Centre for Agricultural Strategy

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Authors' foreword

The authors would like to thank Julian Alston, Chris Barnes, David Egerton, Gordon Myers, Paolo Palladino, and Philip Pardey for comments on earlier drafts of this work, which will appear in due course as Chapter 6 in Alston, J, Pardey, P, Phillips, M & Smith, *V* (Eds) *Paying for Productivity: financing R&D in the Rich Countries*, Johns Hopkins University Press. This book will contain similar chapters on the USA, Australia, the Netherlands and New Zealand, together with background chapters and international comparisons.

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Preface

Rapid changes in technology have characterised post world war agriculture in the UK and elsewhere in the world. One important outcome has been that food output, globally, has risen more than the growth in population. Another, that we make increased calls on the natural resource base. Whilst the ability to produce more food is generally welcomed, the consequences in terms of the environment and the sustainability of the systems cause concern.

At the heart of the advance in productivity has been improved knowledge resulting from research and development. It is to the same source that society must look for ways which reconcile its needs for food with the imperative of developing systems which are sustainable. Some of this research may generate profits in the market place. Other research may depend on funding from public budgets, if it is to occur at all.

This Paper reviews the way in which the funding of research has changed in recent years within the UK. To a substantial extent, fundamental or 'basic' research has depended on public funding. This, in common with all forms of public expenditure, has been subject to increasing scrutiny as Governments seek to limit their financial commitments. Private sector research has been affected by recession and the pressures to defend profits in the short-run by cutting research expenditure. This Paper reviews the development of research policy and expenditure in a dispassionate manner. It makes a timely contribution to a debate which is of importance well beyond the narrow concerns of the agricultural and food industries themselves.

CAS is grateful to the authors and to Johns Hopkins University Press for the opportunity to make this Paper available before its publication

in a later book which will deal with research in other countries as well as the UK. In this country, the role of the state and the private sector in the funding and direction of research relating to agriculture has become a matter of urgent controversy. This Paper should help to inform that debate.

John S Marsh, CBE
Director, Centre for Agricultural Strategy

Contents

Abbreviations and acronyms

ABRC	Advisory Board to the Research Councils
ADAS	Agricultural Development and Advisory Service
AFRC	Agricultural and Food Research Council
AFRS	Agricultural and Food Research Service
ARC	Agricultural Research Council
BBSRC	Biotechnology and Biological Sciences Research Council
BBSRIs	Biotechnology and Biological Sciences Research Institutes
BSE	Bovine Spongiform Encephalopathy
BST	Bovine Somatotropin
CAP	Common Agricultural Policy (of the European Community)
CAS	Centre for Agricultural Strategy
CGIAR	Consultative Group on International Agricultural Research
DAFS	Department of Agriculture and Fisheries, Scotland
DANI	Department of Agriculture, Northern Ireland
DES	Department of Education and Science
DTI	Department of Trade and Industry
EC	European Commission
ECU	European Currency Unit
EEC	European Economic Community
EPARD	Economics Panel for Agricultural Research and Development
EU	European Union
GDP	Gross Domestic Product
HEFC	Higher Education Funding Councils
HEI	Higher Educational Institution
HGCA	Home Grown Cereals Authority
HMSO	Her Majesty's Stationery Office
ISNAR	International Service for National Agricultural Research
JCO	Joint Consultative Organisation
MAFF	Ministry of Agriculture, Fisheries and Food
MLC	Meat and Livestock Commission
MMB	Milk Marketing Board
MRC	Medical Research Council
NA	Not Appropriate

NAAS	National Agricultural Advisory Service
NERC	Natural Environment Research Council
NIAB	National Institute of Agricultural Botany
OST	Office of Science and Technology
PBI	Plant Breeding Institute
PMB	Potato Marketing Board
R&D	Research and Development
RAs	(Food) Research Associations
S&T	Science and Technology
SABRIs	Scottish Agricultural and Biological Research Institutes
SASA	Scottish Agricultural Science Agency
SAC	Scottish Agricultural College
SCRI	Scottish Crop Research Institute
SMEs	Small and Medium-Sized Enterprises
SOAFD	Scottish Office Agriculture and Fisheries Department
TFP	Total Factor Productivity
UK	United Kingdom
WWII	Second World War

1 Introduction

Since the Second World War (WWII), the agricultural sectors of developed economies have experienced rapid increases in both output and productivity. Output per farm worker and output per hectare have risen sharply due to the increased use of mechanical, biological and chemical inputs. This has resulted in a rapid decline in agricultural labour, both in absolute numbers and as a proportion of total employment, while the amount of land in agriculture has remained relatively static or even declined slightly.

