Journal of Rural Studies, Vol. 5, No. 2, pp. 149–160, 1989
Printed in Great Britain

0743–0167/89 $3.00 + 0.00
Pergamon Press plc

Economic Signals, Farmers' Response and Environmental Change*

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Abstract — Economically efficient food production and the achievement of rural environmental goals are, and are always likely to be, in fundamental conflict. Agriculture is a gross intervention on the ecosystem by man to satisfy his own requirements for food, energy and fibre. The competition between agriculture and the environment has intensified in the last few decades and this period has been associated with increased concern about environmental despoilation. The causes of these tensions are complex and unclear. Thus, it is unsafe to expect that a rolling back of agricultural support will automatically restore an environmentally preferred agriculture. Environmental progress in rural areas requires a more positive and targeted approach.

I. Introduction

The dynamism of the agricultural sector throughout the developed world is simultaneously the source of enormous pride and of difficulty. Farmers, their representative organisations, the agricultural supply and processing industries and sponsoring government departments all, and quite reasonably, point with satisfaction to the record of output growth in volume, range and quality and to the accompanying improvement in labour productivity in agriculture. This performance is often held up as an example to other more sluggish sectors of the economy. During the last two decades this pride has been increasingly dented by criticisms of agriculture. The most enduring object of criticism which has grown most in the public eye has been the deleterious impact of modern farming methods on habitat, landscape and air and water quality. That said, the issues of access to the countryside and the treatment of animals in intensive livestock production have also been associated with a large public following which is mostly critical of farmers and landowners. The initial reaction by the agricultural lobby was resentment. Fairly intense hostility was directed towards the critics and the official response, that is, the attitude of the Ministry of Agriculture, was very defensive of the record of the farming industry. It was still maintained that farmers were the best guardians of the countryside and there was little official recognition of the 'environmental' problem. Very crudely, this period of the debate can be marked as covering the period from 1963, with the publication of Rachel Carson's book *Silent Spring*, to 1983, the year of publication of Bowers and Cheshire's critique *Agriculture, the Countryside and Land Use*. During this period there was some success by environmentalists in gaining recognition of the need for government action to conserve and protect habitat. The main achievement was the Wildlife and Countryside Act of 1981. However, the connection between these environmental issues and mainstream agricultural policy was not yet officially acknowledged.

The key which has elevated the environmental impact of modern agriculture into a central concern of agricultural policy has been the emergence of the European Community as a net exporter of most temperate agricultural produce. This transition, which took place during the early 1980s, has been accompanied by an extremely rapid escalation of the budgetary costs of agricultural support. All the while Britain and the EC depended upon, occasionally unreliable, imports for much of their food, environmental despoilation was apparently to be taken as a politically acceptable price to pay to encourage domestic agriculture. As it became clear that food security (which, rather crudely and incorrectly, is taken as being synonymous with self sufficiency) was no longer a problem, the public has gradually become aware that it is paying in four separate ways for continued agricultural support. First, it is paying

*This paper has benefited from helpful comments on earlier drafts by Martin Whitby, Philip Lowe and Christine Ennew. However, they are not responsible for any errors or misconceptions in this final version.

the environmental cost; second, consumers pay higher food prices engendered by the protectionist Common Agricultural Policy; third, the large and rapidly escalating budgetary costs of farm support is paid by taxpayers; and fourth, the disruption to international relations caused by subsidised food exports is a burden carried by European citizens. In short, draining wetlands and destroying hedgerows seems to have been publicly acceptable whilst it enabled displacement of imported grain but is unacceptable when it results in unsaleable export surpluses. It is also the case that both the extent of the environmental damage itself and the extent of public awareness of this damage have both increased alonside the growth in production and surpluses. The result of the combination of these factors is that every European Commission document on agricultural policy now makes a reference to the need to attend to environmental issues.

The linkage of the environmental impact of agriculture to that of the surplus problem is both unsound and unwise. It is unsound because it masks the complex interrelationship between the output of food and the output of environmental 'goods' from the agricultural sector. Thus, irrespective of the degree of food self-sufficiency, the lack of markets for environmental outputs prevents the socially correct mixture emerging. There is no reason to expect that the elimination of surplus food production *per se* will produce a farming industry of the size and type which combines socially optimal levels of food and environmental outputs. Neither is it wise to link the surplus and environmental problems too closely. It may hook what are delicate and often national and site-specific environmental problems to the juggernaut of a supra-national agricultural policy. The process of change in the CAP is subject to highly specific and nationally differentiated considerations of farm income effects, commodity balance and budgetary contributions. Progress in reform is already slow. To add to the complexity of this process the further consideration of the ill-defined concept of environmental improvement may slow the process still further and is unlikely to yield much environmental benefit.

The force of these remarks is that it is necessary to have a very much clearer understanding of the nature of the interaction between agricultural and other policy measures, the farming system and its environmental effects, before useful policy change can be prescribed. Towards this end, this paper continues the search for a suitable analytical framework in which to study the interactions between agricultural policy, agriculture and the natural environment of rural areas. This paper attempts no more than to summarise the state of the art as perceived by a neoclassical economist following 2 years of intermittent discussion of the subject under the aegis of the Economic and Social Research Council working party on Agricultural Land Use and Environmental Sustainability. In section II the technical and economic relationships between food and environmental outputs of agriculture will be considered. Section III will discuss the determinants of change in agriculture. Section IV considers the impacts of economic and agricultural policy on the determinants of agricultural change. Section V then attempts to draw some conclusions for the attainment of rural environmental objectives.

