European agriculture since World War II: technical change in south-west England, 1940-1985

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Introduction

The food shortages that beset individual European countries in 1945 had been transformed into surpluses that a common European agricultural policy struggled in vain to control by the 1980s. In the same period, the volume of agricultural output in the United Kingdom rose by 255 per cent, with the pace of change reaching its peak of 2.8 per cent per annum in the years from 1945 to 1965 (Brassley, 2000). The reasons for this rapid development included price and government policy changes, but technical change was especially significant. British farmers adopted existing technology, such as the use of purchased feedingstuffs and fertilizers, to a greater extent than they had before, and also benefited from several important innovations, including new crop varieties, animal breeds, pesticides, and machines. This process was widely studied by agricultural economists as it was happening (e.g. Hill and Ray 1987), and more recently by historians, either as part of longer-term studies (e.g. Federico, 2005; Lains and Pinilla, 2009) or as part of the growing interest in the history of the later twentieth century. Given the existence of a Common Agricultural Policy that began in the 1960s and gradually came to influence more and more European countries by the end of the twentieth century, the development of international data-gathering organisations, most notably Eurostat and the Food and Agriculture Organisation of the United Nations, and the consequent publication of large quantities of more or less consistent nationally-based data, it is not surprising that these historical studies have often involved international comparisons across European countries (e.g. most recently Martin-Retortillo and Pinilla, 2012).

The results of the various contemporary and historical studies have demonstrated how output increased, albeit at differing rates, across the whole of

Europe, especially in the period between the end of the Second World War and the middle of the 1980s when agricultural policy was consistently aimed at output expansion. On a global scale, Federico (2005: 221) argued that the typical outcome for twentieth-century agriculture was for output to increase as a result of Total Factor Productivity (TFP) growth (i.e. by producing more output per unit of input), in contrast to the nineteenth century, when growth was achieved by increasing inputs, especially, of course, land in the New World. Although there were input increases in the twentieth century, especially of machinery, fertilizers and pesticides from outside the agricultural industry itself, other studies support Federico's findings. For the UK, Thirtle and his co-workers report annual TFP growth of 1.68 per cent up to 1984, but only 0.26 per cent from 1985 to 2000. They also suggest, on the basis of a study of the eastern counties arable area of the UK, that crop TFP increased more rapidly than that in animal enterprises (Thirtle et al, 2004; Amadi et al, 2004). Within this overall pattern of productivity growth, however, there were significant differences between partial productivities. It is clear that land productivity, measured in terms of agricultural output per acre or hectare, increased. Average cereal yields, for example, increased from a little over 1 ton per acre in 1950 to 2.5 tons per acre in 1990. Similarly, as farm labourers left the land, the output (in constant price terms) per head of labour nearly doubled between 1950 and 1987 (Marks and Britton, 1989: 138, 150, 164). On the other hand, capital productivity, which is more difficult to measure, probably decreased. Similarly, if we include the management efforts of farmers and the associated provision of knowledge through scientific research and advisory work by government bodies and the ancillary industries as inputs to the agricultural industry, we might also find that the partial productivity associated with these inputs also decreased, although again this is not easy to measure. Farmers en masse appear to have responded logically to increased labour costs and capital grants from government by adopting new output-increasing or labour-saving technology; individual farmers, however, differed considerably in the extent to which and the time at which they did so. If we are to understand the process of technical change it therefore makes sense to examine it from both the collective and individual perspectives. Much of the work carried out so far and referred to above inevitably, given the statistical evidence that it uses, approaches the problem from the perspective of the industry as a whole. The study currently being carried out at Exeter, in contrast, places much more emphasis on the experiences of individual farms and farmers, and it

is the methods and problems involved in this, and some of the preliminary results, that are discussed in the remainder of this paper.

