

Property rights, politics and innovation: creamery diffusion in pre-1914 Ireland

KEVIN H. O'ROURKE

*Department of Economics and IIIS, Trinity College Dublin,
and CEPR and NBER, kevin.orourke@tcd.ie*

This article examines the impact of endowments, property rights and political conflict on the diffusion of cream separators in late nineteenth-century Ireland. Favourable endowments, access to finance and owner-occupancy promoted the spread of cream separators, while in areas with more small farms political conflict slowed down the diffusion of separators as well as of cooperatives. The structure of property rights and political conflict help explain why Irish agriculture was less successful than Danish agriculture during this period.

1. Introduction

This article explores the diffusion of an important agricultural innovation in late nineteenth-century Ireland: the centrifugal milk separator, which made it possible to extract a greater proportion of the butter fat in milk, and to do so more quickly and hygienically. Throughout, the article uses Denmark as a benchmark by which to judge Irish performance, as was the universal practice among Irish agricultural reformers at that time. Separators spread much more quickly in Denmark than in Ireland, despite the fact that both countries were important dairy producers, located in north-west Europe, and selling to the same market (Britain). This article argues that the slower diffusion in Ireland was not just due to different comparative advantages (for example, related to numbers of dairy cattle, and thus indirectly to variables such as land quality, population and climate), but to a variety of institutional and political factors as well. It argues that the structure of property rights mattered for the productivity of Irish farmers, and thus for the demand for cream separators. Furthermore, O'Rourke (2007) shows that a history of violence and political conflict between different social and religious groups hampered the diffusion of another institutional innovation, namely the cooperative organisational form, in Ireland. This article goes on to argue that this may have mattered for the diffusion of cream separators, at least in those regions where cooperation would have been particularly useful.

This article is thus related to several literatures. First, the findings regarding the structure of property rights in Ireland speak to the theoretical literature on firm ownership (Grossman and Hart 1986), as well as to the literature on land reform (Banerjee 2000). Second, the literature on the impact of ethnic divisions and ethnic conflict on economic policies and performance (Easterly and Levine 1997) finds an echo in this article's argument that political divisions between Catholics and Protestants hampered the diffusion of cooperative organisations in Ireland, and thus the diffusion of cream separators in some regions. However, while that literature largely focuses on the impact of ethnic divisions on public policy decisions, this article is concerned with the private sector diffusion of technological and organisational innovations. Third, the article engages with the empirical findings of authors such as Robert Barro (1991), based on cross-country growth regressions, that education is good for growth: a common interpretation is that poor countries may grow more rapidly than rich ones by importing best-practice technology, but only if their educational levels are sufficiently high (Easterlin 1981, Abramovitz 1986). Of necessity, such cross-country regression exercises tend to be fairly crude. It would be nice to know whether these aggregate correlations are really being driven by the mechanisms identified by theory as being important. Does literacy (or indeed political stability, or well-defined property rights) really promote investment and innovation as the theory suggests? In order to answer such a question, it is necessary to look in greater detail at particular innovations, and identify the factors which facilitated or hindered their diffusion. Dairying in late nineteenth-century Denmark and Ireland offers a promising test case (on Denmark, see Kindleberger 1951). The contribution of this article is that it provides detailed empirical evidence at a fairly disaggregated level on the economic effects of property rights, institutional and political forces, education, and other variables, and on the mechanisms which were involved in linking these variables to economic outcomes. The econometric exercises involve Irish rather than Danish data, and the focus is thus on explaining relatively slow diffusion in Ireland rather than rapid diffusion in Denmark. However, a comparative perspective yields benchmarks by which Irish performance can be judged, as well as a range of hypotheses and qualitative evidence that can help to make sense of the Irish data.

Section 2 establishes that the Irish dairying performance was less satisfactory than the Danish between 1880 and 1913, particularly as regards the diffusion of modern cream separators. Section 3 lists some of the hypotheses that have been advanced to explain this relatively unimpressive Irish performance. Three broad classes of arguments are considered: those relating to the local supply of milk; those relating to the costs of investment in the new technology; and arguments blaming poor education. Section 4 tests these various hypotheses econometrically, using cross-country Irish data for

1906. Section 5 broadens the scope of the article. It first reviews briefly the arguments advanced in a companion paper, O'Rourke (2007), concerning the determinants of cooperation in Irish dairying, and then goes on to argue that an inability to sufficiently cooperate may have been harmful for separator diffusion in certain areas. Section 6 concludes.

2. Dairying in late nineteenth-century Denmark and Ireland¹

Many historians of post-Famine Ireland have commented on the differences between the Irish and Danish economies' performances since the middle of the nineteenth century.² Both countries were agricultural exporters, competing for the British market for breakfast goods: bacon, eggs, and, especially, butter. It was a competition which, by common consent, the Danes won hands down. As an outsider, Barbara Solow felt able to comment that 'the Irish are rightly annoyed at always having Denmark held up to them as a good example', but went on to claim that 'there remains much in the history of Danish agriculture that stands as a reproach to Irish farming'.³ But perhaps the greatest tribute to the hold which Denmark has had on those interested in Ireland's economic welfare comes not from an academic but from Horace Plunkett, a leader in the field of Irish agricultural reform around the turn of the century. In 1908, he wrote that 'I have always felt that *Ireland a second Denmark* was no bad ideal for our reformers to set before them.'⁴

While the Irish dairy industry was larger than the Danish one as late as the 1870s, Danish butter exports exceeded their Irish counterparts in the late 1880s, and were almost three times higher by 1914 (Table 1). Both countries' butter exporters were overwhelmingly reliant on the British market; Ireland's share of that market dropped from over 50 per cent in 1860 to just 12 per cent in 1910, while Denmark's increased from 0.6 per cent in 1860 to 37 per cent in 1914 (*ibid.*).

Price evidence shows clearly that this loss of market share was *not* due to Irish producers substituting quality for quantity. Rather, the average relative quality of Irish butter was steadily deteriorating over this period. Official average butter prices in the two countries are available from 1846. These reflect not just general butter price trends, but changing average qualities as well. As can be seen from Table 1, Irish prices exceeded Danish prices until

¹ This section draws on O'Rourke (2006, 2007).

² See for example Crotty (1966), Ó Gráda (1977), or Lee (1989).

³ Solow (1971, p. 151).

⁴ Cited by Ó Gráda (1977, p. 298). In this ideal Plunkett was fully supported by none other than Andrew Carnegie: see Ehrlich (1981, p. 272).