II. The food and environmental outputs of agriculture

Agriculture has traditionally been viewed as the archetypal competitive industry described in elementary economics textbooks and which combines land, labour and capital to produce an output called food. Food, of course, is not a single homogeneous product but comprises a large number of products which have complex pattern of interdependencies in both production and consumption. Thus, arable crops are substitutes for one another in that they compete for factors of production; yet they also have some features of complementarity illustrated by the practices of crop rotation and double cropping. Livestock outputs also compete with arable crops for land and other resources. The most important complementarity between livestock and crop production is the use of animal waste as manure, but additionally the livestock sector is a most important consumer of crop output (mostly forage, oilseeds and cereals). A further complexity is the existence of joint products of which the most significant are, milk and beef, the co-products of cereals and sugar ranging from straw and beet pulp to starch and corn gluten, and of course meat with hides, skins and wool. The study of the interactions between these commodities at the level of the individual decision making unit, the farm, has been the subject of farm management economics. Agricultural economists more generally have focused on the market level interactions between commodities and the national and international issues which arise.

Although its atomistic structure has encouraged economists to consider farming as a perfectly competitive industry, the special importance of food and farming in the national economy and culture, together with the dynamics of the industry, has been taken to justify a long history of governmental interference in agriculture. Security and stability of food supplies are, naturally enough, high priorities of any government. These objectives have been used

to justify protection and stabilisation of the industry. However, such motives are not sufficient to explain current support levels in the EC and elsewhere in the industrialised world. The tendency of agricultural production growth to exceed the growth in consumption of food is the root cause of the 'farm problem'. The resulting secular decline in the terms of trade for farmers has spawned in all developed countries a battery of policy measures designed to assist the adjustment process, to preserve rural standards of living and to raise farm incomes. Such distributional objectives have generally commanded widespread political support and the costs imposed on the rest of society in terms of either higher food prices or public expenditures, or both, have not been significant political issues. For decades the additional output of farm produce in Europe and North America has been absorbed by displacement of imports and the discovery of export markets, respectively. The expansion of these markets has now slowed, and in the absence of a significant acceleration in the rate of economic growth in developing countries accompanied by a resolution of the problems of international debts in these countries, there is little prospect of substantial new markets for EC and U.S. surplus production. The problem of agricultural overcapacity in the developed world is difficult enough in its own right and agricultural interests would prefer that it is tackled by the preservation of farm incomes whilst natural demographic trends bring about a mass retirement from farming.

This very largely has been the accepted policy pattern until recently. Now, the expensive surplus production together with increased awareness of, and concern for, the environmental consequences of the very rapid pace of technological change are testing this established view. Thus, there are two very substantial problems associated with the rapid pace of technical progress in agriculture. First, how to encourage labour out of the sector fast enough to enable those remaining to make a reasonable living in the face of declining real prices, and yet not so fast as to add to the problem of urban employment. Second, how to deal with the externalities generated in the process of modernising agriculture.

Progress on these two questions depends on a clear understanding of the nature of the relationship between agriculture and the rural environment. One way of viewing this is to consider food and environmental goods as outputs of the agricultural sector. Agriculture does not produce all the food output of the economy; there is an increasingly important component of food value added produced downstream by the food processing and distribution industries. However, these are largely urban, industrialised concerns whose influence on the rural environment is indirect. Likewise, agriculture does not produce all the output of rural environmental goods. Forestry, recreation, the tourist industry and even the Ministry of Defence all have significant effects on the output of these goods. Despite these considerations, the remainder of this paper is focused on agriculture.

The two goods, food and rural environment, are produced using agricultural resources (land, labour and capital) and thus they are fundamentally in competition. More of one good generally means less of the other. It is important to remember that the conflict between agriculture and the rural environment is not something which has only arisen in the post-war period (or since Britain joined the EEC as some would have us believe), but is as old as agriculture itself. Figure 1 illustrates this point by simplifying several thousand years of agricultural development in the form of a shifting production possibility frontier (PPF).[1] The commodity 'rural environment' is taken to represent an index of the state of the natural rural environment incorporating all its components: species, habitats, landscape, clean air and water, access and the desirable social aspects of the rural environment. It is clearly not a homogenous product and there are complex interactions between its components. It is also important to note that part of what is desired in the rural environment is not natural. Some is semi-natural and some is artificial. As will be shown later, these aspects may, in certain circumstances, be complementary outputs with food production. Despite these complications conceptually it is possible to contemplate an index of output of the good 'rural environment' even if the compilation of such an index poses considerable problems both in principle and practice.

The simplification of rural output into two elements, food and rural environment is justified on the grounds that it facilitates analysis and both outputs are concepts which politicians use even they are not amenable to objective scientific measurement.