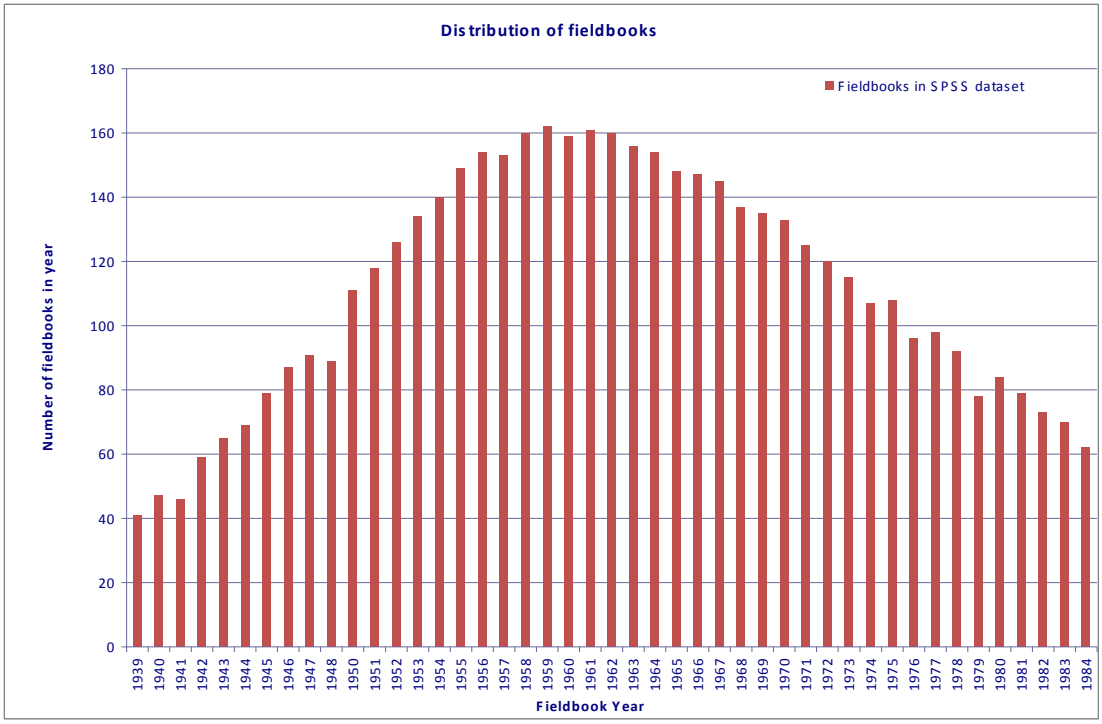
The Farm Management Survey

In November 1928 Mr R.J.Thompson, the assistant secretary in charge of the advisory economics service at the UK Ministry of Agriculture and Fisheries, wrote an internal minute arguing that 'There is no questioning that there is an increasing need for the study of the economics of agriculture …….. exact information is woefully deficient and in the main we are dependent on casual evidence and observation which may be very misleading, whereas reasonably exact statistical data can be obtained and ought to be available to the Government as a guide on questions of policy.' (TNA, MAF 38/198, minute from R.J.Thompson, 8 November 1928). This was by no means the first time that European agricultural bureaucrats had argued for the desirability of data collection to help with the administration of their agricultural industries – there are examples from at least the nineteenth century onwards (the history is discussed at greater length in an article currently in preparation by the authors) – but what Thompson was suggesting was especially sensitive because it involved the collection of financial data that was both commercially sensitive and would also shed light on the incomes, and hence potentially the tax liabilities, of farmers. It was therefore especially important that potential participants in the survey would be confident of its anonymity and disconnection with official government bodies, otherwise they were unlikely to agree to become involved. The solution to this difficulty was found by commissioning the Provincial Agricultural Economists, located in university departments of agricultural economics, to do the actual survey work. They would aggregate the resultant data and send it in anonymised form to the Ministry, so that there could be no question of government civil servants being able to attribute specific sales or income figures to individual farms or farmers. The field books in which the data was originally collected would remain in the university departments.

This was the system that was agreed, and which began operation in 1936. Farms in the counties of Devon and Cornwall were originally surveyed by investigation officers operating at Seale-Hayne Agricultural College, but after the Second World War this responsibility was transferred to the University of Exeter, where it remained until the first decade of the present century, after which it was

transferred to Duchy College in Cornwall. As a result of this latter transfer it was discovered that large quantities of the original fieldbooks used to collect individual farm data remained at Exeter, going back in some cases to the beginnings of the Survey in 1936. It also became clear that although each individual farm was only supposed to remain in the survey for a maximum of fifteen years, in practice some farms had continued to be part of it for much longer, and in some cases up to 1984, when the run of the available fieldbooks ends. There are at least 28 farms for which there is a forty-year run of data, and 42 more with over thirty years in the survey. Although the whole of England and Wales was covered by the Farm Management Survey, with the work being originally split between eleven university departments, the survival of the fieldbooks at Exeter is unusual. In most other cases they have been lost or otherwise disposed of. What remains at Exeter is therefore a rare collection relating to between 200 and 250 individually identifiable farms for each year, with longitudinal comparisons also possible through the survival of farms in the survey over several years. Data from these fieldbooks has been entered on to a computer database that contains details from 4977 individual fieldbooks distributed over the years as figure 1 illustrates.

Figure 1: distribution of fieldbooks 1939-84



Analysing the fieldbooks

It is important to emphasise that the fieldbooks were not designed to explain technical change. The purpose of the data collection was to produce information on farm incomes, and the only other historian who has carried out any significant analysis of them, Dr Crowe, has used them for this purpose (Crowe, 2009). However, since we argue that explaining the process of technical change is the most interesting question about post-war agriculture, we have attempted to use them for this purpose. This means that we have analysed the accounts for 172 farms, 150 of which were in the survey for 20 years or more, and for a subset of these with longer runs in the survey we have used these analyses, with further reference to the original fieldbooks, to write farm histories. For a further subset of these farms for which the farmers survive, we have also carried out oral history interviews. So far we have completed twenty of these, and we expect to complete a total of thirty.

The FMS was designed to produce data on farm incomes, so to record the data useful for the study of technical change involves selective rather than total data extraction. The variables recorded were, firstly, output data

O1 Total output (£)

O2 Cereal sales (£)
O3 Other crops sales (£)
O4 Horticultural crops sales (£)

O5 Cattle sales (£)
O6 Sheep sales (£)
O7 Pig sales (£)

O8 Poultry and eggs sales (£)
O9 Dairy products sales (£)

And secondly input data, for recurring costs

I1 Purchased fertilizers (£)
I2 Pesticides (£)
I3 Miscellaneous crop costs (e.g. baler twine)
I4 Purchased seeds (£)

I5 Purchased feedingstuffs (£)

I6 Vet and medicine costs (£)
I7 Miscellaneous livestock costs (£) (e.g. AI)

I8 Rent and rates (£)
I9 Payments to labour (£) (excluding farmer and spouse)
I10 Machinery maintenance, repairs, fuel, tax (£)
I11 Building and maintenance costs (£)
I12 Drainage costs (£)

I13 Total of all the above recurring costs (£)

And also for capital items, details of which were also recorded

C1 Machinery purchases (£)
C2 Investment in farm buildings (£)

We then used these figures to produce various comparison ratios, such as

Purchased input / labour ratio (I13/I9 for for year 1 to year n), which would be expected to rise over time as farmers attempt to reduce labour costs and increase the use of fertilizers, pesticides, etc

Output per £100 input [(O1/I13) x 100 for year 1 to year n], which would be expected to rise over time if TFP was increasing

The IFS statistic for years 1 to n, which is calculated as follows

Let O1 = total farm output (£)

E_1 = output of the largest enterprise (£)

n = number of enterprises

Then

$$IFS = [(E_1/O1) \times 100] + 1/n\ [(O1-E_1)/O1 \times 100]$$

or, in simpler terms, the percentage share of the largest enterprise plus the share of the remaining enterprises divided by the number of enterprises.

