Introduction

In 1950 there were about 2.4 billion people in the world; the current figure is approaching 7 billion (Cameron, 1993: 193). Hunger has not been eliminated, but the extent of it is not much greater than it was in 1950, and may even be less, so food production on a world scale must have at least doubled in the sixty years since then, more so given the ‘nutrition transition’ towards increased consumption of meat and dairy products. The increase has been particularly marked in the countries of the western developed world – Western Europe, North America, and Australasia (Grigg, 1992). In the United Kingdom the average annual volume of agricultural output increased by three times between the mid-1930s and the mid-1980s. In the twenty years between 1945 and 1965 it was increasing at 2.8 per cent per year, faster than ever before or since (Brassley, 2000: 63 & 84). In the 1930s the UK imported about two thirds of its food; by the mid-1980s the figure was about one third, so the extra agricultural output had been used for import substitution in feeding an increased population that had a higher income and so demanded not only more food, but a greater variety of food (Grigg, 1989: 9). What happened, in the UK in particular, but also in the western world in general, to bring about these increases? Were they the result of increased inputs of fixed and working capital (as in buildings, machinery, feedingstuffs and fertilizers), or of technical change (as in new crop varieties, genetic improvement in livestock, pesticides, and new kinds of machinery)? This paper examines the relative significance of these two possibilities. It explores the use of a long-term ongoing survey of a large sample of UK farms over the period 1935-1985 in the context of the various theoretical approaches to technical change. The

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1 These dates are chosen because they represent a period of reasonably consistent agricultural policy. Before the mid-1930s UK agriculture was mostly operating at world market prices with little government effort to increase farm output above the level produced by those free market prices. After the introduction of milk quotas in 1984 the emphasis on increasing
origins of the survey are briefly explained, and some initial results of our analysis are presented.

The sources of increased outputs

As in any business, farmers have several ways in which they might increase the outputs from their farms. In reality, they are likely to use some or all of them simultaneously, so the following categorisation is schematic, with the various possibilities separated simply as a way to organize thinking. With that caveat in mind, the possibilities are:

1) A change in the output mix – (a) as in the Second World War, when, in response to a shortage of imports, especially of feedingstuffs, UK farmers reduced their output of pig and poultrymeat and increased wheat and potato production at the expense of grassland, so the net output increase was only about 8 per cent (Martin, 2007; Brassley, 2007: 47); or (b) specialisation, which implies that individual farms achieved economies of size (see below), or that regions specialized in what they did best;

2) Increased inputs of fixed and working capital – investment in drainage, buildings, and machinery, and increased expenditure on feeds and fertilizers – which could be brought about by

2a) price effects: the UK agricultural price index in constant price terms began to rise from 1933 onwards, reached a peak from 1947 to 1951, and thereafter declined more or less steadily until by 1985 it was at about a half of its peak level (Brassley, 2000: 83)

domestic agricultural production decreased, although obviously CAP support for agricultural markets did not immediately disappear.
lower prices, as experienced in the interwar period and after 1985, led to greater use of land for water gathering, forestry, and the production of CART (i.e. conservation, amenity, recreation and tourism) goods;

higher prices, conversely, led to increased inputs e.g. feed and fertilizers, but in fact inputs continued to increase even when output prices were falling (Brassley, 2000), a phenomenon explained in different ways by contemporary agricultural economists:

- One theory was what the American economist Willard W. Cochrane called the Treadmill effect, because in an industry with many producers it is worthwhile for an individual to adopt an output-increasing innovation even though the cumulative effect is to drive market prices down (Brassley, 1997: 58-60); or alternatively

- Asset fixity, which explains that the supply of agricultural products is likely to be inelastic in response to falling prices because the acquisition price of a durable farm asset (e.g. a building or machine) is generally much higher than the salvage price, so that the product price has to fall rapidly and significantly before there is any incentive to dispose of the asset (Hill and Ingersent, 1977: 50-52);

2b) cost effects – changes in the relative costs of land, labour, capital and management, the results of which are well known for the 1935-85 period: less labour used on slightly less but better (because of drainage and reclamation) land with more capital. What we know less about is the management input, because it is not so easy to measure. In any case did it simply come from farmers getting better / more entrepreneurial, or can we think of advisory workers, scientists, and the media as external sources of management inputs?

3) Increased output per unit of input – more per hectare of land, per unit of labour, per pound of capital input, and per unit of management, i.e. farmer. Many of these
increases came from new technology: more per land unit from new varieties, breeds and greater use of better fertilizer formulations (and possibly pesticides); more per labour unit from new machinery and pesticides, more per unit of management as a result of farmers being helped to improve their technical competence (which is difficult to measure). The difficult thing to observe is increases per unit of capital, and it may be that capital productivity decreased.

