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ELSEVIER

Agricultural Economics 19 (1998) 269–282

AGRICULTURAL
ECONOMICS

Structures and processes required for research, higher education and technology transfer in the agricultural sciences: a policy appraisal

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Received 8 October 1997; received in revised form 30 April 1998; accepted 20 May 1998

Abstract

Evidence is forwarded of a will for rationalisation of higher education, research and technology transfer processes; but the actions which have taken place in all three structures have, in contrast, produced irrationality and inefficiency. Tertiary education institutions are proposed as the spine for reconstruction, but pre-requisite is a logical hierarchy of missions appropriate to the various educational sectors. This done, research institutions may usefully coalesce with the universities, while development and advisory agencies may beneficially integrate into the polytechnic sector from which their information flow is sourced. There is strong mutually supportive efficiencies from education, research and extension emanating from a single resource base; but that base needs to be tiered according to the aptitude and requirement (science, technology, skills), and integrated with the industry. These proposals are not founded only as coping strategies in the face of funding withdrawals, but as optimisation movements bringing benefits of sharing of common human and physical resource for the three sectors; education, research, and technology transfer. An optimisation lost by their separation, and by competition amongst organisations within each sector (but especially education) striving for similar goals and for limited resources when the national requirement is for diversity. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: Policy; Research; Education; Agriculture; Technology transfer

1. Introduction

When there is a national priority for greater quantities of food at affordable prices, as was the case at the beginning and through the middle years of the 20th Century, there is ready justification for the government support of agricultural research and advisory work, such as to assist improvement in output and efficiency.

But where food supplies are ample and of low cost, as is the present position in many of the developed economies, exchequer expenditure is properly directed elsewhere. This does not imply that agriculture no longer requires effective research, development and advisory structures – and a strong underpinning higher educational system. But a government-centred policy for the structures and processes for delivering research, consultancy and higher education in agriculture does now merit substantial reappraisal.

Issues of the present public concern in the agricultural sector are more social than of production effi-

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ciency; human health, maintenance of the rural way of life, environmental protection, and the like. The UK Government Cabinet Office, 1995, Office of Science & Technology “Forward Look” (OST, 1995) did not especially identify either agriculture or its related industries as deserving of government research support; giving little consideration to the nation’s daily food requirements. The “Forward Look” does however state that “BBSRC will also take forward a programme on wealth-creating products from plants aimed at developing non-food uses of plants, including specialist chemicals, pharmaceuticals and fibres with potential benefits for farming and other industries, and for sustainability of our natural resources. Preservation of our environment is also key to NERC’s Programme of Environmental Diagnostics which will harness techniques such as mathematical modelling to the development of sustainable waste management strategies”. In 1994 (Whittemore, 1995), an analysis had already been completed of UK Ministry of Agriculture Fisheries and Food (MAFF) and Research Council Funding policies, and it was noted that many of the awards made from these sources now explicitly addressed environmental issues. In 1987, 0.34 of AFRC awards to animal sciences and livestock-related topics addressed animal welfare, environmental and green issues. In 1993, the proportion had more than doubled to 0.86. In 1983, the MAFF offered no research studentships targeting environmental or animal welfare issues in the livestock sector, but by 1990, 0.60 of livestock-related projects fell into these categories. In their agricultural research requirements for 1996/97, identified under MAFF open contracting and competition scheme, environmental issues outnumbered production issues 2:1. The UK Agricultural Research Council Programme of work completed in its sponsored institutes in 1970 (ARC, 1970) may be apportioned 0.42 to production/efficiency related research, 0.52 to biotechnology related, and 0.06 to environmentally related projects. The BBSRC (successor to ARC) programme of work in its sponsored institutes in 1995 (BBSRC, 1995) may be apportioned 0.27 to production/efficiency related research, 0.47 to biotechnology related and 0.26 to environmentally related projects. The situation is rapidly developing in UK whereby matters relating to advancement in the agricultural productivity are more likely to be handled by programmes supported from the Department for

International Development or from the European Union, than from the Ministry of Agriculture Fisheries and Food or the Agricultural Research Council’s successor, BBSRC.

It would appear that there is a presumption – as far as production and efficiency is concerned – that support, if any be needed, should come from non-government agencies, such as the industry itself. The UK Technology Foresight Programme, 1995 identified “pressures for change”, in agriculture as follows: “Increasing international competition; use of land for non-food crops and for conservation, development and access; growing resistance to productivity gains at the expense of environmental losses (e.g. pollution, loss of habitat); threat to plant and animal health from the removal of trade barriers; public acceptability of systems of animal-based food production; and decreasing financial support from the common agricultural policy”. This observation was also telling in what it omitted: there was no perceived rate-of-production or efficiency-of-production pressures on the supply of food, fibre and construction materials from the agriculture and forest industries. Conversely, environmental issues at both the global and local levels were identified as the most substantive pressure for change. The foresight report took a specific forward look at agriculture: “Positive effects on the environment will derive from careful afforestation programmes and agro-environment programmes involving clean technology, reduced pollution, extensive practices, preservation of biodiversity, upkeep of abandoned farmland and woodlands for ecological and safety reasons, farmer training in environmental-friendly farming, and land use compatible with the protection of the environment, soil and landscapes”.