The purpose of this calculation is to overcome some of the difficulties resulting from alternative methods of identifying the process of specialisation. Clearly the simplest method is just to record the number of enterprises on a farm, as Britton (1977) did in showing that the number of enterprises per farm fell from 3.18 in 1968 to 2.85 in

1974. The problem with this is that one very small enterprise on an otherwise specialised farm would register as the same degree of specialisation as a farm with two enterprises of equal size. The algorithm above overcomes this problem and allows the calculation of annual data which can be graphed over time.

From these single-farm datasets it is possible to write an outline history of an individual farm for the period in which it was recorded by the FMS. We are still engaged in producing these histories for a subset of those farms that remained longest in the survey. The input and output data usually augmented by further reference to the original fieldbooks for details of the crops grown and numbers of livestock kept, and milk and egg yields. From time to time the fieldbooks also provide information on livestock breeds, types of machinery purchased and so on, but these did not have to be formally recorded so that the coverage of these is uneven. For the subset of farmers who are still available for interview it is possible to secure further details and, most importantly, commentary on the reasons for the decisions made. Some idea of the kind of detail that it is possible to explore can be seen from Figure 2, which shows some of the questions asked of a dairy farmer in Dorset. In addition to the questions relating specifically to the farm, interviewees were also asked questions about their personal characteristics and management activities in order to provide information about their attitudes to risk and other business activities, and the sources of information they used in the course of making decisions. These included questions about their education and training, use of advisory services, membership of farming organisations, and use of printed and broadcast media. The interviews generally took between one and two hours, although some were longer, and when transcribed from the audio-recording were between 5,00 and 10,000 words.

Figure 2 – farm-related questions for farm 3/1

Land and enterprises
Tenanted or owner-occupied?
How long has family farmed here?
Is this part of the Blackmore Vale dairy area?
Did the farm size expand by purchase or tenancy?
Poultry up to 650 hens on deep litter by 1964, but ended 1969 – why?
After 1958 an all-grass farm – why not grow cereals for concentrates?
Were the cattle always dairy followers – no beef?

Labour
Labour decreased by one from 1946 to 1964, when 1 worker + 1 son + farmer, and by 1984 was still 1 worker plus family. Was it never possible to dispense with employed labour?
Your father became a partner in 1950 – how much did grandfather still do?
You became partner in 1976 – how much did father still do?

Investment
Water mains laid 1968?
Always had mains electricity?
1972-1983 drainage schemes – all with grant aid?
What happened to deep litter houses after poultry went?
Grandfather bought a milking machine for £140 in 1946 – was that the first?
First major investment was a new parlour and dairy in 1966 and cubicles for 67 cows. Why was the investment made then?
Was that when you first went to a bulk tank (another bought in 1982)?
More cubicles in various stages between 1973 and 1978 – herd expansion?

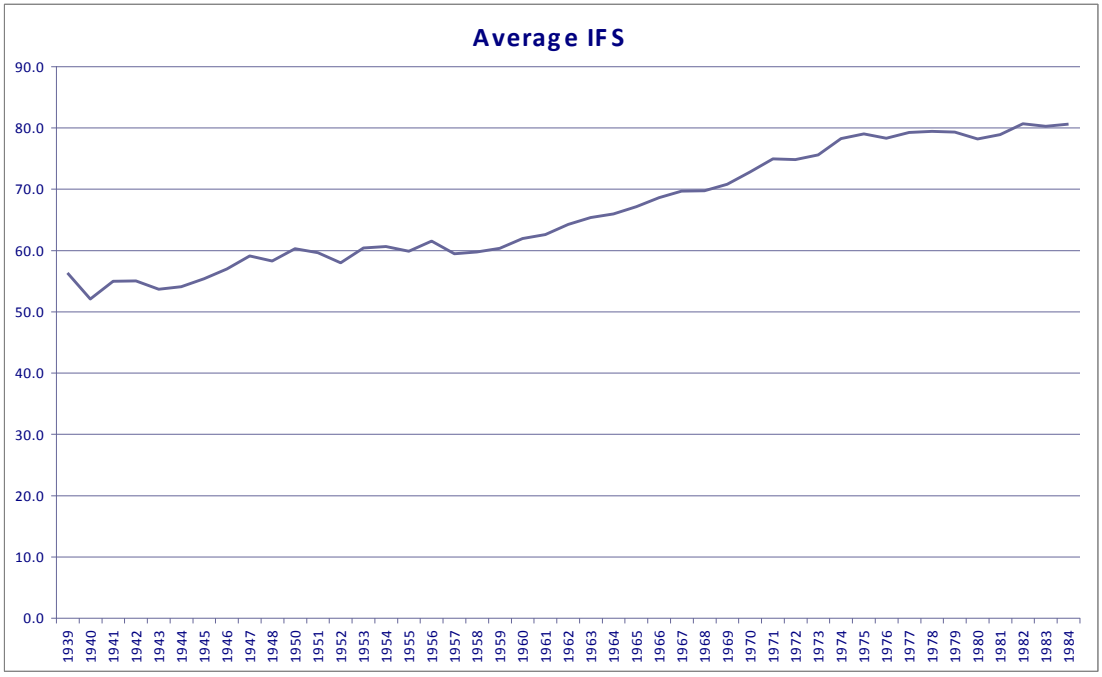
Technical change
Milk production expanded by nearly 5 times over 40 years, with more cows and more milk per cow. How could you keep more cows?
And how did you improve yields?
Breed changes?
You had 3 acres of maize for silage in 1946-7 but the crop failed completely, but you were already producing grass silage – when did that start?
Were you aware of being an early silage adopter or was it common round here?
Moderate fertiliser use (125 units/ac 1984) and stocking rate?
Concentrates equivalent to 3.8 lbs per gallon on 1978 – heavy concentrate use?
First forage harvester in 1963 – how did you make silage then?
New tractor for £303 in 1946 – was it the first?
1/3 share in sprayer after 1972 and buying sprays after that – what for?
Were the changes on this farm typical of those on Blackmore Vale dairy farms?