It should be noted that 1, 2, and 3 are interconnected. Increased use of tractors led to fewer horses which meant that farmers no longer had to breed horses or grow oats, so farmers with poor arable could specialize more in grass, although they had to sell more in order to buy tractors and fuel. Similarly pesticides are both land saving, in the sense that they can increase yields per hectare, and labour saving, especially in the case of herbicides, which can substitute for cultivations and hoeing. In 1919 it was estimated that between a third and a half of the field labour on a farm was devoted to weed control (McConnell, 1919: 278). We would therefore expect to see this combination of changes reflected in the Farm Management Survey data relating to individual farms, although it is important to remember that, since farms are individual businesses affected by personal attributes and family circumstances, it would be surprising if the changes all came about in the same combination at the same time. However, we would expect to find, for example, that pig and poultry outputs would decline during the Second World War, when the availability of purchased feedingstuffs for these enterprises was reduced. Subsequently, we would expect to find that the number of enterprises on each farm would decrease and the degree of specialisation on a single enterprise, or on a few related enterprises, would increase. In the post-war years we would also expect to find increased use of purchased inputs in relation to labour, with greater spending on feedingstuffs, fertilizers and pesticides. We would also expect these developments to produce increased yields of crops, meat, and milk per acre or hectare. These changes follow logically from the theories outlined above; whether or not they occurred in practice, and whether they can be identified from the available data on individual farms, are discussed in the remainder of this paper.

What do we already know?
There is much contemporary economic and social analysis of agricultural change in the UK in the mid-twentieth century, by agricultural economists from Ruth Cohen (1940) and Anne Martin (1958) to Hill and Ingersent (1977), Hill and Ray (1987), Brassley (1997), Bailey et al (2004), and Thirtle at al (2004), all of whom use examples from UK agriculture. These were supported by the ongoing analyses of UK agriculture in the Annual Review White Papers, and statistical compilations such as MAFF (1966) and Marks and Britton (1989). A further sub-genre is what might be termed ‘contemporary critiques’ of agriculture and/or agricultural policy. Some of these celebrated the achievements of UK farmers (Donaldson and Barber, 1969; Beresford, 1975), but more were critical, not, usually, of the farmers themselves, but of the policies that had encouraged them towards the changes they had made (Astor and Rowntree, 1939; Astor and Rowntree, 1946; Selly, 1972; Shoard, 1980; Body, 1980; Bowers and Cheshire, 1983; Lowe et al, 1986). In contrast, there has been relatively little historical analysis of the same period, with the exceptions of Seddon (1989), which was very good journalism rather than history, Blaxter and Robertson (1995), which were more scientific reminiscences than historical analysis, Martin (2000), a chapter in Howkins (2003), and articles by Holderness (1996) and Brassley (2000). Taking a wider geographical remit, there have been analyses of factor productivity changes by Federico, who concluded that, for the world as a whole, agricultural output growth was mainly the result of input increases in the nineteenth century, and of total factor productivity growth in the twentieth (Federico, 2005: 221). Lains and Pinilla (2009) present a collection of national total factor productivity studies for a range of European countries.

The principal conclusions of these studies are well known: that the post-Second World War period in Europe as a whole saw a remarkable growth in agricultural production and land and labour productivity, and that the United Kingdom shared in this growth. Brassley (2000: 63), for example, calculates that the rate of growth in the volume of agricultural output (i.e. using a measurement independent of price changes) in the UK reached an average of 2.8 per cent per year in the period 1946-1965, and continued to increase at 1.4 per cent per year in the following twenty year period. It should be remembered, however, that this growth was not evenly spread over all enterprises and, consequently, over all parts of the country. Since the interwar years had seen a reliance on imports for cereals, and farmers had responded by putting down much land to grass, whereas during the post-war years both arable and livestock products were targeted for government.
support, we would expect to find a relatively greater growth in arable than livestock products after 1940. This is indeed what happened, as tables 1-3 demonstrate.

Table 1: agricultural land use in England and Wales, 1940-1979 (‘000 hectares)

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1960</th>
<th>1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>687</td>
<td>811</td>
<td>1348</td>
</tr>
<tr>
<td>Barley</td>
<td>493</td>
<td>1237</td>
<td>1859</td>
</tr>
<tr>
<td>Oats</td>
<td>847</td>
<td>442</td>
<td>95</td>
</tr>
<tr>
<td>Total cereals</td>
<td>2027</td>
<td>2490</td>
<td>3302</td>
</tr>
<tr>
<td>Potatoes</td>
<td>217</td>
<td>239</td>
<td>155</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>131</td>
<td>170</td>
<td>214</td>
</tr>
<tr>
<td>Permanent grass</td>
<td>5841a</td>
<td>4363a</td>
<td>4300b</td>
</tr>
<tr>
<td>Temporary grass</td>
<td>813a</td>
<td>1784a</td>
<td>1500c</td>
</tr>
</tbody>
</table>