The presumption that the beneficiaries will readily fund that part of science which develops into new and useful technologies is rational, but not dependable. Furthermore, science does not always lead to beneficial applications; nor is there necessarily a linear progression of science, through technology & development, to an advancement in life’s quality. That some of science and the understanding of things may lead nowhere at all has come to be a reason for parsimony in funding the scientific process. Neither does the blue skies argument, that step-advances arise serendipitously from curiosity-driven research, presently hold much sway with science funders.

Where there is a scepticism from the electorate that science is able to deliver sustainable progress for agriculture, then the withdrawal of treasury (taxpayer) funding is less likely to be replaced pro rata with funding from the beneficiaries. But, if funding for agricultural research comes to be restricted to short-term applications and development work, not only is advance suffocated, but it is also risky; as evidenced by the frequency with which technological change has been associated also with ecological crisis. This theme was developed further by Miflin (1997), and by Lewis (1997) at the 1997 meeting of the British Association for the Advancement of Science.

2. Higher education

The first Chair in agriculture was founded at Edinburgh over 200 years ago (1790), but professors of agricultural disciplines have been relatively rare until quite recently. Those universities with an early interest in rural affairs would satisfy their predilections through outreach classes; agriculture was often a subject for postgraduate (not undergraduate) and adult study as typified by the origin of the University of Reading Department of Agriculture in the late 19th century (Harris, 1993).

Improving farmers and landowners were the original driving force not only for UK regional colleges, but also for many of the agricultural research foundations. Advisory services were a part of the educational process, and emanated from the same resources. Before Nottingham University set up its agricultural faculty at Sutton Bonington, and London at Wye, these were the Midland and Southeastern agricultural colleges. At the beginning of this century, it was by no means self-evident that advisory work and research should be independent of educational establishments, nor that the state should be responsible for its funding. The Royal Agricultural College was founded in 1845 following the independent action of farming leaders wishing to advance (at the same institution) education, research, and (by demonstration) the betterment of agricultural practice. Lawes farmed at Rothamsted in the middle of the 19th century. His farm and his “research station” were indistinguishable one from the other. The technological innovations driving the agricultural revolution of the 18th century and leading

to the surge in agricultural science and its applications in the 19th century were not the result of government sponsored programmes, but of the private farming sector (Townsend, Coke, Tull), unaided by the state. Bakewell’s example is germane. He mastered techniques in animal breeding, not only to the advantage of the British Livestock Breeding Industry, but also to his own personal enrichment. He was a private scientific entrepreneur, selling-on his intellectual property through the medium of improved product. Kealey (1996) asks the question as to whether, had government funds been available at that time, scientific progress in agricultural matters might not have been slower than was the case when agricultural science rested in the hands of those who would profit from it.

The recent past saw a logical and well understood hierarchical structure in UK of Local County Agricultural Institutes offering skills-based technical training, agricultural colleges majoring in 2-year technology courses, and some dozen of the universities which offered a range of agricultural and agricultural science degrees. The expansion of the university system following the Robbins report of 1964 did not witness any expansion in agricultural higher education; rather the reverse, four universities foreclosed on their degrees in agriculture and two further threatened to do so.

The loss of the binary divide in 1992 between the national university and the regional polytechnic college sectors (the latter having had no agricultural presence of significance as the agricultural colleges fulfilled the equivalent role) stimulated perturbances that are yet to see sensible resolution. The English colleges have sought to develop degree programmes in various combinations of integration, validation, and co-operation with (mostly) new university institutions from the previous polytechnic sector. The rush to offer degrees has not been restricted to the former “National” agricultural colleges as these have been joined since 1992 by the skills and technical training institutions at the county college level. The school leaver interested in pursuit of a higher education at degree level is now in receipt of blandishments from institutions offering degrees ranging from those whose immediate background is that of technical skills training with little or no science research and development capability, through the agricultural college sector (some of which now controversially style themselves

as university colleges), to the older-established universities with long histories of awarding agricultural degrees and pursuit of agricultural scientific research at fundamental as well as strategic and applied levels.

Where previously there was order and understanding, with a hierarchical approach to offering different types of further and higher education at different types of institutions (institutes/skills training; colleges/technology development; universities/science) there is now a loss of structure; a chaotic system which defies understanding, misses opportunities for specialisation and confuses the public which is now unable to distinguish readily between one type of undergraduate degree and another.

Not only is there the widest possible range of level of school-leaving qualifications with which students may now enter to read for a “university” degree, but there is now an equally wide range in standards and types of degree at the time of their completion. The structure for tertiary education has now fallen apart. The exhortation of HM Government Department for Education and Employment (DfEE, 1997) that “measures should be taken to improve standards in teaching and ensure comparability of awards” can only be realistic if it is accepted that comparability cannot be across the whole (diverse) higher education sector, but only across comparable institutions (research universities, polytechnic universities, technological colleges, training schools, or whatever).

It is pre-requisite that institutions in the university sector offering scientific, research-based and intellectually challenging degrees differentiate themselves from institutions offering technical and skills-based training degrees. It can be of no benefit to the higher education system of a nation that sameness and equality is said to prevail where in reality there is substantive inequality and difference. The National Committee of Inquiry into Higher Education, 1997 seeks “diversity of institutional mission”, a recommendation which runs counter to the loss of the binary divide in 1992, and the aspiration of many Polytechnics to be similar to (not diverse from) the pre-1992 university sector.

Sir Robert May speaking to the Royal Society of Edinburgh in 1997 made the point that while high achieving school leavers have an expectation and right to the highest level of education and research challenge, under-capacity in UK is not in the science

sector, but in technology. A nation requires all the various levels of skills and technical training as best fits the aptitude, aspirations and vocations of what, necessarily, has to be a normal distribution curve of intellectual ability of the school leaving population.