This analysis of the fieldbooks at various levels of detail provides several different kinds of information. As we have examined more and more farms in detail it has become clear that almost all of those covered by Exeter involved dairy farming to some degree or at some point in time. Initially we hoped that we might be able to compare small dairy farms in Devon and Cornwall with large arable farms in Dorset, but examining the Dorset data revealed that all of the farms involved had a dairy herd, even if they also had a large arable enterprise too. At the other end of the scale, most of the small moorland farms that specialised in cattle and sheep rearing also had a small milking herd at some point. The following discussion must therefore be seen as applying to dairy farms in South West England.

Indicators of technical change

The data collected for the FMS did not specifically set out to include indicators of technical change such as the acquisition of new machinery or the adoption of new crop varieties, or breeds of livestock, or new techniques such as silage, artificial insemination (AI), cubicle housing, milking parlours, and so on, although in practice a detailed reading of the fieldbooks can provide much information on these topics. However, there is one measurable indicator of change that can be derived from the analysis of the accounts, and that is the level of specialisation. Agricultural economists have understood for many years that technical change and specialisation have been closely associated (Hill and Ray, 1987: 240-245). Milking parlours, tractors, combine harvesters and other machinery have the capacity to deal with large quantities of throughput, and are thus employed inefficiently on small units. Expert stockmen can deal effectively with large numbers of animals. Hence it is well established that one of the features of postwar agriculture has been specialisation. This can be demonstrated from the fieldbook sample in several ways. Figure 3 shows how the overall Index of Farm Specialisation (IFS) for all 4977 fieldbooks entered in the computer dataset changes over time, from the mid-50s in the war years to around 80 in the 1980s, with the 1960s and early 1970s being the period of most rapid change.

Figure 3 – average index of farm specialisation 1939-84



For most farms, what this meant in practice were changes in both arable and livestock enterprises. In the 1940s it was common for most of the farms in the survey to cultivate a few acres of fodder crops, perhaps an acre of rape, half an acre of flatpoll cabbages, a couple of acres of Swedes or turnips, a patch of mangolds, some kale, and so on, all for winter feed. They also grew a crop of oats to feed the farm horses and often a small acreage of wheat, and perhaps some barley. During the war they were also encouraged, if not compelled, to grow at least an acre or two of potatoes, and to increase the wheat acreage. This pattern often continued into the 1950s, but by the 1970s most of the farms in the sample had simplified their cropping considerably. Many had gone over entirely to silage for winter feed, or a mixture of hay and kale. With a few exceptions, the potato enterprise had entirely disappeared. So had the oats, for the horses had gone, and the cereal crop, where it remained, was normally barley, used for home-mixed rations. These changes are apparent from an examination of the accounts, but are not easy to summarise in figures. It is easier, however, to quantify the changes in the livestock enterprises, because the most common change was the disappearance of the intensive livestock, pigs and poultry. In the 1930s most of the

dairy farms in the sample also kept pigs or laying hens, and often both. The numbers of these declined during the war as feedstuffs were rationed, but increased again in the 1950s. Several farms increased poultry numbers as deep litter housing became popular. But as large specialist poultry units came to dominate the trade, these small units could no longer compete, and by the middle of the 1970s many had been discontinued, as Figure 4, based on data from 32 farms that have been analysed in detail, illustrates. Similarly figure 5 shows the same pattern for pig enterprises, with the early 1970s being the peak time for dairy farms in the south west to get out of the industry. This was the period when specialist pig and poultry producers were beginning to set up large enterprises and realise economies of scale, with the result that prices went down. As a result mixed farmers had to decide whether to expand the size of their intensive livestock enterprises or use scarce capital to expand the size of their main enterprise. As one farmer in Cornwall (no. 209) put it,

