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Abstract

Economic historians have debated the importance of energy for economic development. Energy economists would argue that energy systems need to be adaptable in the face of shocks. In this light, we consider the case of Denmark, a country which was almost entirely dependent on imports of coal, and where a long coastline made imports, largely from the UK, cheap and available. Towards the end of the First World War, however, and well into the 1920s, coal imports were cut off or difficult to obtain. We exploit detailed microlevel data from butter factories, covering the period 1900-28. We find that firms were able to adapt and make use of alternative fuels, notably peat, although its availability varied across the country. Employing a difference-in-differences approach, we find significant productivity advantages for creameries closer to available peat fields in the wake of the coal shortage.

JEL Codes: N54, O13, Q40

Keywords: Coal, dairying, Denmark, energy, geography, peat, productivity

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1 Introduction

In an influential article, Walker et al. (2004) argued that three related attributes of social-ecological systems are important for how they develop: resilience, adaptability, and transformability. Blum and Legey (2012) took this to the concept of energy security, noting the importance of energy as a key-resource to economic development, and that it must be “sufficient, affordable and environmentally sustainable.” Energy economists have noted the importance of diversification in energy baskets, but that large energy producers such as Germany and the UK tended to have higher levels of concentration in their energy mixes, and while small energy producers (often coal-poor countries) had lower levels, by the turn of the twentieth century, most had transitioned to coal (see e.g. Rubio-Varas and Muñoz-Delgado, 2019). Such dependence on one energy source, typically coal at early stages of industrialization, meant that they became locked into coal-dependent means of production with obvious implications for energy security. This led to severe shortfalls when supplies were limited, such as during the First World War and the 1920s. At this point rapid diversification to alternative sources became necessary. From the perspective of economic history, it has long been argued that the availability of coal was crucial for the process of industrialization in the nineteenth century (see for example Cipolla, 1962; Wrigley, 1988, 2010; Pomeranz, 2000; Allen, 2009; Fernihough and O’Rourke, 2020), and cheap coal is considered to have played a role for the timing of industrialization with coal-rich countries and regions industrializing earlier than others (Kander et al., 2017).

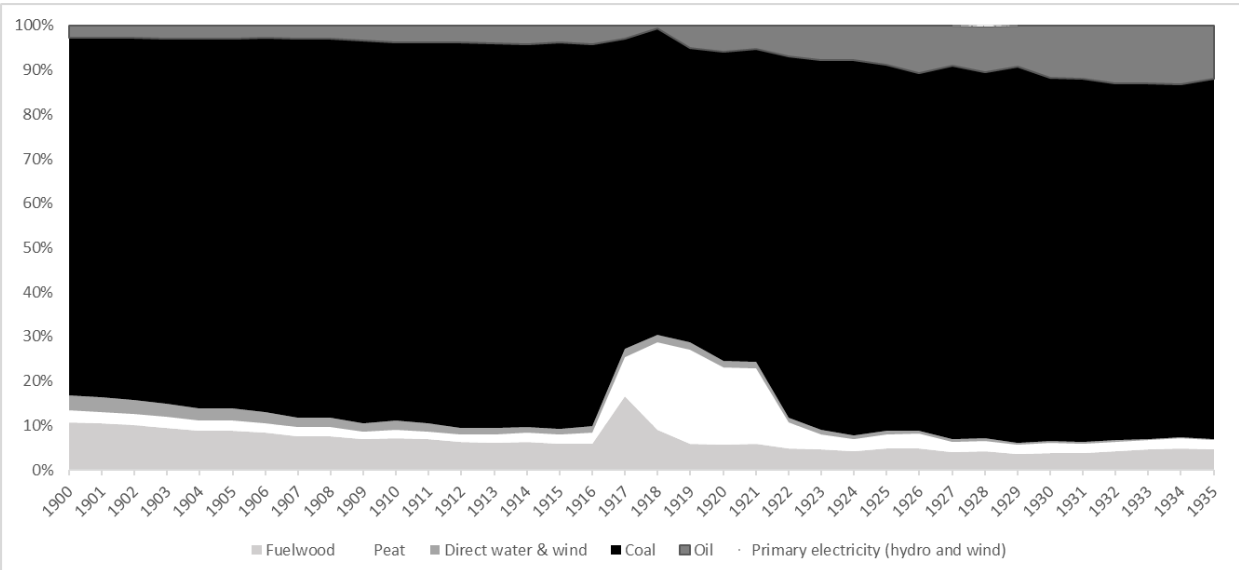
Here, we consider the case of Denmark, a country which became heavily dependent on imports of coal from the UK during its rapid development in the last decades of the nineteenth century, but which suffered from supply constraints towards the end of the First World War until well into the 1920s. To investigate the impact of this, we exploit uniquely detailed firm-level data on butter factories, or creameries, from 1900-1928, covering the period before the crisis and some years after, but stopping before the onset of the Great Depression. Although they were locked into coal-dependent production technologies, we demonstrate that they were able to adapt quickly to the new conditions, in part through the exploitation of local supplies of peat, with factories close to peat especially favored during a period which nevertheless was extremely difficult for the industry and saw massive falls in production. We employ a difference-in-differences strategy, finding that creameries closer to freshwater deposits - a soil type associated with peat formation - were more productive in the wake of coal shortages. Interestingly, this productivity advantage was maintained even after coal supplies resumed.

Blum and Legey (2012) note that energy security “represents the guarantee that individuals and firms in an economy are able to benefit from the welfare that energy can create” (see also Bohi and Toman, 1996 and IEA, 2007). Following Walker et al. (2004) they explain that guaranteeing this requires the economy to demonstrate: resilience, so that temporary and permanent energy related effects can be handled; adaptability, i.e. preparedness to respond to sudden energy related changes, and transformability, so that it can evolve towards a more secure energy configuration. Much work on modern times highlights the role of the government for ensuring this, see for example Lo (2011) on Indonesia, Japan, Korea and Taiwan during recent decades of rapid economic growth, and Vögele et al. (2018) on the phasing out of coal-fired power plants in Germany. The present work contributes through the historical example of a country and industry which was heavily dependent on imported energy, but needed to adapt quickly in the face of unprecedented challenges to supply. As we will discuss below, the government played a role, but individual firms also demonstrated perhaps surprising adaptability.

As is well-known, the story of energy during early industrialization is very much tied up with that of coal. Steam power based on coal eventually spread into most economic sectors including transportation (Kander et al., 2013), and railroads and steamships meant that even countries with no coal, but with long coast-lines, such as Denmark, were able to industrialize (Henriques and Sharp, 2016), while those with large interior regions, such as Portugal, saw industrialization mostly confined to coastal areas (Henriques and Sharp, 2021). In general, the availability of cheap energy sources, combined with market access, has been shown to have determined the scale of industrial production to a greater or lesser degree (Crafts and Wolf, 2014; Nielsen, 2021). By contrast, although non-coal energy resources such as peat might be able to sustain economic growth in preindustrial times, as in the case of the Netherlands (de Zeeuw, 1978), Landes (1969) has pointed out that early industrializers succeeded by copying the British model, and reliance on waterpower or charcoal, due to relative prices, was often an obstacle to successful technology adoption. In a similar vein, Allen (2009) explains that cheap peat in the Low Countries meant that, despite high rates of urbanization, abundant coal stretching from northeastern France through Belgium and into Germany were largely unexploited, and the industrial revolution failed to be a Dutch-German achievement. There was simply no economic incentive to open coal mines, and by the nineteenth century cheap supplies from Newcastle meant that German coal remained unexploited until relatively late. Mokyr (2009), on the other hand, has argued that the industrial revolution did not need steam, and that neither did steam necessarily require coal. In fact, counterexamples for the importance of coal abound, for example the United States (Melosi, 1982; Schurr and Netschert, 1960) and Sweden (Kander, 2002; Kander et al., 2017; Lindmark and Olsson-Spjut, 2018), where wood and charcoal were important energy carriers in early stages of industrialization. Sweden is in fact an interesting case in point, where it proved possible to adapt to the lack of coal and establish a sizeable iron industry in the nineteenth century (Rydén, 2005; Ducoing and Olsson-Spjut, 2021).

Denmark spent centuries looking for coal, but to no avail (Ranestad and Sharp, 2021). British coal (traded for Danish agricultural produce) nevertheless played an important role for Denmark's well-known agricultural transformation and development through the dairy industry from the late nineteenth century (Henriques and Sharp, 2016), where the largely cooperatively owned creameries spread rapidly around the country from 1882 using the steam-powered automatic cream separator, a centrifuge, which greatly increased the scale and quality of production (see e.g. Lampe and Sharp (2018)). Although Denmark had effectively no domestic coal deposits, cheap imports were available across the whole country due to her geography with many natural harbors, no location further than 50 km from the coast, and hence cheap overseas transportation from the UK. With the onset of war in 1914, however, Denmark's favorable access to British coal was threatened, and ultimately creameries were forced to exploit other sources of fuel. This is illustrated in Figure 1, which demonstrates both the heavy reliance of the Danish economy on coal before the Second World War, and its use of domestic peat supplies during the period of coal shortages. For the sake of comparison, energy consumption is converted into petajoules (PJ), a measure of energy.

