Incentives, Technology and the Shift to Year-Round Dairying in Late 19th Century Denmark

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Section 1. Introduction

The grain invasion of the late 19th century has attracted a lot of attention from economic historians and political scientists, who have emphasised the distributional consequences of this episode, and the political responses which it provoked. There has been less written on European private sector responses to the globalization of agriculture which occurred at this time; this is unfortunate, since the ability of societies to adapt to such shocks is crucial for their long-term prosperity. One exception is the literature on Denmark's agricultural transformation during this period. In particular, the success of the late 19th century Danish dairy industry has been noted by a diverse range of scholars and commentators, including Charles Kindleberger, Horace Plunkett, and H. Rider Haggard.[1] Denmark responded to cheap imports of grain from the New World and Ukraine by switching from being a grain exporter to a grain-importing producer of animal products, such as bacon, eggs, and above all butter. Her dairy industry grabbed the lion's share of the rapidly expanding British butter market, establishing a reputation for consistent quality that was reflected in high prices in the market place, which in turn translated into high milk prices for the farmers who supplied Denmark's cooperative creameries.

Viewed from the outside, one of the most noticeable features of the Danish dairy industry was its year-round exports of butter. This contrasted sharply with the very seasonal production patterns common elsewhere. For example, in Ireland in 1909, creameries produced just 22% of their annual output in the six months January-April and November-

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[1] Haggard (1913), Kindleberger (1951), Plunkett (1904). See also Henriksen (1999a, b), Ó Gráda (1977) and O'Rourke (2003) on the development of the Danish and Irish cooperative systems.

December; fully 45% of annual output came in the three months June, July and August.[2] Annual reports of the Irish Agricultural Organisation Society (IAOS) are full of complaints about the impact that this had on the movement's ability to market its butter in Britain; the claim was that not only did this mean that Irish butter only sold during the summer, when prices were substantially lower, but that, having lost their position on the British market during the winter months, creameries were forced to 'bribe' their way back into the market in May or June, by offering their product at a further discount. By contrast, Danish farmers benefited from high winter prices, which as we shall see could be over 30% higher than summer prices; and British retailers were able to rely on regular year-long supplies of Danish butter, which made it much easier for the Danish industry to sell their output there. Evidence of the marketing advantages of winter dairying comes in the fact that it was three large butter grocers who organised, in January 1868, the first of a long series of public exhibitions of winter-produced butters in Denmark's second largest city, Aarhus.[3] This exhibition has been described as a milestone in the history of the Danish dairy industry, and it was extensively covered in the local press. Among other things the importance of early winter calving and winter stall-feeding was underlined at the event.[4]

Why did the Danish industry shift decisively towards a year-round pattern of production, when other major butter producers failed to do so? In what is still the standard English-language history of Danish agriculture during the late 19th and early 20th centuries, Einar Jensen wrote that

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[2]First Report of the Irish Milk Commission, BPP 1913, Cd. 6683, p. 174.

[3] *Tidsskrift for Landøkonomi 1908, p. 354*

[4] Dybdahl (1946-47) p. 72-74.

> ...it is doubtful if Danish farmers consciously have set out to feed the market a regular supply. The real reason seems to be that during the formative period of specialised dairy farming, butter prices during the winter months were so much higher than summer prices that it paid well to develop winter dairying. This fitted in so well with the system of farming that it paid to retain high winter production even after increased supplies from the southern hemisphere changed considerably the seasonal variation in butter prices (Jensen 1937, p. 328).

According to this account, Denmark's timing was fortunate: during the 1870s and early 1880s, when the Danes were developing their dairy industry and the cooperative movement in response to the grain invasion, the absence of refrigeration meant that globalization was not yet affecting the dairy industry. In addition to keeping average prices high, this implied that there was still a substantial winter premium, which provided the incentive for the switch to winter dairying; path dependence (caused, perhaps, by the capital investments required for stall-feeding cattle during the winter) ensured that the new system survived after globalization had removed the incentive.

The argument begs several questions. If Jensen is right, then why did winter dairying not develop elsewhere in response to this incentive? Was the winter premium in fact higher in Denmark than elsewhere during this period, was it particularly high during the 1870s and early 1880s, and did it really decline as suggested above? The Irish cooperative movement was slightly slower to get off the mark than its Danish counterpart, with the first Irish cooperative creamery being set up in 1889, 7 years after the foundation of the Hjedding cooperative in Jutland: was it too late by this stage? If the winter premium did in fact decline, was globalization to blame? How important were southern hemisphere exports during the winter months, and what effect did they have on the winter premium? If the winter premium was in fact similar in different countries, what explains the particularly successful Danish response to the incentive which it represented? And, most fundamentally of all, was the Danish shift to winter dairying in fact as unique as the above discussion has implicitly assumed?

These are important issues in Danish economic history, and in the histories of its economic competitors of the time, such as Ireland. After all, Danish butter exports accounted for roughly 9% of national income in 1900 (Johansen 1985, pp. 191, 391). What is striking about the existing literature is how few data have been brought to bear on the questions outlined above. This paper presents new long run time series evidence, taken from primary sources, on the seasonality of production, trade and prices in the European butter industry, focussing on Denmark, Britain and Ireland. The data allow us to quantify the Danish shift into winter production, and compare this with what was happening elsewhere. They allow us to test the Jensen hypothesis, by comparing winter premia and their evolution across countries, and by assessing the importance of southern hemisphere exports and other factors in driving trends in the premium over time. The paper also uses micro-data for 36 Danish creameries, as well as a range of more qualitative evidence, to describe the forces which led Danish farmers to switch to year-round production.

Section 2 uses new monthly trade data to assess the changing seasonality of British butter imports from Denmark and elsewhere between 1881 and 1914. The evidence shows that the Danish experience was indeed exceptional, and the remainder of the paper is devoted to explaining this development. Section 3 assesses the Jensen argument, by comparing winter premia across countries and over time, using newly collected monthly price data for the period 1870-1914. Section 4 asks what were the determinants of changing price seasonality over time, focussing on the role of southern exports and Denmark’s shift to year-round production, while section 5 looks in detail at the low-tech strategies adopted by Danish farmers which made that shift possible. Section 6 concludes.

Section 2. Changing seasonality in the European dairy industry, 1881-1914

The first task of the paper is to document Denmark's shift to year-round dairying, and to see whether this was indeed an exceptional event as is commonly assumed, or part of a broader European pattern. Ideally, what we would like is seasonal data on production in Denmark, and other traditional butter producers such as Ireland, France and the Netherlands. Section 5 will indeed provide some Danish data along these lines, which will confirm the findings of this section, but not surprisingly such data are not available in a systematic fashion for this period. However, the largest European butter importer of the time, the United Kingdom, did collect monthly data on imports from various countries, and these were published by the British Government in its annual trade returns from 1881. The British import market is a good one to look at for our purposes, since British consumers were very heavily dependent on foreign butter: in 1908, British butter production amounted to just 912,000 cwt.,[5] while imports of butter into the United Kingdom totalled 4,211,195 cwt. Furthermore, Ireland exported 627,000 cwt. of butter in 1908, most of which would have gone to Britain.[6] On the assumption that all UK imports, and all Irish exports, were consumed in Britain, British production accounted for only 16% of British consumption, while imports from outside the United Kingdom accounted for 73%. Imports thus give a good reflection of overall supply in the British butter market. Moreover, in 1908 exports to Britain accounted for 92% of Danish production, so exports to the UK should tell us a lot about the seasonality

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[5] 490,000 cwts. were sold by farmers, and a further 422,000 cwts. were made or blended in factories. *The Agricultural Output of Great Britain*, Cd. 6227, British Parliamentary Papers 1912-13, Vol. X; p. 14.

[6] Solar (1989-90), pp. 159-60.

of Danish production.[7]

Figure 1 gives total imports of butter into the UK (in hundredweight), and also the percentages of imports from a number of individual European countries, as well as from Australasia and North America (i.e. the US and Canada). The sharp decline in total imports in 1885 is an optical illusion, explained by the fact that ‘butterine’ imports were included in the butter totals until that date; these imports had largely been from the Netherlands, which explains the sharp decline in the Dutch share of imports in that date, as well as the rise in the share of Danish and French imports. Otherwise, the figure shows the dramatic rise in the quantity of butter imported by rich, free-trading and industrial Britain during this period; the extraordinary success of Denmark which saw its share of the market rise to over 40% by the end of the period; the gradual decline in the shares of traditional European suppliers such as France, Germany and Friesland, as well as North America; and the rise of new suppliers such as Russia and the Southern Hemisphere. By the end of the period, Australia and New Zealand were accounting for between a fifth and a quarter of total imports, with Argentina (not shown) also supplying between 1 and 2 percent of the market.

Not only did Denmark increase its overall share of the market; it also managed to dramatically lower the seasonality of its exports to the UK. Figure 2 computes an index of the seasonality of imports from the same countries or groups of countries as in Figure 1, for the years 1881-1914. The index is computed as 100*(MAX-MIN)/AVG, where MAX is the maximum observed monthly quantity imported during the year, MIN is the minimum, and AVG is the average monthly quantity imported during the year. Three things stand out from

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[7] *Statistiske Meddelelser*, *Danmarks Vareomsætning med Udlandet*, 4. raekke, 29, 1909.

this figure. First, the seasonality of imports from Denmark declined sharply throughout this period, from about 90 to 30 or 40. The decline was continual throughout the period, rather than being concentrated in a particular subperiod or subperiods. Second, this Danish experience was the exception rather than the rule. The seasonality of Swedish exports remained constant, while the seasonality of imports from traditional suppliers in western Europe, as well as from Russia and North America, increased: for example, the French index increased from 40 to well over 100, while the German index increased from about 100 to 400 or 500. Third, this increase in seasonality from traditional suppliers was sufficiently strong that the overall seasonality of imports into the UK increased very slightly after the late 1890s – from about 30 to between 40 and 50.

Figure 3 gives evidence on the seasonality of production in another major 19th century butter producer, Ireland. From 1870 to 1904, we collected data (published in the *Farmer's Gazette*) on the number of firkins entered for sale in the Cork butter market each week; these were then converted to monthly averages since there were frequently missing data for individual weeks. Figure 3 gives the same seasonality index as before (i.e. 100 times the maximum during the year minus the minimum, divided by the average) for this series for 1870-1904 (after 1904 information on this variable dries up, presumably due to the decline in the importance of the Cork butter market). Coincidentally, from 1904 on the Government started computing official Irish trade statistics after a hiatus of almost 80 years. Figure 3 graphs the seasonality index for this series as well, and the message which emerges is remarkable: it shows that the seasonality of total Irish butter exports (creamery butter as well as farmers' and factory butter) was extremely similar to the seasonality of the Cork butter market.[8] Moreover, the seasonality index for both Irish series is practically constant over time: on the face of it, Irish agriculture made no headway in eradicating this problem, if problem it was, over a thirty year period.