In analysing the situation in earlier papers (Whittemore, 1995, 1996a) two alternative outcomes were elucidated; co-operation between the research science and technical education sectors, or competition. The former was favoured – but alarmingly the latter appears to be the developing position, despite the clear statement from the Department of Education and Employment (DfEE, 1997) that “Universities and colleges should govern and manage themselves to obtain maximum efficiency and effectiveness”.

There is an inherent instability in a research, education and technology transfer structure which not only fails to integrate but also incorporates competitive elements which are unnecessary for delivery of the product. The “public sector” is asked to support the parallel streams of colleges, universities, science agencies, research institutions – all competing for limited resources. The present position denies the benefits of bringing together research, education and technology transfer as a continuum, and hinders the sale of intellectual property and transfer of research findings to the end-user.

The developing interest of some university departments in taking outreach into the community through provision of scientific consultancy services would point to the continuum of research, education and technology transfer being not only possible but also efficient. It would appear reasonable to presume that universities with a science research mission, would offer high-level scientific consultancy services; whilst those undertaking applied development work and teaching at the technical level should provide technical and best-practice extension services. It may be argued that extension is an integral part of the research process, and that research is not completed until the findings are put to good use. In 1995, the Technology Foresight exercise identified for implementation the following recommendations under the heading “Forward with Foresight” (Key Points, 1995): “increased co-ordination and transfer of knowledge from fundamental research to the primary producer, processor, retailer and consumer; increased speed in the uptake of new ideas and technology, for example for: welfare

friendly systems for livestock; use of animal waste; new multi-option pest- and disease-resistant crops; crops as bioreactors; and new bioremediation systems; promote the public and political understanding of the balance between risks and benefits in environmental legislation and regulations”.

Students in the tertiary stage of their education are best served by the teachers who are able to use their own personal experiences to deliver student learning opportunities. For a technology student to be taught by those who also advise the industry and undertake development work is an invaluable educational opportunity which can only come from the same human and institutional resource being used for all three activities. Equally, there are incalculable learning benefits for university students to undertake their studies in an active research and consultancy environment. Not only can undergraduates enter into on-going research programmes at the cutting edge of science, but those who teach them can also bring to the learning situation immediate and personal experience of research and industrial consultancy work. The benefits to both technology and science students of learning in active development or research departments is considered at greater length by Whittemore (1996a). Postgraduate students can, of course, only learn in a strong research-active department.

The United Kingdom Higher Education Funding Councils' Research Assessment Exercises readily identify those universities which offer the highest intellectual challenge and a degree founded in scientific research; while Teaching Quality Assessment gives a measure of standards for the undergraduate student learning environment. Thus far, there has been a reassuring positive association between high levels of research excellence and high standards of teaching quality. High-achieving school leavers targeting this part of the university sector would expect rewarding research-based educational opportunities, and subsequent career development as leaders and captains at the highest scientific and industrial level. The same university sector would, by definition, undertake research at all levels, have active research farms, and outreach to industry through its research findings and consultancy.

The technical level institutions, represented in the main by the erstwhile National Agricultural Colleges and by that part of the post-binary university sector

which emanated from the Polytechnic Colleges, remain well placed to provide technological degrees. Graduates from the Higher end of this educational opportunity will satisfy the substantial demand for skills-led technologists (i) from science (which always requires its findings and understandings moved through technology to development and usage); (ii) from the primary agricultural industry, (iii) from agriculture's upstream allied trade and support industries; and (iv) from the down-stream food manufacturing and retailing businesses. All of which in total employ some 14% of UK workforce. These same technical institutions are particularly able to play a central role in agricultural development, demonstration and advice. The Williams Committee concluded (Williams, 1989), when referring to the future of the “middle tier” of the education sector: “R & D undertaken by the College should be primarily of an applied nature with increasing emphasis in the near-market field”.

A substantial part of the education sector will now inevitably become more independent of central government as private-sector funding streams for research develop further and public sector streams (from Research Councils and Government Departments) continue to diminish. Importantly, The National Committee of Inquiry into Higher Education (1997) and the DfEE (1997) have now accepted that there is a large funding gap between what Higher Education costs and what the government is prepared to pay through the Funding Council within the context of a low-tax society. Students may not only pay for their own living expenses, but now also for some 20–30% (or possibly more) of the tuition costs of their courses as well.

The consequences of students paying a substantial proportion of their higher education costs has yet to be seen, but it would appear inevitable that a closer relationship will develop between course availability and content, and subsequent career development. A coming together of universities with industry would have an important modifying effect upon curricula (see also “Employers to get say on degrees”, THES, 1997). The ultimate employer as sponsor may expect to have a substantial say in the way their protégés are to be educated. The contract between the establishment and the (paying) client will change, and (hopefully) diversity and specialisation within the higher

education sector will better enable prospective students to make informed choices as to where to obtain their tertiary education.

Many research university departments have come to be progressively less dependent on teaching for their income; obtaining 50% or more of their funds from research (funded by both government and private industry), spin-off companies, consultancy, post-graduate and overseas research students, short continuing professional development courses, and alternative usages for the buildings estate (conferences, vacation courses).

It may be salutary, however, to admit that there may be an expectation (not merely a hope) by funders of a positive outcome in terms of qualification awards. Educational establishments receiving fees for tutoring students are expected also to graduate them (not fail them), hence the development of teaching methodologies which allow internal intermittent assessment and repeat attempts at, and re-tutoring for, tests until an adequate level of achievement is attained.