Figure 1: Primary Energy Consumption in Denmark, 1900-1935
(% of total petajoules)

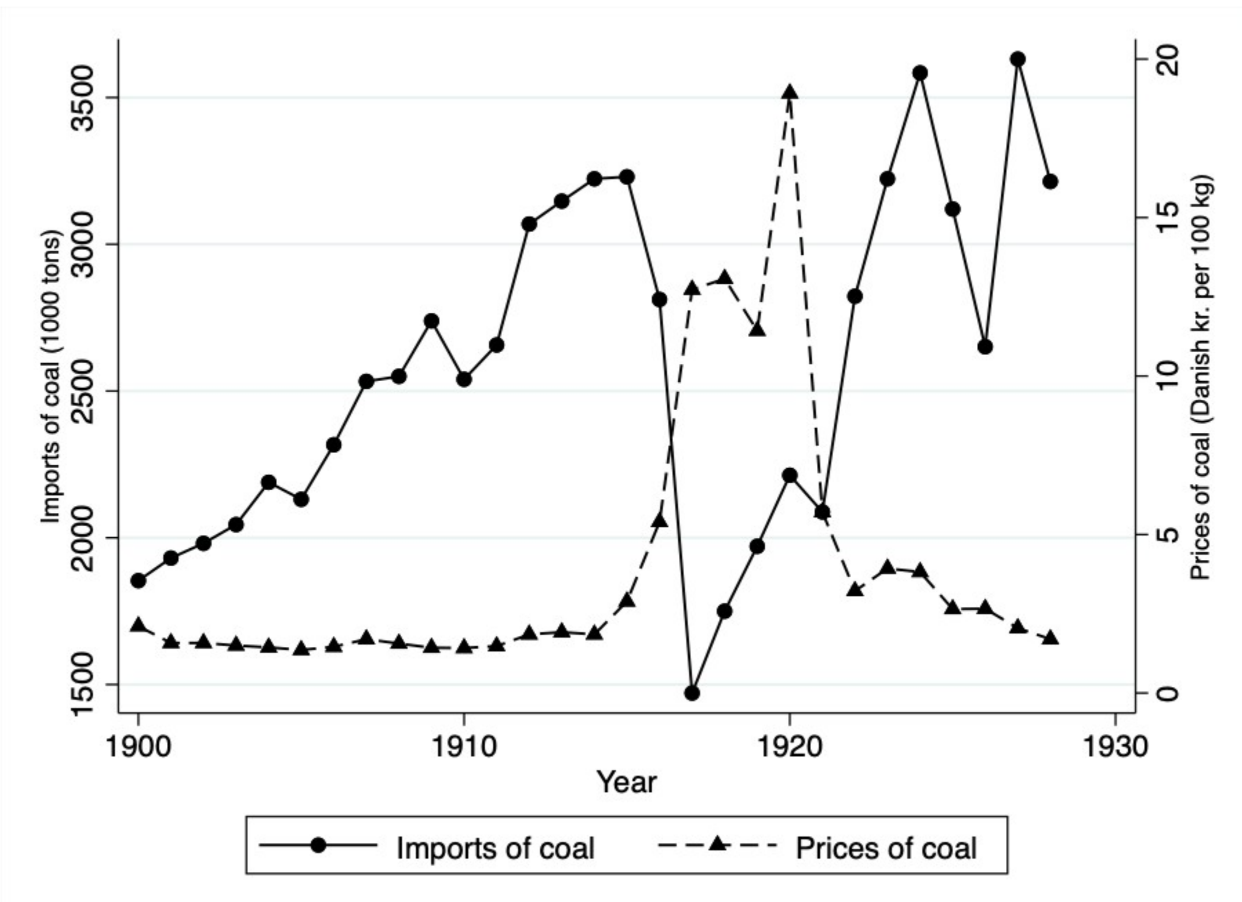


Source: Normann, H. (1959)

The challenges facing coal production and trade during and after the First World War can be divided into four principal elements. First, the war itself meant that shipping became dangerous and expensive, and countries jealously safeguarded access to a resource which was crucial for the war effort. Second, the outbreak of the so-called Spanish flu in 1918 had some direct impact on production of coal, as well as other less direct effects as we discuss briefly below. Third, difficult labor relations followed the war, and miners' strikes had a large impact on supply (Podobnik, 2011). Finally, trade policy became more restrictive in the 1920s. Figure 2 illustrates the impact on coal imports and prices from the Danish perspective, although this does not tell the whole story. Both imports and prices were regulated at times, and there was considerable uncertainty of supply over and beyond the observable fluctuations.

Beyond the obvious effects of the war itself, there is increasing evidence to suggest that the influenza pandemic might also have played a role for the economic difficulties which were to follow. Boberg-Fazlic et al. (2021) demonstrate that the flu had a significant impact, independent of that of the war, on subsequent trade policy, corresponding to an increase of one third of a standard deviation in tariffs for the countries in their sample. More directly, the Spanish flu caused serious disruptions in coal supplies around the world (Kelley and Osterholm, 2008). An article in the New York Times of August 5, 1918, for example, reported that coal had not been delivered from Germany to Switzerland for the last four days after many miners stopped working due to the illness. Similar issues occurred in North America, with one report noting in October 1918 that "coal became difficult to obtain and fuel supplies for the sick and for industry diminished" (MacDougall, 2007). The pandemic resulted in declines in shipments, and numerous collieries were reportedly closed and that those that were open were struggling to produce with "depleted forces" as quoted by Kelley and Osterholm (2008). As Joseph B. Dickson, an anthracite coal distributor, testified on December 2, 1918 to the US Senate "My own feeling is that the gradual shutting down of war industries and the return to natural conditions will relieve the pressure in a very, very short time. I believe it would have been relieved by this time if we had not had this epidemic, which very materially interfered with the production of anthracite coal" (Dickson, 1918). In support of this, Velde (2020) found a relationship between mortality by state in the US and the labor supply shock, although for Denmark itself, Dahl et al. (2020) find that the epidemic, and non-pharmacological interventions, led to short-run declines in income in those municipalities which were hardest hit, although the recession was V-shaped, with full recovery after 2-3 years, as captured by income and unemployment data. The impact on agriculture was quite severe, however, and Figure 3 illustrates clearly the impact on milk and butter production.

Figure 2: Coal Imports and Prices in Denmark, 1900-1928

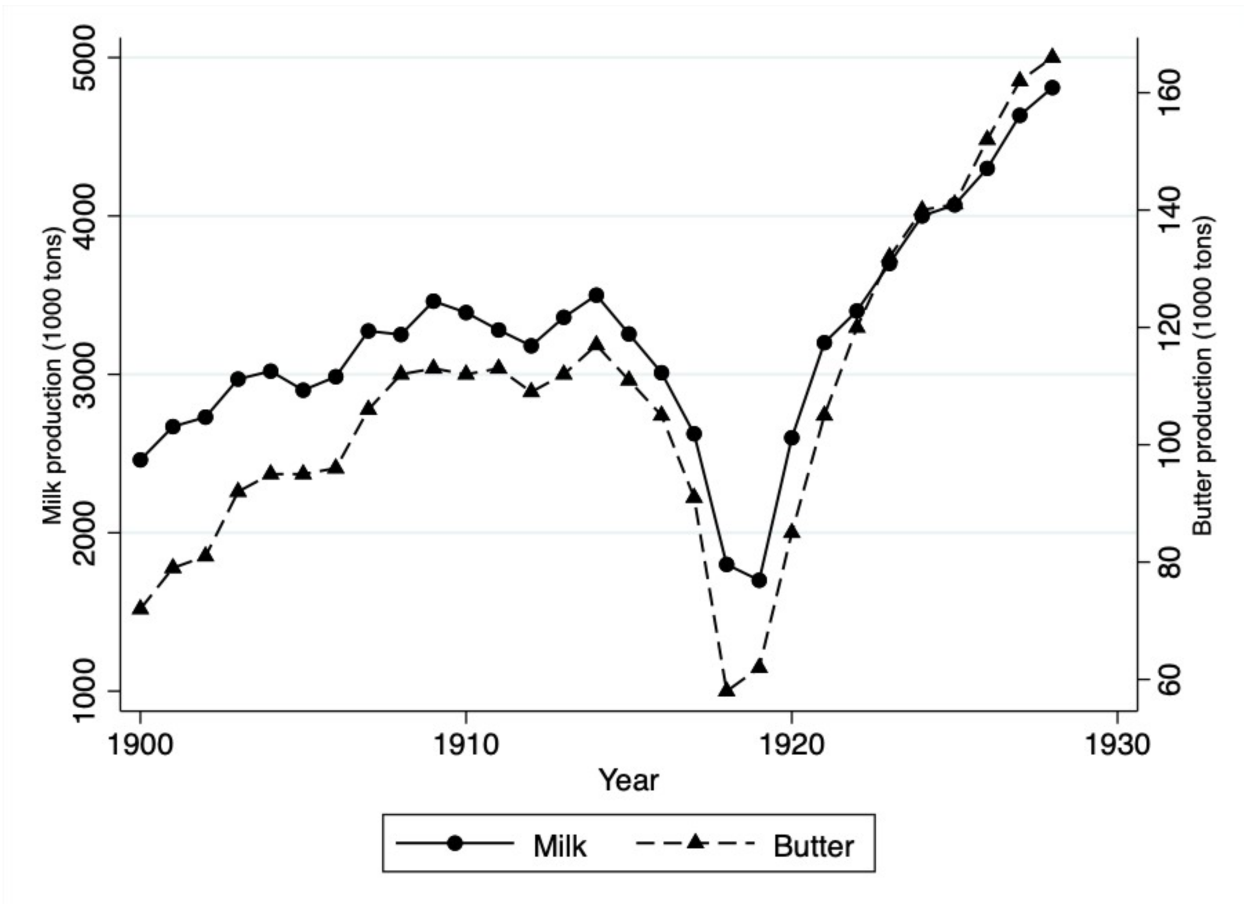


Source: (Normann, 1959)

As we will demonstrate in more detail below, declines in production owed much to the events of the First World War and the 1920s, and to a consequential decline in the productivity of

Danish creameries, in part due to shortages of coal. We hypothesize however, and find both qualitative and empirical evidence for, that those creameries which had access to alternative fuel sources, principally peat, were able to adapt during the 1920s and enjoyed productivity advantages relative to other creameries. The remainder of the present work is structured as follows. The following section provides an overview of the historical background to the Danish case. Section 3 discusses our data, Section 4 provides our methodology, and Section 5 presents our results. Section 6 concludes.