In 1994, the UK agricultural sector accounted for 1.4% of GDP and 2.1% of employment (MAFF, 1994). The sector has conformed with the pattern noted above, but productivity growth is not a new phenomena. Output per hectare (yield) began rising slowly in the mid-17th Century and wheat yields in England and Wales took 250 years to double, which occurred by about 1900 (Grigg, 1989). After WWII, the application of chemical inputs and improved plant varieties doubled wheat yields in no more than 30 years (MAFF, 1968; Burrell *et al* 1990) and from WWII to the present the average annual growth rate has been 2.3% per annum (OST, 1995a). Mechanization increased labour productivity (output per farm worker) far more rapidly at 3.3% per annum (this figure and others in this Chapter not referenced are from productivity calculations made by Khatri & Thirtle, 1996). At the same time, the number of full-time workers (excluding farmers themselves) fell from almost 750 000 to just over 100 000 (MAFF, 1968 & 1994). The total hours worked by all workers, including farmers, is not consistently measured over the full period, but it fell by almost 60% from 1953 to 1990, so that by 1994 the total number of workers was down to 614 000 (MAFF, 1994).

Output per hectare and output per worker are partial productivity measures, in that they do not take increases in chemical and mechanical inputs into account and these changes are important. Between 1945 and the early 1980s, the amount of fertilizer applied to crops increased by 600 % and total tractor horsepower rose by over 1000% (Holderness, 1985). Total factor productivity (TFP) measures incorporate these changes by comparing aggregate output to an aggregate of all inputs. However measured, TFP has doubled between 1953 and 1990, implying an annual growth rate for the sector of 2% (Khatri, 1994).

Increasing TFP, or more output per unit of inputs implies that technology is improving (this is a major cause, but is not synonymous with TFP growth, which also results from increasing returns to scale and switching from less to more productive farm enterprises). The improvement in technology is attributable to the development and application of new knowledge through scientific research conducted by both the private and public sectors of the UK research establishment and to technology transfer from other countries. While technological spillovers from other countries' research establishments have affected UK agricultural productivity (Thirtle *et al* (1995) identified spill-ins from the USA and France), domestic investments in R&D are the major source of TFP growth, in combination with extension activities and the improving education of farm managers (Khatri & Thirtle, 1996).

In 1993/94, total domestic R&D expenditures amounted to almost £900 million. Government agencies spend almost 40% of these funds and private-sector research institutions accounted for the remainder. Much of the Government's expenditures are devoted to 'basic' research in universities, public-sector research institutes, and to public interest research in Ministry of Agriculture, Fisheries and Food (MAFF) laboratories. Private outlays tend to emphasize applied research on 'near-market' projects and product development.

Science policy, reflected in funding levels, the allocation of funds between research institutions, and incentives for private research, is therefore extremely important in the development of new basic knowledge and its application in the agricultural sector. Innovations in agricultural science policy and shifts in policy emphasis are likely to affect the rate at which agricultural productivity increases. Within the UK, changes in agricultural science policy have been linked to changes in general science policy. Thus, Margaret Thatcher's Conservative Government, elected in 1979, substantially changed Government-wide science policy in the mid-1980s and this resulted in important changes in the UK agricultural research system.

This paper examines the postwar history of UK agricultural science policy and agricultural research, concentrating on the policy innovations and shifts in direction that have occurred in the 1980s and

1990s. Six major developments are identified. First, Government has redefined the roles of the public and private sectors, with productivity-enhancing research, near-market research and technology transfer activities becoming the responsibility of the private sector. Public R&D is now concentrated on broadly-based basic scientific research and public interest research. Second, this led to reductions in the expenditures of the public system of 7% and cuts in core funding from taxation of 13%. Third, charges have been introduced where possible, institutions have been privatized, closed and amalgamated and new institutions created to raise funds from commodity producers. Fourth, to create a competitive market in research, competitive bidding for research projects has, to an extent, replaced automatic programme funding. Fifth, to extend market incentives to within the organizations, accountability has been increased by the formation of executive agencies, monitoring and evaluation procedures have been strengthened and increasing numbers of staff have been hired on short-term contracts. Sixth, the Government has committed itself to providing clear policy leadership and improving information flows, by means of publications, improved management structures and increased collaborative research.