The slight increase in the overall seasonality of British imports documented in Figure 2 occurred despite not only the Danish shift to year-round exports, but the emergence of exports from the southern hemisphere. Figure 4 shows that the seasonality of southern hemisphere (here, Australasia) exports was, as would be expected, very different from the seasonality of imports from the northern hemisphere (i.e. total imports minus imports from Australasia and Argentina). The figure simply gives the average quantity imported between 1893 and 1914, by month. As can be seen, the seasonality of imports from Australasia was almost the complete opposite of that from northern countries. Northern imports peaked in July, and declined sharply in the winter, with the nadir occurring in February. Southern imports, on the other hand, were highest during the winter, peaking in January, and vanishing altogether in the summer months.

Ceteris paribus, the fact that southern hemisphere imports were increasing as a share of the total was increasing winter supply, and lowering the overall seasonality of British butter imports. What is striking about Figure 2 is that despite this trend, overall import seasonality actually increased. Denmark's shift to year-round butter exports was definitely *not* part of a broader European trend. Moreover, as Section 5 will show, the decline in Danish seasonality and the increase in its overall share of the market were in fact intimately linked.

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[8] While the archives of the Department of Agriculture and Technical Instruction for Ireland may yet yield better information on monthly exports, we have had to rely on the graphs of monthly butter exports published in each year from 1904 onwards. We adopted the highly scientific procedure of using a ruler to read the monthly figures off the (rather detailed) axes provided in the graphs; Figure 3 is therefore to be regarded as provisional.

Section 3. Assessing the Jensen hypothesis: winter premia 1870-1914

Was the unique Danish experience due to winter premia being higher in Denmark than elsewhere? Was the increased seasonality of exports from other European suppliers due to their being crowded out of winter markets by southern (and possibly Danish) exports? Did the winter premium in fact decline as suggested by Jensen? In order to answer all these questions we need seasonal price data. We thus collected price data from primary sources (newspapers and price currents) for three markets: Denmark and Ireland (both major butter exporters) and Britain (a major butter importer).

Weekly data on Irish and London market prices were gathered from the *Farmer's Gazette* for the years 1870 to 1914. While prices were available for a large variety of butter qualities, in this paper we focus on just those butter grades for which price quotations exist over the whole period, or almost the whole period. The Cork butter market, in the south of Ireland, had always been the main source of traditional Irish salted butter, produced by small farmers using non-mechanical methods and sold in wooden firkins. For this market, we collected data on first, second and third class 'ordinary' butter, which would have been heavily salted and produced in the traditional manner (prices were available until 1912 only). For Dublin, we collected data on the prices of first, second and third class 'cools,' as well as prices for Irish creamery butter (i.e. butter produced in modern creameries, using mechanically powered centrifugal cream separators) once these prices became available (in 1889). For London, we collected prices of butter from Denmark (1873-1914) and Friesland (1870-1902) (another traditionally important supplier). Finally, weekly prices of the highest grade of Danish butter on sale in Copenhagen were collected from *Maeglernes Pris-Kurant Udgiven af Stadens Maeglere* (The Brokers' List) (1870-1914).

We next converted these data into monthly averages, to take account of the fact that there were frequently missing observations for individual weeks. Finally, for each year we computed an index of price seasonality, namely 100*(MAX - MIN)/AVG, where MAX is the highest monthly price observed within the year, MIN is the lowest price, and AVG is the average price for that year. This index would not be suitable in cases were the supply was so seasonal that prices were only quoted in a small number of (possibly adjacent) months each year (the index might then give the appearance of low seasonality, whereas the opposite was in fact the case).[9] These series were however chosen on the basis that they were the most continuously available among the many prices collected from the newspapers. Where only a small number of monthly observations were available for a particular grade of butter during a particular year, the index was not computed for that year.

Table 1 gives averages of our price seasonality index for two subperiods: 1870-1895 and 1895-1914. The table confirms in a European setting the basic stylised fact documented by Goodwin *et al.* (2002): price seasonality was lower in the later period (with winter premia ranging between 21 and 33%, depending on the grade of butter involved) than in the former one (when they had ranged between 27 and 43%). Declines in the winter premium of around 10 percentage points appear to have been commonplace. Seasonality was more acute for the heavily salted Cork butters than for the other butters, despite the fact that salted butter was more easily stored in a world without refrigeration. This suggests that intertemporal storability was not the only factor influencing price seasonality; the most likely explanation is that the production of this grade of butter was especially seasonal. Finally, prices were more heavily seasonal for higher quality butters, which makes sense in that less deterioration would have been tolerated for a butter to be graded as top quality, and thus the relative supply of top

[9] This possibility did not arise for the trade seasonality index in the previous section, since there were no missing data.

quality butter would have been lower during the winter months.

However, focussing on a straightforward comparison between two subperiods (which is the strategy of Goodwin *et al.*) misses a lot of what was going on. Figure 5 shows the evolution of our seasonality index for each of the price series, and a surprising fact emerges: while price seasonality did indeed decline from the mid-1880s, it actually increased during the 1870s and early 1880s (with prices of Dublin cools being an apparent exception to this general rule). For example, the winter premium for Cork butter started out slightly above 20% in the early 1870s; it was in the 40-60% range in the late 1880s and early 1890s; and then declined so that it lay in the 20-30% range in the early 20th century, slightly higher than where it had started out. Copenhagen winter premia were slightly below 20% in 1870; they lay between about 28 and 38% between 1880 and 1895; and fluctuated widely around a 20% average during the end of our period.

These price data allow us to reach several conclusions regarding the questions raised earlier. First, winter price premia were no higher in Denmark than elsewhere during this period, and indeed this is what you would expect in a well-integrated international market. It is not the case that Danish farmers faced a price incentive to develop winter dairying that did not exist elsewhere. The Jensen hypothesis on it own will not do, therefore, in explaining the different path taken by Danish farmers. Second, however, there was a sharp increase in the winter premium precisely at the time that the Danes began to develop an intensive dairying sector, based on winter production and cooperative creameries. The incentive to develop winter dairying was indeed at its highest when Danish agriculture moved in that direction. While the incentive on its own was not sufficient (since it also existed in Ireland and presumably elsewhere in Europe), Jensen may be right in his assertion that price incentives were important in the Danish case, and that they presented Danish farmers with a moment of opportunity that was seized with both hands.[10]

Third, it is not the case that the incentive to develop winter dairying had vanished by the time that Irish cooperative creameries started to emerge around 1890, since the winter premium only began to fall significantly in the mid-1890s. Again, the difference between Denmark and elsewhere seems, at least initially, to have involved different responses to the same price incentives, not different incentives.[11] However, it is true that by the early 20th century the incentive to develop winter dairying was indeed much lower than it had been in the early 1880s; to that extent, traditional suppliers such as France may indeed have been crowded out of the British winter market. The following section will discuss the reasons for this decline in the winter premium.

Section 4. Why did the winter premium decline?

What caused the decline in the winter premium from the mid-1890s onwards? As already mentioned, Goodwin *et al.* (2002) attribute the decline in the American premium to

[10] If winter dairying in Denmark was in part caused by the sharp rise in the winter premium which occurred during the late 1870s, then it becomes interesting to speculate about what might have caused this increase. Goodwin *et al.* argue that the decline in seasonality documented in Table 1 was due to the adoption of mechanical refrigeration in the mid-1890s, which permitted storage and intertemporal arbitrage. In the following section, we will look at this argument in more detail in the European context, and argue that while refrigeration was probably important, other factors were at work as well. The early increase in price seasonality documented in Figure 5 certainly suggests that more than refrigeration was behind trends in price seasonality during this period: presumably storage technology did not deteriorate during the 1870s and early 1880s. One possible explanation for the increase may be that in the third quarter of the 19th century, tastes gradually shifted away from heavily salted butter, such as that traditionally produced in Ireland, and towards fresher-tasting less-salted butter from France and elsewhere which was at this stage becoming available to British consumers, and which would have deteriorated more rapidly. Testing such a hypothesis against possible alternatives is however beyond the scope of this paper.

[11] We are only discussing output price incentives here; possible differences in input prices will be briefly considered in Section 5.

the adoption of mechanical refrigeration. While not excluding this possibility, in this section we explore two alternative hypotheses. The first is the Jensen argument that the rise in Southern Hemisphere butter exports to Europe in the late 19th century played an independent role in smoothing out price fluctuations, by augmenting the supply of butter during the winter months. Obviously, this North-South trade could not have existed without mechanically refrigerated steam ships, and thus was ultimately due to similar technologies to those emphasised by Goodwin *et al*. However, whereas their article emphasises the intertemporal arbitrage effects of refrigeration, the hypothesis explored here is that refrigeration affected price seasonality via interregional arbitrage. The second hypothesis is that price smoothing may have taken place because of the Danish shift to year-round dairying.

The evidence in Figure 2 that the overall seasonality of imports into Britain actually increased between 1881 and 1914 suggests that refrigeration probably played a role in smoothing out prices in Europe. Of course, the fact that these are only import data – albeit import data for the biggest market in Europe – means that we cannot say anything with certainty about what was happening to the overall seasonality of supplies, either in the British market, or in Europe more generally. However, if these data are reflective of the supply situation in Britain generally, then there was a very small increase in overall supply seasonality during this period. If price seasonality declined, then this must have been due to a reduction in the seasonality of demand, and one likely candidate explaining this is cold storage facilities, in the larger British ports such as London or Newcastle, or in the larger British grocery chains, such as Maypole or the Cooperative Wholesale Society.

However, this does not mean that the decline in Danish seasonality, or the emergence of the southern hemisphere as a major source of supply, was irrelevant: far from it. Figure 6 shows the percentages of British imports during the winter months (defined as November through March inclusive) coming from these two sources, as well as from France. From the turn of the century, Denmark and Australasia accounted for over 60% of winter imports; the figure was over 70% by the eve of the Great War. (By contrast, in the early 1880s France accounted for twice as many winter imports as Denmark, and Australasia was not supplying butter to the British market at all.) In the absence of the revolution in Danish production methods, and the development of the North-South butter trade, the seasonality of import supply in the British market would have grown much more sharply, and the winter price premium would not have declined by as much as it actually did.

Figure 7 shows the seasonality of total British imports between 1881 and 1914, as well as the seasonality of non-Danish imports and imports from sources other than Denmark or Australasia. At the beginning of the period, non-Danish imports were about as seasonal as total imports, with imports from both sources about 30% higher in peak months than in trough months. By the end, non-Danish imports were considerably more seasonal: while the seasonality index for total imports had risen to just 49% in 1910-13, it rose to 67% for non-Danish imports. Furthermore, the average seasonality index for 1910-13 for imports from sources other than Danish and Australasia was 123%. To put it another way, Danish and Australasian butter combined to make imports in 1910-13 60% less seasonal than they would otherwise have been. This was a huge effect, although it is an upper bound since it ignores the possibility that exports from these countries crowded out winter exports from elsewhere.