Food output is likewise a heterogeneous collection of goods, although its aggregation into a single index poses far fewer and less fundamental problems than for the environment. The production possibility frontier is the locus of achievable combinations of food and environmental outputs. This frontier represents the maximum which can be produced at any time, given available resources and technology. Over time the frontier shifts up and to the right both because of the expansion of real resources, particularly labour and capital, but also in the context of the development of virgin territory, land. In addition the

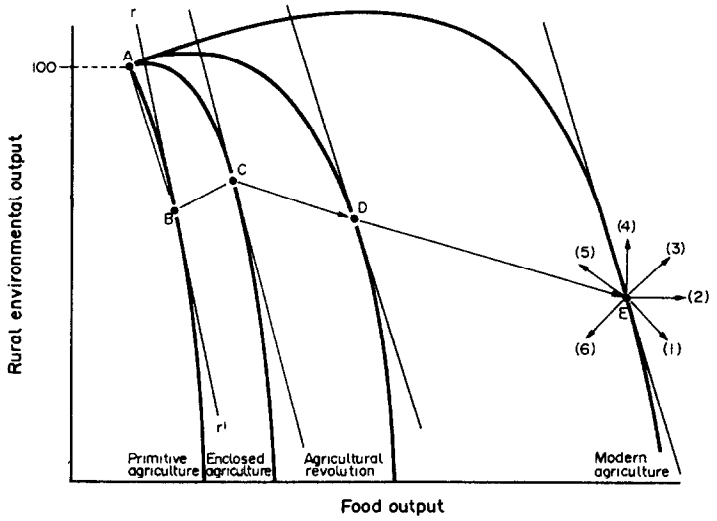

Figure 1. The evolution of the agriculture–environment production possibility frontier.

frontier is shifted by the development of new technologies which enable a greater output to be produced from a given quantity of resources. It might be thought that the PPF can only shift rightwards and not upwards. This is consistent with the view that environmental goods are produced only by 'nature'. This is clearly not the case; man can make investments for the production of environmental goods as exemplified by nature trails, tree planting and the creation of country parks. In addition, as will be discussed below, environmental goods are often joint products with some types of farming, herb-rich meadows, traditional farm buildings and stone walls are examples of such co-products.

In his most primitive state before agriculture was practised, man existed in a state of stable dynamic equilibrium with the natural environment. Food was collected and hunted by man in a comparable way as by other mammals. Food output was low both in an absolute sense, the earth did not support many humans, and in a relative sense compared to modern diets. It is convenient to define the index of environmental output at this stage as 100. This environmental state was not static, the landscape was moulded by forces larger than man and fluctuated over geologic epochs from desert to ice sheet. Since the last ice age the landscape has been created as a product of interaction between climate, flora and fauna. Species have appeared and disappeared as evolution has taken its course. This point may be depicted as A in the diagram.

The development of primitive agriculture which entailed the domestication of animals and the beginnings of cultivation of crops entailed a move from point A to B. Man started his interference with the natural environment clearing forest by cutting and burning, and unwittingly manipulating natural grasslands by encouraging grazing animals. Whilst no doubt still very much at the mercy of the natural conditions, this process of primitive agriculture had the effect of diminishing environmental output, perhaps quite substantially.[2] Food output grew, but slowly relative to current levels. The production possibility segment AB thus represents the range of choice between a completely natural environment supporting very few humans, and primitive, shifting, subsistence agriculture for larger tribes.

It is interesting to pursue the economic logic of the production possibility frontier in this example a little further. The rational choice of combination of environmental and agricultural output should satisfy equality between the marginal rate of substitution of environment for food and the relative prices of food and environment. In the situation of subsistence agriculture with the relative scarcity of food and abundance of 'environment' the price ratio will be extremely high. This is depicted by the steep isorevenue line rr'. As economic development occurs food becomes less scarce, rural environment becomes more scarce and so the ratio of the price of food to environment falls; diagrammatically rr' becomes less steep.

Crudely summarising the culmination of the following few centuries of development, the next landmark shown as point C on Fig. 1 represents early capitalised agriculture. By this stage populations had settled and land was mainly enclosed to protect more productive livestock and crops. Scientific farming emerged with the selection of animal and plant

varieties, primitive rotations and mixed, integrated farming systems. These changes in technology, together with the increased land, labour and capital employed in agriculture, push out the production possibility frontier to that labelled 'Enclosed' agriculture. The shift in the PPF is partly upwards as well as rightwards. This is because the nature of enclosed agriculture itself creates environmental goods. The settlements themselves, the field and settlement boundaries and the social order all represent environmental features which have endured and have become regarded by modern man as desirable. This phase of development might, therefore, be represented as a move in a north-easterly direction onto higher possibility frontiers indicating a complementarity between agriculture and the environment.

The time path of agricultural development between *C* and *D* in Fig. 1 is shown as having only a small negative slope. This represents the changes brought about by the agricultural revolution, that is, the improvement of agriculture through selective breeding, manuring of crops, rotation and mechanisation based still on animal power. This traditional farming, as we now view it, increased food output considerably. It was also associated with environmental degradation in the form of forest felling and the clearance of other ecosystems, drainage, more intensive grazing and the move to monocultures. A balance sheet of the impact of this traditional agriculture on the environment is beyond both this author and this paper. Whilst the extent of farmed land increased with population pressure and thus there was a strong element of the competition between food and environmental output, the nature of the agriculture pursued embraced many features which society has now come to regard as highly desirable. Examples of such agro-environmental joint products are 'Capability Brown' parkland landscapes, traditional wood, stone and brick farm buildings and stone field boundaries which are the products of the previous two or three centuries. The balance between the environmental damage and good during this era is not obvious; Fig. 1 shows it as having been negative; i.e. *D* has a smaller environmental output than *C*.

The final era shown in the diagram is that of modern scientific agriculture which could be thought of as emerging after World War I, and accelerating after World War II. The most striking feature of this period is the rapid expansion of food output. The product of the researches of plant and animal breeders, agricultural chemists and engineers has enabled a dramatic shift rightward in the production possibility frontier. This shift was achieved at the same time as land was continually removed from agriculture and labour in agriculture declined substantially. It was made possible by the combined effect of the rapid substitution of chemical and mechanical inputs for land, and more particularly, labour and by the input-neutral application of scientific knowledge to agriculture.