Figure 3: Danish Milk and Butter Production, 1900-1928



Source of data: Johansen (1985)

2 Historical background

This section draws on three main sources. Rasmusssen (1982) provides an excellent general overview of the state of the Danish dairy sector during the First World War and into the 1920s, but only mentions the issues with supplies of coal in passing. We thus supplement this with detailed information provided in a report presented to the Ministry of the Interior in 1921, following the abolition of limits on the consumption of foreign fuel on January 10 of that year (Cock-Clausen, 1921). In addition, we have information from *Dansk Mejeri-Drifts-*

Statistik (MDS, 'Operational Statistics for Danish Creameries'), which provides the source of much of our data, and where almost every volume begins with a discussion of the state of the industry in the year for which the data is presented (usually the previous year).

From 1899 a Committee for Creamery Statistics was responsible for compiling extremely detailed statistical information annually for a large sample of creameries in Denmark, published as MDS (for more information, see Henriques et al. (2020)). Information on the fuel used by the individual creamery is registered for the years 1900-1928, presumably reflecting the years over which this was considered to be of importance. The vast majority of creameries only used coal until the First World War, but in the final years of the war and subsequently other fuels are reported, reflecting the desperation of the owners, including brushwood, peat, briquettes, firewood, coke, heather, sawdust, lignite, straw, coal scraps, and of course a mixture of these (although no information on the proportions used). Electricity was first reported for the powering the machinery in 1915 and only for one creamery. This contrasts with the rapid expansion of electricity in other sectors at the time, but as van der Vleuten (1998) explains, the Danish dairy industry was slow to express interest in electricity beyond its use for lighting, for which it was usually generated by the creamery's boiler. Some of this might have been due to lock-in to steam-power, but he argues that this was largely a rational decision: steam engines were not only reliable, but also produced the large amount of steam needed for pasteurization. Thus, by 1900 power was simply seen as a "by-product" of heat production, and it was only from the 1930s that butter factories began to shift from steam to purchasing electricity with changes in pasteurization techniques.

The choice of fuel is not discussed in great detail in MDS before the war. The earliest discussion is in the report for 1901, where large differences in the cost of fuel is reported, and creameries are encouraged to look to peat for a cheaper alternative, although the writer states that it would not be possible to use peat alone. The reports for 1912-1915 discuss expensive coal and transportation, and by the report for 1916 (published in 1917) it is described how peat was the cheapest fuel, followed by wood, and then coal. One of the most interesting discussions is given in the report for 1917. The author discussed the declining milk production and the very high price of coal and other necessities, as well as discontent among employees, despite the fact that high demand and prices gave a high net income per pound of milk. He praises the adaptability of the creameries, noting that few used coal alone and importantly that local conditions regarding access to fuel were important, such as access to peat. By the report for 1918 only ten creameries were exclusively using coal, and peat is specifically mentioned as an important fuel source in the report for 1919. Unfortunately, the reports for 1920-25 provide no analysis, but the one for 1926 explains how the early part of the year had witnessed high coal prices due to coal strikes in the UK, but that the creameries had learned to adapt due to the war, although again access to alternative sources of fuel was important. It is these reports which led us to investigate the importance of peat in the following. While coal had previously been more-or-less equally accessible to creameries in all parts of the country, it seems that the compilers of MDS observed that local geography began to play a much larger role towards the end of the First World War, and well into the 1920s.

With regards to the situation of Danish agriculture more generally in this period, Rasmusssen (1982) explains that neutrality during the First World War had been an economic and political priority. 60 percent of Danish exports went to the UK before the war, and 28 percent went to Germany. Denmark was, however, never again to experience as free and open markets for export of its agricultural produce as it had before the war. With the declaration of war on August 4, 1914, it was suddenly impossible to export butter. Danish sailors refused to sail unless they received considerably higher payments and insurance, fearing a largely maritime war.

Eventually an agreement was reached, and the first ships set sail on August 9, 1914. But this episode had cost the creameries dearly, and few buyers were to be found during one of the summer's warmest and most milk-abundant periods. The situation was worst for those without refrigerators, but was also bad for the rest, since it was rare to have capacity for more than 8-10 days of production. For some creameries an additional issue was that 53,000 men were called up to the *"Sikringsstyrken"* (Security Force) in connection with the government's acceptance of German demands to mine the Great Belt between Funen and Zealand.

Denmark had a strong negotiating position for maintaining neutrality due to its importance for both British and German supplies of food, and was able to continue trading with both belligerent parties. A law was passed on August 6, 1914 allowing the Minister of Justice to issue export bans, so that trading patterns from before the war could be maintained and in order to secure a supply of important foodstuffs for Denmark. Then, on August 9, 1914 an Extraordinary Commission (*overordentlig kommission*), under the Minister of the Interior, was constituted which could pass measures to secure the supply of necessary goods, organize distribution, and regulate prices. These two laws formed the basis of the Danish regulation of business during the war.

Some of the first regulations passed regarded agriculture. Thus, on August 28, 1914 the Extraordinary Commission took control of grain storage around Copenhagen, and gradually exerted more control over grains through 1914. On December 11, 1914 an export ban on vegetable oils for margarine production was introduced, since this was considered to be preferable to banning exports of butter, and in general dairying was not much impacted at this stage, reflecting its prioritization as a major source of Danish export revenue. There was an idea that it was better to rely on the UK market despite high prices in Germany, since it was felt that any gains from German exports would be short-lived, although by 1915 the German market became more and more attractive due to increasing prices. Exports became regulated from October 11, 1915, and could henceforth only take place through export channels approved by the Ministry of Agriculture. 57 exporting firms approved this on the condition that they followed a distribution plan. This made it possible to behold previous trading connections, and to divide profit on different markets between the creameries, but of course cost agriculture a significant amount of money.

As Figure 3 illustrates, there was not a large impact on production until 1916, when milk production fell under the level from before the war, and by the end of the war these falls were dramatic. The onset of U-boat warfare from January 31, 1917 meant that any ship, hostile or neutral, would be a target, and trade between Denmark and the UK practically ceased until June 1917 when the convoy system was introduced. The Danish government wanted to avoid trade going to Germany, and began stockpiling goods destined for the UK, but this failed to have much effect, and besides, the UK placed restrictions on trade with neutral countries, making it difficult to get hold of UK goods, including coal. The situation became worse and worse, and from the beginning of July 1917 UK exports of feed to Denmark almost stopped, at the same time as the US, which was Denmark's biggest supplier of grain and feed, introduced export bans. From October 4, 1917 all exports to Denmark, except coal (on which more below), was halted, and Denmark could only trade with the central powers, Sweden and Norway. The resultant fall in grain and feed imports led to a large decline in milk production. With the accompanied loss of raw materials for margarine production, Denmark had to eat its own butter. By the summer and fall of 1917 the government attempted to keep prices down through subsidies, but from January 1, 1918 rationing was introduced. Only in September 1918 was it possible to make a trade agreement with the US, and necessary raw materials arrived again, but this came at a cost. Denmark was obliged to supply shipping to the US on top of that already supplied to the UK (as discussed below), and could only import goods from the US which were strictly necessary for the domestic market, and exports of agricultural goods to Germany was limited, although, since production had fallen so much, this never reached the maximum level permitted.

With the armistice of November 11, 1918 there was no quick return to normality. The milch cow herd had been reduced by 13 percent, and a lack of feed continued to limit milk production. In January 1919 Denmark began negotiating an easing of restrictions on trade, and the following month agreement was reached guaranteeing the supply of feed, seed, artificial fertilizer, corn and copra, marking the beginning of a normalization of trade between the UK and Denmark. The export ban on butter was abolished on December 6, 1920. With continental Europe in chaos, the UK was the only real buyer of large quantities of Danish agricultural products the first year after the war, but prices were low since the British government monopolized the purchase and distribution of bacon and butter. At the same time, feed prices only fell slowly. Only on April 1, 1921 were UK restrictions removed, free trade was reestablished, and Danish milk production almost reached the level of 1915. The UK took most of Danish exports, with Germany taking much of the rest. Nevertheless, prices fell since Danish milk production increased more than demand, made worse by a fluctuating world market price and an increasing krone exchange rate, especially when Denmark rejoined the gold standard in 1924-5, although this had the advantage that imports of feed became cheaper.

As regards the coal trade, Cock-Clausen (1921) explains that with the outbreak of war Denmark was already poorly positioned in terms of energy supplies. Strikes in the UK had meant that the transportation of coal from the UK to Denmark was extremely limited from July 1914 to the middle of August. Thus, when the UK entered the war on August 4 and regular shipments stopped, Denmark was extremely ill prepared in terms of coal reserves, since nearly all had been used during the strike. On August 18, 1914 the Extraordinary Commission reached an agreement so that coal importers lowered the price of coal and coke and calmer conditions were maintained through the remainder of 1914, although towards the end of the year prices again began to increase due to lower production in the UK (in part due to miners being called into service) and increasing demand from the UK itself as well as France, Italy, Russia and the rest of Scandinavia. In February 1915 the British government established a committee to investigate the reasons for the increasing price of coal. This suggested that exports to neutral countries should be limited, and from May 13, 1915 coal and coke could only be exported to neutral countries with special permission, and should not be reexported to the countries which were at war with the entente. Eventually Denmark reached agreement with the UK authorities that they would not limit coal exports to Denmark below the quantity which was usually used.