'Dad never had pig houses with dunging passages where you could go down

Figure 4: the end of poultry on mixed farms

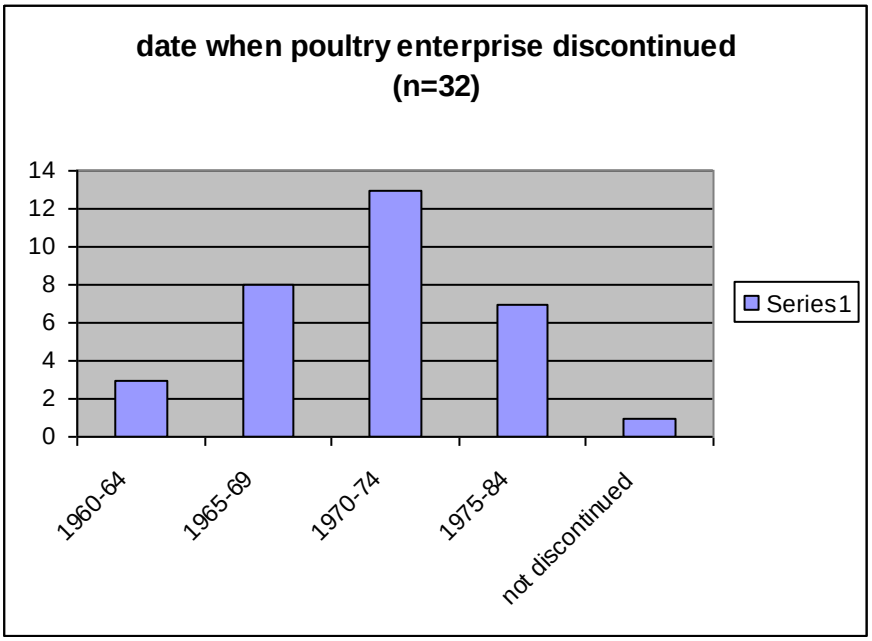
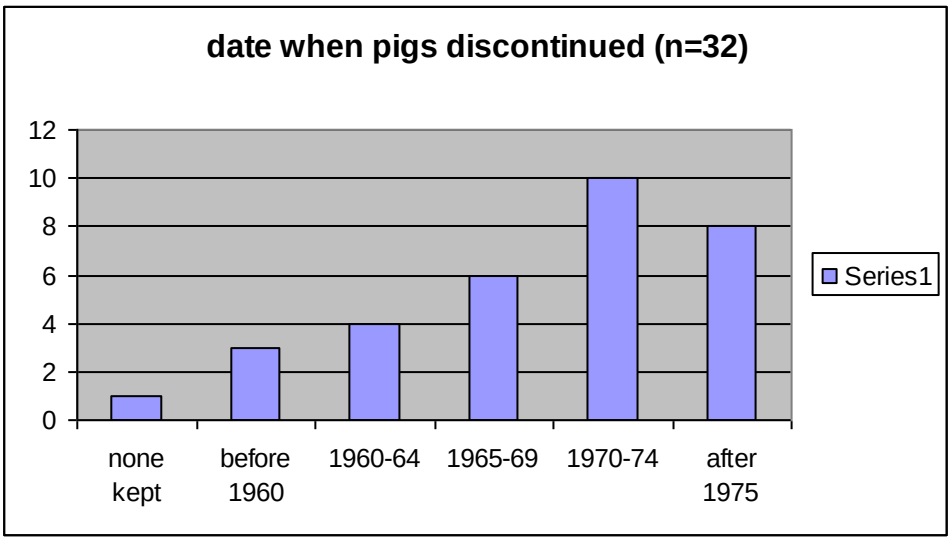


Fig 5: the end of pigs on mixed farms



> with a hand or tractor squeegee, it was always fork, shovel, and broom, so that was far too labour consuming …So we had the choice to do it properly or get out, but [we] knew that if we wanted modern dairy, pig, and poultry units we could do it if we had money enough, but we only had money enough to modernise one commodity, so that had to be the dairy. So it was a capital constraint. Dad had 15 sows in the mid-1960s, and that wasn't a very big unit, and keeping going with an uneconomic unit would affect the whole business.'

For another Cornish farmer (no.272) getting out of egg production was the result of marketing problems: '… it was a job to get rid of them because they all had to be graded, and they were so particular, we gave it up. It was a job to get rid of the hens at the end of the lay', but for a Devon farmer (no.243) whose parents had kept up to 2,000 laying hens the motivation was simpler: 'I can't stand poultry'.

Measuring the effects of technical change

Although the fieldbooks may not record specific indicators of technical change, they do enable some measurement of the effects of technical change to be made. As suggested above, the data enable calculations of the output per acre in real terms and

the purchased input to labour ratio to be made for both individual farms and the whole recorded sample, and we are currently carrying out these calculations. One of the most interesting ratios is the output per £100 of inputs, for, as Federico (2005) suggests, there are two ways of increasing agricultural output: get bigger or get better. In other words, farmers can either increase output by using more inputs, or by producing more per unit of input. The figures for output per £100 of inputs should tell us which of these happened. If output was increased simply by increasing inputs, of feedingstuffs and fertilisers for example, output per unit of input will remain constant or decrease. But if the output per £100 of inputs increases, this is evidence that farmers are increasingly efficient and that the technical changes they have adopted enable them to produce more from the resources available to them. In addition to reporting the FMS data to the Ministry of Agriculture each year, the agricultural economists at Exeter also produced and published annual reports on farm organisation and incomes in the south west of England. These contained summary data from all the farms then surveyed by the FMS, and so for the years between 1947 and 1980, after which the reporting format was changed, figures are available for the values of the total gross output and inputs of all the farms in the survey (Morris and Luxton, 1954; Morris et al, 1963; Morris et al, 1970. For 1970-80 annual reports were published by a variety of authors). This means that in addition to examining the trends on individual farms, it is also possible to examine, for these two variables, the trends in the region as a whole, at least as far as they are measured by the FMS sample.

In the 1954 report the input data are listed as wages (excluding those of the farmer and spouse), rent and rates, feedingstuffs, seeds, fertilisers, power and transport, contracting, and other overhead costs. The same items appear to be used in subsequent reports up to 1974, but from 1976 onwards there are separate statements of variable costs (feed, livestock costs, seeds, fertilisers, crop costs, casual labour and contracting) and fixed costs (regular labour, excluding that of the farmer and spouse, machinery, rent and rates, and other overheads). In the following calculations these are added together to be roughly comparable with the pre-1974 series. In addition, the post-1976 figures in the original sources are given in terms of costs per hectare, but there are also figures for the averages sizes of the farms involved for 1972 to 1974, and for 1980. Interpolating from these it is possible to estimate farm sizes for the years 1975 to 1979, and so to convert the per hectare data for costs and output to total

costs and output for the average farm in the Survey. Furthermore, since there are no data for 1975 the figures for that year have been estimated as the mid-point between 1974 and 1976.