This account has been a gross simplification, both in terms of economic history and the rather complex nature of the interaction between farming and environment. However, it serves the purpose of making three major points.

First, the relationship is predominantly one of competition, hence the generally negative slope of the PPF. Over the long sweep of history, the impact of man on the environment has been to replace diversity with uniformity. In terms of the sheer area of natural habitats destroyed, the bulk of the damage in western Europe was done one or two centuries ago. Competition and not complementarity has been the predominant relationship between food production and output of environmental goods. Only the middle period of this historical development is characterised as one of much less disharmony between food production and its effects on the environment as we now view it. Whether mediaeval ecologists would have shared this opinion as they watched the wholesale destruction of hardwood forests is less clear.

The second point is to observe the main driving forces of the steady erosion of the natural environment in favour of greater food output, that is, economic growth driven by population pressure and fueled by technological change. The rate of change at each stage in the development path was conditioned by a multitude of economic, social and political factors existing at the time. In the most recent few decades, agricultural policy has been added to the list of such influencing factors. Contrary to popular wisdom it may be the case that such policies, implemented to ease the rate of adjustment of agriculture to the new technologies and operating by maintaining in production high cost inefficient producers, have slowed the technically driven outward shift of the frontier. On the other hand, policies which artificially raise the price of food, such as have been pursued in most of western Europe since the nineteenth century and in Britain since the 1930s, will stimulate greater food output at the expense of environment. In the diagram the price ratio between food and environmental output is shown to fall. That is, the implicit price of environmental output rises faster than the price of food. The argument to support this is that in the modern era environmental output has become relatively scarce and food output has reached a point of satiation.

This argument is deemed to outweigh any impact of artificially supported prices for food. The main point to observe is that quite large changes in these relative prices are unlikely to have as much influence on the balance of food and environmental output as changes in resource availability and technology. The shifts in the PPF are much more important than movements round the frontier.

Third, it is interesting to speculate on the relative positions of points A–E in the food–environment space. The horizontal ordinates of these points are reasonably well known from the historical record of food consumption patterns and total population. Whilst not drawn to scale, the relative size of the growth in food output in the four eras (which themselves have not been precisely defined) is roughly correct. The vertical ordinates are much more controversial. The author's casual judgement is as shown, but whether point D is half-way between A and E or more or less than half-way is debatable. Similarly, given the definition of point A as 100% on the vertical axis, is point E at 10% or 50%? Resolution of these questions is important if one takes the rational economising approach to the food–environment debate.

There is considerable dissatisfaction with the present mix of outputs represented by point E. Moving to a preferred point to the north of point E (i.e. with higher environmental output) will require either a change in relative prices of food and environment or a mixture of public subsidy and regulation and it may entail a reduction of food output. Unless the view is taken that any environmental improvement is desirable, irrespective of the cost of achieving it, arriving at a socially optimal point on the frontier requires some guide to the magnitudes on the vertical scale and their value. It is useful to characterise the array of possible future paths for the PPF. Continuation of past trends will take us in a south-easterly direction [shown as (1)]. This is not desirable because there is no market for the food output and there is almost universal acceptance that environmental output is already sub-optimal. Environmentally neutral 'progress' in which food output continues to rise is shown as (2). This minimalist strategy is the prevention of further environmental loss. Environmental friendly moves are shown as the range of paths (3)–(5). From the natural environmentalist viewpoint, the worst of all worlds is trajectory (6) which involves a reduction of food output but a further despoilation of the rural environment. This is the path on which farmers make up their income losses brought about by cuts in support by diversifying into large scale coniferous forestry or by selling land wherever possible for urban development. As much as it may seem desirable to be moving NW in the diagram, reducing food output whilst increasing production of environmental goods, this will be an historically unprecedented step. Technical progress in agriculture is likely to continue and the most favourable outcome is a repeat of the 'mediaeval' path (3), that is continued expansion of food production coupled with a greater environmental output.

III. Determinants of agricultural change

Taking the historical perspective serves the useful purpose of clearly identifying the forces behind agricultural change. These can be summarised as economic growth, technical change, factor price change and product price change. These forces do not operate independently but in a rather complex interactive manner. Nonetheless it helps to separate their influence. There is a degree of simultaneity between the growth in demand for food, which is conditioned mostly by population and income growth, and the output of food. Output rises to satisfy growing demand, but also rising nutritional levels enable faster population and income growth. The predominant relationship is the former one in which demand pressure forces agriculture to expand. This has only very recently ceased to be the case in Europe and North America but is still one of the most important factors in most of the rest of the world.

Economic growth and technical change

Pressure of demand, sometimes, but not always, signalled by high or rising prices, serves to attract resources of all kinds towards increasing agricultural production. One such category of resources is the input of agricultural research and development (R & D). There can be no doubt that over a long period of time food demand pressure has created the justification for considerable public funds to be devoted to R & D. Similarly, much of the private R & D has been attracted by the same forces. However, it would be a mistake to assume that all research, and the technological shifts which result from its application, is motivated by demand pressure. Irrespective of the pressure of demand and the state of the market, the drive to reduce production costs and thereby to create short run profit is a powerful incentive for innovation and thus research. To some extent technology truly appears as 'manna from heaven' propelled by nothing more than the sheer curiosity of trying to do it better than we used to or better than someone else does. The momentum behind this process of technical development and change should not be underestimated. The effort is