Table 1. *Butter exports, prices and cooperatives, 1850–1914*

Year	Exports, 000 tons		Share of British imports		Official prices, s. per cwt.		Number of coops	
	Denmark	Ireland	Denmark	Ireland	Denmark	Ireland	Denmark	Ireland
1850	2	28	n/a	n/a	39.2	63.0	0	0
1860	2	37	0.6	46.6	57.1	88.5	0	0
1870	7	37	6.8	38.3	82.8	120.0	0	0
1881	12	34	10.3	24.5	107.4	108.3	0	0
1885	18	32	12.5	20.7	95.1	86.3	74	0
1890	43	29	31.7	22.0	101.8	86.6	711	1
1895	52	34	33.2	19.3	102.9	87.4	934*	64
1900	61	35	36.6	16.8	111.9	95.8	1029	240
1905	80	29	34.5	12.1	110.8	99.5	1087	331
1910	89	30	35.2	11.9	109.7	102.6	1164	391
1914	95	36	37.2	15.2	134.3	108.5	1168	445

Notes: n/a = not available. * Obtained by interpolation between figures for 1894 and 1896. Shares of British butter imports are calculated assuming that all Irish exports went to Britain, and that all UK imports were consumed in Britain. Before 1887 the UK import statistics include substantial margarine imports, mostly from Holland; thus Ireland in fact accounted for over 50 per cent of British butter imports in 1860.

Sources: Exports: Johansen (1985, pp. 199–201), Solar (1989–90, pp. 159–60). Shares of British market: Solar (1959–90); Nüchel Thomsen and Thomas (1966, p. 152); Ó Gráda (1977, p. 206). Prices: Danish *Statistiske Meddelelser* (various issues), Irish *Agricultural Statistics* (various years). Cooperative numbers: Danish figures kindly supplied by Ingrid Henriksen; IAOS Annual Reports (various years).

the 1870s, but the gap was rapidly eliminated thereafter, and average Danish prices were higher than Irish ones from 1885. The gap averaged 14.8 per cent between 1905 and 1914. During that time, first-quality Danish creamery butter fetched 6.4 per cent more than Irish creamery butter in Britain, while the margin was 7.3 per cent for second-quality butter (O'Rourke 2006). Roughly half of the 14.8 percentage point gap was therefore due to quality differences within particular product classes, while the remaining half was due to an inferior Irish quality mix.⁵

This inferior quality mix was above all due to the fact that not enough Irish butter was produced in modern creameries, using the new cream separator technology which had been invented in Scandinavia in the late 1870s. Prior to the introduction of the separator, milk and cream had been separated by allowing the milk to sit in containers while the cream rose to the top. The cream was then skimmed off and churned. Separators extracted more cream from the milk (leaving 0.1–0.25 per cent butter fat in the skim milk, as opposed to a minimum of 0.5–1.0 per cent, and more probably 1.0–1.5

⁵ In principle higher transport costs between Britain and Ireland could also have been to blame for lower average Irish prices, but in fact Anglo-Danish price gaps were higher than Anglo-Irish ones for most of the period.

per cent under the old system).⁶ Just as importantly, they also extracted fat from milk which had been shaken in transit, and they extracted the cream more quickly and hygienically. Separators diffused rapidly in Denmark, and by 1914 the overwhelming majority of butter was produced using them. By contrast, in 1907 only 37.2 per cent of Irish butter was produced in creameries, according to a witness to the 1911 Irish Milk Commission. 50 per cent of Irish butter consisted of 'farmers' butter', produced on farms using traditional methods; the remaining 12.7 per cent was 'factory butter', which sounds technologically advanced but was in fact farmers' butter which had been bought up by factory owners and blended to produce a more uniform consistency. The quality advantages of the new technology can be seen from the fact that creamery butter fetched 15 per cent more than factory butter, and 16 per cent more than farmers' butter.⁷ Why was the Irish farming community so much slower than its Danish counterpart in adopting this beneficial new technology?

3. The causes of creamery diffusion in Ireland: hypotheses

Why did cream separators diffuse more slowly in Ireland than in Denmark?

One key factor determining the diffusion of cream separators was of course the availability of local milk supplies. Without milk to process, there was no need for such a technology; the milk supplies needed to be local, since fresh milk was costly to transport. What determined local milk supplies? The most obvious variable is the *number of milch cows*. A second is the *human population* in the area, since people drank liquid milk, and thus reduced the supply of milk available for butter-making, *ceteris paribus*. A third variable, stressed by Cormac Ó Gráda (1977), is the *density of cows* in an area. He argued that it was rational for Irish farmers not to adopt cooperative creameries as enthusiastically as their Danish counterparts, since they faced an economic environment that was different in one crucial respect: Ireland had almost twice as many acres per cow as did Denmark. Creameries needed a minimum milk supply to cover their fixed costs. If there were not enough cows within easy reach, a creamery would not be viable. Ó Gráda found that the number of cooperative creameries in each county or poor law union in 1913 was well explained statistically by cow density, milch cow numbers and population. In areas such as Limerick, which most resembled Denmark, creameries (both private and cooperative) were widely diffused;

⁶ Whole milk contains approximately 3.5 per cent butter fat. See Jensen (1937, pp. 174–6) from where this discussion is drawn.

⁷ These are average figures for 1905–14: see O'Rourke (2006).

they had ‘spread as far as was viable in the Irish context by the 1910’s’ (p. 299).⁸

In the econometrics, I control for two other variables that may have had an influence on the supply of milk. The first is farm size, and in particular the share of very small farms. These are likely to have been less efficient than other farms. In addition, a greater proportion of the milk produced on such farms would have been consumed on the farm (given that a farming family would have consumed roughly the same amount of milk, regardless of whether they worked a small or a large farm), leaving less for the creameries. The regressions will thus include the *share of farms less than five acres in size*. Second, there were topographical and land quality differences between the four Irish provinces that traditionally implied different agricultural specialisations and productivities. Poverty-stricken Connaught in the west had generally poor land, and was the least prosperous province. While there were also several poor areas along the western seaboard of Munster, this southern province contained many of Ireland’s most prosperous dairying areas, in particular the so-called Golden Vale, whose fertile land implied high milk yields. The land in Leinster was relatively good, but cattle farmers there tended (relatively speaking) to specialise in beef rather than dairying. Ulster was the most prosperous province, but this was primarily based on its industry rather on its agriculture; indeed, the land in Ulster was not particularly fertile, and the climate there was slightly harsher than it was further south. The expectation is thus that a *Munster dummy variable* would have a significant and positive effect on the diffusion of cream separators.

Were these endowment variables the only ones that mattered for separator diffusion, or did other factors matter as well, for example the institutional environment of the day? Another factor determining the supply of milk in an area was the productivity of the individual farmer, which was reflected in the milk yields which he obtained from his cattle, and in the butter fat content of the milk. An important tradition in the Irish historiography has debated whether farmer productivity might have been related to the Irish system of land tenure. Irish agricultural land had traditionally been owned by landlords, who let it out to tenant farmers. However, the landlords played no role in running their tenants’ farms. Not only did tenant farmers and their families do all the work on their farms (by the late nineteenth century, labour on the farms was carried out by the farmers themselves, since landless agricultural labourers effectively vanished as a class in the decades following the Famine: see Fitzpatrick 1980); key decisions about how to run their farms, as well as key investment decisions, were taken by the farmers on the ground rather than by the landlords. Indeed, the landlords often lived

⁸ The key variable for Ó Gráda is cow density. He also included the number of cows in his regressions since if you take two hypothetical counties with identical cow densities, there should be more milk, and more creameries, in the larger county with the larger milk herd.

in Britain rather than Ireland, invested little (Ó Gráda 1975), and were for the most part content merely to collect their rent from farmers who farmed the same holding all their lives, and passed it on to their children. The traditional view among Irish commentators held that this landlord-tenant system discouraged investment in agriculture. Not only did absentee landlords not invest, but tenants feared that if they themselves invested, any benefit they derived would be appropriated by landlords raising their rent. If this argument is correct, then owner-occupancy of farms should have been positively related to economic performance. In terms of Grossman and Hart (1986), owner-occupancy represented an allocation of ownership rights that minimised *ex ante* investment distortions (or at least lowered them substantially relative to the traditional landlord-tenant system).