Inflation did not affect all items of costs and output equally. Ideally this would imply that the current-price figures for an item should be deflated by the relevant price series for that item before summing to produce total costs and output. In practice this would not only be cumbersome but would also require a lot of work to collect the relevant price data, even if it were all available. However, it seems clear that the most important variation from the general agricultural price index concerns labour costs: whereas the API (1962 = 100) increased by a factor of 4.6, wages increased by a factor of 16.9. It therefore makes sense to deflate labour costs by the weekly wage series, leaving non-labour costs and output to be deflated by the API.[1]

This produces a further difficulty, which is that only the 1947-1952 dataset contained year-by-year labour cost (excluding farmer and spouse labour) estimates (see Morris and Luxton, 1954). Subsequent reports only contained labour cost data for the reporting years, although these change in a fairly consistent way, as table 1 overleaf suggests. Current-price wage costs have therefore been estimated by applying these figures to the total cost data as table 1 indicates. These calculations enable the construction of a labour cost series which can be deflated by the weekly wage index, and a non-labour cost series to be deflated by the API. The resultant labour and non-labour cost figures are then summed to produce a real total cost series, which is combined with the real output series to produce a series for output per £100 input, as illustrated in figure 6.

[1] We are grateful to Dr Hilary Crowe for extensive discussions on this point, and for suggesting the calculation technique used here.

Table 1: wages as a proportion of total costs

	Wages (i.e. non-farmer + spouse labour costs) as a percentage of total inputs	Time period and wage percentage applied to total cost data
1952	26.8	1953: 25%
1956 1957	22.2 22.4	1954-58: 22.3%
1960 1961	22.2 21.4	1959-64: 21.8%
1967 1968	19.3 19.1	1965-69: 19.2%
1971 1972	18.3 19.1	1970-75: 18.7%
1979	14.3	1976-80: 14.3%

Figure 6: output/input relationships on all FMS farms

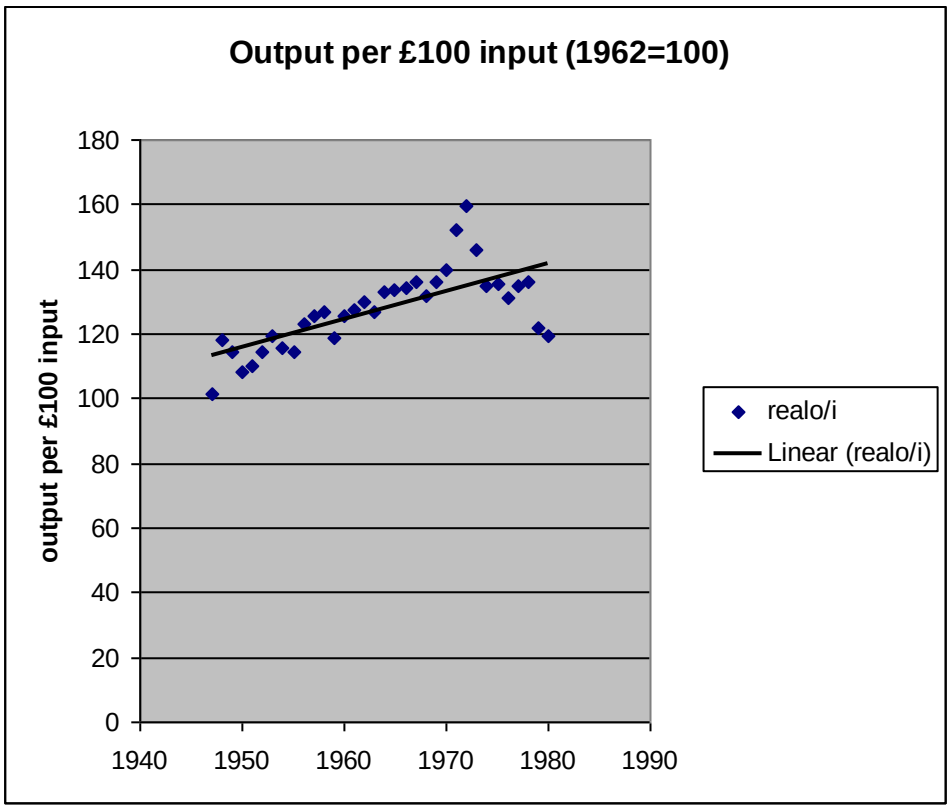
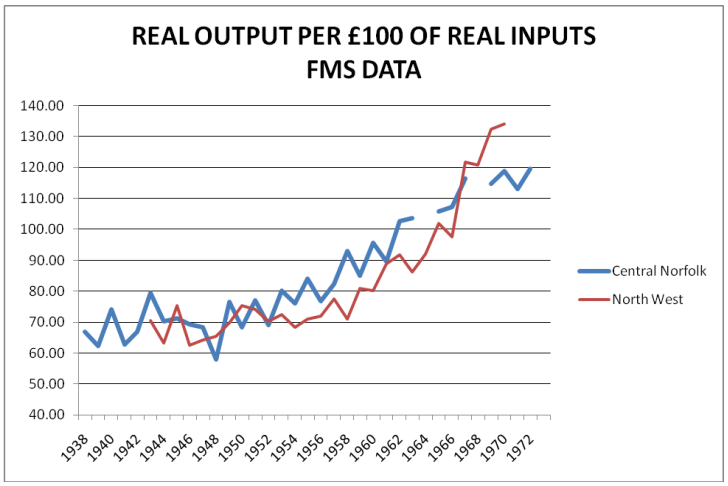


Figure 6 therefore suggests that south western farms were able to produce increasing outputs per unit of input between the end of the war and about 1980. It is interesting to note that the outliers from the trend line occur in the early 1970s, at

about the time that farm prices rose as a result of higher world prices and the UK's entry into the European Economic Community (as it then was), and in 1979 and 1980, when surpluses in the European market were beginning to have a depressive effect on prices, although the extent to which these variations affected the overall graphed results probably needs further investigation which is beyond the scope of this paper. The important overall conclusion is that the output/input ratio was rising in the long run, and the fact that this is demonstrated only when labour and non-labour costs are deflated at different rates suggests that this efficiency gain was brought about, in part at least, by farmers making an economically logical response to rising real labour costs. In other words, they used new technology to replace labour and/or to increase output without having to use more labour. This included mechanisation, new techniques such as AI and silage, and pesticides, although the individual contributions made by these, or any other, technical changes cannot be estimated from these data. It should also be noted that these results are consistent with those of Federico and Thirtle et al noted above, and with Hilary Crowe's results, using the same calculation process, albeit over a slightly different time period, for Westmorland and Norfolk farms (see Figure 7).