worldwide, taking place in multinational private corporations and public institutions as well as in national private and public organisations. The existence of what are regarded as politically induced disruptions in food and environmental markets in Europe and N. America will have very little bearing on the volume and nature of agricultural R & D.[3] Even if particular governments, finding themselves dealing with an embarrassment of food output, decide to trim their agricultural R & D budgets, this may have little effect on the rate of technical progress in agriculture. Technology is extremely mobile internationally and thus new techniques can just as easily be imported if they are not available domestically. A further feature of new developments in agricultural technology is that many will be the by-product of more general research in biotechnology and medical research.[4] The implication stemming from these observations about the nature and origins of new agricultural technologies is that even supposing it were agreed that technical change should be impeded or stopped, this would be difficult or impossible to achieve. It would require a tight control on the agricultural supply industries and farming itself and thence strict border controls to prevent the import of either the new technologies themselves or the fruits of their application in other countries. This does not sound a likely prospect for countries with a strong commitment to the ideology of the liberal trading regime. Foremost amongst such countries is the United Kingdom.

In short, continued rapid developments in agricultural science will perpetuate the upward drift of the agricultural production function and the consequential rightward shift of the environmental/food production possibility frontier.

The classification and analysis of technical progress has been an important area of economic theory which has application to all sectors of the economy. Its application to consider technical change in agriculture has received a good deal of attention especially in recent years in connection with the constraints on the growth of agricultural output in the developing countries.[5] This body of theory has usefully made a number of distinctions such as between technical changes embodied in inputs and those disembodied changes which are not dependent on new investment for their adoption, and between those changes which are biased towards using or saving particular inputs and those which are neutral as between inputs. Likewise, theorists have distinguished autonomous technical change from change induced by relative factor scarcity. However, as is often the case in economics, these theoretical distinctions turn out to be extraordinarily difficult to make empirically. Given the rather small range of mathematical production function forms in common use and the considerable econometric difficulties of separating changes in input quantities, input qualities, management input and embodied and disembodied technical change, very little progress has been made in quantifying the contributions made by different determinants of technical progress in agriculture. In the absence of such an understanding our ability to manipulate the technically induced shifts in food supply by changing economic incentives is severely blunted.

Factor price change

A large part of the process of agricultural change outlined in section II has been brought about by the substitution of capital for labour. The form and the origins of this capital have themselves changed substantially over the centuries. Much agricultural capital was initially produced within the sector itself, particularly the source of power, which was supplied by cattle and horses. In the modern era the tendency has been for capital increasingly to be supplied by the industrial sector. In the process, the variety of forms of capital inputs has multiplied dramatically as a result of the scientific revolution in agriculture. Farmers are now confronted with a bewildering array of industrial inputs in the form of chemicals, machinery and, more recently, informatics. The extremely rapid adoption of techniques requiring these inputs is to a large extent a reflection of their effect on profitability. To put this another way, the relative price of labour to capital has changed significantly and it is this which has been mostly responsible for the change in the factor mix in agriculture and for the consequential technical change. Diagrammatically, in terms of the simple neoclassical isoquants shown in Fig. 2, the relative price of labour (w) to capital (r) has risen from $(w/r)_1$ to $(w/r)_2$. At the same time, labour-saving technical change has renumbered the isoquants. The result is a

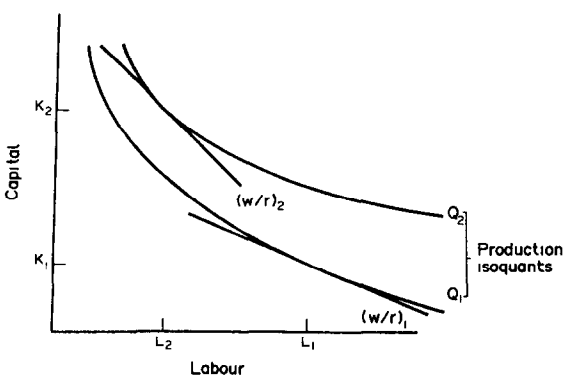

Figure 2. Technical change and factor price change.

substitution of capital for labour and a large increase in output.[6] Whilst the labour–capital substitution is the most important change in input mix, there has also been substitution between capital and land. This too has enabled embodied technical change to push out the production function.

Product price change

For the bulk of the agricultural history outlined in section II food prices at the farm gate have been a *consequence* of the interaction of food supply and demand. Autonomous, neutral technical change and factor price-induced embodied technical change have been the biggest supply shifters. Growth of income and population have shifted demand most. Economic historians have charted the resulting fortunes of agriculture and the successive periods of overproduction, low prices and depression or scarcity, high prices and farming prosperity. During such periods, therefore, product prices may be considered indicators of the dynamics of agricultural markets, but they are not causes of the observed agricultural changes. From time to time, and usually arising out of depression, farmers have successfully persuaded government to provide support and protection. When this has been done by manipulating product prices it has invariably inhibited or prevented prices from performing their equilibration role and such policies have themselves become a causal factor in agricultural change. This explanation of agricultural change takes on most relevance since the 1930s in the U.K. and perhaps even more since the end of World War II or since EC entry in 1973, for it is in this period that agricultural price support has developed most.

The mechanism through which product prices effect agricultural change is traditionally summarised in the concept of the supply function. Economic theory suggests a positive relationship between product prices and output. In the short run, this works by encouragement of the use of more variable inputs. Given more time to adjust, and provided farmers are convinced that the price supports are there to stay, new investment is encouraged and short run profits from the higher prices provide some of the funds for the capital expenditures. In the longer run, the benefits of price supports are drained away by the owners of those factors with least elastic supply or those in which the supplier has most market power, i.e. land and purchased agricultural inputs respectively.