3. Research institutions

For most part the network of UK Agricultural Research Institutes was set up in the middle years of this century. Through the medium of the Agricultural Research Council, the research institutions had a clear purpose, and in fulfilling it gave UK a leadership position in agricultural research. Seminal to the arrangements was single mindedness of purpose; research at research institutes, education at universities, and outreach from the advisory service. All of these three elements were separate from each other (a structure almost unique to agriculture, and unheard of in the majority of industrial sectors), but with linkages between them such as to (hopefully) allow information flow. In the event single-mindedness of purpose may have triumphed over the more altruistic demands of inter-linkages. The Agricultural Research Council Institutes set about with a will the twin tasks of basic and applied agricultural research. The mission was to provide food for the (beleaguered) UK population at affordable prices from within UK farming base, and to do this through discovery, innovation and application. Scientific method – objectively pursued and financed independently of interested parties – was used to

understand and promulgate fundamental elements of agriculture; such as the specification of animal and crop nutrient requirement, techniques for the control of diseases and pests, the genetic improvement of animals, and crops, and the control of reproduction. One of the principles of the approach, allowed only by the use of government funding, was that the scientific community was free both from following anecdote emanating from farming leaders, and from the commercial industrial pressures which come with a direct financial interest in the outcome of research into new ideas and technologies. The loss of the principle of research independence, the withdrawal of funding from “near-market” (i.e. evidently useful) research following the MAFF Review of Agriculture R & D (Barnes Review) in 1988, and the encouragement by research councils for industry associations (rather than industry distancing) in the 1980s and 1990s, has caused a sea change in both the ethos and direction of research at the research institutes. The end results of these developments have yet to be seen but the dis-benefits of the loss of disinterest on the part of agricultural scientists has been alluded to with some alarm by Whittemore (1996b), now that both sponsor and researcher may share the same agenda for a positive outcome to any investigation which could have a political or commercial dimension.

The UK Research Institute community has suffered in recent years major impacts from frank funding withdrawals from all quarters, but especially government and government-related departments. Over-capacity of agricultural research facilities was identified in the 1970s as a consequence of government’s earlier priority that all UK food requirements be met from UK resources. It was then realised that this was neither required (there being no strategic defence imperative such as the threat of international hostilities), nor was it beneficial to European or world trade, or demanded by the buying and voting public. There followed a succession of reorganisations, regroupings, down-sizings and institute closures.

The Agricultural Research Council transmogrified into the Biotechnology and Biological Sciences Research Council, and the early 1990s saw the government White Paper CM2250, 1993 “Realising our Potential” followed by a series of reviews with the objective of delineating some sort of policy for the Agricultural Research Institute Network, and to deter-

mine if options other than the present *modus operandi* were available. The Scrutiny of Public Sector Research Establishments (PSREs) in 1994 (Cabinet Office Efficiency Unit, 1994) had the remit of identifying “those public sector research establishments where early privatisation is feasible and desirable”, “potential for rationalisation”, and “changes to current ownership”, and had trustworthily recommended “Privatisation and transfers to universities”. The government response of 1995 recommended that “Departments and Research Councils should routinely examine the potential for transferring public sector research establishments to universities”, and that “Public sector research establishments should develop effective formal links with universities where these do not already exist”. The government response specifically cited the benefits of “staff from public sector research establishments holding posts at universities”. It is germane that The Royal Society’s response to the Scrutiny (The Royal Society, 1995), includes within an otherwise largely damning commentary, “closer relationships between PSREs and the university sector, including transfer of ownership in some cases, are desirable”, albeit there followed a number of reservations as to appropriate method. These PSRE reviews, their reports and responses which included both imaginative and unimaginable propositions ran into the sand in 1996 due amongst other things to financial constraints relating to property, redundancy provisions and pensions, and now appear to be abandoned; but not before a number of central-funded institutions had been “sold-off” or “moved-out”, and others placed into positions of sufficient jeopardy to require radical action for resolution. It would appear that apart from the undisputed need to reduce expenditures no coherent plan is yet discernible since the original cataclysmic upheavals resulted in closure of research institutes in the 1980s, through to the recent traumas of government institutions hastening to distance themselves from dependence upon government funding.

The original plan, sketched out in the earlier decades of the century, for the trio of University agricultural education, a network of Agricultural Research Institutes, and a National Agricultural Advisory Service, to forward agricultural development, was dependent for its success on integration between these three elements. But the striving for autonomy and expansion

which is inherent in all organisations led over subsequent years to their separate development. Agricultural education and research at universities came to be disassociated and disadvantaged through the bleeding of funds and talent to the research institutions; professional scientists dedicated only to research having no educational or extension roles became progressively more introspective and their science self-serving. Meanwhile the advisory services saw the promulgation of existing best practice as taking priority over the transfer of new technologies and novel scientific applications from the research sector to the industry user community. All of this was contrary to the original vision of the universities working with the Research Institutions to provide new knowledge through the application of science, while the advisory services extended research innovations out to farmers. When writing about the Edinburgh Centre for Rural Research, Wilson (1997) referred to the benefits that accrue from teachers, researchers and technical advisers “rubbing shoulders”, and expresses regret that in England the three related fields of research, teaching and advisory work were hived off into different organisations, located in different centres and funded by different government agencies.

