controls" since the formation of CTAs may have also impacted these outcomes. Compared to the main results, the effects are mostly unchanged

Table A3: Regression of specification (1) with levels of immigrants

	Specification (1)	Specification (2)
Danish level × 1910	0.000007	-0.000026
	(0.000035)	(0.000043)
Danish level × 1920	-0.000009	0.000013
	(0.000046)	(0.000073)
Dutch level × 1910	0.000034	0.000077**
	(0.000026)	(0.000034)
Dutch level × 1920	-0.000031*	-0.000069*
	(0.000016)	(0.00004)
County and time fixed effects	Yes	Yes
Controls	Yes	Yes
N	1584	1527
Adjusted R^2	0.304	0.316

Notes: This table shows the results of running the regression for running specifications (1) and (2) but using levels of immigrants instead of their shares. The dependent variable in both columns is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. For column (1), the Danish and Dutch level variables measure the level of the 2 immigrant groups in absolute terms in 1900. For column (2), these variables measure the change in the levels of the 2 immigrant groups between 1880 and 1900. Then, they are interacted with time dummies. The dependent variable is binary which takes a value of 1 if the county has an operational CTA and 0 otherwise. The Danish and Dutch levels variables are the levels of the 1st generation of immigrants for each group in 1900. Then, they are interacted with time dummies. The same covariates/controls used and shown in Table 2 are included here. County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

apart from the Danish share in 1900 becoming 90% significant in 1920. We also see a negative effect of Dutch share in 1900 but the effect is quite small compared to the others.

Table A4: Specifications (1) and (2) with farmland value and dairy product value as control variables

	CTA Operating (0 or 1)	
	Share in 1900	Share Diff, 1900 - 1880
Danish share × 1910	1.960	1.959
	(1.338)	(1.503)
Danish share × 1920	2.982*	7.850***
	(1.606)	(2.665)
Dutch share × 1910	0.754	6.139
	(1.058)	(4.064)
Dutch share × 1920	-0.967*	-2.555
	(0.496)	(3.226)
N	1584	1527
adj. R^2	0.326	0.338

Standard errors in parentheses

* p¡.1, ** p¡.05, *** p¡.01

Notes: County and time fixed effects are added. Standard errors are clustered at the county level. * indicates p-value<=0.1, ** indicates p-value<=0.05, *** indicates p-value<=0.01.

A.5 Prediction of CTAs Closing

Between 1910 and 1920, 11 counties that had CTAs lost their CTA. The reasons behind a CTA forming and then closing may be distinct from the successful forming of a CTA. To shed light on the reasons behind a CTA closing, we estimate a linear regression model of a cross-section of all of the counties and define the dependent variable as having a CTA in 1910 but not in 1920. The results of this analysis are in Table A5 and show that none of our chosen covariates explain CTA closing. Understanding the dynamics of CTAs opening and closing likely requires a more careful analysis and better data than we have in this study.

B Additional Figures

References

Table A5: Prediction of whether a CTA in 1910 was closed in 1920

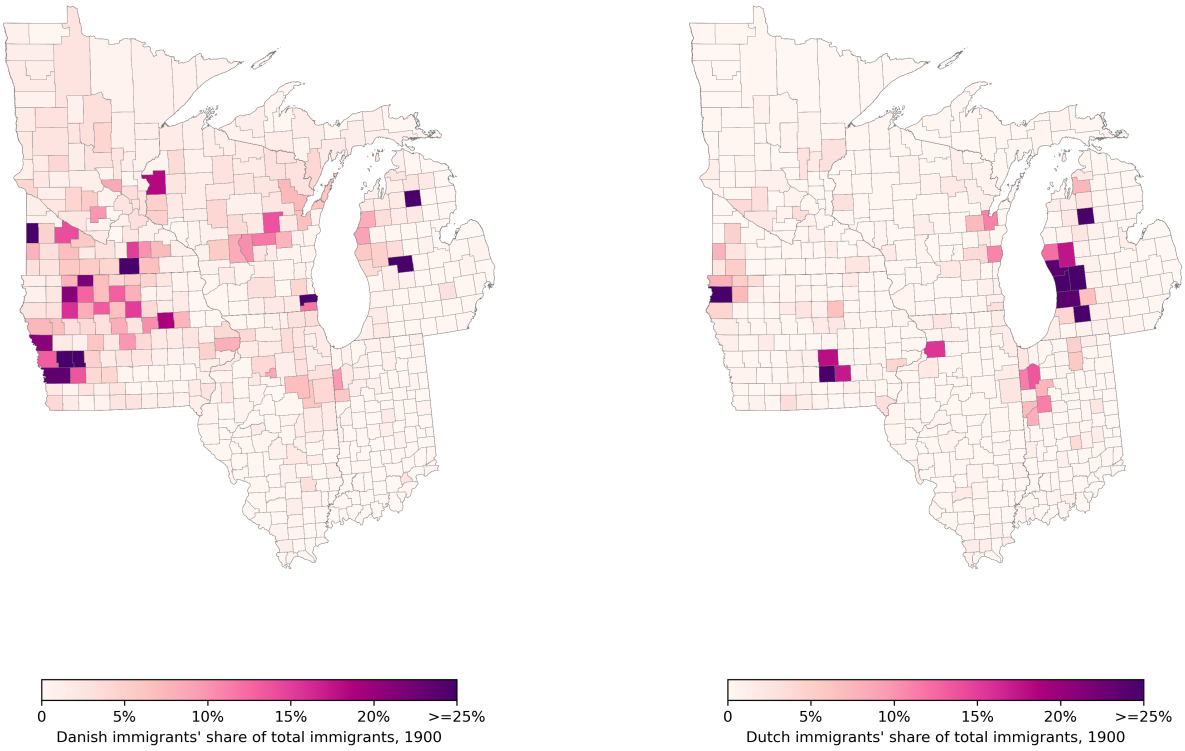
	(1) CTA Closed, 1910-1920
Change in Danish Share, 1880-1900	1.529
	(1.226)
Change in Dutch Share, 1880-1900	6.137
	(4.232)
Milk Cows in 1900	0.000000263
	(0.00000130)
Butter Production in 1900	-3.38e-09
	(2.36e-08)
Creameries and Cheese Factories	-0.000289
	(0.00107)
Dairy Occupation Share in 1900	27.64
	(25.19)
Dist. to land grant uni	-0.0000589
	(0.0000790)
Elevation mean	-0.0000422
	(0.0000619)
Pasture high share	0.0146
	(0.0150)
Wheat high share	-0.0242
	(0.0260)
Constant	0.0316
	(0.0263)
Observations	509
Adjusted R^2	0.030

Clustered standard errors in parentheses
* p¡.1, ** p¡.05, *** p¡.01

Figure B1: Share of all immigrants instead of county population

(a) Panel A: Danish immigrants among all immigrants in 1900

(b) Panel B: Dutch immigrants among all immigrants in 1900



Source: Full-count individual IPUMS micro-censuses (**?**)