In the first half of 1916 Denmark was witnessing smaller imports of coal from the UK at higher prices and began looking for alternative sources. By October 1916 regular imports were arriving from Germany, and on October 24, 1916 the Ministry of the Interior established the "Continental Coal Committee" (*Fastlandskuludvalget*), which was to administer a reserve of ca. 90,000 tons of German fuel. Already at the end of January 1917 there was a shortage of fuel, but the Continental Coal Committee initially refused to release its reserves since it did not want to create competition for private importers. Then, the blockade of the North Sea from February 1, 1917 meant severe coal shortages, and the Ministry of the Interior introduced price regulation of foreign fuel and regulated the trade of coal, coke, cinders, and briquettes. The Committee began selling reserves, which kept many businesses, including creameries, afloat, despite few imports. The reserves were depleted by September 1917, and the Committee was wound up. Fortunately, imports from the UK had resumed in April 1917, but on April 10 the UK decided that all ships coming from the west could only take goods for the countries for which they flew the flag, and that ships could not load bunker coal in British ports without first taking on duties to help the UK. For Denmark, this meant that on June 20, 1917 agreement was reached with the UK to supply 200,000 tons deadweight for British use, and thereby acquired the right and the duty to import 100,000 tons of coal from the UK. Towards the end of the war, even the UK was experiencing coal shortages, and exports were banned to most neutral countries until mid-January 1919. Denmark had however imported a large amount of German fuel in the first ten months of 1918, and had some reserves.

The end of the war brought little respite. In January 1919 British miners called for higher wages, shorter working days, and the nationalization of coal mines. In response, the British government set up the "Sankey commission", named after the judge who chaired it, and a temporary agreement was reached in the Spring, and imports returned to similar levels to before the war. Nevertheless, the question of rapid nationalization continued to fuel conflicts, and the British government started to stockpile coal in preparation for a strike, with miners in Yorkshire striking in the fall.

The UK response was to require that Danish shipping brought timber from the Baltic in return for coal from August. While the Danish government attempted to negotiate, Danish shipping became trapped in British ports due to a rail strike which in turn led to a ban on the export of fuel until October. Denmark was forced to charter Swedish and Norwegian shipping, which was extremely expensive, and looked for alternative suppliers to the UK and Germany, although options were limited. Belgium met some of the demand, but ran into problems when they banned exports, so by May 1919 Denmark was forced to turn to US coal. Only small amounts arrived, however, due to an increased dollar exchange rate, a miners' strike from November 1919 to March 1920, and a strike among rail officials in April and May 1920. It was only from the fall of 1920 that exports increased.

Thus, the first half of 1920 witnessed very limited coal imports and massive increases in prices, with the US and Germany continuing to be of minor importance, and UK imports uncertain. Denmark was again forced to agree to export timber. Miners stopped working during Christmas and well into January, particularly due to Scottish workers' demand for a long Christmas and New Year vacation. Danish shipping again became trapped in UK ports as coal from neutral ships was requisitioned for reserves, and when supplies increased again at the end of January, British, French and Italian vessels were prioritized. The Danish krone's declining value from the end of 1919 meant that the government set up the Common Currency Council (*Valutafællesraadet*), which from January 1920 determined that currency would not be allowed to be used for imports of coal and coke except in authorized vessels. However, imports were mostly limited due to the situation in the UK. Although the UK decided that Denmark could be guaranteed at least 60,000 tons per month, and in fact supplies were never as low as that, it was anyway far from enough to cover what the country needed, estimated to have been around 200,000 to 250,000 tons per month. Danish reserves fell to less than during the U-boat blockade.

Responding to the crisis, in 1920 the Extraordinary Commission and other bodies encouraged the greatest possible care in the use of fuel. Measures were enacted to enforce this for the use of gas, electricity, and fuel for heating. Bans on the import of coal to Jutland were considered, since they had local reserves of peat and lignite, but this proved impossible. A port strike from March 31 to June 15, 1920 frustrated efforts, but imports were coordinated through Copenhagen. In the second half of 1920 prices increased very rapidly, and although large imports from the UK and the US alleviated this, it was decided to continue with a cautious approach, since it was believed that the situation could change rapidly: although Denmark had large reserves, there was still the threat of a coal miners' strike in the UK. The UK removed all domestic restrictions on July 1, but regulated exports, but then a strike began on October 16 and the exports were halted again. Although the strike ended on November 5, higher wages had been offered, so it was impossible to import as cheaply as before. Nevertheless, the last two months of 1920 saw very rapid falls in prices and on January 10, 1921 the Ministry of the Interior removed all regulations of prices, distribution, etc. It was not until the end of the 1920s that coal prices and imports stabilized.

3 Data

To understand the impact of coal shortages and uncertainty on the Danish creameries, as well as the importance of peat as an available fuel source, we take data from the aforementioned MDS, for which we refer to Henriques et al. (2020) for a full discussion of all the variables in the data, which we hand-collected from the original sources. For the present purposes, we use the milk/butter ratio, i.e. the kilograms of milk required for 1 kilogram of butter, which was a standard measure of productivity at the time (the lower the better). The automatic cream separator required a certain minimum level of input to function effectively (see e.g. Henriksen et al. 2011), so any stoppages in production, for example due to fuel shortages, would have a negative impact.

We also take from MDS whether or not the creamery used peat, coal and/or electricity, which we code as dummies, leaving other sources of fuel, principally firewood, as the reference category. Another important characteristic of the creamery is the number of shareholders, which indicates the size of the creamery and might also be important for productivity. We take the location of the creameries from Ellbrecht (1915-18), who provides the postal address of all creameries for the years 1915-18. We have converted this to geographical coordinates manually. The main explanatory variable is the inverse distance to peat. Using the map of freshwater deposits provided by Pedersen et al. (2011), we construct the distance between the freshwater soil type, that is reported to be suitable for peat formation, and the creamery. Since this soil type formed at the beginning of the Holocene, around 12,000 years ago, it is clearly exogenous to the other variables we consider. Then, to proxy for the ease of access to coal, we use distance to the coast (in km). Summary statistics are provided in Table 1.

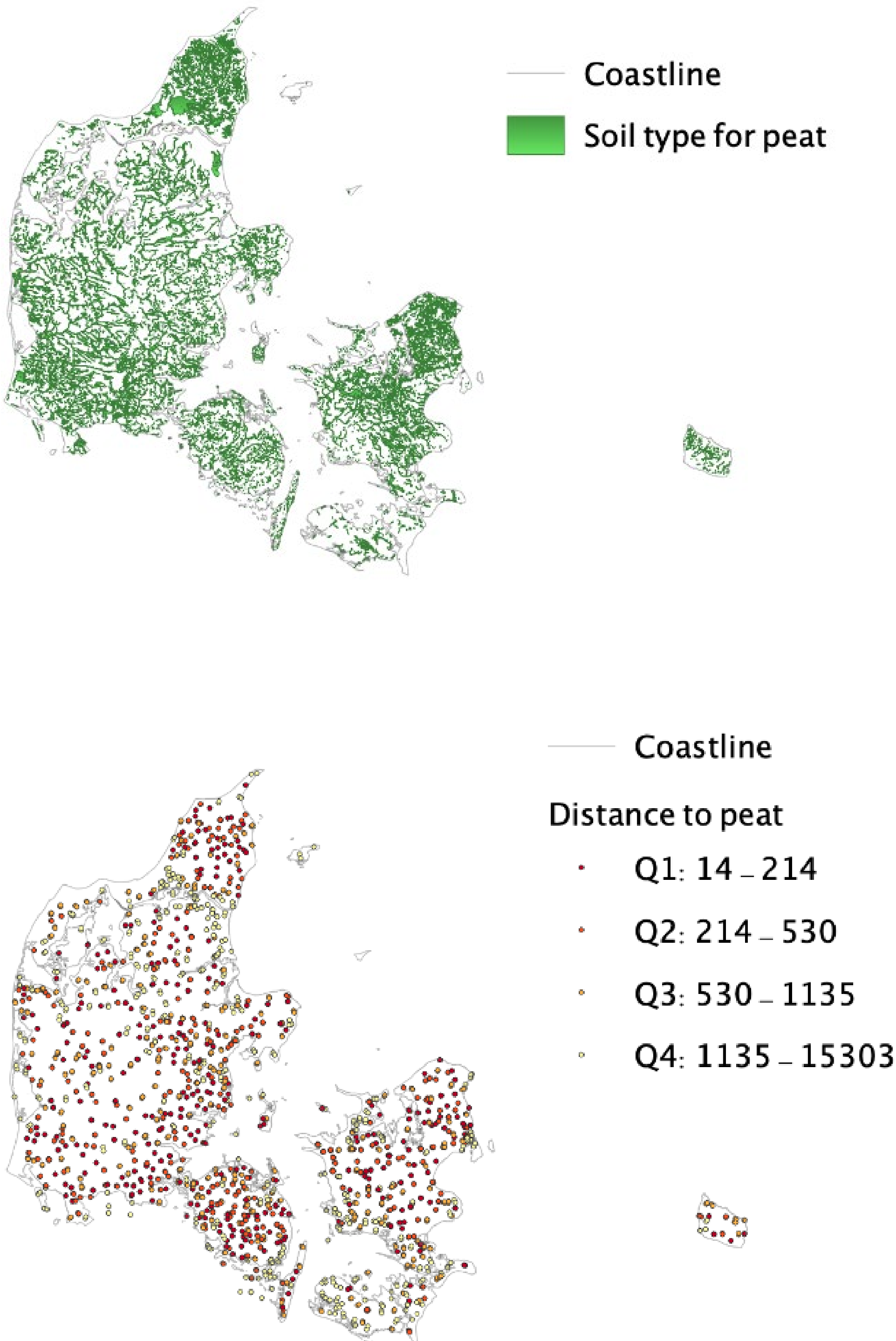
Table 1: Summary statistics

	Observations	Mean	St.Dev.	Min	Max
Year	14292	1915.025	7.842	1900	1928
Region	14225	11.893	7.533	1	25
MB ratio	13858	25.093	.866	20.4	28.5
Inverse log(Distance)	13968	-5.96e-10	1	-4.724	1.199
log(Shareholders)	13804	4.954	.475	2.708	6.328
log(Distance to Coast)	13968	1.622	1.345	-3.371	3.848
Coal	13639	.842	.365	0	1
Peat	13639	.047	.212	0	1
Electricity	13639	.001	.032	0	1
N	14292				

Creameries missing 4 or more annual observations before and after 1913 were excluded. The inverse log(Distance) is standardized.