There are immense conceptual and data problems in trying to assign by careful empirical analysis the observed changes in agriculture to the three main causal forces outlined above. Paradoxically, whilst the difficulty of this research task is compounded if the analysis is to be undertaken with reference to a long period of agricultural history, the longer the period the easier it is to draw some very broad conclusions. Thus, over a long period it is clear that agricultural product prices have fallen in real terms. Over such a period, it must therefore be the case that all of the observed increases in agricultural output are the result of technical change and factor price change.

Even over specific shorter periods the same result may be broadly true. For example, following U.K. entry into the EC there was a large rise in money prices of agricultural products which was then more than offset by a rise in the prices paid by farmers for their inputs. The terms of trade have thus generally been downward. These trends make no allowance for productivity improvement, but even when this is done (for example by looking at the time path in farming income which allows for adjustment of the volume of inputs and outputs) the result is still a downward trend. Thus, despite the barrage of public comment about the unbounded generosity of the CAP in supporting farmers and their prices, the superficial evidence at least does not point to high product prices being a prime factor in bringing about the wholesale changes in farming intensity observed throughout this period. The explanation is again picked up by factor price change and technical change.[7]

IV. The policy environment of agricultural change

If the general policy of agricultural product price support has not created a regime of real product prices which account for the rapid expansion in output this does not mean that policy has played no role in the observed agricultural changes. Three other considerations are relevant, the effect of agricultural policies on producers' expectations, more specific support measures aimed at changing real input costs and wider economic policy.

Producer expectations are clearly influenced by the existence of elaborate, statutorily entrenched support policies. Over a long period of time such measures encourage a sense of security and protection which is likely to modify the risk behaviour of farmers encouraging them to greater investment than they would undertake if exposed to the uncertainties of unsupported markets. The effect of product price support under this hypothesis is thus not to provide incentives for expansion of output *per se*, but to reduce uncertainty and in particular to eliminate the possibility of complete collapse in the

market. It is in the provision of this safety net that price supports have their greatest long term effects. Thus, all the while farmers expect that the general system of product price support will continue the fact that the level of support does not guarantee rising, or even stable, long run terms of trade will not necessarily discourage investment. Only when the prevailing expectations are modified such that there are real fears that the market props might be taken away is it reasonable to anticipate significant disinvestment in agriculture. Such changes in expectations may occur gradually or precipitately. If gradual, it is likely that they would be accompanied by falls in land prices. This adjustment might in itself be sufficient to restore faith in the long run viability of the industry and permit return to the established pattern of technical change, structural concentration and declining real terms of trade. A more dramatic collapse in confidence in the industry would precipitate a comparable collapse in land values and a spate of bankruptcies. After the dust has settled there would be an even more concentrated commercial farm sector with perhaps an even greater number of small, non-commercial farming operations in which significant non-farm income maintains household economic sustainability. In either case, if product prices do actually fall, then the adjustments described continue. In both cases it is unavoidable that the aggregate income on the sector falls and this is either borne by all farmers or, more likely, disproportionately by some farmers who, therefore, are driven out of business. The larger and more rapid the price fall the greater this effect and the less it is masked by the output increasing effects of new technology.

The discussion so far on the effects of agricultural policies has concentrated on the production incentives provided and the impacts on producers' expectations of product price supports. These are by no means the only types of support nor the only types of effects. Governments have evolved a large arsenal of *other methods of supporting farmers*. Under the Common Agricultural Policy there are funds available under the Guidance fund for structural support. The amount of money is small in relation to Guarantee expenditures which are mostly spent on price support measures. Guidance funds have generally been less than 5% of total CAP expenditures. However, these structural funds may in some cases have important direct environmental effects. An important element of structural policy has been the 'improvement' of farms under a succession of Development Schemes. Under these schemes, farmers who can demonstrate that their business viability is thereby lifted, may be eligible for grants to enable drainage, land reclamation, building construction and other capital works. The focus of such schemes was initially productivity enhancement although more recently with the emergence of surpluses the focus has changed to quality of output, value added and environmental conservation.[8]

Whilst Community expenditure on structural measures has been the poor relation of product price support measures, this has in large measure been balanced by the very large sums Member State governments themselves have spent directly on agricultural support. Reliable data on these Member State expenditures on agriculture is difficult to come by, a Commission study relating to 1980 indicated a total which was broadly the same magnitude as the CAP guarantee expenditure itself.[9] These large sums are spent on a variety of measures including: improvement of farm structures, development of rural areas, processing and marketing, market support, income aids, and research and development.

This is still not the whole story on government support for agriculture. In addition to all these formal measures which spend tax-payer funds to assist agriculture, there are numerous provisions concerning taxation which work to the benefit of farming. The range is almost as comprehensive as the range of taxes themselves. Thus, farmers enjoy special and generally favourable provisions for income tax, they may offset investments against tax, they have lower duties on fuel oil and they are treated differently to other businesses in regard to local taxes and capital taxation. The extent and terms of these concessions varies between countries and over time. The precise magnitude of the concession in the United Kingdom is controversial, but it is without doubt very large in relation to the other more explicit supports.[10]

The point of describing all these other measures of farm support is two-fold. First, to emphasise that the extent of the support for agriculture indicated by public expenditure costs for the guarantee section of the CAP is a serious underestimate of the total taxpayer cost of all the policy measures directed to assist agriculture. Second, these structural and fiscal measures may well be much more important in determining the extent, pace and nature of technical and structural change in farming than the price support measures. The direct grants for farm investments in drainage, other land improvements, farm roads, fencing, plant, buildings and machinery plus the considerable fiscal incentives for such investments, have clearly been of great importance in lowering the real user cost of capital.[11] Together with the minimum wage legislation in agriculture, these policies have brought about much of the shift

in the relative costs of labour and capital. In turn, the resulting factor substitution and induced technical change must account for a large proportion of the agricultural change which has, *inter alia*, come to be associated with environmental degradation.