The paper is organized as follows. Chapter 2 explains the current organization of agricultural research in the UK, showing the flows of funds and the expenditures of the institutions involved. Next, Chapter 3 examines the institutional history of public agricultural R&D and R&D policy in the UK since WWII. Then, Chapter 4 provides a quantitative review of public funding and expenditures in the period since WWII. More recent changes are investigated in Chapter 5 by comparing public and private R&D funding and expenditures in 1987/88 with those in 1993/94. Chapter 6 concludes the paper by summarizing our findings.

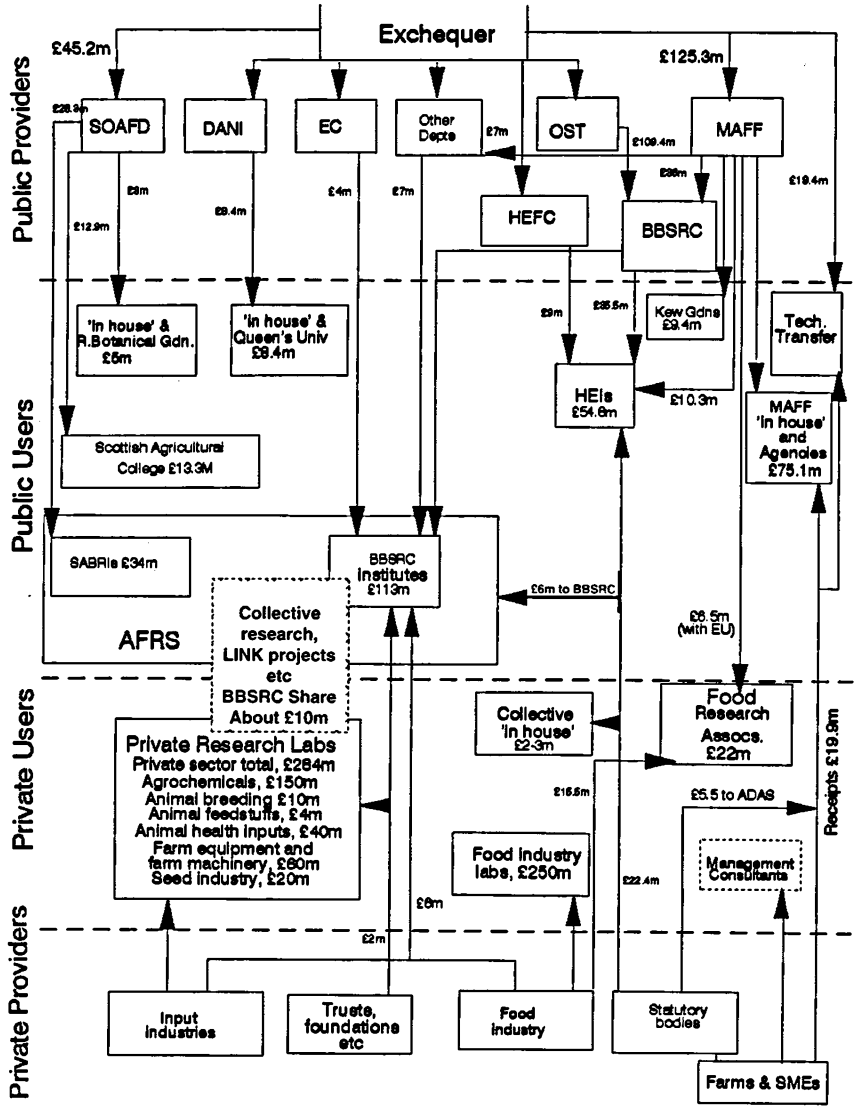
2 An overview of the current research system

INTRODUCTION

This Chapter examines the current agricultural research system, showing funding levels and expenditures for agricultural and food research by both public and private agencies. (Many of the amounts reported can be better followed by referring to Tables 6 to 11 in Chapter 5, which compare expenditures and funding in 1987/88 with 1993/94.) The data are for the 1993/94 fiscal year, which was the final year of operation of the Agricultural and Food Research Council (AFRC) for, on 1 April 1994, it was incorporated into the Biotechnology and Biological Sciences Research Council (BBSRC), making comparisons with previous years practically impossible. The new names of the institutions are used in this Chapter, to enable readers to understand the current system. These data are summarized in Figure 1, where the flows of funds are shown by the amounts attached to the arrows and the expenditures of the agencies are shown in the boxes, wherever possible.