On the other hand, a more recent revisionist literature has argued that (a) the traditional Irish land tenure system did not harm Irish agriculture, and (b) that land reform did not benefit it. The first position was most famously articulated in Barbara Solow's (1971) pioneering contribution. Solow convincingly showed that Irish landlords did not rack-rent or capriciously evict in the years prior to 1870, as the traditional historiography suggested. She then went on the counter-offensive: not only were the land reforms of the late nineteenth century based on a mistaken analysis of landlord-tenant relations, but they actually hurt Irish agriculture. The 1870 Land Act made landlords compensate tenants for (1) eviction (unless the eviction was for non-payment of rent), and (2) the value of any improvements the tenants had made to their holding. Solow claims that one effect of (2) was to cut off landlord investment, as landlords were afraid that tenants might claim compensation for investments the landlords had funded. Thus the Act reduced investment in Irish agriculture at precisely the time when the Great Depression and developments in Denmark and elsewhere made such investment essential.⁹

Second, Solow emphasised that one effect of the turmoil over property rights in land was that enormous effort and resources went, literally, into rent-seeking activities. (By contrast, tenant reform in Denmark had already largely taken place by mid century: see Jensen 1937, pp. 125–6.) The effect of the 1870 Act was, she writes, 'a signal to both sides to "look to their rights" and gird for further battle. But the real problem in Ireland was not the division of a given pie, but the provision of a larger one. . .'¹⁰ She is even harsher about the effects of the 1881 Land Act, which enabled tenant farmers to go to court to obtain judicially determined rent reductions:

Incentives to adjust the economy in the face of new international conditions were to some extent paralysed. There is no need to take too seriously landlord contentions that everybody rushed to court and neglected his farming, but if tenants could increase

⁹ Solow (1971, pp. 86, 198).

¹⁰ *Ibid.*, p. 88.

income more by litigation than by changing agricultural techniques, they would certainly do so. If valuers were swayed by appearances, a premium was even put on worse farming, and consequent dilapidation . . . with the tenants of Ireland crowding into court, no one was thinking about agricultural education, credit and marketing programs, improved cropping, selective breeding, and, in general, ways of assisting tenants to adjust to changed economic conditions.¹¹

More recently, Guinnane and Miller (1997, p. 591) have argued that ‘The Irish [land] reforms contained little that could better the allocation of resources and so had little impact on economic efficiency, even though the end result was the creation of a class of peasant proprietors operating in a free market . . . Land reform in Ireland was much more a wealth-redistribution program financed by Britain than a serious effort to improve the efficiency of agriculture.’

As it happens, these traditional and revisionist hypotheses can be tested with the available data, at least insofar as they relate to dairying. Prior to the Wyndham Act, British government land reform policies had not led to any great transfer of ownership towards tenant farmers. However, that piece of legislation massively subsidised such transfers (see Guinnane and Miller 1997 for details). Landlords were encouraged to sell their estates to the government via cash bonuses and other incentives; tenants were encouraged to buy their farms from the government by a provision which stated that their annual payments would be 10 to 30 per cent *lower* than their existing rents. This meant that all tenants faced an irresistible incentive to buy. Predictably, tenants everywhere immediately tried to buy out their holdings. The resulting transfers of ownership were limited only by the willingness of landlords to sell, and that depended on their own financial and personal circumstances rather than on any pressure from tenants.¹² The Wyndham Act thus gave rise to a massive transfer of ownership of family farms away from absentee landlords and towards farming families; moreover, this transfer of ownership was essentially exogenous to the farmers themselves. By 1906, the year for which there are data, the share of tenant farmers owning their own property ranged from 15.4 per cent in County Louth to 52.5 per cent in County Londonderry. The prediction of the traditional argument regarding Irish landlord-tenant relations is thus that in counties with higher levels of *owner occupancy*, farm productivity was higher, and milk supplies (and therefore the demand for cream separators) was higher, *ceteris paribus*, than in counties where the transfer of ownership from landlord to tenant was less advanced.¹³

So far the discussion has emphasised the supply of milk, and thus the demand for cream separators. But what about their cost? Cream separators required investment, not just in the separator itself, but in the steam engines

¹¹ *Ibid.*, pp. 165–6.

¹² See for example the case of Lord Granard, in Dooley (2001).

¹³ In the discussion that follows, the term ‘farmer’ is used throughout to refer to tenant farmers, or owner-occupiers. It does not refer to landlords.

required to power them, and in the buildings required to house them. Some contemporary observers (and in particular the promoters of the cooperative credit movement) argued that Irish financial institutions were conservative lenders, and that would-be borrowers found it difficult to obtain funds, particularly in the more underdeveloped parts of the country. On the other hand, bank archives reveal substantial lending to farmers and creameries (Ó Gráda 1994), and cooperative creamery records reveal substantial borrowing from banks and other financial institutions. Despite such evidence, I will test the 'financial underdevelopment hypothesis' by including the *number of bank branches per county, per 100,000 of population*, in regressions explaining the diffusion of cream separators.

Another variable which some commentators have argued may have mattered for diffusion is *literacy*, or education more generally. An important strand in the international literature has emphasised the importance of education for technological diffusion in general (Easterlin 1981, Abramovitz 1986, Barro 1991), and for technological diffusion in agriculture specifically. Thus, Schultz (1983, p. 189) argues that education was crucial for Danish innovation, while Griliches (1963) documents the links between education and agricultural productivity in the twentieth-century US. Corresponding to such arguments is one which was widespread in Ireland at the time, namely that Irish peasant farmers were too conservative, suspicious, poorly educated or ignorant to adopt cooperation and the milk separator. Smith-Gordon and Staples, the former an employee of the Irish Agricultural Organisation Society (IAOS, the umbrella group for Irish agricultural cooperative societies), wrote in 1917 that 'the most serious obstacle to the co-operative movement was and remains the conservatism of the Irish farmer. Many projects which would have brought great benefit to the country have been abandoned because the lords of the soil were suspicious, or did not understand' (Smith-Gordon and Staples 1917, pp. 47–8), an opinion with which Liam Kennedy (1976, p. 177) concurs. Even when they did establish creameries, it was claimed that they were often reluctant to invest adequately in them:

It seems absurd to some farmers to sanction the payment of a salary to a skilled Manager (of the creamery) in excess of their own incomes. This is one of the chief short-comings in productive co-operation, and it is this that gives the proprietor his chance. His business instinct shows him plainly that a good man is worth a good wage, and hence it is that some of the very best men the movement has produced have been tempted to leave it for situations outside, where their brains and skill will be adequately rewarded. The Co-operative Creamery Manager is too often driven by circumstances to become a 'rolling stone' . . . He seldom is provided with an adequate residence and his wages are frequently cut down during the winter months, though he has been obliged to compress more than a year's work, done at high pressure, into the summer months. (IAOS 1904, p. 16)

Poor farming might not just have been responsible for the failure to adopt modern creameries. Milk yields in Ireland on the eve of the Great War were at most 400 gallons per cow, up from perhaps 350 gallons in the mid-1850s

(Solar 1989–90, p. 153): an increase of 14 per cent over some sixty years. It was reckoned by contemporaries that they were perhaps 100 gallons less in Connaught (IAOS 1914, p. 11). By contrast, Danish milk yields rose by 22 per cent in the 15 years before 1914, by which time they stood at some 700 gallons per cow (O'Rourke 2006). Ireland's dismal performance in this regard was partly attributed to bulls in Ulster being selected for their meat potential, arguably an example of comparative advantage at work; elsewhere, however, it was claimed that the best heifers were sold, and the 'culls' retained to renew the farmer's dairy herd (IAOS 1914, p. 11). Similarly, the Irish farmer's refusal to engage in winter dairying was often decried as an example of self-defeating conservatism, although the counter-argument just as often heard was that it would not be worth the farmer's while.

The allegation of entrepreneurial failure relies in part on the Irish peasant's supposedly poor education. How did education in Denmark and Ireland compare at this time? Denmark was clearly a more educated society than Ireland in the nineteenth century. Compulsory education, for three days a week between the ages of 7 and 14, was introduced in Denmark in 1814; in 1849 compulsory education was extended to cover a six-day week. Although there are comparatively few data to support the claim, it seems clear that near universal literacy had been achieved in Denmark, certainly by the middle of the century, and probably a lot earlier. In 1859–60, only 3 per cent of military recruits in Denmark were completely illiterate, while 9 per cent could read but not write.¹⁴

By contrast, in Ireland only 74 per cent of bridegrooms could write their names as late as 1880.¹⁵ In 1841, 53 per cent of the Irish population over the age of 5 could neither read nor write; the percentage figure fell to 46.8 in 1851, 38.7 in 1861, 33.4 in 1871, 25.2 in 1881, 18.4 in 1891, 13.7 in 1901, and 11.9 in 1911 (O'Rourke 2006). While a successful national elementary school system had been established in Ireland in 1831, education was made compulsory only in 1892 (1898 for rural areas). Ireland was clearly less literate than Denmark. It is however important to note that educationally Ireland was not a backward society for the time. Mokyr and Ó Gráda show that this was true even for the pre-Famine period, and conclude that pre-Famine Ireland 'was something of an "impoverished sophisticate", in the sense that its literacy level was probably higher than its income level would indicate.'¹⁶ In 1900, literacy in Ireland was higher than in Italy and Austria, insignificantly higher than literacy in Belgium, and insignificantly lower than literacy in France.¹⁷

¹⁴ Cipolla (1969, p. 14).

¹⁵ Flora *et al.* (1987, vol. 1, p. 82). Army recruit data and bridegroom data are fairly comparable for other countries at the time: see Flora *et al.*

¹⁶ Mokyr and Ó Gráda (1988, p. 226).

¹⁷ Flora *et al.*, 1987. Irish literacy was less than Belgian literacy in 1870/71 (64.1 per cent of the population at age 10 and over could read and write in Ireland, compared with 69.4 per cent in Belgium); Ireland had caught up by 1880/81.

However, there were large regional variations in literacy within Ireland. The proportion of the population aged 9 years and over which could neither read nor write in 1911 ranged from 3.4 per cent in County Dublin to 20.6 per cent in County Donegal. The next section will ask whether this variation can help explain the regional diffusion of the creamery cooperative in the early twentieth century.

4. The causes of creamery diffusion in Ireland: evidence

In order to test the hypotheses outlined above, I collected data on the number of creameries in each of the 32 Irish counties in 1906. This year was chosen since it is the only year for which data are available on both private and cooperative creameries, as well as on owner-occupancy. (A data appendix gives data sources and descriptive statistics.) I also collected county-level data on the number of milch cows in 1906 (expressed in thousands); cow density in 1906, defined as milch cows per 1000 acres; population size in 1901 (expressed in thousands); the percentage of farms which were owner-occupied in 1906; the illiteracy rate in 1901; the size distribution of landholdings in 1906; and the number of bank branches per 100,000 of population in 1906.¹⁸

If Ó Gráda (1977) is right, then the only variables that should matter for the diffusion of separators across counties are the number of milch cows, cow density, and population. *Milch cow numbers* and *cow density* should be positively related to creamery numbers, while *population* should have a negative effect. Equation (1) of Table 2 tests these predictions, by regressing total creamery numbers on milch cow numbers (in thousands), population, and milch cows per 1000 acres. A count specification is used because of the nature of the dependent variable, which takes on low integer values for most counties, and is equal to zero in the others. A negative binomial specification is preferred to a Poisson specification, since, when Poisson models are estimated, goodness of fit chi-squared tests show that the data are not Poisson-distributed. Correspondingly, when negative binomial regressions are estimated, LR tests indicate that the overdispersion parameter α is greater than zero. I use the standard NB2 model with mean μ_i and variance $\mu_i(1 + \alpha \mu_i)$ as described in Cameron and Trivedi (1998, pp. 71–2), and implemented via the nbreg command in Stata 8, to model overdispersion.

¹⁸ The population variables were collected for 1901 since there was a population census in 1901 (as well as in 1911). I also ran the regressions using 1906 values for these variables, which were generated by interpolation between 1901 and 1911. Not surprisingly, the results were unaffected. I have presented here the results using 1901 data since these are ‘real’ data, in contrast to the interpolated data which are merely informed speculation. A data appendix gives the sources for all variables.