Source: all data from Marks and Britton (1989), except for the following:

a: from MAFF (1966: 96-7)

b: estimated. Marks and Britton (1989: 130, table 3.1) shows the UK permanent grass area declining by a small amount between 1960 and 1979, so it has been assumed that the England and Wales area will decline in proportion
c: estimated, given the declining trend for temporary grass in England and Wales (MAFF, 1966: 97) and confirmed for England alone in Martin (2000: 95)

As would be expected, table 1 shows how the area of oats declined as tractors took over from horses in farm work. In total, however, the cereal area increased steadily as first the barley, and then the wheat acreage increased. The sugar beet area increased in roughly the same proportion (about 60 per cent), but the potato acreage was controlled by a marketing board which attempted to maintain prices by adjusting output to demand. These expansions in the arable area were matched by corresponding contractions in the areas of fodder crops and rough grazing (not shown here, but see Brassley, 2000: 64) and permanent grass. Farmers were thus planning to expand their arable crop production by increasing the overall area devoted to these enterprises, but they could also increase output by increasing yields. In part this was a matter of their farm management decisions, most obviously to use more fertilizer or pesticide, but it was also affected by the varieties made available to them by plant breeders and the seed trade. The combined impact of these two factors is demonstrated in table 2.

Table 2: output of arable products in England and Wales, 1942-1980 (‘000 tonnes)

<table>
<thead>
<tr>
<th></th>
<th>1942</th>
<th>1960</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2459</td>
<td>2889</td>
<td>8327</td>
</tr>
<tr>
<td>Barley</td>
<td>1293</td>
<td>3880</td>
<td>8179</td>
</tr>
<tr>
<td>Oats</td>
<td>1753&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1163&lt;sup&gt;a&lt;/sup&gt;</td>
<td>386&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total cereals</td>
<td>5505</td>
<td>7932</td>
<td>16892</td>
</tr>
<tr>
<td>Potatoes</td>
<td>6757</td>
<td>5182</td>
<td>5066</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>2700&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7330</td>
<td>7659</td>
</tr>
</tbody>
</table>

Source: all data from Marks and Britton (1989) except the following

a from MAFF, 1966: 113
b estimated from the oats area multiplied by the 1980 yield figure in Marks and Britton (1989: 164, table 10.9)

c pre-war yield, similar to the 1940 area multiplied by the pre-war yield (Marks and Britton, 1989: 180, table 13.4)

It is clear from table 2 that the productivity of arable land increased considerably in the forty years or so after the beginning of the Second World War. Whereas the area devoted to cereals and sugar beet increased by a little over sixty per cent, the output of those crops increased by three times. But it was not a simple process of steady change. Up to 1960, although there was some growth in cereal yields, the main change was in the expansion of the cereal area; from 1960 to 1980 the area increased by a further third, but total cereal output more than doubled. Overall, therefore, it appears that the whole post-war period, but especially the second half of it, saw significant technical change in arable farming.

Was the same growth apparent in livestock farming? As table 3 reveals, there was certainly a growth in livestock output.

Table 3: Livestock numbers in England and Wales 1940-1979 (‘000)