The next question that we ask takes account of this last qualification, and it is: by how much would winter prices in Britain have increased during 1906-10, if Danish and Australian winter supplies had been withdrawn from the market? As was the case in Figure 6, winter is here defined as November-March inclusive. Obviously the answer will depend on elasticities of demand and supply, as well as on the size of alternative sources of supply. We consider two possible elasticities of demand: 0.2 and 0.8, both of which correspond to various late 20th century estimates. Elasticities of supply are a trickier concept in this context. The relevant elasticity includes not only the elasticity of domestic (i.e. British) supply, but the elasticity of foreign (including Irish) supply, and also (on the assumption that refrigeration was a serious option at this time) an intertemporal elasticity of supply; that is, if winter imports from Denmark and Australasia had dried up, and the winter premium had increased, then there might have been some summer supplies diverted to winter use. For this reason we assume that the relevant supply elasticities were large, and consider values of 2 and 10 in our analysis.[12]

We consider the following simple relationship:

$$W + S(p) = D(p) \qquad \textbf{(1)}$$

where W represents winter imports from Denmark and Australasia, a parameter whose value will be changed exogenously; S represents all other sources of supply to the UK market, both foreign and domestic, which are taken to depend on the domestic price p; and D represents UK demand, which also depends on p. Totally differentiating this expression yields the following expression (after some manipulation):

$$dW/S + dS/dp(p/S)(dp/p) = dD/dP(p/Q)(dp/p)(Q/S) \qquad \textbf{(2)}$$

where Q is the total amount supplied to the UK market (i.e. Q = W + S). Solving this for the

[12] If the true elasticities were lower, this would of course strengthen our argument that imports from Australasia and Denmark had a large impact on British price seasonality.

percentage change in prices yields

$$dp/p = (-dW/S)/[E_S - E_D(Q/S)] \qquad \textbf{(3)}$$

where E_S and E_D represent elasticities of supply and demand respectively.

Between 1906 and 1910, winter imports from Australasia averaged 581,549 cwt. annually, while winter imports from Denmark averaged 722,726 cwt. *W* in the expression above was thus 1,304,276 cwt.[13] Imports from the rest of the world averaged 483,743 cwt. while Irish exports averaged 617,400 cwt.;[14] S(p) was thus 1,101,143 cwt. Finally, as already mentioned the 1908 Census of Production estimated British annual butter production as 912,000 cwt. We made two alternative and extreme assumptions about the seasonality of this production. The first is that British production was spaced evenly throughout the year, and that British winter production was thus 380,000 cwts. (=912,000*5/12). The second is that British seasonality was so pronounced that British winter supplies were zero. In the first case, *S* in the equations above is 1,481,143 cwt.; in the second case, *S* is equal to 1,101,143 cwt. The truth presumably lay somewhere between these two estimates.

Table 2 gives the results. The final column shows the percentage change in the British winter price resulting from (A) withdrawing Danish winter supplies from the market; (B) withdrawing Australasian winter supplies from the market; and (C) withdrawing both these sources of winter supplies from the market simultaneously. For each scenario 8 estimates are

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[13] Figures cited in text do not add up exactly because of rounding.

[14] Solar, *ibid.* We assume that all Irish exports went to Britain; if some went elsewhere, we are underestimating the impact of Danish and southern hemisphere supplies on British winter butter prices.

given, corresponding to our two assumptions about demand elasticities, our two assumptions about supply elasticities, and our two assumptions about the spacing of British domestic supply. As expected, the impact on domestic winter prices of withdrawing Danish or Australasian winter supplies from the market is higher the lower are elasticities of demand and supply, and the lower is domestic winter supply. The estimates are quite large. Even assuming supply elasticities of 10, the average impact of withdrawing Danish supplies on the British winter price is around 5%, while the average impact of withdrawing Australasian supplies is around 4%. Together, winter imports from these two sources lowered British winter prices by 9% on average, even assuming these high supply elasticities; and by around 35% assuming unitary supply elasticities. This compares with a decline in the winter premium of 10-20% between 1890 or so and the start of the First World War. Clearly the advent of Southern Hemisphere butter on the European market had a large impact on European price seasonality; and Denmark's swimming against the tide, and shifting into winter dairying despite Australasian competition, had an even bigger impact. To this extent Denmark may have benefited from a first mover advantage of sorts, in that its own shift to winter dairying made a similar shift less attractive for others. But what were the forces that underlay this Danish shift in the first place?

Section 5. The decline in Danish supply seasonality

Section 2 and Figure 6 demonstrated a dramatic increase in the amount of Danish butter being shipped to the British market during the winter months. It is not the case that mechanical refrigeration was a force behind the early acceleration in winter exports of butter from Scandinavia to Britain. Mechanical refrigeration was only diffused in the Danish dairy sector during the second decade of the 20th century (Etwil 1993) and storing facilities in

Danish harbours could not have accounted for any large intertemporal arbitrage on the Danish side of the North Sea. Rather, this smoothing of exports from Denmark was the result of a conscious effort by Danish dairy farmers to raise production in the winter months.

We would have liked to supplement the data in Figure 2 on trends in the seasonality of exports with corresponding official data on trends in the seasonality of Danish milk production. Not surprisingly, this cannot be done. However, reliable information from a large number of ordinary farms was collected on the initiative of the cooperative creameries from 1898 onwards. Participating in this survey was optional and the rate of participation grew rapidly over time. It appears that the creameries which sent in their data were a fairly representative sample of cooperative creameries generally.[15]

We have collected information on the annual distribution of milk production for a panel of 36 creameries in six counties, representing a variety of geographical environments within Denmark. Each of the 36 creameries had 100-175 members. Some creameries reported their annual production in 13 four week periods (probably for reasons of accountancy) whereas others reported monthly production. The information is summarized in Table 3.[16] We compare the average seasonality in the first year in which this is possible with the average 11 years later, in 1908. Even at this relatively late stage we see that the creameries were making progress in smoothing out production. This is consistent with the finding in Figure 2 that the seasonality of Danish exports declined continuously from 1881 to 1914. In 1898, the ratio between the share of production in the peak month (June) and the trough month (November)

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[15] Based on a reading of more than 200 books of minutes of cooperative creameries, it appears that some elite creameries did not report until late on, while some less successful creameries reported at an early date. Whether creameries participated in the survey or not appears to have been to some extent random.

[16] Appendix A gives the figures for individual creameries in both years.

was 1.6; by 1908, this ratio had declined to 1.4. To put the achievement in context, the scattered evidence which we have suggests that seasonality had historically been a serious problem in Denmark. For example, in the 1830s just 1% of the annual production of a farm in Fyn took place in December, January and February, while 56% took place in June, July and August, an even higher proportion than the 45% cited earlier for Ireland in 1909: “it was [then] considered the trick to overwinter the cows with as little concentrates as possible” one author tells us.[17] By contrast, in Denmark in 1908, creameries produced 46% of their annual output during January-April and November-December, and 27% in June, July and August.

How was this decline in the seasonality of Danish milk supply achieved? Note first that the fact that Danish seasonality had historically been high implies that there was no immutable geographical reason forcing Danish farmers to produce all year round. Such was the argument of an Irish commentator of the mid-20th century, J.P. Beddy (1943), who stated that Denmark's “rainfall and general climatic conditions did not point the way to grazing,” and that her agricultural policy thus

> involves the growing of large quantities of cereals and forage crops for animal fodder which is supplemented by imported feeding-stuffs of high protein content...Climatic conditions are such that animals must be housed for a comparatively large part of the year and hence extensive farm buildings are required not only for this purpose but for the storage of fodder. This constant care of livestock is associated with that regular, as opposed to seasonal, production of livestock products which is so important a feature of marketing...

Figure 7 showed that Danish exports were no less seasonal than exports from other non-UK sources as late as 1881; there was thus a shift in production structures away from an Irish-style seasonality which remains to be explained. One possibility is that Denmark’s transition to intensive dairying may have been facilitated by relatively low wages. In 1870,

[17] J. B. Krarup (1901) p. 245.

unskilled urban male wages in Ireland were 49% of British wages in 1905, and Dutch wages were 57%; Danish wages were just 36%. In 1890, the figures were 75%, 83% and 57% respectively; it was only in the following decade that Danish wages overtook wages in the other two countries, but by that stage the transition to cooperative winter dairying had already taken place (Williamson 1995). Furthermore, the increased labour requirements of dairy farming, that is the milking work and the work related to the growing of root crops for animal feed, was first met by women who had until then been underemployed. However, low wages on their own were neither sufficient nor necessary, since otherwise Denmark would have shifted to winter production even earlier, and perhaps abandoned the strategy in the 20th century, by which time her wages were amongst the highest in Europe.

Another argument is that capital may have been relatively abundant in Denmark; a Danish expert visiting Ireland in 1909 argued that

> For the Irish butter exports to be tolerably distributed over the year the present system will have to be revolutionized. The calving is timed in the spring for the sake of raising the young calves. Should this be changed byres will have to be built and feed stuffs imported.... Purchase of feeds and building of byres requires big outlays and, in addition to that, the whole working of the farm must be changed from permanent grass to arable land. The Irish farmer lacks the funds for making this transformation and unlike the Danish farmer he does not reckon the manure to be of value. Since he owes the whole purchase sum of his farm no money can be raised unless the government will lend it to him. And the crux of the matter is, I suppose, whether butter is more profitable than beef. A change towards whole year butter production necessitates the growing of roots [beets] and these plants take, besides some experience, more labour.[18]

It is unlikely that capital was scarcer during this period in the United Kingdom, of which Ireland was a member, than it was in Denmark; after all, Britain was the world's foremost capital exporter of the time, and the available evidence suggests that Ireland was exporting capital as well (O'Rourke and Williamson 1999, Chapter 11). It is possible, though,

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[18] Schou (1910), p. 266.

that capital markets may not have worked sufficiently well to channel investment funds to Irish farmers. Credit cooperatives never really took off in Ireland as they had done in Germany (Guinnane 1994); while in Denmark small local savings banks to a large extent fulfilled the same task as credit cooperatives elsewhere, supplying credit to people with little or no security for loans.[19] Besides, the cooperative creameries in Denmark in some instances granted credit for the purchase of feed stuffs, cf. below. Furthermore, the transfer of land from landlords to farmers was taking place in Ireland during the period, whereas in Denmark land reform had taken place much earlier: already by 1835 there were 41,695 peasant proprietors in Denmark, as opposed to 24,795 tenant farmers.[20] In addition to occupying peoples' energies and fuelling agrarian unrest, this may have locked up farmers' capital in the purchase of their own land, as the above quotation suggests, when it might have been more usefully employed in various productive investments, including facilities for stall feeding.[21] On the other hand, a comparison with Holland suggests that agrarian calm and the availability of capital were not sufficient to ensure a shift towards winter dairying, since both conditions were present in this traditional dairy producer,[22] and yet as Figure 2 showed Dutch exports to Britain became more seasonal during the late 19th century, not less so.[23]

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[19] Guinnane and Henriksen (1998) p. 52-54.
[20] Jensen (1937), pp. 125-26.
[21] More useful, that it, for total agricultural output, but not necessarily for individual farmers' incomes. On the Irish Land Wars, see also Solow (1971) and Guinnane and Miller (1997).
[22] Dutch farmers borrowed heavily to finance purchases of fodder, artificial fertiliser and cattle during the crisis of 1880-1900. On the other hand, by 1890 they were sufficiently heavily indebted that their borrowings were seen as a serious problem impeding the further development of the industry (van Zanden 1994, p. 133). As in the Irish case, therefore, there may have been some problems with the way in which Dutch capital markets worked in practice.
[23] On the other hand, we do not know what happened to the seasonality of Holland's exports to Germany during this period, which were a significant proportion of total Dutch exports (Smidt 1996, p. 142). It is also possible that Dutch winter production largely supplied the domestic market.