Total agricultural and food research expenditures for the financial year amounted to £897 million (Tables 6 and 10), of which only £339 million, or 38%, was spent in public institutions (this sum includes MAFF's technology transfer expenditures of £19.4 million (see Table 6) which does not appear in Tables 4 and 5 as it was published since 1987/88). However, the private sector dominates food research, spending £272 million (Table 10), while the public sector adds only about £38 million (Table 4), to give a total of £310 million. Thus, the public share of food research expenditures is only about 12%. This leaves public agricultural research expenditures of £301 million, which with private expenditures of £286 million gives a total of £587 million

Figure 1
Sponsors and users of agricultural and food research funding, 1993/94



and a public sector share of just over half. It follows from the above that two-thirds of total expenditures were for agricultural research and one third were for food research.

Almost £270 million of public expenditures were in the form of core funding to the major institutions, from general Government revenues (Table 5), with the remainder being contract work for public and private agencies. As with expenditures, although almost £38 million (14%) of public funding was for research on food and food safety, the bulk of public money was for agricultural research. Thus, 40% of agricultural research was publicly funded. Private funding of £48 million (Table 11) was spent in public institutions, paying for almost 15% of public research. (It should be noted that this figure of £48 million exceeds the total of contract funding from both public and private sources in Table 5 because the Table excludes MAFF's technology transfer budget and Higher Education Funding Councils (HEFC) funding of the universities. If these are included, the 'new funding' would be £71 million, over two-thirds of which is from the private sector.)

Figure 1 shows the interdependency of the public and private systems in research and technology generation, which the government (OST, 1995a) has described as a partnership, in which the public institutions produce basic scientific and public interest research and the private sector is responsible for product development, near-market and productivity-enhancing research. Thus, the public sector should provide the scientific base for the applied research and development of the private institutions, and we begin by examining the current organization and structure of public-sector agricultural research.

THE PUBLIC SECTOR

Overview

The UK system is complicated because it has evolved over the period since provision was first made for a national agricultural research system, under the Development and Road Improvement Act, 1909, and also by the degree of autonomy granted to Scotland and Northern Ireland, by membership of the EU, and by the dual system, whereby responsibility for agricultural R&D is divided between a research council and the agricultural ministry.

Thus, as Figure 1 shows (see also Table 6 which further explains the calculations), central Government (the Exchequer) disburses funds to MAFF, which is responsible mainly for R&D in support of policy and the 'public interest' and for the botanical gardens at Kew. Smaller amounts go to the Department of Agriculture for Northern Ireland (DANI), which has special responsibilities for the particular problems of agriculture in Northern Ireland and to the Scottish Office Agricultural and Fisheries Department (SOAFD), which covers Scottish interests. (On 2 October 1995, SOAFD joined with the Scottish Office Environment Department. In this paper, as we are dealing with 1993/94 figures, we will continue to refer to SOAFD). SOAFD, like MAFF, has

departmental duties (particularly with regard to fisheries, which account for most of its in-house expenditures) but passes on the bulk of its funding to the Scottish Agricultural College (SAC) and the five Scottish Agricultural and Biological Research Institutes (SABRIs). These, together with the eight institutes of the BBSRC comprise the Agricultural and Food Research System (AFRS), which is responsible for basic scientific research. Thus, about 40% of SOAFD funding is allocated to basic scientific research, whereas the only basic components of MAFF-funded research are some of the work undertaken by the Royal Botanical Gardens at Kew.

The BBSRC institutes (one is in Scotland and one in Wales) receive some funding from MAFF, but the bulk is from the Office of Science and Technology (OST). Other central Government funds go through HEFCS to the universities, through other Government departments, or are recycled through EC research programs. In terms of research performed, MAFF, SOAFD and DANI undertake more applied work and perform statutory duties, whilst they commission basic research from the BBSRC institutes, the SABRIs and the universities.

The lower part of Figure 1 shows the private sector, which is covered at the end of this Chapter, after considering the activities of the public institutions.