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1960</th>
<th>1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>7001</td>
<td>8769</td>
<td>9650</td>
</tr>
<tr>
<td>Sheep</td>
<td>17700</td>
<td>18400</td>
<td>21600</td>
</tr>
<tr>
<td>Pigs</td>
<td>3400</td>
<td>4300</td>
<td>6600</td>
</tr>
<tr>
<td>Poultry</td>
<td>51800</td>
<td>82700</td>
<td>108600</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>3160a</td>
<td>2595</td>
<td>2672b</td>
</tr>
<tr>
<td>UK milk production (million litres)</td>
<td>8065c</td>
<td>11892</td>
<td>15354</td>
</tr>
<tr>
<td>Yield per cow</td>
<td>2457c</td>
<td>3381</td>
<td>4714b</td>
</tr>
</tbody>
</table>
Table 3 shows that livestock numbers increased over these forty years. The difficulty lies in moving from simple totals to some idea of livestock yield. It appears to be most simple in the case of milk yields, where it is relatively easy to extract the yield per cow from the available data, and to show that it almost doubled. But it is less easy to calculate the milk yield per acre of grass, because the cows shared the decreasing area of permanent grass, and the fluctuating area of temporary grass, with the other grazing livestock, and their numbers increased too. To further complicate matters, it needs to be remembered that some of the cattle and sheep, unlike the vast majority of the dairy cows, also had a declining area of rough grazing at their disposal (due to both land improvement and afforestation). And as a further complication, increasing livestock numbers by themselves may not equate to increasing meat output if the slaughter weight of fat cattle and fat lambs, or their conformation, changes, as it certainly did. However, while remembering all of these caveats, the overall impression gained from comparing tables 1, 2, and 3 is that livestock output increased less than arable output. Whereas the cereal output trebled in this period, the fastest-expanding livestock sectors – the pigs and poultry – only doubled their numbers, and cattle and sheep numbers only increased by about a third and a quarter respectively. The overall conclusion therefore seems to be that livestock farming did not quite match arable farming in output expansion. Does it follow from this that the pace of technical change in the livestock sector was slower than in the arable sector, or was there some alternative explanation for the differences in output growth? Can we also conclude that geographical regions, or farm size groups, dominated by livestock farming were less likely to be aware of, or adopt, technical developments?
From the work of contemporary agricultural economists, and from the sort of national data analysed here, we have quite extensive knowledge of the economics of the agricultural industry and the impact, at a national level, of agricultural policy. Rather less seems to be known about why some farmers innovated, expanded, and prospered and why others merely survived, or indeed failed. There is a tendency to know more about the successes than the failures, presumably because successful farmers were much more willing to discuss their exploits than failing farmers were anxious to explore the reasons for their failure. Nevertheless, the fall in the number of active farmers since 1940 suggests that not all of those in the industry did survive. The example of some farmers known to the author provides some interesting insights. Those who left the industry had small farms with small dairy herds, with Ayrshire or Shorthorn cows, and several subsidiary enterprises such as pigs and laying hens, all on a small scale. One seemed to have a knack of changing enterprises at exactly the wrong time, so that when returns in battery hen enterprises were declining he invested in battery hens. He also found it difficult to prioritise, and would spend much time repairing and servicing machinery, in which he was interested, when other jobs needed to be done. Another found it difficult to adjust to the need to do more physical work himself when he could no longer afford full-time hired labour. However, even if there are more published memoirs by successful farmers, such as George Henderson (1944), John Cherrington (1979), Tony Harman (1986) and Arthur Court (1987), they still form a tiny percentage of the whole farming population. Consequently important questions remain unanswered. Why was there such a difference between the interwar and postwar responses to price changes? How great were the variations between one farm, or farmer, and another, in their willingness and ability to adopt new technology and change their farming methods? Were there similar variations between types of farming and farming regions? And how important were price and cost signals as against the exhortations of industry leaders, increasing levels of technical education and advice, or the effect of simply reading the farming press, in changing the objectives of farmers? All of these questions suggest that there is a good case for a farm-level historical survey of technical changes in agriculture, coupled with an investigation of the governmental

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2 Although a senior agricultural economist of the Ministry of Agriculture, Fisheries and Food complained in a meeting at which the author was present in the 1970s that even after all the research grants that his Ministry had given to university departments of agricultural economics, the recipients could still not tell him how much more milk an extra penny on the milk price would produce.
efforts to influence those changes, and, fortunately, there are now sources available which enable such investigations to take place.

The Exeter FMS project

As Brian Short and his colleagues have demonstrated, the first half of the twentieth century saw an increasing interest in the collection and analysis of statistical data. The annual June Returns, listing crop acreages and numbers of animals, had been collected since 1866, and there was an estimate of agricultural output in 1908, but in the 1930s these were joined by Stamp’s Land Use Survey and Stapledon and Davies’s grassland survey, and between 1941 and 1943 there was a National Farm Survey of England and Wales. At the same time, statisticians such as Pearson, Gosset, Fisher and Yates developed many of the basic methods of statistical analysis still in use today (Short et al, 2000: 1-3). The surveys previously mentioned collected physical data. Official interest in the collection of financial data can be traced back at least as far as 1918, when the Agricultural Wages Board set up a Committee ‘To enquire into the financial results of the occupation of agricultural land and the cost of living of rural workers’, which emphasised ‘…the immediate urgency of undertaking investigations and preparing records showing the general financial results of farming’ (Cmd.76, 1919: 38). Its recommendations, in this matter at least, were largely ignored. Then in 1936, following the introduction of various grant schemes for agriculture, the Ministry of Agriculture commissioned the Farm Management Survey in order to measure the impact of state support. Initially this involved seven provincial agricultural economics centres and about 1300 farms, or less than one per cent of all the farms in the country, although the numbers involved subsequently increased. Each farmer involved in the survey had to be willing to provide complete statistical and financial data about his or her farm, which was collected by an investigation officer who completed a field book for each farm (Whetham, 1978: 297; Anon, 1938: 42). The survey, now known as the Farm Business Survey, continues to the present day. For the far south western counties of England (Cornwall and Devon) the provincial agricultural economist was originally based at Seale-Hayne College, and subsequently transferred to the University of Exeter. By 1950 Exeter had also taken over survey responsibilities for arable farms in Dorset. The original field books from the inception

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3 Similar surveys were carried out at roughly the same time in Germany and Austria, and Hungary (I am indebted to Dr Ernst Langthaler and Dr Zsuzsanna Varga for this information).
of the survey remain in Exeter. There are some 10,000 of these, each specifying the name and address of the farmer concerned, covering the period from 1936 to 1985, and they form an invaluable source for analysing changes that occurred at the level of the individual farm. Dr Hilary Crowe has used an anonymised sample covering farms in a small district in the north west of England to investigate changes in farm profitability in the mid-twentieth century, but the purpose of the Exeter project (directed by Professor Michael Winter, with the other authors as co-investigators) is to investigate technical change over the period from the mid-1930s to the mid-1980s.