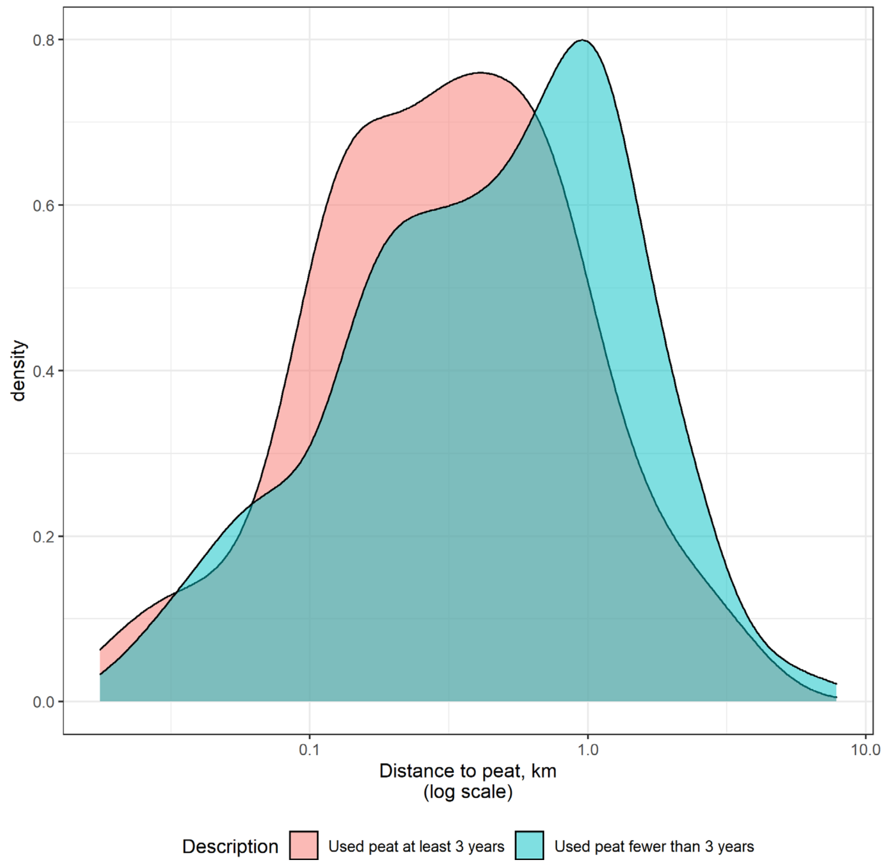
Figure 4 provides a map of Denmark (in its pre-1920 borders), where we have illustrated both the location of peat and the creameries in our sample. Note that this illustrates where it was possible to extract peat, and not whether this actually took place, for which data is lacking. It is clear that there is variation in the distance of creameries to the nearest land with soil type that is suitable for peat, which motivates our empirical strategy below. From Figure 5, it is apparent that there is some correlation between those creameries which were located close to peat, and those that are recorded in MDS as having used peat for at least three years, motivating our use of the exogenous soil measure. Finally, Figure 6 demonstrates the declining share of creameries reporting use of peat (often together with other fuels), consistent with the historical narrative.

Figure 4: Map of Peat and Location of Creameries in our Sample



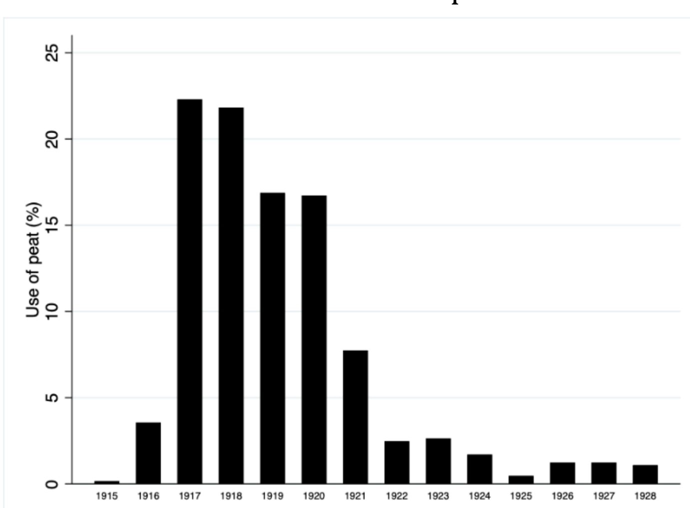
Source: Geographical Survey of Denmark and Greenland (GEUS); Ellbrecht (1915-18)

Figure 5: Distance to peat and use of peat



Source: Own calculations.

Figure 6: Percentage of creameries reporting use of peat as part of their fuel consumption



We have excluded creameries which did not report for 4 years before and after 1913 leaving us with a total of 619 creameries and 14,292 observations. Apart from ensuring variation before and after the outbreak of the First World War, this also means that those which were located in the part of southern Jutland which became German after the Second Schleswig War of 1864, but voted to become part of Denmark from 1920, are not included. Apart from the obvious issue that none of them reported prior to 1920, they were also rather different from the other creameries in our sample, having experienced multiple difficulties following "reunification". Rasmussen (1982) explains how they had to transition rapidly after having suffered from years of under-investment, and whole creameries had to be replaced. The region was also characterized by a larger proportion of private creameries which had a reputation for poorer quality. In fact, recognizing a threat to the reputation of Danish produce, measures were taken to discriminate against the newly Danish creameries, and they were given easily identifiable numbers under the *lurmærke* system, which guaranteed Danish standards of production through an official brand. Although they improved somewhat through the 1920s, in the 1930s they still used more milk per butter than rest of Denmark, and had lower quality. It was only in 1950 that these differences disappeared.

4 Empirical strategy

To investigate the effects of the inverse distance to peat on productivity, a difference-in-differences approach is used. Identification comes from relative changes in milk/butter ratios across creameries with varying levels of inverse distance to peat. The baseline results are estimated using the following specification:

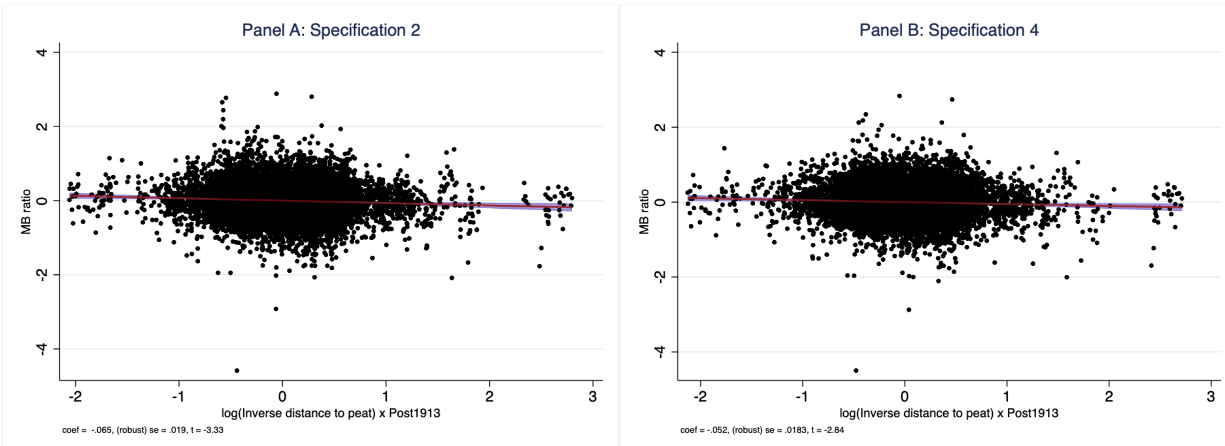
$$MBratio_{c,t} = InverseLogDistance_c \beta \times post1913_t + \gamma_c + \delta_t + \varepsilon_{c,t} \quad (1)$$

where $MBratio_{c,t}$ denotes the milk/butter ratio of creamery c in year t. $InverseLogDistance_c$ is the inverse distance to the freshwater deposits, that are suitable for peat, in creamery c. The inverse value of the distance is calculated as 1/log(*Distance* + 1). $Post1913_t$ is an indicator for year t>1913, i.e. the year before the beginning of the First World War.

Creamery fixed effects γ_c are included in the estimation. Creamery fixed effects control for creamery-specific unobservable characteristics that are constant over time and could influence levels of productivity, which might for example be geographical factors not controlled for. Year fixed effects δ_t control for temporal shocks that are common to all creameries. The coefficient of interest is β and is interpreted as the change in kilograms of milk to produce one kilogram of butter as given by a one standard deviation change in the inverse log distance to land suitable for peat after coal was restricted in 1913. A positive coefficient indicates that peat proximity mattered more after 1913.

Prior to showing the OLS estimates, Figure 7 illustrates the main finding in the post period. The graph plots standardized values of milk/butter ratios over standardized logarithmic values of inverse distance to peat. The closer the creamery is to peat, the less milk is needed to produce one kilogram of butter. This means that the creamery is more productive when it is closer to areas where the soil type is suitable for peat. The baseline relationship in Panel A is negative and statistically significant with a t-statistic of -3.33. When including all controls in Panel B, a similar pattern is illustrated with similar magnitude and a t-statistic of -2.84.