The major elements of the UK public research system

In the UK, most domestic public-sector research is funded through MAFF and the OST, which was established in 1992, combining parts of the Department of Education and Science (DES) and the Cabinet Office. The name change reflects the Government's increased focus on the role of science and technology in economic growth. We begin by explaining the agencies that are responsible for research with a UK-wide focus, before covering the regional variations.

The OST funds research in all areas of science, including agriculture. In 1993/94, its total budget for all research councils was about £1.15 billion of which almost £110 million went to the BBSRC. The BBSRC also received £36 million from MAFF for commissioned research and about £11 million from industry, other Government departments and agencies and miscellaneous sales (BBSRC, 1994). The BBSRC institutes raised a further £15 million from contracts with Government departments, industry, the EU, foundations and trusts, adding to a total income of over £170 million (see Table 7). The BBSRC used some of this income to commission £35.5 million of research with universities, £2.3 million with other councils and departments and paid £20 million in pensions. The remainder funded its eight institutes, which allowed them to spend about £113 million. This included about £10 million which was spent on collaborative research projects with private research laboratories and universities. The institutes, with their areas

Table 1
BBSRC Institutes: locations, functions and grants, 1993/94, £ million[1]

Institute (and area of research)	Location	Recurrent Grant	Capital Grant
Babraham Institute (animal physiology and genetics)	Cambridge	8.2	2.6
Institute of Arable Crops	Harpenden, Bristol and Bury St Edmunds	12.5	1.3
Institute for Animal Health	Newbury and Woking	11.0	1.8
Institute of Food Research	Reading and Norwich	11.6	1.2
Institute of Grassland and Environmental Research	Aberystwyth, Brecon and Okehampton	8.0	1.2
John Innes Centre (plant science)	Norwich	9.2	1.4
Roslin Institute (animal physiology and genetics)	Edinburgh	5.2	0.7
Silsoe Research Institute (engineering)	Bedford	4.9	1.2
		70.6	11.4

[1]In 1993 prices.
Sources: AFRC (1991) and BBSRC (1994).

of research, locations and the BBSRC grants that are their main source of funding, are listed in Table 1.

The other component of UK-wide basic agricultural research is commissioned research undertaken by the universities, which spent almost £55 million. In addition to BBSRC and MAFF commissions, it can be seen in Figure 1 that they received about £9 million from Government by way of HEFC, to fund agricultural and food research.

MAFF supports a substantial in-house research operation through the facilities of its four executive agencies, which were founded between 1990 and 1992. The four components of MAFF with research responsibilities which were given executive agency status in this period are: the Veterinary Medical Directive (1990); the Central Veterinary Laboratory (1990); the Central Science Laboratory (1992); and the Agricultural Development and Advisory Service (1992). The Central Veterinary Laboratory has since taken over the Veterinary Invistigation Service, to form the Veterinary Laboratories Agency. MAFF has a mandate to perform statutory duties and research to support

Government policy. Thus, over 60% of MAFF's R&D budget is allocated to policy support (to 'protect the public', farm animals, and the rural and marine environment) and less than 40% is spent on applied research intended to improve productivity (MAFF, 1994). The Agricultural Development and Advisory Service (ADAS) is the largest agency, with an income in 1993/94 of £76 million (ADAS, 1994), two-thirds of which was from public funds. ADAS has a responsibility for extension services (for which charges have been imposed since 1987) as well as applied research functions through its experimental farms.

MAFF's core funding of about £125 million, plus almost £20 million in receipts for services (including £5.5 million from the statutory bodies to ADAS) and the technology transfer budget of £19.4 million adds to a total income of almost £165 million (see Table 8). This income, less disbursements of £36 million to the BBSRC, £10 million in commissioned research with the universities, £7 million to other departments, £9 million for botanical research at Kew Gardens and £7.4 million (much of it to the food research associations - the Campden Food and Drink Research Association (CFDRA), the Flour Milling and Baking Research Association (FMBRA), the Leatherhead Food Research Association and the British Industrial Biological Research Association. In 1994, CFDRA and FMBRA merged to form the Campden and Chorleywood Food Research Association), leaves intramural research expenditures of £75 million. In addition, MAFF spent £19.4 million on its technology transfer activities, giving a total of £95 million for the total science and technology (S&T) budget.