Table 2. *Negative binomial regressions: the diffusion of separators, 1906 (dependent variable: total number of creameries)*

Sample	(1) All	(2) All	(3) All	(4) All	(5) All	(6) All	(7) Non-Ulster
Milch cows	0.02854*** [0.00695]	0.03275*** [0.00786]	0.00632 [0.00637]	0.01254 [0.00978]			0.01498 [0.00960]
Milch cows per 1000 acres	0.04050*** [0.01080]	0.02653** [0.01066]	0.02925*** [0.00831]	0.02969*** [0.00809]			0.01802* [0.00984]
Milch cows (1871)					0.00906 [0.00634]	0.01603 [0.01087]	
Milch cows per 1000 acres (1871)					0.02187*** [0.00704]	0.01998*** [0.00696]	
Population (thousands)	-0.00612*** [0.00182]	-0.00570*** [0.00162]	0.00124 [0.00203]	-0.00118 [0.00274]	0.00131 [0.00202]	-0.0005 [0.00253]	-0.00511 [0.00336]
Share of owner- occupied farms		0.05173*** [0.01947]	0.06544*** [0.01832]	0.06644*** [0.02125]	0.06716*** [0.02068]	0.07379*** [0.02283]	0.14770*** [0.02982]
Bank branches per 100,000 population			0.06741* [0.03728]	0.07223* [0.04349]	0.06231 [0.04061]	0.0476 [0.04364]	0.04828 [0.10196]
Illiteracy rate			0.04074 [0.03479]	0.05117 [0.03752]	0.02012 [0.03443]	0.00727 [0.03424]	-0.01923 [0.08720]
Share of farms less than 5 acres			-0.10063*** [0.02203]	-0.12260*** [0.03434]	-0.08389*** [0.02221]	-0.08037*** [0.03030]	-0.13058* [0.06678]
Munster			1.88868*** [0.54823]	2.18613** [0.87413]	1.94824*** [0.58609]	2.06409** [0.91420]	2.05025*** [0.76255]
Ulster			-0.3852 [0.34312]	-1.17323 [0.91815]	-0.41004 [0.39142]	-0.59011 [0.98301]	
Leinster			0.63584 [0.51173]	0.76769 [0.69186]	0.29756 [0.54683]	0.26064 [0.71556]	-0.5483 [0.59614]

Catholic share (Catholic-majority counties)				-0.02757 [0.03225]		-0.00714 [0.02841]	
Catholic share (Protestant-majority counties)				-0.04364 [0.04792]		-0.0233 [0.04176]	
Share of farms between 5 and 30 acres				-0.0001 [0.02413]		0.00754 [0.02845]	
Agrarian outrages per 10,000 population				-0.01883 [0.01853]		-0.0177 [0.02051]	
Outrages* share of farms between 5 and 30 acres							-0.00054* [0.00032]
Constant	-1.24562 [0.82150]	-2.07975** [0.81994]	-2.25384* [1.23501]	0.72335 [3.49623]	-1.9341 [1.23415]	-1.01051 [3.32750]	-0.65708 [2.34335]
Observations	32	32	32	32	32	32	23
Log likelihood	-101.1	-97.37	-87.82	-86.82	-89.81	-88.75	-48.49
Pseudo-R-squared	0.17	0.2	0.28	0.29	0.26	0.27	0.41

Notes: Robust standard errors in brackets. *significant at 10%; **significant at 5%; ***significant at 1%.

The three variables all have the signs predicted by theory, and are highly statistically significant. Cow density is the key variable in Ó Gráda's analysis and this remains strongly positive throughout. However, the other two variables lose statistical significance once enough other control variables have been added (Equations 3 and 4). The impact of cow density is large: increasing the number of cows per 1000 acres by one standard deviation (28.3) relative to its mean value of 72.7 increases the expected number of creameries per county by 8.76, relative to an expected value of 6.56 when all right-hand-side variables are set equal to their mean values.¹⁹

However, cow density is not the beginning and end of the story. Column (2) introduces the share of owner-occupied farms into the specification, and the result is a striking confirmation of the argument that owner-occupancy was better for productivity than traditional landlord-tenant arrangements. Moreover, it is also economically significant. The coefficient on owner-occupancy is positive and strongly statistically significant; increasing the share of owner-occupied farms by one standard deviation (9.2) relative to its mean value (29.6) would lead to the expected number of creameries per county increasing by 5.46, relative to an expected value of 6.56 when all right-hand-side variables are set equal to their mean values.

These are big effects. Moreover, this is a robust finding, as a glance across the successive columns in Table 2 will confirm. The results vindicate not only traditional nationalist critiques of the Irish landlord-tenant system, but the predictions of Grossman and Hart (1986) and the associated literature on vertical integration.²⁰ Property rights mattered for the productivity of Irish agriculture, and owner-occupancy was beneficial: this is the first major finding of this article.

Equation (3) introduces the other variables that the previous discussion suggested should matter for the diffusion of cream separators. Bank branch density is positively and significantly related to diffusion, which is a somewhat revisionist finding in the light of Ó Gráda's (1994) view that access to capital was not an obstacle to development in rural Ireland. By contrast, these results suggest that there were more creameries, other things being equal, where there was a greater density of banks. The effect is not as large as the effect for owner-occupancy. Increasing the number of bank branches per 100,000 of

¹⁹ Here and elsewhere results are calculated using CLARIFY (Tomz *et al.* 2001), as described in King *et al.* (2000), and use the specification in Equation (3).

²⁰ In principle one might worry about tenants and owner-occupiers differing in some unobservable way that accounted for the difference in productivity between the two groups, but this was not a factor in this instance. As explained above, the provisions of the Wyndham Act implied that tenants everywhere wished to become owner-occupiers; whether they had in fact become so by 1906 depended solely on their landlords, and there was nothing that tenants could do, or did do, to speed up the process.

population by one standard deviation (4.75) relative to its mean value (17.4) increases the expected number of creameries per county by 2.7, relative to an expected value of 6.56 when all right-hand-side variables are set equal to their mean values. The coefficient loses statistical significance at conventional levels in some other specifications (Equations 5 to 7); nevertheless it remains positive (and roughly the same size) throughout.

Surprisingly, illiteracy does not appear to be related to diffusion (and indeed, while it is statistically insignificant, it has the 'wrong' sign in regressions 3 to 6). There is no evidence here that a lack of education was hampering agricultural performance in late nineteenth-century Ireland, which is a noteworthy finding given the exasperated nature of agricultural reformers' comments on the Irish peasantry of that time. It may be true in general, as Easterlin (1981), Abramowitz (1986) and Barro (1991) argue, that education is a crucial determinant of societies' abilities to adopt new technologies, but literacy does not seem to have mattered for the diffusion of cream separators in Ireland. The other control variables perform better: the share of very small farms (that is, less than 5 acres in size) is, as expected, negatively related to diffusion. Increasing the share of such farms by one standard deviation (10.5) relative to its mean value of 26.3 reduces the expected value of the number of creameries per county by 4.2, relative to an expected value of 6.56 when all right-hand-side variables are set equal to their mean values. Again as expected, the Munster dummy variable is positive and strongly statistically significant.²¹

Finally, one possible objection to Ó Gráda's argument that cow density was the crucial factor explaining separator diffusion in Ireland is the possibility that cow density might be endogenous (and in particular, that an increase in creamery activity in an area might lead to a corresponding rise in the local herd). Although Ó Gráda's argument is not the focus of this article,²² columns (5) and (6) replicate the specifications of columns (3) and (4), but replace cow numbers and cow density in 1906 with cow numbers and cow density in 1871. Milch cow numbers in 1871 were clearly exogenous to the number of cream separators in 1906, and indeed in any other year, since cream separators had not yet been invented in 1871 (they were invented in 1878). As can be seen, the results are qualitatively identical to those obtained earlier (with the coefficients on cow numbers becoming larger, and those on cow density becoming smaller – the only difference is that the banking coefficient now becomes statistically insignificant). This is hardly surprising, given that regions which had specialised in dairying in the past continued

²¹ The omitted province in these regressions is Connaught.