The key factor in the Danish case was technology: not the ‘high-tech’ technologies associated with refrigeration, but new ways of feeding cattle, which were transmitted rapidly throughout Danish agricultural society. It was the systematic creation of knowledge based on experimentation and observation by practitioners and academics, and the diffusion of that knowledge, which were crucial. First, a correlation was established between the amount of concentrates, in the form of grain, bran, and oil seed cakes, fed to a milch cow, and the amount of milk it yielded at any time. This corresponded with the experience of some large dairy farmers and agricultural schools but did not go unquestioned until well into the 1880’s. A series of scientific experiments that started in 1883 supervised by the Agricultural University provided the evidence. The main result (summarized in *Mælkeritidende* 1895, p. 731) was that within a fairly wide interval there was a close correlation between the input of various feeds of equivalent nutritional value, and the output of milk per period of the experiment (Table 4). Furthermore, as indicated in the footnote to Table 4 these experiments provided the basis for substituting various fodder materials for each other.

Second, it was found that by feeding in the winter time the milking period could be prolonged by the same number of months, thus maximising lactation. Not only could cows yield more milk at any time as a result of more fodder; they could also give more milk over a longer time period. The increase in winter production was thus closely correlated with a rise in total production. A cow that calved in, for example, November would continue to give milk throughout the summer after it was put out to graze in April or May, and would only go dry in September or October. Left to itself the active milking period of an animal in the Northern Hemisphere would typically be from May to about September-October. Popular understanding of this fact apparently dates far back in time. According to a textbook edited in 1875,

"…it was said, more than twenty years ago that a cow that calves in March calves twice…Consequently you lost none of the summer's production by bringing the cow to produce something also in the winter. By now, however, there has been a further demand on the cow's nutrition and production and the time of calving has been pushed further forward so that now the proverb says it is a Christmas cow that calves twice." (Buus 1875, p. 52)

Textbooks recorded the results of various experiments speaking to this issue. Thus, Buus (p. 78) reported an annual surplus production of between 23 and 31% per animal, depending upon breed, for cows that calved in February compared with April.

What was needed for this to have an effect on the behaviour of dairy farmers was convincing evidence of the economy of this measure. In order to make their point to the reader, Danish textbooks on dairy farming from the 1870s onwards introduced the pedagogical concepts of 'maintenance' and 'production' fodder. The first served only to keep the animal alive during the winter season, whereas the second served to expand milk production. Translated into economic terms the argument for winter stall-feeding was that the maintenance cost and other fixed costs of a cow were so large that minimum average total costs were only obtained at a much larger scale of production than that applied by most farmers. Thus, Svendsen (1886, p. 270), in the most influential textbook of the late 19th century, compared the practice quoted by Buus with his own. By adding 36 per cent more fodder he obtained an increase in production of 71 per cent. To put it another way, sparse winter stall-feeding implied under-utilization of the farmer's animals, which formed an important part of his capital equipment. One further advantage was that a highly recommended ingredient in the cows' winter feed, rapeseed cakes, demonstrably had a good effect on the texture and taste of the butter (Svendsen 1886, p. 112)

To further convince dairy farmers of the advantages of winter production the seasonal variation in product prices was brought in as a strong argument, consistent with Jensen. The product in question was light salted butter that fetched the highest price but would not keep for very long in the absence of cold storage. Information first came to the dairy farmers from merchants who traded on the British market, for example via the butter exhibitions mentioned earlier. The textbooks then diffused this knowledge about winter prices more widely; for example, Buus (1875, p. 56) sets the winter premium as high as 30 per cent in the early 1870s, slightly higher than the premia apparent in Figure 5. What is striking in the Danish case, therefore, is the way in which technical information was sold to farmers on the basis of hard-headed commercial considerations.

The ways in which this scientific and commercial knowledge was diffused to dairy farmers cannot be fully documented. We can observe formal channels of information: journals and books, the teachings of agricultural schools and, most importantly, the Danish agricultural extension service. It is difficult to quantify the effectiveness of these channels in Denmark compared with in other countries. The number of agricultural advisers in cattle and dairy farming was not particularly impressive: 37 advisers in cattle farming and 8 in dairy science was the maximum during this period, attained in 1905. However, Denmark was fortunate in that three factors facilitated communication: a high rate of literacy, a homogenous population and a small geographical size. In this context, one person would have a wide audience.

The various agricultural associations that flourished from the 1860s were probably most influential in the diffusion of knowledge. Among the associations the cooperative creameries were crucial.[24] Not only did they impart knowledge by inviting agricultural advisers to give lectures, and sometimes by handing out leaflets to the members; most of

[24] In 1903 the cooperatives processed the milk from 81 per cent of all Danish milch cows.

them forced specific feeding practices on their members. The statutes of the cooperative creameries invariably made provision for winter production by stall-feeding. To take one example, the Dybdal cooperative on the island of Bornholm simply bought the prescribed amount of rape seed cakes and sold it on to the members. The price was deducted from the members' payment for their milk supply. Another, more typical, model was found in Sæby, Northern Jutland. The acquisition of feedstuffs was left to the individual farmer, but he had to present the invoice for rape seed cakes at the request of the cooperative board. Failing to do was penalised. Just like individual farmers, or even more so, the cooperative had a strong incentive to utilize its capital equipment and its skilled staff at an optimum scale throughout the year.

The creamery statutes on feeding only applied to cows that were actually giving milk in the winter months. This extra feed would have been wasted on dry cows. Consequently, there must have been an inducement for dairy farmers to start production in, for example, November, in the first place. Very likely the explanation was the easier access to economies of scale in marketing, including the winter premium, offered by the cooperatives.[25] Being in a cooperative offered dairy farmers a safer return on their investment. Small and medium sized farmers were dependent on a guaranteed outlet of their milk in the winter before they ventured into winter stall-feeding. Big farmers were big enough to have a personal reputation with the grocer, and therefore could reap the potential winter premium anyhow. (The evidence we have on the early encouragement of winter production by butter grocers tells us that big farmers was their main initial target group.) There are no written records on the fate of individual private creameries in Denmark (since they were not associations and therefore

[25] See Rashid (1988) on the quality problem in contestable markets. This can be overcome when small sellers collude.

not faced with the obligation to hold meetings and write minutes), and so it is difficult to quantify the extent to which cooperatives were more successful than private creameries at stimulating winter production.. However, a jubilee publication of a cooperative on the island of Funen tells us of the private precursers to cooperatives in that region that "in summer the quantitity of milk could be satisfatory but in the winter it would decline to a minimum."[26]

To summarize: the decline in the seasonality of the Danish dairy industry was the result of an increase in winter stall-feeding. This not only reduced seasonality, but increased the milk yield per cow: thus, the shift to year-round dairying and the overall increase in Denmark's share of the international market were intimately linked. Equations (1) and (2) in Table 5 make use of the survey data on Danish cooperatives alluded to earlier; they regress the yield per cow on the seasonality of milk production in both 1898 and 1908. Consistent with our argument, there is a very strong relationship between these two variables in 1898 (that is, yields were higher where seasonality was lower), with variations in seasonality across cooperatives accounting for nearly 40% of the variation in milk yields in the sample. The elasticity of milk yields with respect to seasonality is smaller in 1908, and the equation only explains about 20% of the variation in milk yields. This is presumably due to the fact that there was less variation in seasonality across creameries: equation (3) shows that declines in seasonality between 1898 and 1908 were higher in creameries where the seasonality had initially been higher: i.e. there was a convergence across creameries during this period.

Further evidence of the importance of stall-feeding comes from a comparison between Denmark, Ireland and Holland. Prior to the grain invasion of the 1870s and 1880s, Denmark

[26] *Bregninge andelsmejeri* (1924) p. 2. Presumably private creameries might have made contractual provisions for winter production. Since, however, for other reasons, the number of cooperatives grew remarkably fast in Denmark they took upon themselves the task of promoting winter production among small and medium sized dairy farmers.

had been a net exporter of grain, suggesting a potential comparative advantage (relative to its western European competitors) in tillage activities (see Table 6). A rough comparison using cattle units and crop units in the late 1870’s shows that Irish farmers were at an *initial* disadvantage, with a ratio between feed and animals of about 6 compared to a Danish ratio of about 9 (Henriksen 1999a). From 1883 on, Denmark became a net importer of grain and other types of concentrated fodder; at this stage, all countries could potentially import crucial feedstuffs such as oilseed and oilseed cakes. However, in the early 20th century the figures for imported feed stuffs were 372 Kilos per cattle unit for Denmark, but only 28 Kilos for Ireland (Schou, 1910, pp. 266-67). Table 7 contrasts the development of winter stall-feeding in Denmark and Holland; it gives the use of or the imports of[27] oilseed and oilseed cakes, because these were mainly stall-fed to milch cows. It shows that both countries expanded production by having more animals and by feeding them better. It also shows that the use of this specific feed stuff accelerated considerably faster in Denmark than in the Netherlands. This fits well with the development of the relative seasonality of their butter exports which can be observed in Figure 2. We cannot explain why Dutch dairy farmers chose a different strategy from their Danish colleagues. We can, however, observe a notable difference in the point of departure. Figure 8 indicates that Dutch dairy farmers initially had much better breeds of animals. In spite of low winter production compared to Denmark, their annual yield was higher. In 1914 the difference in annual yield per cow was small. Danish dairy farmers had increased their annual production, mainly through added winter production.[28]

[27] Which are in the Danish case identical.
[28] Further indirect evidence of the link between stall-feeding and seasonality can be seen in Figure 2: the seasonality of butter imports from several European countries increased dramatically in 1914, when imports of overseas fodder to Europe decreased. Denmark was an exception during the first years of the war, when Britain facilitated a continuation of imports to Denmark. (In 1917, however, the Danish luck ran out, and during the last years of the war

Section 6. Conclusion

Moving to winter dairying allowed Danish farmers not only to reduce the seasonality of their supply, but to increase overall output, by making maximum use of their fixed capital. What have we learned about the reasons for Denmark's success?