Fully-charging advisory services – as has become the position in UK – coming essentially from a private sector comprising both advisory organisations and individual consultants, will irrevocably deny the possibility of a single funding agency (government) supporting education, research and advice in the agricultural sector. However, the same position now facilitates research organisations (both universities and research institutions) grasping the essential nettle of the value of intellectual property and its direct transfer (either exclusively or inclusively) to paying users. In their recent “Forward Look” (OST, 1996), the Natural Environment Research Council states as one of its seven strategic aims “ensuring linkage with the user community and effective technology transfer”. Indeed, five of the seven strategic aims of NERC would fall under the classification of development, TT and Outreach, and only two under the heading of winning new knowledge. Some of the funding of applied research, its development and the ultimate demonstration of its benefit would most naturally appear to fall within the ambit of a levy upon the beneficiaries; as is the case of the Meat & Livestock

Commission, the Home Grown Cereals Authority and the Milk Development Council. Levy income is, as presently constituted, insufficient to cover all the activities that perhaps it should, which would imply a need either to scale-down the applied research and development elements of the science-into-practice continuum, or to increase the scale of the levy. The debate remains unresolved as to whether all of a levy should be devoted to the funding of R & D and its extension, or whether some (or most) should be devoted to generic advertising.

The progressive loss of integration between the universities and research Institutes has precluded three essential efficiencies which come from the combination of educational (especially postgraduate) and research processes: (i) researchers need mental refreshment and invigoration if they are not to become jaded, and lest their investigations which should be multilateral become unilateral; (ii) educators and students at universities benefit from an active research environment and, (iii) the combination of education and research is inherently efficient in its use of equipment and human resource. Now there is the further inefficiency of a vibrant and effective university research sector in competition with research institutions for diminishing research funds (from government, non-government organisations and industry sources). There is no clearly distinguishing mission, method, or ethos differences evident between research institutions and university research groups – a situation which will be more evident with the continuing rise of the RAE-elevated research universities.

There has been a rapid recent increase in the proportion of research institute income coming from private industry, contract research and spin-off ventures operated in partnership with private industry. All of which might also be taken up with benefit by the university sector. The Biological sciences at the University of Edinburgh have been well served by royalties deriving from the work of Sir Kenneth Murray on hepatitis vaccine which has brought research posts, funding support and even buildings. In the Institute sector, the Edward Jenner Institute for Vaccine Research at IAH has been established jointly between The Research Councils, the Department of Health and GLAXO; ReNo is now the newly formed commercial arm of the Institute of Food Research; Rosgen and Roslin Nutrition have been spun off from the Roslin

Institute; and at Babraham, the Biosciences Technology umbrella facilitates the spinning out of companies to handle particular developments. The relationship between Roslin and PPL Therapeutics Ltd resulting in the cloning of Dolly from a somatic cell is indicative of the developing line not only for universities but also for Research Council Research Institutes.

Presently industrial corporations tend to divide their (limited) R & D spend between Research Institutions, Universities, and their own in-house programmes. The comparative cost advantage seems with the Research Institutes and Universities, but should this not remain the case there would be a move toward more in-house investment in R & D. Changes of this nature may not be as dramatic as at first sight, because relationships between Research Institutes and Universities on the one hand and the private industry sector on the other are becoming increasingly close, and closed-contract work more common. Executive decisions to increase the “in-house” R & D may therefore simply accelerate the agglomeration of university and research institutes together with private industry research interests. Closed-contracts, protection of intellectual and patentable property and preclusion of the option to publish in the public domain become not optional but pre-requisite. Nor should the existing educational and research sectors fear a rise in industry in-house R & D – there would be less differences evident between “previously public” and “nouveau private” research endeavours.

4. Research & development farms

Research and development farms have many roles ranging from basic research through to frank demonstration. Research farms rarely, if ever, research into farming. Farming is a complex holistic and integrative activity which is not readily comprehended through reductionist scientific method. Farming systems have however been investigated at development/demonstration level where particular husbandry techniques may be combined into presumptive best practice, and the presumption tested. But such studies invariably have in common an investigation not of a whole farm but of a self-contained part, or sub-farm. Three categories of R & D farms can be distinguished; research, development and demonstration.

Research farms generally have a primary purpose of providing research materials, are heavily subvented, and often have husbandry practices bearing little resemblance to normal farming method. And as the purpose of fundamental experiment is not immediate application, there is no development or demonstration function. These types of research farm are necessary adjuncts to Research Institutes and Research Universities, and are a legitimate direct cost to experimental programmes. They have no other purpose than to service the experimental programme and thus require direct research sponsorship. Where there is no research programme requiring their services, such farms have no role to play. There is a contradiction inherent in a research support system which funds research costs on a short 3–5 year time-scale, while the infrastructure for such research (research farms) requires to be funded on long-term 5–15 year time-scales. Farms cannot be picked up and put down on a short-term basis, while the source of between-experiment bridging funding for such research facilities is not apparent. To be effective many experimental programmes require the maintenance of farm enterprises of substantial size. Operation scale adds to the difficulties of short-term management horizons for funding streams.