Several stages are involved in this process. The first is to produce a fine-grained and locally specific survey of agricultural change in general, and technical change in particular, by identifying how and when outputs and inputs changed on a sample of farms spread over the two (later three) counties between 1936 and 1985. The original instruction to the surveyors from the Ministry of Agriculture was that no farm was to stay in the survey for more than fifteen years, in order to avoid survey farms becoming untypical, but a search of the archive of field books revealed that twelve farms which had been in the survey in 1940 were still part of it in 1979. The reasons for this are unclear, but it means that we have a much longer-term perspective on these farms than we originally expected. The initial analysis of the field books, which is still in progress, has therefore concentrated on them. For each farm the field books enable us to produce financial data (in £ sterling at current prices) on

- Total output
- Sales of cereals, other crops, and horticultural crops
- Cattle, sheep and pig sales
- Sales of poultry and eggs, and dairy produce

Since specialisation, or concentration on a smaller number of enterprises on any one farm, has been an important dimension of post-war agricultural change, we have used these data to produce an index of farm specialisation (IFS). For the twelve farms so far analysed, the

\[ IFS = \left( \frac{E_1}{O_1} \times 100 \right) + \frac{1}{n} \left( \frac{(O_1 - E_1)}{O_1} \times 100 \right) \]

\[ O_1 = \text{total farm output (£)}, E_1 = \text{output of the largest enterprise (£)}, \text{and} n = \text{number of enterprises}, \text{then} IFS = \left( \frac{E_1}{O_1} \times 100 \right) + \frac{1}{n} \left( \frac{(O_1 - E_1)}{O_1} \times 100 \right) \]
average IFS scores are shown in Table 4, which suggests that although farms became somewhat more specialised in the twenty post-war years, the major increase in specialisation was after 1970. It is important to recognize, however, that even within this small sample of farms the range of IFS scores was large: the least specialised had a score of 43.8, and the most specialised 64.1, in 1940. Twenty years later the range was still wider (40.4 to 72.4), and although it had decreased again by 1979 (60.4 to 87.1) it was still significant. The average number of enterprises per farm on these twelve farms decreased from 5.58 in 1940 to 

<table>
<thead>
<tr>
<th>Year</th>
<th>IFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>50.6</td>
</tr>
<tr>
<td>1945</td>
<td>49.2</td>
</tr>
<tr>
<td>1950</td>
<td>51.1</td>
</tr>
<tr>
<td>1955</td>
<td>52.4</td>
</tr>
<tr>
<td>1960</td>
<td>56.0</td>
</tr>
</tbody>
</table>

or, in simpler terms, the percentage share of the largest enterprise plus the share of the remaining enterprises divided by the number of enterprises. Applying this formula to theoretical examples,

in the first case, when the farm sells only wheat,

\[
IFS = \left( \frac{100}{100} \right) \times 100 + \frac{1}{1} \left[ \frac{(100-100)}{100} \times 100 \right] = 100;
\]

But when the output is equally split between wheat and potatoes

\[
IFS = \left( \frac{50}{100} \right) \times 100 + \left[ \frac{(100-50)}{100} \times 100 \right] = 75
\]

And when a small third enterprise – egg production - is added

\[
IFS = \left( \frac{50}{100} \right) \times 100 + \frac{1}{3} \left[ \frac{(100-50)}{100} \times 100 \right] = 66.6'
\]

At the opposite end of the scale, when there are 20 enterprises and the largest accounts for only 5 per cent of the total output, IFS = 5 + 95/20 = 9.75.
By way of comparison, the national average in 1974 was 2.85 (Hill and Ray, 1987: 238-45). The enterprises that were most frequently discontinued were pigs and poultry – ten of the farms kept both of them in 1940, but none did so in 1979 – and next came arable crops, with seven of the farms either going out of arable production altogether or ceasing production of potatoes or sugar beet. Thus the pattern that emerges is one of concentration on grazing livestock, with either cattle and sheep production or dairy farming with a subsidiary cattle enterprise.

The sales figures, being measured in current prices at a time of inflation, cannot by themselves tell us anything about the impact of technical change on yields over time. However, since there is also an agricultural price index (API) in current prices (1986=100), we can calculate output volumes, in 1986 prices, from the total farm output (O1) used above, using the formula: output volume = O1 x 100/API. Since we also know the acreage of each farm, we can calculate the volume of output per acre, and this can be expressed as an index of the 1940 output for each of the twelve farms. The results of this operation are reported in table 5.