The agricultural policies of the European Community and of its Member States are enacted in a *wider economic and political environment*. The economic policies pursued and their effects on the general level of inflation, interest rates and exchange rates may well have as much impact on the agricultural sector as the explicit agricultural policies. Of course agriculture itself is part of the total economy and therefore has an impact on these macroeconomic variables. However, given the small part of GDP generated in agriculture, the predominant direction of cause and effect is from the macroeconomy to the farm sector and not the other way round. The way in which these macroeconomic variables affect the farming industry is complex and has not been the subject of very much research in Europe. They have their impact through the general cost price squeeze on agriculture, through changing relative prices of labour and capital, through oil prices and hence on the costs of agro-chemicals and machinery operating costs, through the costs of borrowing and also on the development of asset values in agriculture.

The economic environment in which farming operates is thus conditioned by factors much wider than agricultural price policy. Manipulating these conditions in ways which encourage farming practices which are friendly to the natural environment is, therefore, likely to be a difficult task. Even supposing that it is possible to determine and implement a preferred direction for the CAP to bring about desired change in agriculture there is no guarantee that the combined effects of autonomous technical change, fiscal arrangements for farmers, oil prices, inflation and interest rates may not neutralise or counteract these policy reforms.

V. Summary, conclusions and pointers for research

Economically efficient food production, as judged by private entrepreneurial farmers, and the achievement of rural environmental goals are, and always will be, in fundamental conflict. Agriculture is, by definition, a gross intervention in the ecosystem by man to satisfy his own requirements for food and fibre. The culmination of centuries of technical progress in the science of food production, the intensity of population pressure, the highly integrated nature of modern farming with the up-stream and down-stream sectors and the international interconnections in agricultural markets will together ensure that there is no general retreat from high technology farming. This is not to say that scientifically-based farming must always have undesirable spillover effects on water supplies, the atmosphere and neighbouring habitats. With a better understanding of crop plants and animals, their competitors and predators it is both possible and desirable that such spillover effects are reduced if not eliminated. Even with enormous progress in this direction it will remain the case that the production of large volumes of food under competitive market conditions will mean the effective sterilisation of large tracts of land from a wildlife and habitat point of view as perceived by those who are informed about the natural environment.

The evolution of agriculture has been underway for a considerable time now and throughout most of this time agricultural developments have been at the expense of the natural rural environment. An exception to this pattern is the creation of various semi-natural habitats and man-made features in the rural landscape which have subsequently acquired environmental value in their own right; examples are herb-rich grazing meadows and stone field boundaries. The determinants of agricultural change have been pressure of demand, the changing costs of land, labour and capital, and the discovery of new technologies. During the present century, and motivated by the need to mitigate the effects of rapid agricultural adjustment, a battery of policy measures directed towards the farm sector has modified the economic signals faced by farmers. The efforts of economists and other social scientists to unscramble these complex processes to clarify cause and effect have not yet borne much fruit.

In these circumstances the arguments of many who are concerned with the despoilation of the natural environment and who point the finger of blame at agricultural support measures are misplaced in their confidence and clarity. There are many justifications for criticisms of present support arrangements under the CAP as being wasteful, inefficient, regressive and regionally biased.[12] However, the idea that CAP price supports have been solely or even largely responsible for the current expression of deep-seated trends in agricultural production which have been destructive of the natural environment is too simplistic. Worse still, the naïve assumption that the removal of these support policies will somehow lead to the reappearance of an environmentally wholesome rural idyll is potentially lethal both to the social and to the natural environmental fabric of the countryside.

The conclusion is that those who are leading the

environmental crusade have a responsibility to narrow the focus of their attacks on agriculture and in the process provide guidelines for desirable change. Generalised criticism of general policies in relation to the generality of farming land is of little benefit. Resources for environmental amelioration will always be scarce and this requires a more specific, targeted approach. This in turn places difficult, and thus unwelcome, responsibility on environmental groups to find ways of establishing priorities for environmental improvement. If conservation groups are not able or prepared to do this no one else will and the result is bound to be negligible progress at best and, at worst, further environmental damage.

Important areas for research flow from these arguments. First, the nature and determinants of agricultural change is an area in need of considerable further effort. Some more progress could be made at the aggregate, sector level although methodological problems make this a difficult area. It will, therefore, be necessary to conduct analyses of case studies of particular agricultural technologies which are thought to have had particularly damaging effects. Such analyses should focus on the policy factors which have had a bearing on the adoption of the technology. More work should also be conducted at the individual farm level to obtain better understanding of the decision process of farmers. In all such research it should constantly be borne in mind that unless the findings are capable of a degree of generalisation and linkage to controllable policy variables they will have little tangible impact.