Seasonal price data show that the incentives to shift into winter dairying were particularly high in the late 1870s and early 1880s, which is precisely when the Danish shift took place. Furthermore, several factors served to lower the winter premium from the mid-1890s; not just refrigeration, the factor stressed by Goodwin *et al.*, but also the emergence of southern hemisphere exports, and the Danish shift to winter dairying itself: in the case of the latter factor, the Danes benefited from a first mover advantage, in that once they had entered the winter market, it was less attractive for others to follow suit.

Jensen is probably right therefore to stress the price incentives which Danish farmers faced; indeed, as we have seen, those price incentives were stressed by Danish agricultural reformers. However, these incentives cannot on their own explain the Danish shift, since our price data show that farmers elsewhere faced winter premia that were every bit as high as the Danish premia. Prices may have created a demand for innovation, but the supply of innovation varied across countries. While initially low wages may have helped, the crucial factor in Denmark was the generation of empirical knowledge by a combination of the private and public sectors systematically analysing the empirical evidence; the rapid diffusion of this knowledge in a highly educated society via lectures, exhibitions and written materials, as well as by institutions such as the new cooperative sector; and a willingness to absorb this knowledge by profit-maximising farmers.

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milk production per cow decreased by 39 per cent.)

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Table 1. Seasonal price gaps, 1870-1895 and 1895-1914

100*(Maximum-Minimum)/Average

	1870-1895	1895-1914
Cork 1sts	37.3	32.8
Cork 2nds	43.2	31.0
Cork 3rds	38.0	28.4
Dublin cools, 1sts	34.5	25.4
Dublin cools, 2nds	34.1	24.4
Dublin cools, 3rds	30.6	22.0
Dublin, Irish creameries	31.7	21.0
London, Danish	27.4	22.0
London, Friesland	36.5	27.7
Copenhagen, highest price	28.9	23.7

Source: see text.

Table 2. Effects of withdrawal of Australasian and Danish supplies on winter prices

Panel A. Impact of withdrawing Danish supplies on winter price

Domestic supply assumptions	Elasticity of demand	Elasticity of supply	Percentage change in price
Evenly spaced	-0.2	2	20.5
No winter production	-0.2	2	26.9
Evenly spaced	-0.8	2	13.9
No winter production	-0.8	2	17.5
Evenly spaced	-0.2	10	4.7
No winter production	-0.2	10	6.3
Evenly spaced	-0.8	10	4.2
No winter production	-0.8	10	5.6

Panel B. Impact of withdrawing Australasian supplies on winter price

Domestic supply assumptions	Elasticity of demand	Elasticity of supply	Percentage change in price
Evenly spaced	-0.2	2	16.5
No winter production	-0.2	2	21.7
Evenly spaced	-0.8	2	11.2
No winter production	-0.8	2	14.1
Evenly spaced	-0.2	10	3.8
No winter production	-0.2	10	5.1
Evenly spaced	-0.8	10	3.4
No winter production	-0.8	10	4.5

Panel C. Impact of withdrawing Australasian and Danish supplies on winter price

Domestic supply assumptions	Elasticity of demand	Elasticity of supply	Percentage change in price
Evenly spaced	-0.2	2	37.1
No winter production	-0.2	2	48.6
Evenly spaced	-0.8	2	25.1
No winter production	-0.8	2	31.6
Evenly spaced	-0.2	10	8.5
No winter production	-0.2	10	11.3
Evenly spaced	-0.8	10	7.7
No winter production	-0.8	10	10.1

Source: see text.

Table 3. The annual distribution of milk production, Denmark
(per cent of annual production)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	
Period	1	2	3	4	5	6	7	8	9	10	11	12	13
1898	6.29	6.94	7.12	7.14	7.84	8.32	9.17	10.26	9.83	8.82	7.83	7.09	6.68
1908	6.86	7.22	7.39	7.72	8.06	8.53	9.11	9.61	8.97	8.06	7.33	6.86	6.7
Diff.	0.57	0.28	0.27	0.58	0.21	0.21	-0.1	-0.65	-0.85	-0.76	-0.49	-0.23	0.02

Source: *Mejeri-Drifts-Statistik*. Odense: Miloske bogtrykkeri 1899 and 1909.

Table 4. Feed and output

No. of Feed units[1]	Fat per cent	Kilos of milk	Kilos of butter
154	3.21	102	3.70
168	3.22	110	3.82
184	3.21	122	4.24

[1] 1 feed unit in this particular context was equal to 0.5 kilo of grain, 0.5 kilo of oil cakes, 0.5 kilo of bran, 5 kilos of beets, 6.25 kilos of turnips, 1 kilo of hay and 2 kilos of straw.

Source: see text.

Table 5. Seasonality and yields, 1898-1908

Equation	(1)	(2)	(3)
Dependent variable	Yield in 1898	Yield in 1908	Change in seasonality, 1898-1909
Constant	8.24	8.5	-0.41
	(-150.29)	(-168.65)	(-3.74)
Seasonality in 1898	-0.39		-0.32
	(-4.74)		(-1.97)
Seasonality in 1908		-0.16	
		(-2.83)	
R squared	0.398	0.196	0.102

Source: *Mejeri-Drifts-Statistik* 1899 and 1909. T-statistics in parentheses. Seasonality = (MAX-MIN)/AVG; yield in pund per cow per year (2 pund = 1 kilogram).

Table 6. Grain yields in Kilos per head in Europe 1871-80

Rye	Denmark	212
	Northwest Europe	89
	Europe	97
Barley	Denmark	265
	Northwest Europe	57
	Europe	47
Oats	Denmark	261
	Northwest Europe	97
	Europe	78

Source: Thomsen and Thomas (1966), p. 139.

Table 7. Indices of the number of cows and the quantity of oil cakes

	The Netherlands		Denmark	
Year	Number of cows	Use of feed cakes	Number of cows	Imports of oil seed cakes
1877[1]	100	100	100	100
1893[2]	96	150	125	310
1903	107	359	135	1352
1910	117	429	143	1803

Source Knibbe (1993) and Bjørn (1988).

[1] Average 1875-79 for Denmark. [2] Average 1890-94 for Denmark.