Development farms take basic and strategic research findings on into application. They also take innovations and technologies arising from both research and from the industry base itself into practicable systems formats. As there is an expectation of success, indeed of improvement, the underlying farms operations may be expected to be profitable. Of course, there will be elevated overhead and recurrent costs, as expected when novel practices require implementation into conventional infrastructures, and where record keeping is required in unusual detail. There will be failures along the way as lessons are learned from the movement of basic and strategic sciences into agricultural practice. These recurrent marginal expenditures and the costs of underpinning failures are legitimate uses of research funds; although it is often difficult for research sponsors to accept this. Applied research and development farms demonstrate the next generation of farm improvement and best practice, and might therefore be expected to be found associated with educational establishments, and with the extension and consultancy arms of the agricul-

turally allied trades and industries both upstream and downstream of primary production. Farms associated with the educational establishments may legitimately expect that additional marginal expenditures resulting from the developmental nature of their activities would be met from either the educational purse or from subvention by those benefiting from the activity; namely, the industry in its broadest sense. A product-based levy, or payment through co-operative group membership, has the effect of putting sponsorship and ownership of the intellectual property directly into the hands of the beneficiary. Such a culture is found more commonly on the European continent as exemplified by successful levy and co-operative schemes in Denmark and The Netherlands. There is benefit in short communication lines and small bureaucracies standing between the levy payer and the information paid for. Failing the tax-payers willingness to pay, the direct levy will become increasingly important as a means of securing research, development and extension independently of the “interested parties” which comprise the upstream and downstream allied trades. Until now, however, the farming industry has been reluctant to pay a reasonable scale of product levy to finance all that requires to be done. Sponsorship by statutory levy would seem to be a natural choice for funding research undertaken on development farms; be they associated with colleges, universities, or private sector extension services. Present funding arrangements for applied Research & Development are becoming ever more dependent upon partnerships between government, levy paying organisations representing the primary industry, the allied industries (retailers, feed manufacturers, breeding companies, pharmaceutical and agrochemical companies), and the contractors themselves (Research Institutions, Universities, Colleges). This pattern would appear appropriate and worthy of further expansion. The interest of the government in the developmental and applied research sector tends to relate to strategic issues and now that food is perceived to be abundant in UK, political interest tends toward food safety, animal welfare, and environmental protection & sustainability. Where development farms provide a basic resource for extension and consultancy services, it would be legitimate to expect funding from those who benefit from receipt of the resultant advisory services. The general trend of closer associations between

industry research and university research interests has been recently exemplified by the setting up of R & D centres jointly between industry and the university or research institute sector. There would appear to be no role for the central government in resourcing consultancy and extension work (in which it no longer has an interest) through the medium of supporting development farms. Where the additional recurrent costs of applied research and development work are provided, such farms should not be a burden on the system or require subvention from any other source. By the same token, there will be no requirement for bridging funding when projects lapse or reach completion.

Demonstration of best practice was an important plank in the government-funded drive to improve the level of UK agricultural output in the middle years of this century. Its purpose was to show those farmers not following best practice how to do so. In fulfilling this function demonstration farms needed to be local and typical. No such requirement is apparent at the present time. Some benefit may be obtained from the demonstration of new and improved practices to better farm practitioners, but there is no imperative to support average or below average practitioners, who demonstrably should be left to market forces. Demonstration farms have within them a transparent fiction, resulting in loss of credibility. Successful commercial farms are the best demonstrators and monitors of the rewards of novel technologies, and also benefit from being local and typical. Even for educational institutions, it would be difficult to present a case for setting up demonstration farms if successful farming practices are available locally.

Nevertheless, as a part of mid-century UK government investment into increasing agricultural output a series of experimental husbandry farms were set up around England as a part of the MAFF Agricultural Development & Advisory Services. These were to reflect regional farming best-practice; to be the source of inspiration to the local farming community. From the outset, there was criticism of the EHF's. Levels of husbandry and profit were compromised by experimentation, and it was not always evident that the best practice was demonstrated in a way superior to nearby leading commercial farmers. Experimentation on the other hand was difficult to manage and control, and results from EHF's were often received with scepticism by the scientific community. In loosening the link

between the field advisors and the experimental farms, the service failed to fully capitalise on the essential flow of new findings from development work out into practice. In the "Scottish System" the specialist advisors were not only located on the development farms, but were themselves the very same scientists involved in both the experimental husbandry and in extension. These advisors had credibility with both the farming and the scientific communities. If there be a future for the Experimental Husbandry Farm concept it would, it seems, best be through their becoming an integral part of the "private enterprise" advisory services (including trade-based) or the research/higher education sector, or (preferably) both (as is the case for joint industry/university ventures).

5. Advisory services

The National Agricultural Advisory Service, set up in UK in the middle of the century and its successor the Agricultural Development & Advisory Services, together with the regionalised advisory services of the (north, east and west) Scottish Agricultural Colleges were all presumptive of a passive client and an interested third party. The latter was the populace which was to be provided, through the elected government, with plentiful and cheap food; and the passive clients were the middle and bottom levels of farmers, judged on productivity/efficiency grounds to require to improve their performance. Not only did the government – as intermediary – give production subsidies to encourage farm-gate output, but it also gave free advice to those who were not actively seeking it.