Table 5: output per acre indices (1940 = 100) for twelve farms in Devon and Cornwall

<table>
<thead>
<tr>
<th>Farm code number</th>
<th>1960</th>
<th>1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>101 dairying</td>
<td>216</td>
<td>304</td>
</tr>
<tr>
<td>115 dairying</td>
<td>135</td>
<td>177</td>
</tr>
<tr>
<td>Farm No.</td>
<td>Enterprise Type</td>
<td>1940</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------</td>
<td>------</td>
</tr>
<tr>
<td>192</td>
<td>dairying</td>
<td>186</td>
</tr>
<tr>
<td>209</td>
<td>dairying</td>
<td>162</td>
</tr>
<tr>
<td>466</td>
<td>dairying</td>
<td>173</td>
</tr>
<tr>
<td>515</td>
<td>dairying</td>
<td>228</td>
</tr>
<tr>
<td>524</td>
<td>dairying</td>
<td>230</td>
</tr>
<tr>
<td>106</td>
<td>lowland cattle &amp; sheep</td>
<td>224</td>
</tr>
<tr>
<td>469</td>
<td>lowland cattle &amp; sheep</td>
<td>136</td>
</tr>
<tr>
<td>497</td>
<td>lowland cattle &amp; sheep</td>
<td>156</td>
</tr>
<tr>
<td>162</td>
<td>upland cattle &amp; sheep</td>
<td>349</td>
</tr>
<tr>
<td>324</td>
<td>upland cattle &amp; sheep</td>
<td>307</td>
</tr>
</tbody>
</table>

The most obvious feature of the figures in table 5 is their considerable variation, with one that shows a decrease in output per acre in 1979 compared with 1940, and another that shows only a small increase, to others that show output increasing fourfold or more. Farm 209, where output per acre in volume terms decreased, has some special features which may account for the apparent anomaly. In 1940 it was a very small – only 36 acres – holding concentrating on dairying, pigs and poultry. In other words, it was very intensive. By 1960 the farm had grown to 65 acres, but it remained essentially a small intensive dairy farm with pig and poultry enterprises. But in 1979 it had expanded to 250 acres, the pigs and poultry had gone, and it was a fairly standard dairy farm with a subsidiary cattle enterprise, and thus operating much less intensively. Farm 469, on the other hand, which is the one showing only a very small increase in output per acre, exhibits very different features. It remained at roughly the same size – 132 acres in 1940 and 166 acres in 1979 – and retained a variety of enterprises, producing cereals, cattle, sheep, pigs and milk in 1940 and the same, except for milk, in 1979. In contrast, farm 466 was one of those that specialised. In 1940 it was an ordinary mixed farm with six arable and livestock enterprises on about 200 acres; by 1979 it had expanded to 551 acres and operated as a specialist dairy farm with a few beef cattle and sheep. Total output had grown by five times since 1940, and it was by far the biggest.
business in the twelve farm sample, but output per acre growth was relatively modest. Conversely, farm 515, which achieved the biggest growth in output per acre, remained at roughly the same size and only specialised to the extent of getting rid of the pigs and poultry.

The conclusion that emerges from these figures is that there is no obvious connection between output per acre growth and factors such as specialisation, farm size, or particular enterprises. Most farms doubled their output per acre, and some more than quadrupled it, but further analysis is required to find out how they did so. Unfortunately there are no specialist arable farms in this sample, but it would also be interesting to see if there was a difference in the performance of arable and livestock farms that replicates the national differences discussed above in relation to tables 1, 2 and 3. Expansion of the sample will probably permit this comparison in future. The most striking impression remains the inter-farm variation.

The fieldbooks also have yield figures for crops in most years. The main problem with the farms studied so far is that cropping generally forms a minor part of the farm business, and that crops are sometimes grown as feedingstuffs rather than being sold. The design of the field books, which is not unchanging, generally contains provision for stating or calculating crop yields, but in the sample of twelve under discussion at this point only one farm, in lowland Devon, grew wheat, barley and potatoes in both 1940 and 1979. In 1940 it produced 1.17 tons of wheat, 0.96 tons of barley and 4.7 tons of potatoes per acre; the corresponding figures in 1979 were 2.2, 1.7 and 11.8 tons. These figures are not very different from the national averages for the time (although the potato yields are a little low), but the important point is not that one can generalise from a sample of one, but that the field books can provide data for a much larger sample of cereal and potato yields.

Computing livestock yields is more complex, and this is a significant problem in a livestock area such as south west England. Fat cattle take more than a year from calving to be produced, and vary in weight. Not all calves are sold as fat cattle – some may be sold as stores for further fattening elsewhere – and not all cattle sold were specifically grown for meat, since some would have been cull cows. A sow may have more than one litter a year, the produce of which may be sold as fat pigs, either as porkers or heavier baconers, or as
weaners or stores for further fattening. The method we have used is to divide the output for any one year for any species of animal (i.e. cattle, sheep and pigs), measured in pounds sterling, by an average price figure for that year, derived from UK national statistics, thus producing a notional volume figure. This should effectively reflect the annual yield of livestock from the farm, changes in which can therefore be tracked over time. However, for grazing livestock these need to be related to the grassland area, details of which have still to be extracted from the field books. In addition, dairy cows compete with other grazing livestock for the grassland, so ideally we need to find a way of adding milk and meat outputs, and this is a problem we have not yet solved.