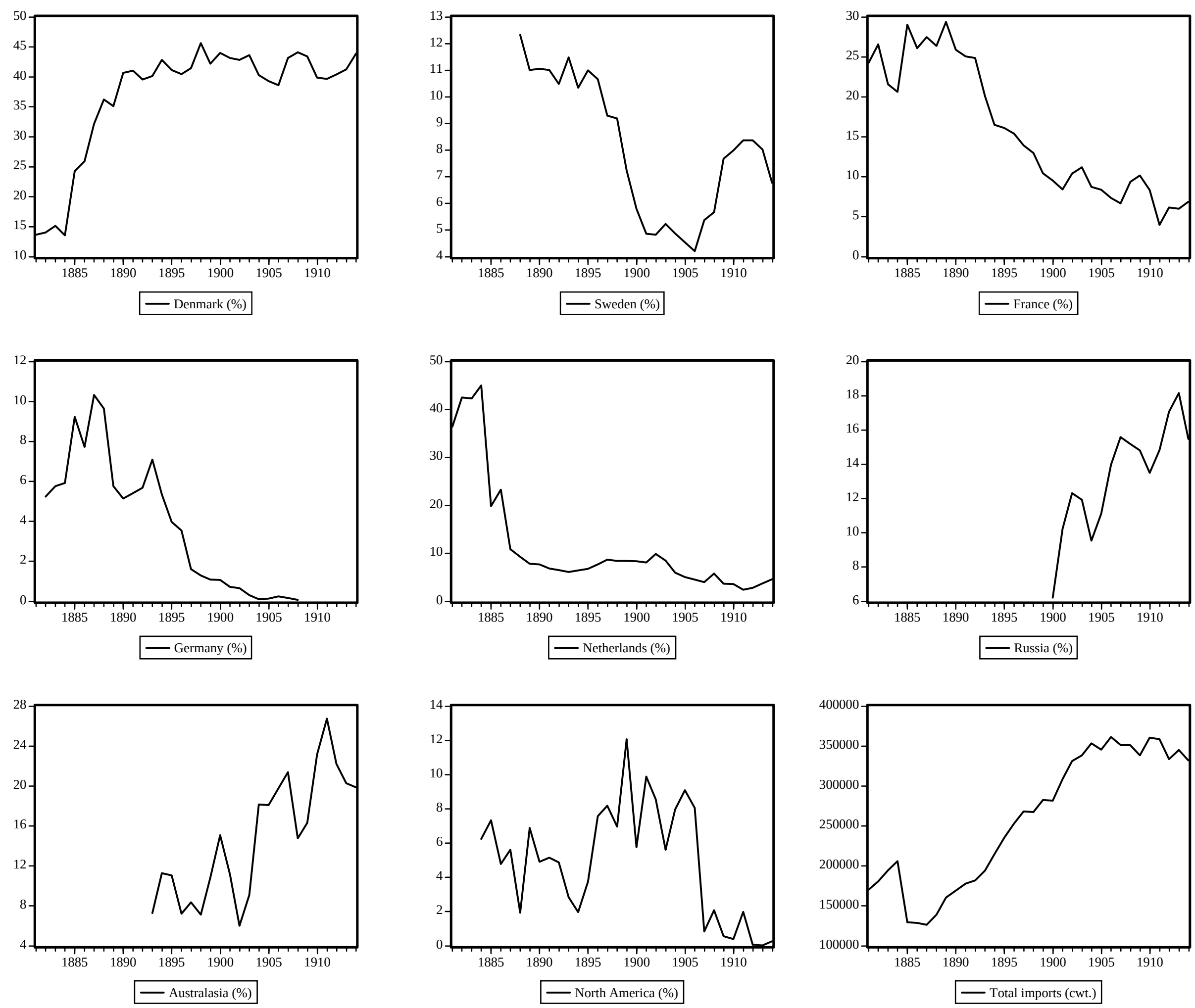


Figure 1. Average monthly butter imports, 1881-1914

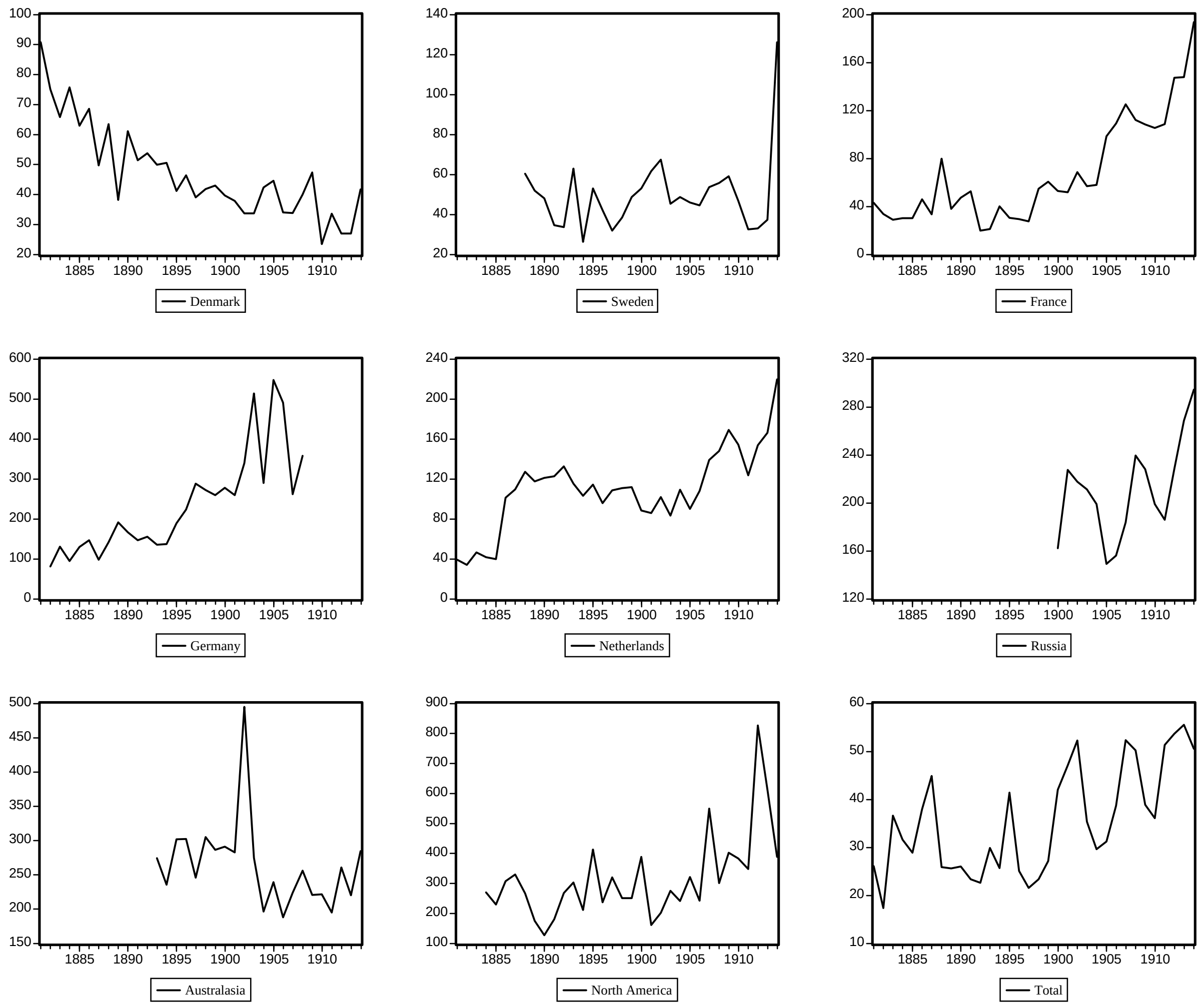
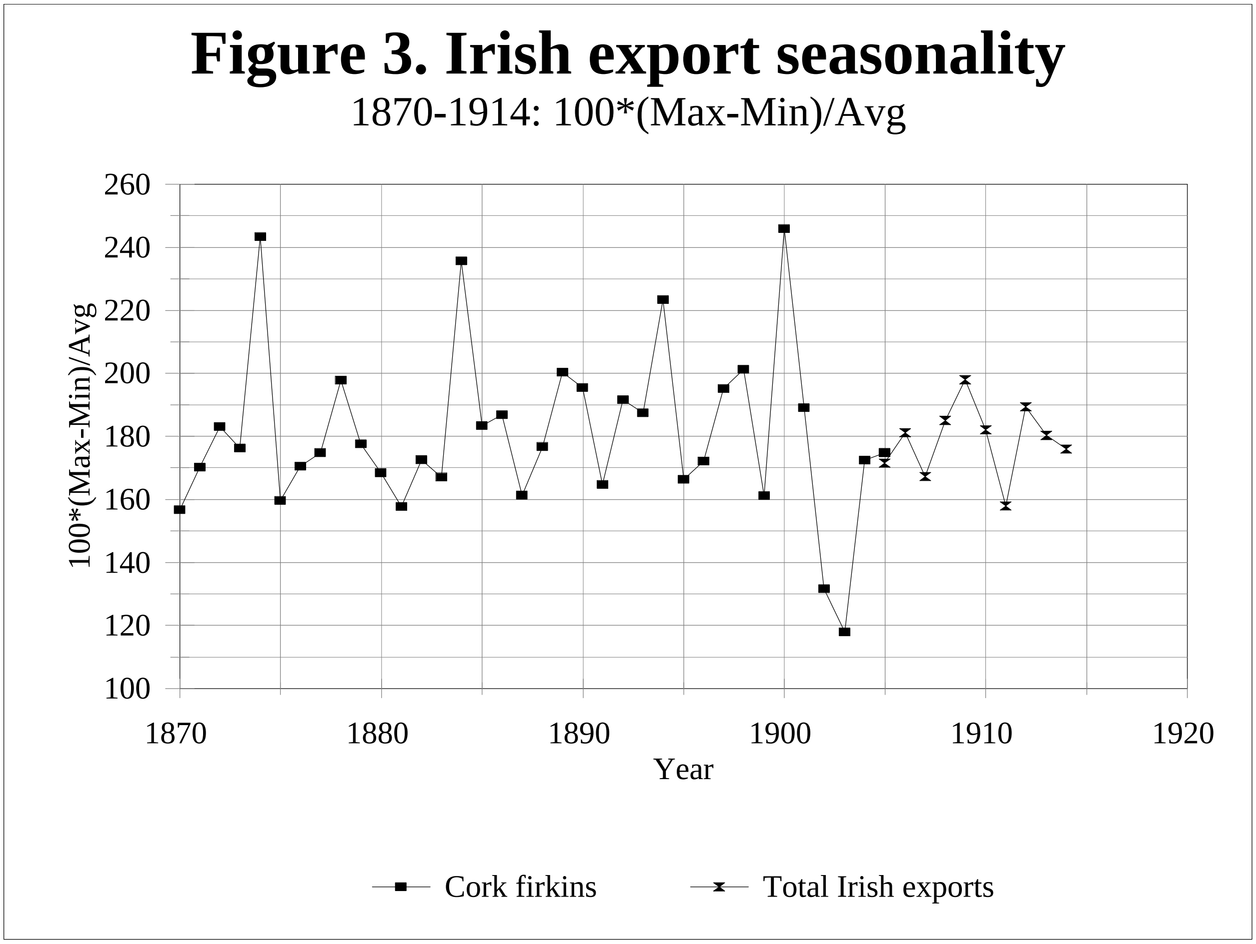


Figure 2. Import seasonality, 1881-1914: 100*(MIN-MAX)/AVG



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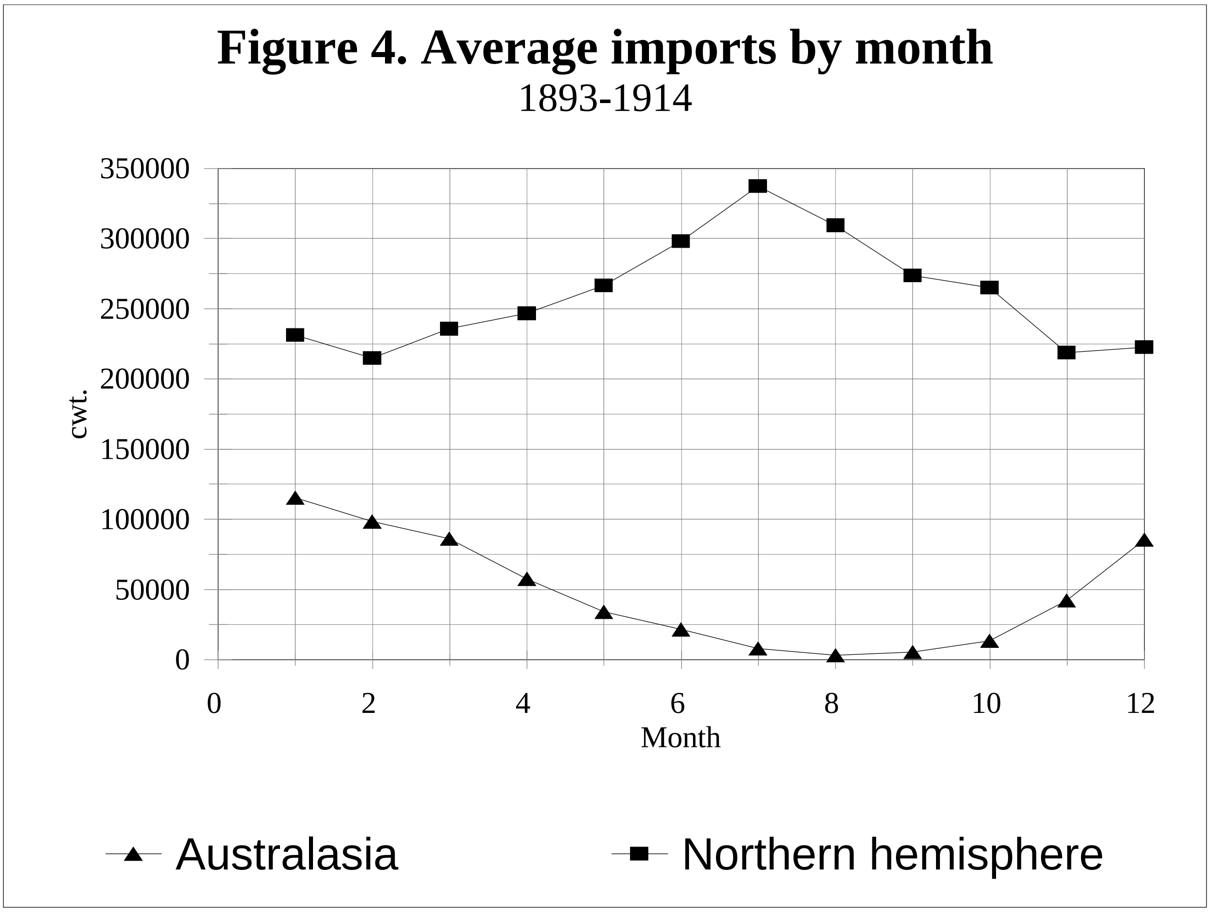