Figure 7: Partial Correlations of Inverse Distance to Peat and the Milk/Butter Ratio



Notes: Panel A uses the specification that includes year fixed effects, creamery fixed effects, number of shareholders (in log) and distance to coast (in log) interacted with year (specification 2 in Table 2). Panel B uses all controls: year fixed effects, creamery fixed effects, number of shareholders (in log), distance to coast (in log) interacted with year, dairy association (region) interacted with year, dummies for energy sources (coal, peat, electricity) (specification 4 in Table 2).

Finally, to understand the effects through time, as well as to investigate the identifying assumption that peat played no role for productivity prior to the First World War, the assumption that the effect was constant is now relaxed and the year-specific effects are estimated using a flexible difference-in-differences approach as specified in the following equation:

$$MBratio_{c,t} = \sum_{\substack{t=1900 \\ t\neq 1913}}^{1928} (InverseLogDistance_c \times Year_t \beta_t) + \gamma_c + \delta_t + \varepsilon_{c,t} \quad (2)$$

$Year_t$ is an indicator for each of our sample years, including all years from 1900 until 1928, with the exception of the reference year, 1913.

5 Results

Table 2 reports the OLS estimates of the effect of inverse distance to peat on milk/butter ratios. Column (1) includes only year fixed effects, creamery fixed effects, as well as the number of shareholders in logs, while column (2) reports the estimates when adding a control for log(distance) to coast interacted with time. The coefficient β is negative, statistically significant and is not affected by the controls. After 1913, a one standard deviation increase in inverse distance to peat results in an approximately 0.06 decrease in the milk/butter ratio. This suggests that creameries closer to areas where the soil type is suitable for peat and therefore more likely to be able to use peat, used fewer kilograms of milk to produce one kilogram of butter, and were thus more productive.

Table 2: Standard Difference-in-differences results

	MB ratio			
	(1)	(2)	(3)	(4)
Inverse Log Distance x Post1913	-0.057***	-0.065***	-0.051***	-0.052***
	(0.019)	(0.019)	(0.018)	(0.018)
log(Shareholders)	0.012	0.008	0.019	0.025
	(0.071)	(0.072)	(0.063)	(0.063)
Coal				-0.034
				(0.023)
Peat				0.028
				(0.031)
Electricity				-0.034
				(0.202)
Constant	25.306***	18.342***	32.038***	31.521***
	(0.353)	(3.139)	(3.549)	(3.578)
Year Fes	Yes	Yes	Yes	Yes
Creamery Fes	Yes	Yes	Yes	Yes
log(Distance to coast) x Year	No	Yes	Yes	Yes
Region x Year Fes	No	No	Yes	Yes
R^2	0.619	0.621	0.646	0.650
N	13156	13156	13156	12652

Standard errors clustered in 603 creameries in parentheses. Years included are 1900 – 1928.

Energy includes dummies for use of peat, coal and electricity.

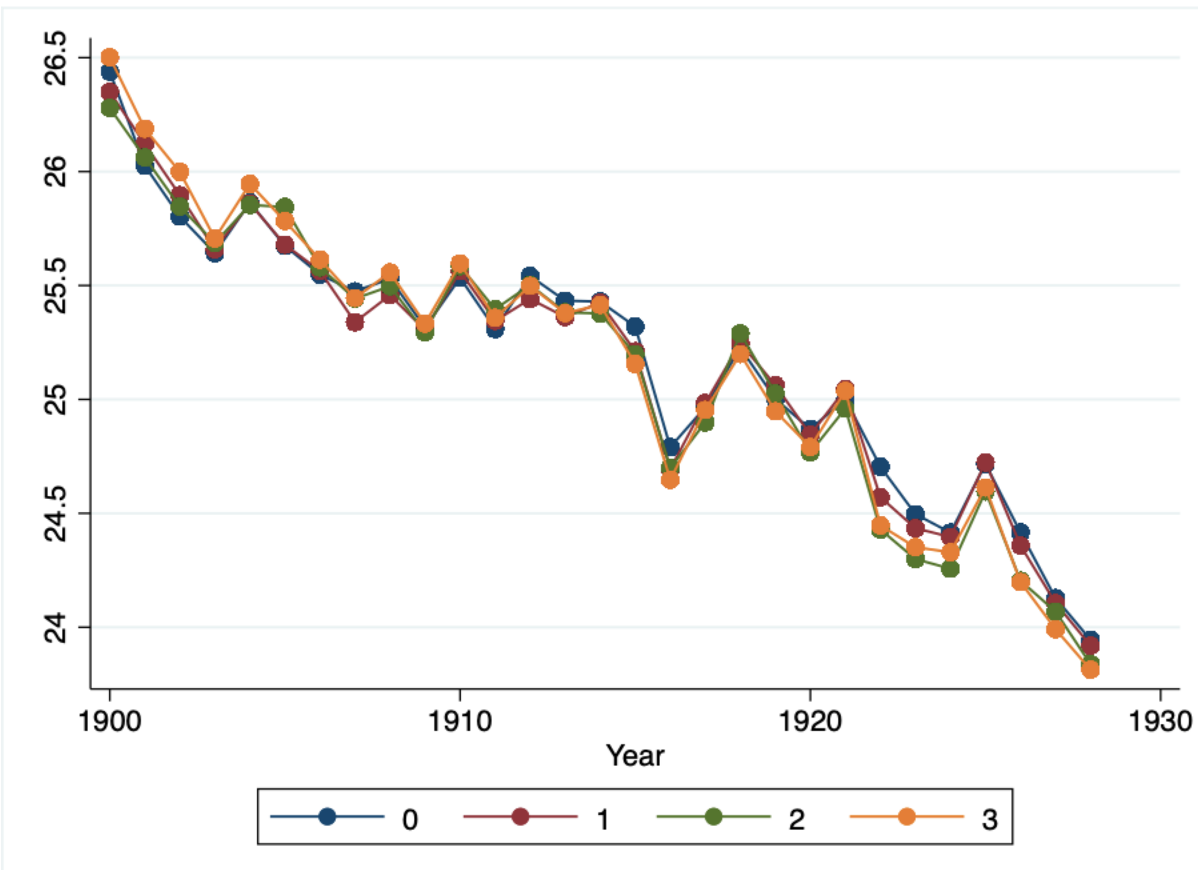
MB ratio and Inverse log(distance) to peat are standardized.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

When further controlling for region-specific linear time trends, the magnitude of the results does not change significantly (column 3) and remains statistically significant.[1] Including further controls for coal use, peat use and electricity use as recorded by MDS (column 4), the magnitude of the result remains the same without losing its statistical significance. Consistent with the main hypothesis, creameries that had access to peat based on their location were significantly more productive than those that did not, following the First World War when imports of coal decreased.

Another way of seeing this is to group the creameries in our sample by *InverseLogDistance* into 4 groups: 0: less than the 25th percentile, i.e. furthest away from peat; 1: 25th-50th percentile; 2: 50th-75th percentile; and 3: more than the 75th percentile, i.e. closest to peat. Figure 8 illustrates the change in *Mbratio* over time. The four groups follow each other closely from around 1900 but from around the time of the First World War groups 3 and 4 are clearly the most productive.

Figure 8: Development of *Mbratio* over time, based on treatment groups by *InverseLogDistance*.



Notes: Group 3 is the average for the 75th percentile of creameries closest to areas suitable for peat extraction.

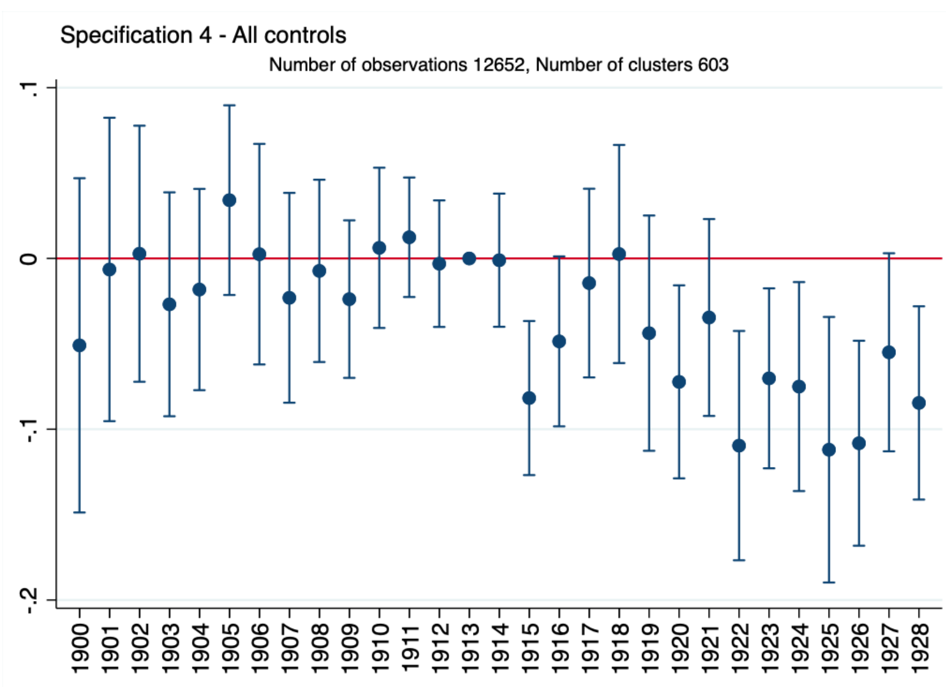
What implications did this have for the individual creamery? In 1916, the creameries in

[1] Region here is the dairy association (following MDS) that the creameries were part of.