The present position differs on all fronts, and further inevitable changes in agricultural (CAP) subsidies will encourage more changes along the presently defined directions. The populace no longer seeks high volumes of home-produced, cheap food. At only 12% of income expenditure, food price is not a priority and no scarcity is perceived in the supermarket supply. Indeed, it may be argued that the interested third party is no longer the public/government, but the supermarket wholesale buyer; the latter having an interest in the effectiveness of information transfer in the agricultural industry on behalf of their customers seeking food quality and safety in its widest context. It is not easy to see how government should have any part to

play in a structure that can be driven effectively through the mechanism of the market-place, and the floating-off (privatisation) of ADAS in 1997 was, in retrospect, entirely to be expected, as were the conclusions in that regard of the 1994 Prior Options Review and the subsequent government recommendation (Public Sector Research Establishments CM2991, 1995) that ADAS be privatised. The agricultural community was always equivocal in its use of the free, government, advisory services. Farmers would opt to reject free offers from the government services, preferring often to use advice coming from the allied trades, private enterprise agencies, levy-funded organisations, and from specialist individual private consultants; all of which have to be paid for one way or another. It remains unclear as to how the former public sector advisory services will now behave as private businesses, but there can be no special cachet in having emanated from a government department. Established private consultancy firms may have more to offer, and graduates attracted to a career in the Advisory and Consultancy business may aspire equally to employment by a diversity of agencies, and indeed progress their careers by moving from one to the other.

The erstwhile advisory services served two masters: the government employer and the (oft reluctant) farmer. Both are now lost. Those farmers requiring advice perceive the need in terms of their own (market-place) survival and will therefore see as legitimate costs on their businesses the information and knowledge needed to satisfy their post-farm-gate customers. The choice of each individual business as to how much advice they may need is surely a matter of supreme uninterest to the tax payer and the government of the day.

Agricultural businesses may choose to invest in advice directly, or indirectly through the medium of the upstream and downstream allied industries. There may be a legitimate expectation that agricultural chemical, feed and other supply trades which sell to farmers, and the human food retailing sector which buys from them, will both become increasingly involved in the provision of technological back up and information services. Indeed, in the latter case the buyers are now not so much advising, as telling, the agricultural production sector how their product is to be produced. Now that it is evident that the customer

lies beyond the farm gate – at the supermarket – it follows that consultancy services should target downstream food processors and retailers equally as the primary producers. Problems requiring urgent resolution, and the need for new initiatives and technologies, lie as much, if not more, in the food processing sector as in the production sector (not least in matters of food safety and environmental protection). Businesses in receipt of agricultural products are likely to impact to an ever-greater extent on agricultural production methodologies, and will advise through edict, and upon which purchase is contingent. The drive for safer, higher quality, more wholesome and environmentally sustainable food is leading to obligatory quality assurance schemes which effectively control the whole of the production process. How farmers come to produce their product is as likely to be consequent upon a set of detailed rules laid down by the buyer as upon considerations of yield and efficiency.

Organisations trading with agriculture have always seen the benefit of a technical advisory arm to support both sales and new product development. Not only does the availability of advice and consultancy help to bind the customer to the company, but it also ensures that the product is properly and beneficially used. As agriculture becomes (a) increasingly science-based and (b) increasingly environmentally sensitive, the need for advice on product use to follow up product sales becomes paramount. It may be possible that the allied trades will re-develop and expand their technical advisory arms, and also see the need to provide (either independently or through liaisons) science support through both contract and in-house research and development.

A consultancy service with the ability to solve problems, propose initiatives and introduce new technologies is unlikely to be able to develop solely from within. An advisory function which simply transfers the knowledge already existing in the industry base may under the old rules have served to lift the performance of the “bottom third”, and so improve the production efficiency of the nation’s farming industry; but it is not appropriate in the present circumstances. Problem-solving skills, novel initiatives, and new technologies all arise from the education and research sector.

If it is accepted that the majority of those seeking consultancy advice will be positioned above the indus-

try's mean, then it follows that those educational and research establishments majoring at the technological educational and applied research levels have a substantial consultancy opportunity; and conversely, consultants and advisers will have much to gain from close liaison with such establishments. In referring precisely to this middle "technological" tier of agricultural education and development Williams (1989) states that "R & D undertaken by the college should be primarily of an applied nature with increasing emphasis in the near-market field", and that "there should be enhanced collaboration between the network of field advisers and the college-based specialists and advisers for the greater benefit of education and R & D as well as the extension work", and that "the Advisory service should remain as a fully integrated part of the collegiate system".

Basic and strategic research establishments, and research universities concentrating on science and higher degrees, would have more value for that part of the consultancy sector dealing with leading industrial innovators and the tackling of particularly difficult and intransigent problems. Harrington (1997), when considering technology transfer in the livestock and meat industry, mentions that many reports confirming the movement of research findings into practice tend to accept that technology transfer has to be hived off as a separate activity, "whereas TT should be an integral part of the research programme". Harrington (1997) points out "There should be a common budget, and a decision to commission research should imply a commitment to fund the necessary development and TT if the research is successful", and although "it may be possible for the individual or firm to take the (TT) message and put it into practice without further information" this is unlikely. More often interpretation is necessary to allow for the special conditions of the business, and "this can only be achieved by face-to-face contact on-site between the potential user and a technically competent adviser". The emphasis on technical competence implies the need for a particularly close association between the originator of the research funding and the adviser who is charged with its effective transfer into practice.

It would appear reasonable to presume the shift of emphasis of advisory and consultancy services will continue away from exploitative increases in production, and toward matters of environment, sustainabil-

ity, food safety and food quality; as will be the need for the industry to be legal, efficient and competitive in the market place. The response to the environmental and welfare imperatives by UK livestock production industries and research services is further discussed by Whittemore (1995). There is no reason to argue, however, that the structure of funding of the environmental advice would be any different to that of production advice. Nor that the educational and research resources feeding into the environmental services should somehow behave any differently in kind in their response to an environmental ethic than a production one.