²² Indeed, my main purpose is to show that endowments alone cannot explain the diffusion of creameries and cooperatives; therefore anything that weakens his argument strengthens mine.

to do so after the advent of the separator.²³ Of greater interest to this article is the fact that the coefficients on owner occupancy are larger under these alternative specifications, while the coefficients on illiteracy remain statistically insignificant.

5. Political conflict, cooperation and separator diffusion

Thus far, the discussion has focused solely on the diffusion of a new technology, cream separators. However, Ireland was also slower than Denmark at adopting an important organisational innovation, namely agricultural cooperatives. As Henriksen (1999) and others have argued, cooperatives were particularly useful in dairying. Economies of scale and small farm sizes meant that creameries in both Ireland and Denmark required the milk from many farms – perhaps around 50 – to be viable. A crucial problem facing creameries was how to ensure that all suppliers provided them with high-quality milk, since the quality of the creamery's output as a whole would suffer if individuals supplied milk that was not clean and fresh-tasting. Cooperative creameries in Denmark locked their members into exclusivity arrangements, and were able to impose a variety of penalties on farmers who supplied low-quality milk. They were thus at an advantage relative to private creameries who would find it difficult to turn away low-quality farmers, for fear of not operating at minimum efficient scale. Presumably this advantage would have been greatest in regions with predominantly small farms, since big farms were likely to be more efficient and produce high-quality milk, even without the beneficial incentives provided by cooperation.²⁴

O'Rourke (2007) looks at the determinants of the propensity to cooperate in the Irish dairy industry, that is to say of the share of the creameries in each county in 1906 that was cooperative. That article is particularly concerned to test an argument associated with La Porta *et al.* (1997) (LLSV), and others, namely that culture may have been an important determinant of trust, and hence of cooperation or its absence. Specifically, LLSV argue that 'hierarchical' religions such as Catholicism are negatively related to peoples' trust in each other. If they are right, and if trust is essential for people to cooperate, then one might expect that the propensity to cooperate would have been lower in more Catholic counties in Ireland. Strikingly, while the propensity to cooperate was 82 per cent in largely Protestant Ulster in 1906, it was just 28 per cent in the rest of Ireland, where the population was overwhelmingly Catholic. On the face of it, this seems a

²³ Henriksen (1999) tries to instrument for cow density in the Danish context and finds that doing this makes no difference to her results.

²⁴ For an extended discussion of the cooperative organisational form, and its advantages relative to private creameries, see O'Rourke (2007). See also Henriksen and Hviid (2004).

Table 3. *Determinants of the cooperative share (OLS regressions)*

	(1)	(2)	(3)	(4)	(5)
Catholic share (Catholic-majority counties)	-1.11996* [0.58385]			0.29245 [0.51941]	0.17718 [0.54230]
Catholic share (Protestant-majority counties)	-1.67783 [1.02926]			-0.06437 [0.78696]	-0.16709 [0.82039]
Share of farms between 5 and 30 acres		1.16665*** [0.34998]		1.00755*** [0.32879]	1.07552*** [0.36212]
Agrarian outrages per 10,000 population Ulster			-1.37903*** [0.30574]	-1.74519*** [0.48101]	-1.83437*** [0.59691]
Constant	144.87703*** [46.49843]	2.64341 [19.72621]	90.45397*** [8.05361]	31.7565 [44.32109]	41.89787 [49.34650]
Observations	24	24	24	24	24
R-squared	0.22	0.33	0.4	0.65	0.65

Notes: Robust standard errors in brackets. *significant at 10%; **significant at 5%; ***significant at 1%.

powerful vindication of the LLSV argument. However, as Table 3 indicates, this negative association between cooperation and Catholicism disappears once another, political, factor is taken account of, namely the conflict between (mostly Protestant) landlords and (largely Catholic) tenants over who should own the land. Even after a series of Land Acts effectively settled this issue, by transferring control of the land to tenant farmers, the divisions persisted, and they would flare into life again in the early twentieth century as Catholics demanded Home Rule or independence for Ireland, while Protestants favoured the maintenance of the Union with Britain. The problem for the Irish cooperative movement was that, while the IAOS was apolitical and interdenominational, it was perceived as a largely landlord association by the very farmers it was trying to convince of the benefits of cooperation. Indeed, between 1894 and 1915, 21 out of the 49 people to have served as committee members of the IAOS were landlords (King 1996, p. 73). There is abundant qualitative evidence of nationalist antipathy towards the cooperative movement, and this naturally hampered the efforts of cooperative reformers (O'Rourke 2007).

Table 3 presents regressions of the cooperative share on the share of Catholics, and on a measure of the depth of landlord-tenant hostility during the Land Wars, namely the number of 'agrarian outrages' (that is, crimes against persons or property) during 1880-2, at the height of that conflict.²⁵ The regressions also include an Ulster dummy variable, as well as the share

²⁵ These regressions are slightly different in their specification from those presented in O'Rourke (2007), but the qualitative results are identical.

of small farms (that is, the share of farms above 5 acres accounted for by farms under 30 acres).²⁶ What can be seen is that while Catholicism and cooperation were negatively related (Equation 1), this negative relationship disappears once farm size and (in particular) landlord-tenant conflict have been accounted for. As expected, the propensity to cooperate was higher in counties with smaller farms, as well as in counties with a lesser history of antagonism between landlords and tenants. The results suggest that it was the particular coincidence between religious, class and national divisions within Ireland that was responsible for the relatively slow diffusion of cooperatives outside Ulster, rather than any supposed cultural characteristics of Catholicism *per se*. Politics, not culture, was the problem in Ireland. By contrast, Denmark was an unusually homogenous country, and this homogeneity may, as Kindleberger (1951) and Henriksen (1999) suggest, have been crucially important in facilitating the rapid spread of cooperative creameries there.

Social and political conflict thus impeded the diffusion of the cooperative organisational form in Ireland. Moreover, this lack of social cohesion might have impeded the diffusion of cream separators in areas where the cooperative organisational form was potentially most useful, that is to say in areas with small farms. Column (7) in Table 2 explores the diffusion of separators outside Ulster. It uses the baseline specification in column (3), but adds an interaction term between the number of agrarian outrages in a county and the share of small farms there. The coefficient is negative and statistically significant at the 10 per cent level. The coefficient implies that increasing the size of this interaction term by one standard deviation (810.0) relative to its mean value (1023.7) reduces the expected number of creameries by 0.9, relative to an expected value of 2.8 when all right-hand-side variables are set equal to their mean values: that is to say, by roughly a third. The results suggest that in areas with particularly high shares of small farms, a history of intercommunal tension did not just retard the spread of cooperatives, but was an obstacle to the spread of the new cream separator technology as well.