Group 0 produced on average 93,660 kg of butter using 2,337,232 kg of milk, giving an *Mbratio* of 24.79 on average. The same year, the creameries in Group 3 produced on average 99,193 kg of butter using 2,478,291 kg of milk, giving an *Mbratio* of 24.64 on average. Thus, the difference in the production of butter was 5,532 kg. This difference in production was worth 17,402.75 kroner (based on export prices), the equivalent of around $120 thousand in today's prices, and not insignificant in a highly competitive industry. On the macro level this would have had massive implications for the Danish economy: Denmark exported ca. 96,000 tons of butter in 1916 to a value of 302 million kroner.

The year-specific results specified in equation 2 are illustrated in Figure 9. The coefficients of the effect on pre-war years are close to zero and not statistically significant, suggesting that there are no pre-war trends in milk/butter ratios that are driving the results. The effects in the years following the war are negative and (most of them) statistically significant with an increase during the years 1917 to 1919, as to be expected given the historical narrative presented above since coal only became scarce towards the end of the war. Specifically, creameries that were closer to peat by one standard deviation experienced a decrease in their use of milk for production of one kilogram of butter ranging from approximately 0.09 standard deviations in 1915 to approximately 0.08 in 1920. When including controls, the results do not change much. What is striking is that the importance of inverse distance to peat persists and even slightly increases in magnitude. Table A.1 in Appendix A reports the year-specific estimates in detail.

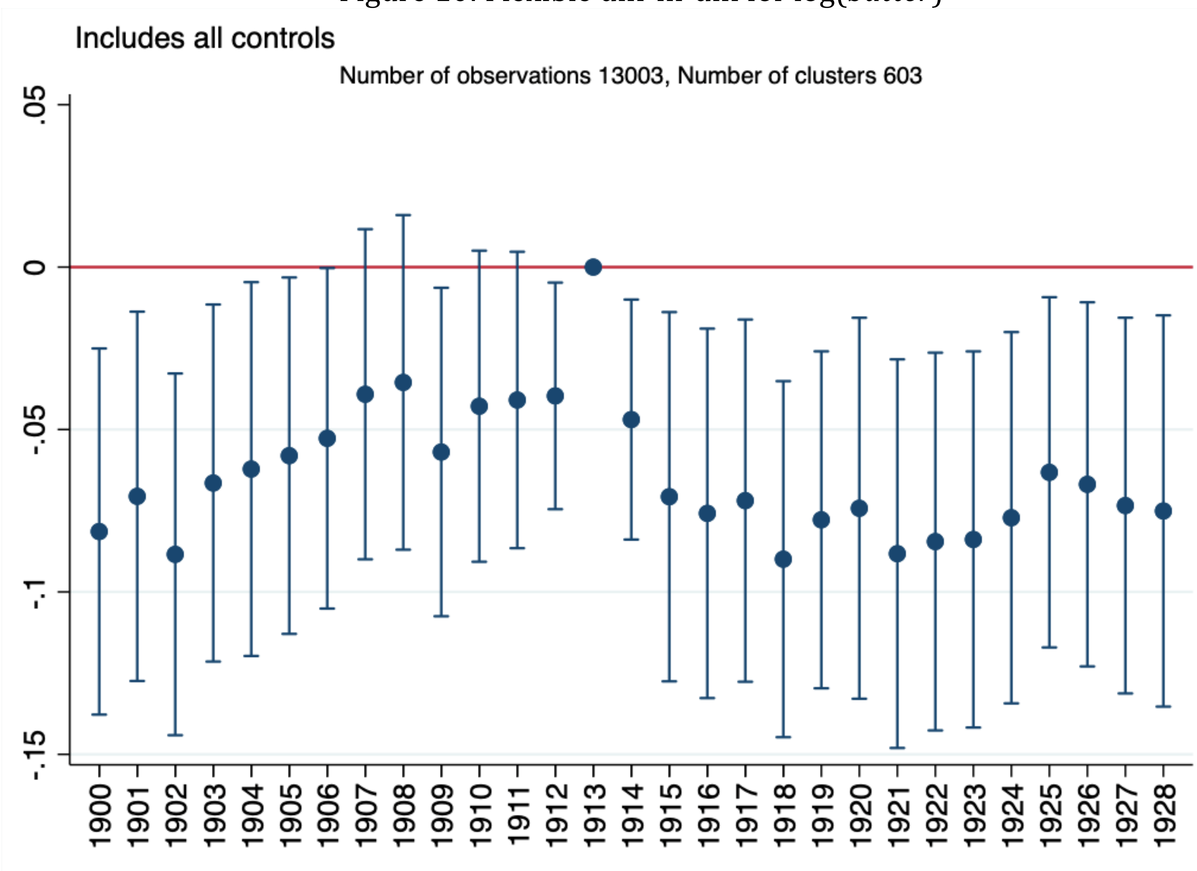
Figure 9: Flexible difference-in-differences results



Notes: We report 95% confidence intervals.

Finally, we consider whether there were differences in the scale of production between creameries located closer to or further away from peat. Thus, Figure 10 performs the same exercise as for Figure 8, but where we consider log(*butter*) rather than *Mbratio* as the outcome variable. One might imagine that the size of the creameries is driving our results, despite our control for the number of shareholders. This does not appear to be the case. Smaller creameries, i.e. those producing less butter, seem generally to have been located closer to peat deposits, and this was the case both before and after the First World War.

Figure 10: Flexible diff-in-diff for log(*butter*)



6 Conclusion

There is a broad consensus that energy resources are important for development, that coal was essential for early industrialization, and some suggestion that alternative energy sources might have been a barrier to modern economic development. Energy economists have, however, highlighted that energy systems need to be adaptable in the face of shocks. We explore this using the case of Denmark, a country dependent on imports of coal for industrialization, but which faced sudden coal constraints with the onset of the First World War. Using a novel dataset of firm-level data on Danish butter factories, we explore their productivity before and after the First World War, when imports of coal from the UK declined and became more uncertain. In a difference-in-differences approach, we showed that creameries closer to areas with soil type suitable for peat were more productive, i.e. they used less milk to produce one kilogram of butter. Thus, as contemporary reports noted, and our empirical results support, Danish creameries proved able to adapt to this difficult situation. However, geographical factors meant that this favored some creameries over others, introducing Denmark to the issues of local energy supply often considered to have been crucial for early industrialization, but which had not previously been an issue (Henriques and Sharp, 2016), due to the easy import of coal to any part of Denmark. Nevertheless, we find that those creameries that were able to adapt maintained a productivity lead until the late-1920s, when shortages of coal ceased to be a concern. Peat was certainly not sufficient to provide a long-term energy diversification strategy, but its availability, and the ability of the creameries to adapt, meant that the industry was not as hard hit as might otherwise have been the case.

References

Allen, R. (2009). *The British Industrial Revolution in Global Perspective*. Cambridge University Press.

Blum, H., and Legey, L. F. (2012). The challenging economics of energy security: Ensuring energy benefits in support to sustainable development. *Energy Economics*, 34(6), 1982-1989.

Boberg-Fazlic, N., Lampe, M., Pedersen, M. U., and Sharp, P. (2021). Pandemics and Protectionism: Evidence from the "Spanish" flu. *Humanities and Social Sciences Communications*, 8(1): 1-9.

Bohi, D.R., and Toman, M.A., (1996). *The Economics of Energy Security.* Kluwer Academic Publishers, Boston/Dordrecht/London.

Cipolla, C. M. (1962). *The Economic History of World Population*. Pelican Books, London.

Cock-Clausen, H. (1921). *Kulforholdene i Danmark 1914-1920*. Copenhagen: Statens Kulfordelingsudvalg.

Crafts, N., and Wolf, N. (2014). The Location of the UK Cotton Textiles Industry in 1838: A Quantitative Analysis. *Journal of Economic History* 74: 1103–1139.

Dahl, C. M., Hansen, C. W., and Jensen, P. S. (2020). The 1918 epidemic and a v-shaped recession: Evidence from municipal income data. *Covid Economics*, 6.

de Zeeuw, J. W. (1978). Peat and the Dutch Golden Age. The historical meaning of energy-attainability. AAG Bijdragen, 21, 3-31.

Dickson, J. (1918). *Shortage of coal and sugar. Statement to Senate Committee on Manufacturing*. Government Printing Office, Washington, DC.

Ducoing, C., and Olsson-Spjut, F. (2021). The energy transition in the Swedish iron and steel sector, 1800–1939. *Journal of Energy History/Revue d'histoire de l'énergie* (JEHRHE), 4.

Ellbrecht, G. (1915–18). *Danske Mejerier. Illustreret haandbog for mejeribruget i Danmark.* Copenhagen: Selskabet til Udgivelse af Nationale Haandbøger.

Fernihough, A. and O'Rourke, K. H. (2020). Coal and the European Industrial Revolution. *The Economic Journal*, 131(635):1135–1149.

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.

Henriques, S., McLaughlin, E., Sharp, P., Tsoukli, X., and Veddel, C. (2020). Opening the black box of the Danish dairy cooperatives: A productivity analysis. Working Papers 0203, European Historical Economics Society (EHES).

Henriques, S. T. and Sharp, P. (2016). The Danish agricultural revolution in an energy perspective: a case of development with few domestic energy sources. *The Economic History Review*, 69(3):844–869.

Henriques, S. T. and Sharp, P. (2021). Without coal in the age of steam and dams in the age of electricity: an explanation for the failure of Portugal to industrialize before the Second World War. *European Review of Economic History*, 25(1):85–105.

IEA (2007). *Energy Security and Climate Policy — Assessing Interactions*. International Energy Agency, Paris, France.

Johansen, H. (1985). *Danmarks Historie, Bind 9*. Danish Historical Statistics 1814-1980.