Measuring recurring costs from the fieldbooks should be straightforward, because they contain data for purchases of fertilizers, pesticides, feedingstuffs, seeds, etc, together with vet bills, machinery maintenance and fuel costs, and so on. The analysis of these figures for the twelve farms is still in progress, but preliminary results show some interesting patterns. Given the national trends of increasing feed, fertilizer and farm machinery use, and decreasing numbers of farm workers in the post-war period, we would expect to find that labour costs would account for a decreasing percentage of total costs, while the opposite would be the case for purchased inputs. On a lowland dairy farm near Tiverton in Devon (code no.192) this was more or less what happened. The labour costs declined from 44% of total costs in 1940 to 35% in 1979, while fertilizer costs rose from 7.7 per cent to 9.8 percent in the same period, with feed costs increasing from 11.4 to 19 per cent, and machinery costs from 4 per cent to 9 per cent of total costs. But not all of the farms so far analysed conformed to this pattern. On an upland farm on the side of Exmoor, for example, labour costs rose from 39 per cent of total costs in 1940 to 43 per cent in 1979, while machinery costs also rose from 5 to 16 per cent of the total but purchased feedingstuffs declined from 36 to 9 per cent of the total costs. And there are more unexpected results in several of the other farms in the sample of twelve. One possible approach to understanding these variations is to calculate accounting ratios such as the purchased input / labour ratio, the output/labour ratio, and total outputs per £100 of input, and again tracking these over time, and identifying variations, if any, between farm types, regions, and size groups. Some preliminary results from this exercise are shown in table 6.

Table 6: average ratios for 12 farms
The figures in table 6 clearly do not conform to the expected pattern, in which we would expect purchased inputs and output to increase per £100 of labour cost as farms shed labour. This could simply be an effect of a small sample size with three representative years picked at random in which these averages hide considerable variation. On one farm, for example, purchased inputs per £100 of labour cost decreased from £610 in 1940 to 250 in 1979, while on others they increased. As these figures suggest, the range of variation around the average was also large. On the other hand, the data on the change from horse to tractor power is much more consistent. All but three of the twelve farms still had working horses in 1950, but none still had them in 1955. All but two of the farms bought tractors during the war, and of the two that did not, one already had a tractor.

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1960</th>
<th>1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchased inputs per £100 of labour cost</td>
<td>329</td>
<td>310</td>
<td>309</td>
</tr>
<tr>
<td>Output per £100 of labour cost</td>
<td>384</td>
<td>421</td>
<td>388</td>
</tr>
<tr>
<td>Output per £100 of input</td>
<td>115</td>
<td>135</td>
<td>130</td>
</tr>
</tbody>
</table>

Several questions and conclusions emerge from this preliminary (and it is important to stress that it is still very preliminary) analysis. Is the choice of 1940 and 1960 as comparison years sensible – would 1950 and 1965 reveal any different results? Are there other figures (apart from the obvious one – the grassland acreage) that still need to be extracted from the field books? The archive is large, with thousands of field books covering hundreds of farms, but the work done so far has dealt only with twelve farms, although they are the twelve for which most data is available. We therefore need to examine further ways of using the whole archive to produce comparative data. On the other hand, there is a good case for writing field-book-data-based histories of individual farms, examining changes from year to year rather than simply focussing on individual years which may be atypical for an individual farm. This material can then be supported by going back to the farmers concerned, or their successors. While the field book studies may reveal how farms responded to changes in prices, input
costs, and the availability of new technologies, they do not tell us why farmers made decisions to change at specific points in time. The second part of the Exeter project therefore aims to identify farmers for oral history interviews. A particular strength of the field book archive is that it contains addresses of specific farms. Although the original survey was carried out on the assumption of anonymity, we feel that, after a gap of at least twenty five years (and in most cases much more), surviving farmers and their descendants will be willing to be approached for such interviews, on the clear understanding that they can always refuse. In any case, the approach will be made by Exeter researchers in accordance with the terms of the original confidentiality agreements. A farmer born in 1930, and so beginning to take a significant part in decision making on the farm in the crucial decades of the 1950s and ‘60s, will be 80 in 2010, so the next few years may well represent the last opportunity to find a reasonably large sample of such people. We argue that the availability of field book data on the interviewee’s farm should make the dialogue between historian / interviewer and interviewee more specific and realistic. Instead of simply asking for general recollections and anecdotes, it should be possible to pursue a line of questioning that explores individual farm management decisions at particular times. Well-established as it is, oral history has not been without its critics, who have argued that it could be subjective and unreliable, or that much popular oral history has concentrated upon and celebrated older technologies more than recent technical change. There is some substance in this latter criticism as far as agriculture is concerned, because the pioneers of oral history did their work when they could still interview farm workers who remembered a largely pre-mechanised countryside (Evans, 1956 & 1960). Much subsequent popular history, especially on radio and television, has adopted the same viewpoint, although it is notable that a recent television series, Mud, Sweat and Tractors, based on contemporary amateur film mostly shot by farmers themselves with commentary by agricultural historians, analysed and to some degree celebrated technical change (www.availablelight.tv). Oral history does not necessarily have to be populist, uncritical, or unanalytical. Work by Riley and Harvey, for example, shows how oral history can be used to reveal historical complexity, or the way in which technical change was not inevitable, or simply resisted, but negotiated and debatable (Riley, 2004; Riley, 2006; Riley and Harvey, 2007). Technical change clearly involves more than farmers simply deciding to adopt or not adopt a technology that just appears as if by magic from some external source.