6. Conclusion

There were very different forces at work explaining the introduction of the new cream separator technology into Ireland, on the one hand, and the cooperative organisational form on the other. Cream separators diffused where there were lots of cows per acre, just as Ó Gráda (1977) suggested. However, this article has also shown that the structure of property rights in Ireland held back progress there. Diffusion was slower where farmers still

²⁶ Farms below 5 acres were essentially irrelevant for creamery milk supplies, as suggested earlier, hence this definition of 'small farms'.

rented their land from absentee landlords, consistent both with nationalist claims and with the theoretical literature on vertical integration.

On the other hand, the diffusion of the cooperative organisational form seems to be strongly linked to non-economic, and in particular to political factors. The propensity to cooperate was much less pronounced in Catholic areas than in Protestant ones, but this was more a result of intercommunal conflict than of any inherent disadvantages of Catholic culture *per se*. Importantly, in areas where small farms were particularly important, such conflict reduced the spread not just of cooperation, but of the cream separator technology as well.

In terms of the literature on Irish land tenure and land reform, this article might be seen as taking an intermediate position. Its finding that owner-occupancy was beneficial is consistent with the traditional historiography, and is at odds with revisionist historians such as Solow, and Guinnane and Miller. On the other hand, the process of land reform was not painless, and the divisions and violence associated with the Land Wars seem to have left a long-lasting negative imprint on the Irish rural economy.

It seems that Denmark benefited from several advantages that Ireland did not enjoy during this period. As regards the diffusion of cream separators, Denmark enjoyed a higher cow density: 133.2 cows per thousand acres, as opposed to 71.7 cows per thousand acres in Ireland.²⁷ As regards land ownership, peasant proprietorship in Denmark was given a boost by the government during the 'period of reform' from 1784 to 1807, and the transition to that institution proceeded throughout the nineteenth century. Already by 1835 there were 41,695 peasant proprietors in Denmark, as opposed to 24,795 tenant farmers, and by the early twentieth century Danish farmers were essentially all owner-occupiers.²⁸ According to Wade (1981, p. 56), the Danish 'freehold form had the effect of avoiding the problem of who owned improvements made to increase livestock operations that tenant farmers faced in Great Britain in the nineteenth century'. Both a high cow density and peasant proprietorship help explain why separators spread more rapidly in Denmark than in Ireland.

As for the more rapid diffusion of cooperatives in Denmark, Denmark was an extremely homogenous country. There was no conflict over who should own the land, nor was there any ethnic conflict, or conflict over where national boundaries should lie (all such controversies became redundant following the loss of Schleswig-Holstein, with its large German population, to Prussia in 1864). The results of Section 5 suggest that the homogeneity of Danish society may help in explaining not just the success of cooperation there, but the faster introduction of modern dairying technology as well.

²⁷ Based on data in Central Statistics Office (1997); Jensen (1937, p. 393); Bjørn (1988, p. 252); Mitchell (1988, p. 13).

²⁸ Jensen (1937, pp. 125–6).

Acknowledgements

Much of the work for this paper was done while the author was a Government of Ireland Senior Research Fellow. I am grateful to the Irish Research Council for the Humanities and Social Sciences for their generous funding, and to University College Dublin's ISSC for its hospitality. I am also grateful to the European Union for funding under its Marie Curie Research Training Networks programme (Contract Number MRTN-CT-2004-512439). I wish to thank the following for their advice and encouragement: Neal Beck, Liam Brunt, Charles Calomiris, Bruce Campbell, Arnaud Chevalier, Kevin Denny, Terence Dooley, Ed Glaeser, Claudia Goldin, Avner Greif, Tim Guinnane, Colm Harmon, Mike Harrison, Ingrid Henriksen, Mike Kunz, Philip Lane, Peter Lindert, Jim Livesey, Joel Mokyr, Anthony Murphy, Andy Newman, Cormac Ó Gráda, Tim Park, Roberto Perotti, Andrei Shleifer, Javier Silvestre, Ian Walker, Eugene White, Jeffrey Williamson, Rainer Winkelmann, the editors of the *Review* as well as anonymous referees, and seminar participants at Bergen, Cambridge, Harvard, the LSE, Northwestern, Oxford, Rutgers, Toulouse, UC Davis, UCL, Yale, the Dublin Economics Workshop, the conference on 'Patterns of Danish Development' held at the University of Copenhagen, and the Third Congress of the European Historical Economics Society, Lisbon. Hampus Wilfors and William Hynes provided able research assistance. The usual disclaimer applies.

References

- ABRAMOVITZ, M. (1986). Catching up, forging ahead, and falling behind. *Journal of Economic History* **46**, pp. 385–406.
- BANERJEE, A. (2000). Prospects and strategies for land reforms. In B. Pleskovic and J. E. Stiglitz (eds.), *Annual Bank Conference on Development Economics 1999*. Washington, DC: World Bank.
- BARRO, R. J. (1991). Economic growth in a cross section of countries. *Journal of Political Economy* **106**, pp. 407–43.
- BJØRN, C. (ed.) (1988). *Det Danske Landbrugs Historie III: 1810–1914*. Copenhagen: Landbohistorisk Selskab.
- CAMERON, A. C. and TRIVEDI, P. K. (1998). *Regression Analysis of Count Data*. Cambridge: Cambridge University Press.
- CENTRAL STATISTICS OFFICE (1997). *Farming Since the Famine: Irish Farm Statistics 1847–1996*. Dublin: Stationery Office.
- CIPOLLA, C. (1969). *Literacy and Development in the West*. London: Penguin.
- CROTTY, R. (1966). *Irish Agricultural Production: Its Volume and Structure*. Cork: Cork University Press.
- DOOLEY, T. (2001). *The Decline of the Big House in Ireland*. Dublin: Merlin.
- EASTERLIN, R. A. (1981). Why isn't the whole world developed? *Journal of Economic History* **41**, pp. 1–19.
- EASTERLY, W. and LEVINE, R. (1997). Africa's growth tragedy: policies and ethnic divisions. *Quarterly Journal of Economics* **112**, pp. 1203–50.
- EHRlich, C. (1981). Horace Plunkett and agricultural reform. In J. M. Goldstrom and L. A. Clarkson (eds.), *Irish Population, Economy and Society*. Oxford: Clarendon Press.