Second, whilst acquiring better understanding of which policy strings can be pulled to effect given desired changes in farming practices, it is also necessary to clarify feasible environmental goals. Such goals will comprise several dimensions. They may be defined in terms of areas of particular habitats to be re-created or conserved, they could relate to presence, frequency or density of particular species, and they will almost certainly have a geographical dimension. In each case it is not only necessary to identify targets but also to define criteria for monitoring the success or otherwise of policy changes designed to achieve specified targets. It is, of course, likely that there will be wide disagreement on the establishment of priorities amongst these targets. This issue cannot be dodged as it will not be possible to attack all targets at once. Furthermore, interaction effects will almost certainly mean that achievement of some objectives may make it harder to achieve another. Elucidating these choices and their interactions is an immense task, but without this little progress is likely. If reasonably well defined economic goals (food security and farm income parity) are not achieved by policies with as much resource input as the CAP, there is little prospect for the achievement of environmental goals if they are not spelled out with elephantine clarity. Given the wide and disparate nature of the countryside lobby spanning the Royal Society for the Protection of Birds, via conservation groups to the Ramblers Association, the very process of the articulation of achievable environmental objectives in a coherent way is a subject deserving research in itself.

In conclusion, rural environmental damage is a result of market failure. Society has no clear mechanism to signal the socially optimal level of output of environmental goods. The distortions in agricultural markets caused by the CAP may have exacerbated some environmental problems, but the solution to these problems is unlikely to lie in changes in agricultural policy alone. To deal with environmental problems it will be necessary to have an environmental policy. The precise objectives of such policy and the instruments for achieving these objectives lie outside the scope of this paper.

In the meantime it is of course reasonable that in the political debate conservationists should use emotionally charged issues such as food surpluses to help draw attention to the things which concern them. As these campaigns succeed and the political will to do something emerges it is rather important that the rhetoric is moved to one side and a battery of well considered practical policy measures is ready for implementation. There remains much to be done to arrive at this point.

Notes

1. In the account which follows, a highly stylised economic history of several thousand years is compressed into a few paragraphs. This account is not intended accurately to portray the history of any single country. Economic historians and anthropologists are requested to suspend their disbelief whilst an economist tries to make some points to environmentalists.
2. It will rapidly become clear that a simple two-dimensional diagram is not really adequate to encompass the agricultural and natural environmental history of man! The view of whether the clearing of forests by man was environmentally destructive or creative is no doubt conditioned by the point in history at which the judgement is made and the degree of anthropomorphism felt by the observer. Primitive man, concerned only for his own survival, might have felt the forest clearance to be a wholesale environmental improvement. Modern man, with his greater concern for the (scarcer) unspoiled natural environment, looks at forest clearance as an environmentally bad thing.
3. In the U.K. in the 1980s it has been government policy to cut public spending on agricultural research and

development channelled through the Agriculture and Food Research Council. The extent of this cut is quite significant (26% in real terms between 1983/4 and 1990/91). However, much of this work will be substituted by privately funded research. In a worldwide context this effect will be minimal.

4. See Prescott (1987) for a discussion of the potential for application in livestock production of modern medical developments in immunology.
5. See Thirtle and Ruttan (1987) for a comprehensive review of this work.
6. The least cost combinations of inputs are shown as the points of tangency between isocost lines $(w/r)_1$ and $(w/r)_2$ and the isoquants Q_1 and Q_2. Because of technical change isoquant Q_1 itself is renumbered referring to higher and higher output. The fact that Q_2 is shown up and to the right of Q_1 indicates even faster rate of output growth.
7. A graphic illustration of this general observation is provided by the dairy sector. In an analysis of changes in milk output in England and Wales over the period 1964–1982, Buckwell (1984) calculated that the observed change was very largely due to yield increase rather than cow numbers. In turn he demonstrated that the yield increase could be wholly ascribed to technical change as the changes in relevant prices, if anything, caused a fall in yield over that period.
8. See the new Structural Regulation Commission (1985) and the even more recent proposals on socio-structural measures Commission (1986) and House of Lords (1986).
9. See Commission (1985), pp. 284–285, and the Commission (1985) study p. 229, 'Public Expenditure in Favour of Agriculture'.
10. See Body (1982), chapter 2, for some estimates of these concessions in the U.K.
11. See Traill (1982) for a discussion and empirical analysis of the effects of these subsidies to agricultural capital.
12. The author has contributed to the analysis of some of these undesirable effects of the CAP, see Buckwell *et al.* (1982) and Buckwell (1986).

References

Body, R. (1983) *Agriculture: the Triumph and the Shame.* Temple Smith, London.

Bowers, J.K. and Cheshire, P. (1983) *Agriculture, the Countryside and Land Use: an Economic Critique.* Methuen, London.

Buckwell, A.E. (1984) Herd size and milk supply response. *Journal of Agricultural Economics* **XXV**, 341–353.

Buckwell, A.E., Harvey, D.R., Parton, K. and Thomson, K.J. (1982) *Costs of the Common Agricultural Policy.* Croom Helm, London.

Buckwell, A.E. (1986) Food surpluses: insurance insensitive or insane. Paper given to the British Association for the Advancement of Science, Bristol University.

Carson, R. (1963) *Silent Spring.* Hamilton, London.

Commission of the European Communities (1985) *Agricultural Situation in the Community 1985 Report*, p. 229. Agriculture Study, Brussels.

Prescott, J. (1987) Animal Technology 2000, Farming 2000, Department of Agricultural Economics, Wye College, London University.

Thirtle, C.G. and Ruttan, V.W. (1986) *The Role of Demand and Supply in the Generation and Diffusion of Technical Change.* Bulletin no. 86-5, Economic Development Center, Department of Economics, University of Minnesota.

Traill, B. (1982) Taxes, investment incentives and the cost of agricultural inputs. *Journal of Agricultural Economics* **XXXIII**, 1–12.