6. Summary and conclusions

Agriculture as a "special case" was accepted through the most-part of this century and by successive governments anxious to ensure ample and cheap food. This special case no longer pertains and government support for agricultural Science & Technology is reduced. That the government support for Education is a necessary social investment is presumed, but not argued in this paper; as is government support for basic and strategic research. (Although withdrawal of funds from higher education, and from the Agricultural Science Base has resulted in a diminishment in the size of the latter, while the need for some students to now pay up to 30% of their fees as well as their maintenance costs will possibly result in scale reductions in the case of higher education).

The complete withdrawal of government support for a technology transfer (TT) service for Agriculture, while understandable, does not gainsay that for Science & Technology to be advanced, technology must be transferred by some agency or another.

In the face of the fall in budget, rationalisation has not been evident. Successive government reviews have come close to it, but each time the initiative has petered out. Meanwhile a free-for-all in the Agricultural Higher and Further Education sector has caused confusion and inefficiency, and a failure on the part of the educational institutions to identify and pursue logical, different and complementary missions to supply the nation's needs for scientists, technologists and trained workers. The potential for the universities was admittedly obfuscated in the past by the presence

of a strong and large research institute network, while the potential for the technical colleges was blocked by the activities of separate Agricultural Advisory Services. The present *mêlée* has not addressed these issues, but rather has contrived to confound all of them. The report of The National Committee of Inquiry into Higher Education (1997) is supportive of the contention that sub-degree provision should be concentrated into the further education sector, with a counter implication that FE should be discouraged from offering science degrees. Nevertheless, essentially FE institutions are now advertising degrees, and entering for them are students with mediocre school-leaving qualifications. The DfEE (1997) paper encourages the FE sector thus; “Participation should be increased and widened mainly through 2-year sub-degree courses of higher education provided in colleges of further education”. Helpful sentiment towards the return of a meaningful hierarchical educational structure, but unfortunate in confounding “higher” and “further”.

This paper sees an imperative for action and concludes the following.

Structure should be given to the agricultural higher and further education system such as to identify missions for the various sectors which will credit institutions with clearly defined tertiary educational roles. Universities to provide for the education of the highest achieving school leavers, and to do so on a research foundation. Colleges to provide for the education of the middle tier and to do so on a technology base. Skills training to be provided by the local institutions and agencies.

The now tiered and mission-orientated educational system is appropriate to provide the axis for efficiency gains for both Research and Development, and for technology transfer. Van Crowder and Andersson (1997) writing recently on the benefits of linking research, extension and education within an integrated agricultural technology system, bring a range of international authorities to bear in support of strong links facilitating an improvement in the overall performance of agriculture. In quoting Moris (1991): “It would be difficult to over-emphasise the enormous tactical importance of having smooth inter-organisational linkages for achieving sustained agricultural development”, these authors have fallen short only in failing to point out that the strongest possible

linkage would result not from inter- but from intra-organisational linkages; and that there are strong internal mutually supportive mechanisms in operation when the three functions of education, research and extension emanate from within a single resource base.

Research institutions have missions close to those of research universities, and the continuing of the maintenance of distance between the two is not easy to argue. There is no barrier to integration at the levels of the research programmes themselves, nor of equipment and facilities, nor (especially) of human resource aptitude, ability or commitment. The search for greater efficiency in the face of continuing step-withdrawals of funding must inevitably lead to integration of the previously separate agricultural research institute sector with the research universities. Their coming together would enhance both sectors at the same time as reducing overall costs. These notions have found support in the report of The National Committee of Inquiry into Higher Education: Report of the Scottish Committee (1997) which recommends to both the Higher Education Funding Council and the Research Council “That they should, as appropriate, make available funding to ensure that outside researchers, irrespective of location, have an access to the research facilities”.

The initiatives taken by some research institutions and (rather fewer) universities with regard to offering consultancy service businesses, creating spin-out commercial companies, and closed-contract industrial liaisons, require further positive development if the benefits of industry partnerships for Education and Research are to be fully realised; this will inevitably change the structure and nature of research.

The Mission of the Experimental Husbandry and Development farms, and of the Advisory Services are closely allied to those of Technology Colleges (as evident through the highly successfully Scottish Colleges of Agriculture). The opportunity for the Colleges to prioritise a development role along with their education, and to fully support an industry-targeted field Advisory Service is unparalleled. Indeed, it is inconceivable to believe that a stand-alone technology transfer Service is tenable, as it can only recycle existing technologies; while those institutions actually undertaking development programmes are well placed to be responsible for the transfer of their own innovations. The intimate involvement of all sectors of the

industry base in technological education, development work and technology transfer is essential to their success. Funds for technological development should come, for the most part, directly from the industrial beneficiaries.

It is not clear why the government should subvent Science & Technology R & D and TT outside of a closely integrated structure based upon an axis of a government supported tertiary education system, the highest levels of which fulfil the government's need for basic and strategic research.

Advisory Services, paid for by those who get benefit from them, will likely be supplied not only by the (agglomerated) research, development and educational sectors, but additionally by the up-stream and down-stream industries as a part of their market service. While there is little real evidence of direct government support of either the front-line TT services, or Development Farm back-up; there is a reasonable expectation of generic support for the educational and strategic research in which all innovative extension must necessarily have its ultimate routes.

Progressive withdrawal of further government funding from Agricultural Education, Research and technology transfer can only strengthen the likelihood of efficiency gains by such mergings and rationalisations as here argued.

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