- FITZPATRICK, D. (1980). The disappearance of the Irish agricultural labourer, 1841–1912. *Irish Economic and Social History* 7, pp. 66–92.
- FLORA, P., KRAUS, F. and PFENNING, W. (1987). *State, Economy and Society in Western Europe 1815–1975: A Data Handbook*, Vol. I. Chicago: St James Press.
- GRILICHES, Z. (1963). The sources of measured productivity growth: United States agriculture, 1940–1960. *Journal of Political Economy* 71, pp. 331–46.
- GROSSMAN, S. J. and HART, O. D. (1986). The costs and benefits of ownership: a theory of vertical and lateral integration. *Journal of Political Economy* 94, pp. 691–719.
- GUINNANE, T. W. and MILLER, R. I. (1997). The limits to land reform: the Land Acts in Ireland, 1870–1909. *Economic Development and Cultural Change* 45, pp. 591–612.
- HENRIKSEN, I. (1999). Avoiding lock-in: co-operative creameries in Denmark, 1882–1903. *European Review of Economic History* 3, pp. 57–78.
- HENRIKSEN, I. and HVIID, M. (2004). Contracts in the governance of the early Danish dairy sector. Mimeo, University of Copenhagen.
- IAOS (various years). *Annual Reports of the Irish Agricultural Organisation Society, Ltd.* Dublin.
- JENSEN, E. (1937). *Danish Agriculture*. Copenhagen: J. H. Schultz Forlag.
- JOHANSEN, H. C. (1985). *Danmarks Historie*, Bind 9: *Danish Historical Statistics 1814–1980*. Copenhagen: Gyldendal.
- KENNEDY, L. (1976). The decline of the Cork butter market: a comment. *Studia Hibernica* 16, pp. 175–7.
- KINDLEBERGER, C. P. (1951). Group behavior and international trade. *Journal of Political Economy* 59, pp. 30–46.
- KING, C. (1996). The early development of agricultural cooperation: some French and Irish comparisons. *Proceedings of the Royal Irish Academy*, 96, C, pp. 67–86.
- KING, G., TOMZ, M. and WITTENBERG, J. (2000). Making the most of statistical analyses: improving interpretation and presentation. *American Journal of Political Science* 44, pp. 347–61.
- LA PORTA, R., LOPEZ-DE-SILANES, F., SHLEIFER, A. and VISHNY, R. W. (1997). Trust in large organizations. *American Economic Review Papers and Proceedings* 87, pp. 333–8.
- LEE, J. J. (1989). *Ireland 1912–1985: Politics and Society*. Cambridge: Cambridge University Press.
- MITCHELL, B. R. (1988). *British Historical Statistics*. Cambridge: Cambridge University Press.
- MOKYR, J. and Ó GRÁDA, C. (1988). Poor and getting poorer? Living standards in Ireland before the Famine. *Economic History Review* 41, pp. 209–35.
- NÜCHEL THOMSEN, B. and THOMAS, B. (1966). *Dansk-Engelsk Samhandel: Et Historisk Rids 1661–1963*. Århus: Universitetsforlaget i Århus.
- Ó GRÁDA, C. (1975). The investment behaviour of Irish landlords 1850–75: some preliminary findings. *Agricultural History Review* 23, pp. 139–55.
- Ó GRÁDA, C. (1977). The beginnings of the Irish creamery system, 1880–1914. *Economic History Review* 30, pp. 284–305.

- Ó GRÁDA, C. (1994), *Ireland 1780–1939: A New Economic History*. Oxford: Oxford University Press.
- O’ROURKE, K. H. (2006). Late 19th century Denmark in an Irish mirror: land tenure, homogeneity and the roots of Danish success. In J. L. Campbell, J. A. Hall and O. K. Pedersen (eds.), *The State of Denmark: Small States, Corporatism and the Varieties of Capitalism*. Montreal: McGill-Queen’s University Press.
- O’ROURKE, K. H. (2007). Culture, conflict and cooperation: Irish dairying before the Great War. *Economic Journal*, forthcoming.
- RUMPF, E. and HEPBURN, A. C. (1977). *Nationalism and Socialism in Twentieth-Century Ireland*. Liverpool: Liverpool University Press.
- SCHULTZ, T. W. (1983). *Transforming Traditional Agriculture*. Chicago, IL: University of Chicago Press.
- SMITH-GORDON, L. and STAPLES, L. C. (1917). *Rural Reconstruction in Ireland: A Record of Cooperative Organisation*. London: P. S. King and Son.
- SOLAR, P. M. (1989–90). The Irish butter trade in the nineteenth century: new estimates and their implications. *Studia Hibernica* 25, pp. 134–61.
- SOLOW, B. (1971). *The Land Question and the Irish Economy, 1870–1903*. Cambridge, MA: Harvard University Press.
- TOMZ, M., WITTENBERG, J. and KING, G. (2001). CLARIFY: software for interpreting and presenting statistical results. Version 2.0. Cambridge, MA: Harvard University, accessed 1 June. <<http://gking.harvard.edu>>
- WADE, W. W. (1981). *Institutional Determinants of Technical Change and Agricultural Productivity Growth: Denmark, France, and Great Britain, 1870–1965*. New York: Arno Press.

Data appendix

- Number of cooperative creameries per county. Source: *Reports of the Irish Agricultural Organisation Society, Ltd. for the Year Ending 30th June, 1907*. Dublin: Sealy, Bryers and Walker (1908).
- Private creameries per county. Source: *Agricultural Statistics, Ireland, 1907*.
- Number of milch cows per county. Source: as above.
- Milch cows per thousand acres. Source: as above.
- (Data on the above two variables are also available in Central Statistics Office (1997), from which the data on cow numbers in 1871 were taken.)
- Share of farms less than 5 acres, between 5 and 30 acres, and above 30 acres. Source: as above.
- Owner-occupied farms, as a percentage of total farm numbers. Source: as above.
- Population (in thousands). Source: *Census of Ireland (1901)*.
- Share of Roman Catholics in population. Source: as above.
- Illiteracy rate. Source: as above.
- Outrages per 10,000 of population in 1880–2: Rumpf and Hepburn (1977, p. 52).
- Bank branches per county: *Thom’s Directory of Ireland, 1906*, pp. 1072–81. The directory listed bank branches by company and town; county-level data were generated by summing over banks, and matching towns to counties.

Appendix table. *Summary statistics, county data 1906*

	Mean	Median	Std. dev.	Min.	Max.
Cooperatives	8.8	4.5	10.2	0.0	37.0
Private creameries	13.6	1.0	28.1	0.0	108.0
Milch cows (thousands)	46.8	38.1	37.2	10.5	192.0
Milch cows per 1000 acres	72.7	75.6	28.3	29.6	155.3
Milch cows in 1871 (thousands)	48.3	42.0	35.8	9.0	182.0
Milch cows per 1000 acres in 1871	76.6	78.7	30.4	28.6	147.6
Population (thousands)	147.0	111.8	109.8	40.9	471.2
Share of owner-occupied farms	29.6	30.7	9.2	15.4	52.5
Bank branches per 100,000 population	17.4	17.1	4.8	9.1	27.1
Illiteracy rate	14.0	13.2	4.6	7.3	26.0
Catholic share	74.0	81.5	18.3	26.6	89.6
Share of farms less than 5 acres	26.3	26.2	10.5	11.6	55.3
Share of farms between 5 and 30 acres	46.1	43.4	15.5	25.2	70.6
Agrarian outrages per 10,000 population	22.5	19.5	15.2	2.0	52.0