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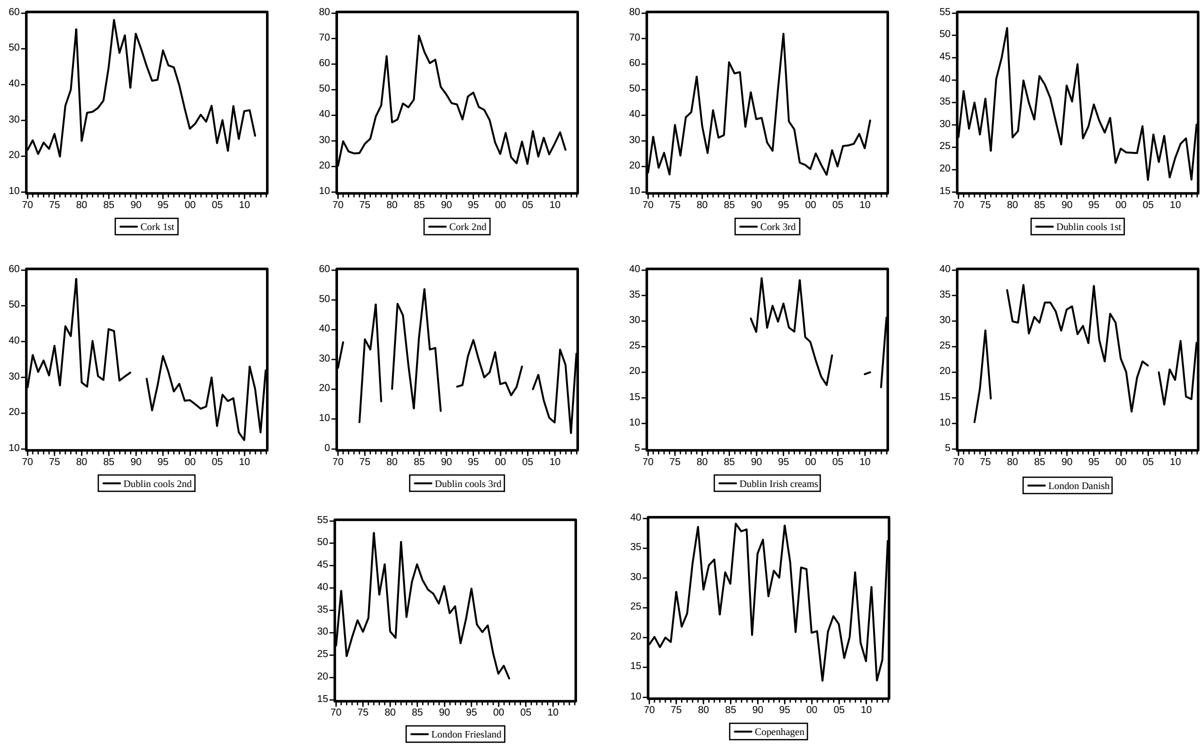
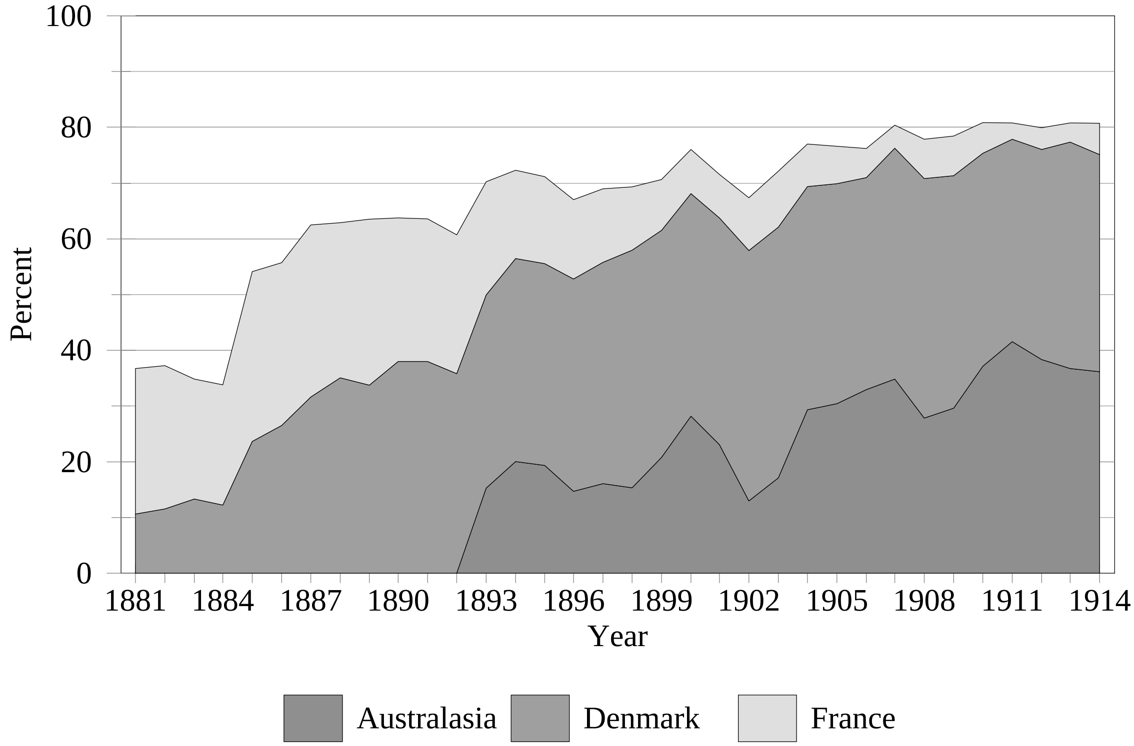


Figure 5. Price seasonality, 1870-1914: 100*(MAX-MIN)/AVG

Figure 6. Winter imports 1881-1914

Percent of imports, November-March



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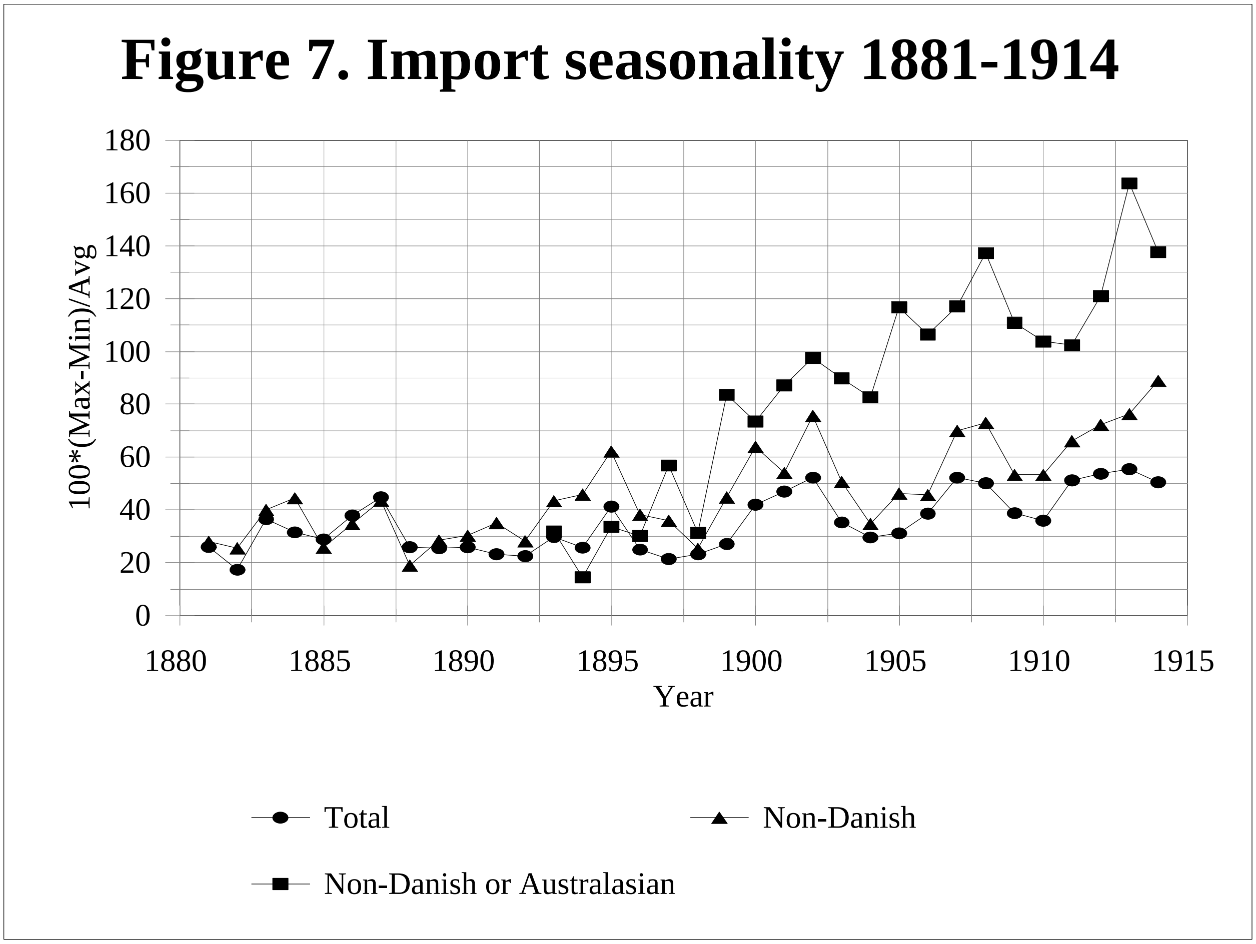
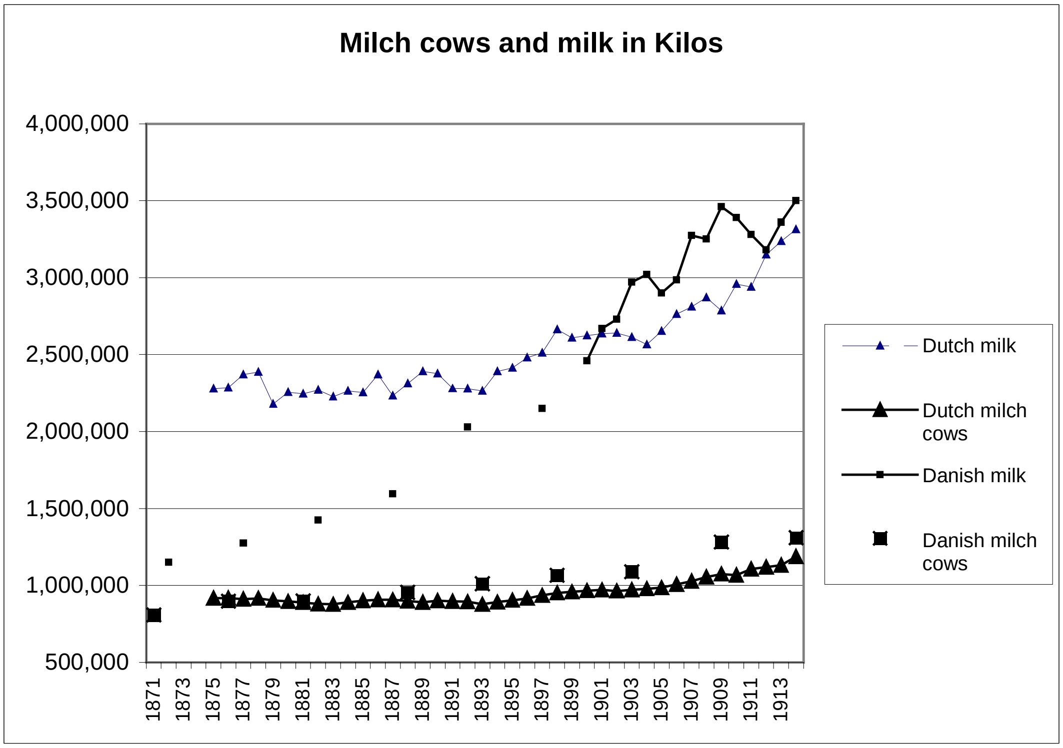