Figure 7: Output per £100 input in two other FMS regions 1938-72



Evidence from oral history

The other principal source of evidence for technical change used in this study is oral history. Oral history interviews are currently in progress, with about twenty

completed so far and another ten surviving farmers identified as potential interviewees, as discussed above. The conclusion so far from these interviews is that they do not alert us to technical changes of which we were previously unaware, but they do provide a lot of data on the processes of change and the contemporary thinking of farmers about the reasons for adopting new technologies. It is important to remember, for example, that most technical changes in agriculture (as, probably, in most other industries) are not introduced in their fully-functioning form by some outside agency and handed over to farmers as a quantum leap forward. In the case of silage, which underwent several changes both in terms of the techniques employed and the machinery available, the evidence from farmers is that numerous factors were involved in perfecting the technique. On a farm near Exeter, for example (no. 101) where silage was first made in the early 1950s, the farmer recalled that

> '…we got a green crop loader, one of those things that you tow behind the trailer, and the chap on the trailer has to throw it to the front, and build the load on the trailer, very hard work, green grass, and if you had some red clover and long ryegrass, tangled together … and then of course it was all hand work, it was before the days of buckrakes, it was about 1958 that people started using buckrakes very much'.

These problems of materials handling and the advantages of overcoming them were similarly highlighted by a farmer in the mining district of Cornwall (no. 209):

> 'As far as machinery is concerned, the thing that's transformed everything is hydraulics, right up to a telescopic loader, we do everything with them, they're wonderful, it affects materials handling, ploughing – hydraulic instead of hand-draulic. If you went back 70 or 80 years [i.e. to the 1930s and 1940s] a big farm could have twenty staff because the materials handling was enormous. It was better than being a miner, because you were working in decent air, but you were shovelling as many tons.'

The same farmer made the point that going over to silage was not just a matter of overcoming the vagaries of the weather, but a complete system change that enabled both improvements in feed quality and a simplification of the farm cropping pattern:

> '…about 1971, when the silage barn went up, we foraged our own grass and self-fed it. There was an improvement in milk quality and cattle condition, and you didn't have to use so much concentrate, because there's a lot more feed value in well-made silage than in well-made hay. When we were on hay we

were on kale and rape as well, strip grazing through the winter, and once we went on to silage those fodder crops gradually went…'.

Another Cornish farmer (no. 466) confirmed the advantages of good silage: '…it became obvious that if you had better quality silage the cow would eat more, and every kilogramme she ate would nourish her more, so there was a double whammy in the right direction'.

The transition to silage, along with fertilizers, better grass varieties, the introduction of milking machines and later milking parlours, and improved purchased feedingstuffs, all worked together to enable dairy farmers to keep more cows. The other major change was that each cow produced more milk. In the 1940s and '50s the fieldbooks show milk yields commonly in the range of 400 to 600 gallons per cow per year, with the better herds managing up to 700 gallons on average. By the 1980s few herds were producing less than 1000 gallons per cow, and some were managing up to 1200 gallons. The principal reason for this was the change in the breed of dairy cow commonly kept on farm in the south west. In the 1940s most herds had either Shorthorns, South Devons, or Ayrshires, with a few Jerseys or Guernseys. Between 1950 and 1970 most farmers went over to Friesians.

> 'The trouble with South Devons was, as a milk breed there was too much wastage, calving troubles, mastitis troubles, shapeless udders, fine for beef but no good for milk. There was a big argument in the breed about which way they should go, to beef or milk. There was a premium for many years for butterfat, if you could keep above 4 per cent, so you were chopping out cows that gave below 4 per cent and the herd never expanded very fast, you couldn't make it expand, whereas when we got Friesians you could breed your own replacements and scale up gradually. The Friesians came in about 1961, we needed more cows if we were going to scale up to save labour, that pushed us to black and whites' (no.466).

Some farmers bought in Friesian heifers, and others graded up their existing herds, either by buying a Friesian bull or by using artificial insemination (AI). Many farmers were enthusiastic about the advantages of AI, not only because it saved the expense of keeping a bull, but more because it improved the genetic quality of their herds. As an East Devon farmer (no.139) put it: '… the genetics through AI has been immense, the ability to select, as a general farmer, not a pedigree breeder, we had access to some of

the best bloodlines in the world, and that wasn't happening before'. Science, in the words of farmer 466, 'changed the biology of the cow'.

The impact of science on postwar agriculture is widely recognized and has been discussed, to some degree, by Blaxter and Robertson (1995). The transmission of the science to the farmer and its conversion to workable technology has not been so extensively analysed, and consequently exploring education, training, use of advisory services and sources of information formed an important part of the interview programme. The level of education experienced by the farmers interviewed varied considerably. Some went to work on their father's farms as soon as they left school and had no training beyond what they learned from their father. At the opposite extreme, one of the interviewees had a university degree in agriculture and a Master's degree in agricultural economics. In between, several farmers went to their local county agricultural college, either for one-year certificate courses or on day-release programmes, and a few went to Seale-Hayne College, where two and three-year courses were available. Similarly, there was considerable variety in the extent to which farmers made use of advisory and extension services, with some apparently being content to operate with whatever knowledge they gleaned from conversations with their neighbours, while others went to some lengths to acquire technical knowledge and advice. Many, however, spoke enthusiastically about the advice they received from the technical representatives employed by agricultural merchants, feed firms and chemical companies. As farmer 466 put it:

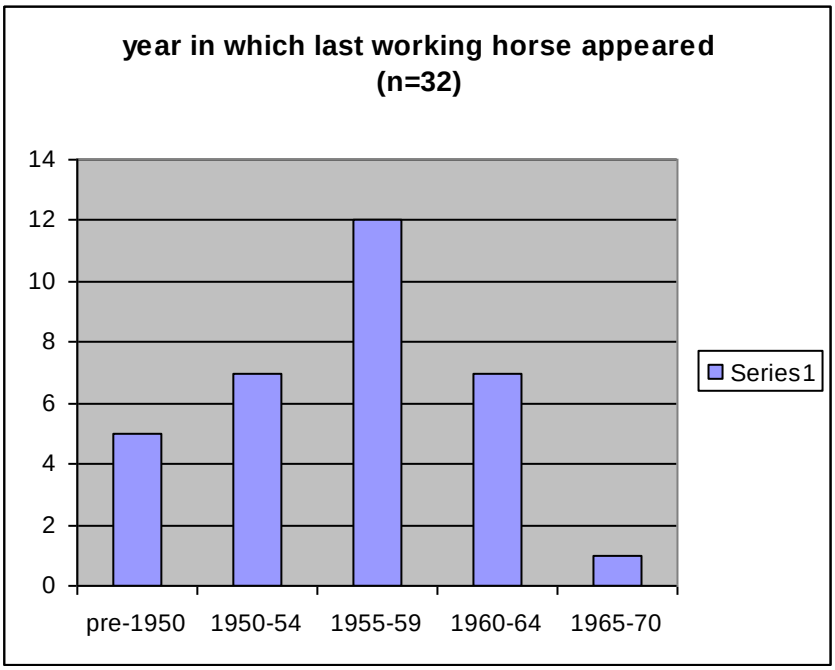
> 'ICI used to have men out in the sticks, teaching farmers to use fertiliser and that sort of thing, there was one in this village who only died recently, from the days when my father and uncle were together in the early 30s, right up to the time they abolished them altogether, in the 1990s, and there was one after another, and they all happened to live in this village. They weren't called salesmen, but they were selling the ideas. They were technical reps. They ran things like grassland clubs, and we all trotted off to the grassland society, and it was very effective technical extension work, and later on we said we don't want to be in hock to those people, but as well as using ADAS [the Agricultural Development and Advisory Service, the successor to the National Agricultural Advisory Service, NAAS] we would use these people, because they would pay for us to go places and look at things. It was effective because

new ideas were coming along quickly – one thinks of tractors, but it was much broader than that, fertilisers, weedkillers, new varieties of seed, and it was effective because these people would take a bunch of farmers to farmer so-and-so and it was very practical extension work at no cost to the farmer except his time. You could see it happening on the ground. With milking parlours, ADAS would have a demonstration if somebody had a new milking parlour.'

This process of transforming science into practical technology is being further investigated, not only from the perspective of the farmers but also from that of the providers.

One of the impressions that emerges strongly from the farmer interviews and the analysis of the accounts is of the enormous variation between farms. While some were milking by machine before the Second World War, we interviewed one moorland-edge farmer whose father bought his first milking machine in 1961. This variation is difficult to quantify overall, but figure 8, which shows how some farms had dispensed with their working horses before 1950 while others still had them after 1965, gives some idea of how extended one important technical change could be.

Figure 8: the disappearance of the working horse



Other variations have to be treated more impressionistically at present, although it may be possible to quantify them eventually. One is that bigger farms, in acreage

terms, tended to innovate earlier. This is hardly surprising, but there is also the impression that tenanted farms innovated later, which is less intuitively obvious, but suggests that the unwillingness of agricultural landlords to invest in buildings may have restricted the rate at which their tenants could introduce technical changes. On the other hand, government grants combined with inflation in the 1960s and '70s to promote innovation. As one farmer (no.209) whose family began with 34 rented acres and who now farms over 700 acres put it: '…at one stage [we] borrowed £70,000 from Barclays to put in a milking parlour, cubicle house, silage barn – we had grant on it – and that was big borrowing back then, but in a year or two, with inflation, you could stop worrying about it'. It is also interesting to note, again impressionistically, that the fieldbooks do not seem to reveal much technical change in the years of the Second World War. The war years have often been seen as a time of significant agricultural change, although recent historical work has questioned and modified this impression (for the UK see Short et al, 2006, and for Europe as a whole see Brassley at al, 2012). Although many farms acquired tractors during the war, their basic pattern of mixed farming continued, and a sample of the 16 farms, covering 2,500 acres, so far analysed that were farming between 1939 and 1945 shows that their average output per acre, in constant (1939) prices, fell from £12.28 in 1939 to £8.63 in 1943 and £7.85 in 1945. Whether a sample of arable farms would reveal the same pattern of change is an interesting question.

Finally…

It should be clear from the foregoing discussion that this paper gives an account of an ongoing research project in which firm conclusions have yet to be reached. One of the reasons for presenting these interim questions to this conference is that we would value the comments of other historians on what we have done so far and what else we might do. Should we, for example, concentrate on analysing the interviews we have carried out with farmers, which could produce as much as 150,000 words of transcript text by the time they are finished, or should we pay more attention to the quantitative analysis of the accounts? Since one of the differences between the interwar and post-war years in the UK seems to be the confidence of farmers to invest and innovate, is there some way in which we can use this material to test that idea? And can we treat the farmers in the FMS sample as typical? We have data from the Ministry of Agriculture which suggests that FMS farms were larger than average, but at least

some of the evidence presented here should suggest that they cover a wide range of attitudes to technical change. Finally, are there sources in other European countries that might provide similar comparative evidence?

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