Kander, A. (2002). *Economic growth, energy consumption and CO2 emissions in Sweden 1800–2000*. Lund.

Kander, A., Malanima, P., and Warde, P. (2013). *Power to the People: Energy in Europe over the Last Five Centuries*. Princeton University Press, Princeton.

Kander, A., Warde, P., Henriques, S., Nielsen, H., Kulionis, V., and Hagen, S. (2017). International trade and energy intensity during European industrialization, 1870–1935. *Ecological Economics*, 139:33–44.

Kelley, N. and Osterholm, M. (2008). Pandemic influenza, electricity, and the coal supply chain: Addressing crucial preparedness gaps in the united states. Technical report, The Center for Infectious Disease Research and Policy (CIDRAP).

Lampe, M. and Sharp, P. (2018). *A land of milk and butter: How elites created the modern Danish dairy industry*. University of Chicago Press.

Landes, D. S. (1969). *The unbound Prometheus: Technological change and development in Western Europe from 1750 to the present.* Cambridge University Press.

Lindmark, M., and Olsson-Spjut, F. (2018). From organic to fossil and in-between: new estimates of energy consumption in the Swedish manufacturing industry during 1800–1913. *Scandinavian Economic History Review*, 66(1): 18-33.

Lo, L. H. (2011, November). Diversity; security; and adaptability in energy systems: a comparative analysis of four countries in Asia. In World Renewable Energy Congress-Sweden; 8-13 May; 2011; Linköping; Sweden (No. 057, pp. 2401-2408). Linköping University Electronic Press.

MacDougall, H. (2007). Toronto's health department in action: influenza in 1918 and SARS in 2003. *Journal of the history of medicine and allied sciences*, 62:56–89.

Melosi, M. V. (1982). Energy transitions in the nineteenth century economy. In H.Daniels, G. and H.Rose, M., editors, *Energy and transport: Historical perspectives and policy issues*. Sage.

Mokyr, J. (2009). *The Enlightened Economy: An Economic History of Britain, 1700-1850*. Yale University Press, New Haven, CT.

Nielsen, H. (2021). Coal and Sugar: The Black and White Gold of Czech Industrialization (1841-1863). *Lund Papers in Economic history*, No. 2021:229.

Normann, H. (1959). *Danmarks Energiforsyning 1900-1958 / Energy Supply of Denmark. Statistiske Undersogelser No. 2*. The Statistical Department, Copenhagen.

Pedersen, S. A. S., Hermansen, B., Nathan, C., and Tougaard, L. (2011). Digitalt kort over danmarks jordarter. 1:200.000. De Nationale Geologiske Undersøgelser for Danmark og Grønland, Klima- og Energiministeriet, Denmark, 2nd edition.

Podobnik, B. (2006). *Global Energy Shifts*. The Energy and Resources Institute (TERI).

Pomeranz, K. (2000). *The Great Divergence: China, Europe and the Making of the Modern World Economy*. Princeton University Press, Princeton.

Ranestad, K. and Sharp, P. R. (2021). Success through failure? four centuries of searching for Danish coal. *Business History* (forthcoming).

Rasmusssen, J. (1982). Dansk mejeribrug 1914-55. In Bjørn, C., editor, *Dansk mejeribrug 1882-2000*, pages 189–308. De danske Mejeriers Fællesorganisation, Odense, Denmark.

Rubio Varas, M. D. M., and Muñoz Delgado, B. (2019). Long-term diversification paths and energy transitions in Europe. *Ecological Economics*, 163: 158-168.

Rydén, G. (2017). Responses to coal technology without coal. Swedish iron making in the nineteenth century. In Evans, C. and Rydén, G. (eds.), *The Industrial Revolution in Iron* (pp. 111-127). London: Routledge.

Schurr, S. H. and Netschert, C. (1960). *Energy in the American economy 1850-1975: An economic study of its history and prospects*. The Johns Hopkins Press.

van der Vleuten, E. (1998). *Electrifying Denmark: A symmetrical history of central and decentral electricity supply until 1970*. Unpublished PhD thesis, History of Science Department, University of Aarhus.

Velde, F. R. (2020). What happened to the US economy during the 1918 influenza pan- demic? a view through high-frequency data. Working Papers 2020-11, Federal Reserve Bank of Chicago WP.

Vögele, S., Kunz, P., Rübbelke, D., and Stahlke, T. (2018). Transformation pathways of phasing out coal-fired power plants in Germany. *Energy, Sustainability and Society*, 8(1), 1-18.

Walker, B., Holling, C. S., Carpenter, S. R., and Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society*, 9(2).

Wrigley, E. (1988). *Continuity, chance and change*. Cambridge University Press, Cambridge, UK.

Wrigley, E. (2010). *Energy and the English Industrial Revolution*. Cambridge University Press, Cambridge, UK.

Appendices

A Table of flexible results

Table A.1: Flexible Difference-in-differences results

	MB ratio			
	(1)	(2)	(3)	(4)
Inverse Log Distance x 1900	-0.056	-0.047	-0.053	-0.051
	(0.043)	(0.044)	(0.048)	(0.050)
Inverse Log Distance x 1901	-0.008	-0.001	-0.016	-0.006
	(0.045)	(0.045)	(0.045)	(0.045)
Inverse Log Distance x 1902	0.010	0.018	-0.001	0.003
	(0.037)	(0.038)	(0.038)	(0.038)
Inverse Log Distance x 1903	-0.025	-0.018	-0.024	-0.027
	(0.034)	(0.034)	(0.033)	(0.033)
Inverse Log Distance x 1904	-0.009	-0.005	-0.020	-0.018
	(0.031)	(0.031)	(0.030)	(0.030)
Inverse Log Distance x 1905	0.046	0.052*	0.034	0.034
	(0.029)	(0.029)	(0.028)	(0.028)
Inverse Log Distance x 1906	0.013	0.018	0.002	0.002
	(0.033)	(0.033)	(0.033)	(0.033)
Inverse Log Distance x 1907	-0.016	-0.012	-0.024	-0.023
	(0.031)	(0.031)	(0.031)	(0.031)
Inverse Log Distance x 1908	-0.002	0.001	-0.008	-0.007
	(0.028)	(0.028)	(0.027)	(0.027)
Inverse Log Distance x 1909	-0.022	-0.019	-0.025	-0.024
	(0.024)	(0.024)	(0.023)	(0.023)
Inverse Log Distance x 1910	0.005	0.007	0.005	0.006
	(0.024)	(0.024)	(0.024)	(0.024)
Inverse Log Distance x 1911	0.012	0.013	0.011	0.012
	(0.018)	(0.018)	(0.018)	(0.018)
Inverse Log Distance x 1912	-0.004	-0.003	-0.004	-0.003

	(0.019)	(0.019)	(0.019)	(0.019)
Inverse Log Distance x 1914	-0.000	-0.001	-0.002	-0.001
	(0.020)	(0.020)	(0.020)	(0.020)
Inverse Log Distance x 1915	-0.079***	-0.081***	-0.081***	-0.082***
	(0.023)	(0.023)	(0.023)	(0.023)
Inverse Log Distance x 1916	-0.046*	-0.048*	-0.047*	-0.049*
	(0.025)	(0.025)	(0.025)	(0.025)
Inverse Log Distance x 1917	-0.016	-0.019	-0.017	-0.014
	(0.028)	(0.028)	(0.028)	(0.028)
Inverse Log Distance x 1918	0.001	-0.003	0.000	0.003
	(0.032)	(0.032)	(0.032)	(0.033)
Inverse Log Distance x 1919	-0.043	-0.048	-0.043	-0.044
	(0.036)	(0.036)	(0.035)	(0.035)
Inverse Log Distance x 1920	-0.069**	-0.074**	-0.070**	-0.072**
	(0.029)	(0.029)	(0.029)	(0.029)
Inverse Log Distance x 1921	-0.034	-0.039	-0.035	-0.035
	(0.029)	(0.029)	(0.029)	(0.029)
Inverse Log Distance x 1922	-0.109***	-0.115***	-0.110***	-0.110***
	(0.034)	(0.034)	(0.034)	(0.034)
Inverse Log Distance x 1923	-0.073***	-0.080***	-0.072***	-0.070***
	(0.027)	(0.027)	(0.027)	(0.027)
Inverse Log Distance x 1924	-0.076**	-0.083***	-0.076**	-0.075**
	(0.030)	(0.030)	(0.031)	(0.031)
Inverse Log Distance x 1925	-0.073***	-0.082***	-0.070***	-0.112***
	(0.027)	(0.027)	(0.027)	(0.040)
Inverse Log Distance x 1926	-0.111***	-0.120***	-0.109***	-0.108***
	(0.030)	(0.030)	(0.030)	(0.031)
Inverse Log Distance x 1927	-0.066**	-0.076**	-0.059**	-0.055*
	(0.030)	(0.030)	(0.029)	(0.030)
Inverse Log Distance x 1928	-0.096***	-0.106***	-0.086***	-0.085***
	(0.030)	(0.030)	(0.029)	(0.029)

log(Shareholders)	0.016	0.003	0.016	0.021
	(0.070)	(0.071)	(0.063)	(0.063)
Coal				-0.034
				(0.023)
Peat				0.023
				(0.031)
Electricity				-0.041
				(0.215)
Constant	25.288***	15.662***	30.197***	29.658***
	(0.351)	(2.575)	(3.126)	(3.113)
Year FEs	Yes	Yes	Yes	Yes
Creamery FEs	Yes	Yes	Yes	Yes
log(Distance to coast) x Year	No	Yes	Yes	Yes
Region x Year FEs	No	No	Yes	Yes
R^2	0.621	0.624	0.649	0.653
N	13238	13238	13238	12723

Standard errors clustered in 603 creameries in parentheses. Years included are 1900 - 1928.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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