Source: see text.

Figure 8. Milk production in Denmark and the Netherlands, 1871-1914



Appendix A

The distribution of milk production by 13 four week periods or by month (percent)

1898

County	Creamery	1	2	3	4	5	6	7	8	9	10	11	12	13
Fyn	Skovgaarde	6,2	6,9	7,3	6,8	7,9	8,4	10,6	11,2	10,4	9,3	8	7	
Fyn	Rosvang	6,1	6,6	7,3	7,7	8	8,5	8,8	9,7	9	8	7,5	6,7	6,1
Fyn	Kappendrup	6,1	7,1	7,7	8,3	8,6	8,9	9	9,4	9,2	7,4	6,5	6	5,7
Fyn	Guldbjerg	6,1	6,6	7,5	7,8	8	8,2	8,5	9,6	8,8	7,8	7,5	6,8	6,8
Fyn	Aunslev	5,5	6,1	6,4	6,7	7,3	7,8	8	9,7	9,6	9,2	8,6	7,4	7,7
Fyn	Holmstrup	6,8	7,1	7,7	7,2	8,2	8,2	9,7	10,3	9,7	9,2	8,1	7,8	
Fyn	Engholm	6,4	6,6	6,8	7	7,4	8	9,8	9,8	9,1	8,6	7,9	6,5	6,1
Fyn	Aastrup	6,3	7,3	8,5	7,8	9	8,9	9	9,1	8,2	7,3	6,5	6,2	5,9
Fyn	Jægersminde	5,4	5,7	6,1	6,3	6,5	7,1	8	10,7	10,5	9,6	8,9	8	7,2
Fyn	Tallerup	5,7	5,7	6	6,6	6,5	6,9	8	10	10,1	9,8	9,3	8,4	7
Fyn	Tarup	6,3	6,7	7,2	7,6	8	8,3	8,5	9,6	8,9	7,9	7,5	6,9	6,6
Fyn	N. Lyndelse	6,2	6,2	6,3	6,8	7,1	7,3	7,8	9,3	9,8	9,3	8,9	8	7
Fyn	Ubberud	6,4	6,8	7	6,5	8	8,3	10,1	11,1	10,3	9,6	8,6	7,3	
Fyn	Heden Vantínge	5,4	5,9	6,2	6,4	6,7	7,2	7,9	9,8	9,6	9,4	9,6	8,5	7,4
Fyn	Jordløse	6,8	6,5	6,7	7	7,1	8,4	9	8	9,1	8,6	8,1	7,9	6,8
Fyn	Skydebjerg	6,3	7	7,1	7,3	8	8,4	10,4	10	8,7	7,7	6,9	6	6,2
Fyn	Baaring	6,9	7,3	7,7	7,3	8,5	8,7	9,6	10,4	9,6	8,4	8,1	7,5	
Aarhus	Nonnebjerg	5,6	6	6,7	7,1	7,4	7,8	9,6	11,2	11,1	9,8	9	8,7	
Aarhus	Viruplund	7,5	8,1	7,6	7,2	8,5	8,7	9,8	10,4	9,4	8,4	7,3	7,1	
Aarhus	Kildevang	6,9	9,2	7,8	8	8,2	10,5	8,4	9,1	9,9	8,7	6,5	6,8	
Aarhus	Alhøj	6,5	6,8	6,8	7	7,5	7,5	8,8	11,1	10	9	10	9,1	
Aarhus	Søkilde	4,9	5,7	6,5	6,6	8,2	8,7	10,6	12,9	11,9	10,2	8,1	5,7	
Aarhus	Skovly	5,8	6,3	7	6,9	8,7	9	10,9	11,8	10,5	9,2	7,4	6,5	
Aarhus	Helgenæs	7,2	8,4	6,9	7,4	8,1	8,4	8,4	10,4	9,3	7,9	6,4	5,5	5,7
Aarhus	Tranbjerg	6,6	6,7	6,7	7,2	7,6	7,7	8,4	10,1	9,1	8,2	7,7	7,1	6,9
Aarhus	Lystrup	5,7	6,2	8,3	6,5	6,7	9	9,2	10,9	12,2	8,7	7,7	8,3	
Sorø	Vemmelev	5,3	6,2	6,7	7	7,4	8	8,3	9,8	9,5	8,9	8,6	7,1	7,2
Sorø	Boslunde	6,5	8,7	7,4	7,4	8	10,2	9,1	9,5	10,4	8,1	6,9	7,8	
Sorø	Lundshøj	6,4	7,3	8,3	7,9	9,2	9,3	10,6	10,5	9,2	8,4	6,6	6,3	
Sorø	Harrested	6,6	6,4	6,7	7	9,7	8,6	12,2	8,7	9,9	10,5	7	6,7	
Sorø	Kobberdal	6,6	7,1	7,4	7	7,9	8,2	9,7	10,2	9,7	9,8	8,7	7,7	
Sorø	Bjørnskilde	6,5	6,6	6,5	6,3	8,4	8,9	10,4	10,7	10,6	10,1	8,1	6,9	
Ringkjøbing	Bækmarksbro	6,4	7,5	6,6	6,6	6,8	6,8	7,8	10,3	10,3	9,3	7,2	6	8,4
Ringkjøbing	Phønix	7,1	9,4	7,7	7,6	9,2	8,6	7,2	12,9	9,5	7,4	7,3	6,1	
Silkeborg	Økilde	7,4	8,3	8	7,5	6,3	8,3	9,4	11,1	10,3	9,1	7,4	6,9	
Silkeborg	Vattrup	5,9	6,8	7,2	7,7	7,8	7,8	8,7	10,1	10,3	8,7	7,4	6,1	5,5

1908

County	Creamery	1	2	3	4	5	6	7	8	9	10	11	12	13
Fyn	Skovgaarde	6	7	8	8	9	9	10	10	9	9	8	7	
Fyn	Rosvang	7	8	8	8	8	8	9	9	8	8	7	6	6
Fyn	Kappendrup	7	8	9	9	9	9	9	8	7	7	6	6	6
Fyn	Guldbjerg	7	7	7	8	8	9	8	9	8	7	7	8	7
Fyn	Aunslev	6	6	6	7	7	9	10	10	9	8	8	7	7
Fyn	Holmstrup	7	7	7	8	8	8	8	9	9	8	7	7	7
Fyn	Engholm	7	7	7	7	7	8	9	9	9	8	8	7	7
Fyn	Aastrup	7	7	8	8	8	8	9	11	10	9	7	8	
Fyn	Jægersminde	6	6	7	7	8	8	9	10	10	9	8	6	6
Fyn	Tallerup	6	7	7	7	8	8	8	10	9	9	8	7	6
Fyn	Tarup	7	8	8	8	8	9	10	10	9	8	8	7	
Fyn	Nr. Lyndelse	7	7	7	7	8	9	9	9	8	8	7	7	7
Fyn	Ubberud	6	6	6	7	8	9	10	10	10	8	7	7	6
Fyn	Heden Vantínge	7	7	7	8	8	8	8	10	9	8	7	6	7
Fyn	Jordløse	6	7	7	7	8	8	10	8	9	9	8	6	7
Fyn	Skydebjerg	6	7	7	8	8	8	9	9	9	8	8	7	6
Fyn	Baaring	7	7	7	8	8	8	8	9	9	8	8	6	7
Aarhus	Nonnebjerg	7	7	7	7	8	8	9	10	9	8	7	6	7
Aarhus	Viruplund	8	7	8	8	8	8	8	9	8	7	7	7	7
Aarhus	Kildevang	8	8	9	9	9	9	9	9	8	8	8	6	
Aarhus	Alhøj	8	8	9	9	9	9	10	10	8	7	6	7	
Aarhus	Søkilde	5	6	6	7	7	8	8	10	10	9	9	8	7
Aarhus	Skovly	7	8	7	7	9	9	10	10	9	8	7	9	
Aarhus	Helgenæs	8	8	8	8	7	8	10	12	10	8	6	7	
Aarhus	Tranbjerg	8	8	9	9	9	9	9	9	8	8	8	6	
Aarhus	Lystrup	7	8	8	8	7	9	9	10	11	9	8	6	
Sorø	Vemmelev	6	7	8	8	8	8	9	9	9	8	7	6	7
Sorø	Boeslunde	8	8	8	8	9	9	10	10	8	7	7	8	
Sorø	Lundshøj	7	8	8	8	9	10	10	9	9	8	7	7	
Sorø	Harrested	5	6	6	7	8	9	9	10	10	9	8	7	6
Sorø	Kobberdal	8	7	6	9	9	11	11	8	8	7	7	9	
Sorø	Bjørnskilde	7	8	6	7	8	8	8	9	9	8	8	7	7
Ringkøbing	Bækmarksbro	7	7	8	8	7	8	8	11	9	8	7	6	6
Ringkøbing	Phønix	8	8	8	7	8	8	11	11	10	8	6	7	
Silkeborg	Økilde	6	7	7	7	7	7	8	10	10	8	7	7	9
Silkeborg	Vattrup	7	7	7	7	8	9	9	10	9	8	7	6	6

Source: *Mejeri-Drifts-Statistik* 1899 and 1909.