Conclusions
This paper sets out to describe the initial results from a three year research project which, at the time of writing is only ten months old. Consequently analysis of the research results is still in its exploratory stage. One of the purposes of the paper is to generate feedback on the research programme, so all comments will be gratefully received.

The Exeter FMS project begins with the analysis of data from three counties in the south west of England, and one of the first questions that arises is whether or not this region is typical to the point that the results produced by this study will have any relevance to the study of technical change in agriculture in the UK as a whole, western Europe, or the world in general. The south west of England is, and for several centuries has been, an area dominated by grassland farming and the production of dairy products and meat. On the other hand, there are significant areas of arable farming in Dorset. However, the best answer to the question of typicality is that we are interested in the process of technical change, so that the particular technical changes that occurred in one region are essentially no more than a framework upon which to hang the analysis of the process. Although this paper does not discuss them, many of the variables with which we are concerned, such as the policy environment, the educational and advisory systems, and so on, are much the same over the whole of the UK (albeit with some interesting variations in Scotland), and, in the case of the CAP, over western Europe as a whole.

It should also be noted that an implied objective of the project is to explore the use of the field books as a data source. We are unlikely to exhaust their possibilities in a three year project. Since there are summary sheets available at the University of Reading, one extension of this project (admittedly more difficult in the absence of names and addresses) would be similar studies on other parts of the UK. Another, rather easier, would be to use the Exeter fieldbooks for studies of other topics, such as farm incomes (as Hilary Crowe has investigated for parts of Cumbria). Methodologically, the other important parts of the project are the use of oral history, the investigation of UK National Archive material relating to technical change, and the exploration of various theoretical positions (not discussed here, but considered in an earlier paper given at Gent in April 2010 – see www2.iisg.nl/esshc/2010.php), but it is still too early to say anything about these.

The major question remains the relative importance of the factors affecting agricultural output growth. Does Federico’s (2005) conclusion that agricultural growth in the twentieth century depended on increasing output per unit of inputs, rather than simply
increasing inputs, apply to the UK in the mid-twentieth century, or was it in fact agricultural-
policy-driven increases in those inputs which are especially difficult to measure, capital and
management (which includes management inputs from outside the farm in the form of
advice), that produced the indisputably rapid growth in outputs? In either case, was it
increased use of the technology that had been gradually developing, at least conceptually,
since the nineteenth century, that had the bigger impact, or innovations that suddenly
appeared during and after the Second World War? If so, what produced the sudden rapid
efflorescence of science-based high technology in an apparently tradition-bound industry?
The war and the years after it saw changes in attitudes to farming and its role in society. To
what extent did the farmers’ perception of their role change, and how did that affect their
business goals or objectives? These are not necessarily new questions, but they are still
questions without agreed answers. Our analysis of the Farm Management Survey data has
now reached a point where we can begin to see how we might produce some evidence that is
relevant to them, although definitive answers at present remain tantalisingly beyond our
grasp.

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A survey of grassland on 127 farms in south-west England was conducted in order to investigate the cutting and grazing management of grassland, botanical composition and the use of fertilizer N, and to quantify recent trends in reseeding and the age structure of swards. Twenty-six percent of the grassland surveyed was classified as arable grassland (in rotation with crops) and 74% as permanent grassland. It is mainly found in south-western England, the lowland areas of Wales and in Lancashire. Dairy farmers prefer fertile, well-drained soils that produce high quality grass. Dairy farms supply milk to nearby urban areas as well as to dairies for the production of milk products such as butter and cheese. Arable farms are mainly found in eastern England, including Norfolk and Lincolnshire, as well as the east of Scotland. The farmers use machinery and so prefer flatter land. An ideal climate has warm summers with rain during the summer growing season. Arable crops attract guaranteed prices through the Common Agricultural Policy (CAP) of the European Union. Sheep farming. Sheep produce meat and wool. Agriculture in the United Kingdom uses 69% of the country's land area, employs 1.5% of its workforce (476,000 people) and contributes 0.6% of its gross value added (£9.9 billion). The UK produces less than 60% of the food it consumes. Agricultural activity occurs in most rural locations, it is concentrated in East Anglia (for crops) and the South West (livestock). There are 212,000 farm holdings, which vary widely in size.