Scotland

Although limited, the autonomy of Scotland has led to public funding for most agricultural research in Scotland being disbursed by SOAFD. In 1993/94, SOAFD's research budget amounted to about £45 million (Table 9). Like MAFF, SOAFD allocates research resources to in-house activities, including the Scottish Agricultural Science Agency (formed in 1992) and the Royal Botanical Gardens in Edinburgh. However, only about 7% of SOAFD's budget was used to support in-house research, compared with 52% for MAFF. In contrast, 75% of SOAFD's budget (£34 million) was allocated to the five SABRIs, compared with less than 25% for MAFF. The SABRIs are listed in Table 2, with their areas of research and SOAFD grants. No doubt the Scottish institutes, which have a long history, began as an expression of Scottish autonomy and had special Scottish interests. However, this is no longer of such great importance and they overlap with the BBSRC institutes, adding a further element of dualism to the UK system (whereas the dual ministry and research council system has attracted considerable criticism (Arnon, 1989; Ruttan, 1982), this anomaly has been largely overlooked in the literature). Indeed, the SABRIs both collaborate with

Table 2
Scottish Agricultural and Biological Research Institutes: locations, functions and grants, 1993/94, £ million[1]

Institute	Area of Research	SOAFD Grant	Other Income
Hannah Research Institute	Biological and food research	3.6	0.6
Moredun Research Institute	Animal health	4.2	1.1
Macaulay Land Use Research Institute	Land use	6.5	0.8
Scottish Crop Research Institute	Crop research	8.0	2.0
Rowett Research Institute	Nutrition	6.0	1.2
		28.3	5.7

[1]In 1993 prices.

Sources: Annual Reports of the Institutes.

the BBSRC and compete with its institutes for commissioned research, both within the UK and abroad, which accounts for the contract income reported in Table 9. The remaining 18% of SOAFD's budget (£13.3 million) provided support for the SAC system, which is peculiar to Scotland, and consists of a central office in Edinburgh and three regional colleges.

Northern Ireland

In Northern Ireland, the agency responsible for the allocation of public agricultural research funds, for local problems, is DANI. All of its research budget is allocated either to in-house research activities or to support research at Queen's University, Belfast. No independent research institutes are supported by the Government in Northern Ireland, partly because Northern Ireland is relatively small and partly because of close links between DANI and Queen's University.

European Union funding

Finally, the UK contributes to EU research projects and by 1993/94 about £8 million of food and agricultural research funding was entering the system by this route. In Figure 1 this is allocated to the BBSRC institutes and the food research organizations, but it is actually spread widely across the system, favouring collaborative projects involving the institutes, MAFF agencies, universities and private sector laboratories, with European partners. MAFF has shown a special

interest in ensuring that UK agriculture benefits from Framework Programme IV (described in OST, 1995a), which will distribute 684 million ECUs (£560 million at the June 1995 exchange rate of £0.82 to the ECU) to all areas of research, from 1994 to 1998.

Concentrating on research funding understates the influence of the EU on UK agricultural research institutions. EU regulations are partly responsible for the UK abandoning the system of marketing boards that functioned as commodity-based marketing, promotion, and research organizations. The promotional and research functions that the marketing boards performed are now the responsibility of the statutory bodies, which are discussed in the next sub-section and in Chapter 3.

THE PRIVATE SECTOR

The lower part of Figure 1 shows the private sector comprising the input industries, non-profit trusts and foundations, food industry companies, statutory bodies, farms and small and medium enterprises (mostly connected with the food industry). Moving upwards, the input industries expenditures are concentrated in private facilities, but there is also a small amount spent in collective (commodity-level) research institutions (see also Table 10 in Chapter 5).

The food industry spent some £272 million, £250 million in private facilities, and the rest with the food research associations. The private sector also spent almost £50 million paying MAFF for research-related services and commissioning research with the AFRS institutes, MAFF agencies and the universities (see Table 11). Thus, there is some private funding of publicly conducted research, so that public execution of research exceeds public funding. The statutory bodies collect levies on producers of particular commodities and have some facilities which conduct collective research to serve the needs of the producers. These facilities are limited and spend only £2-3 million at present, while the remainder of the £22 million collected is spent on commissioned research, performed mainly by the AFRS institutes, the MAFF agencies and the universities (Tables 10 and 11). The other important recipient of funds is the National Institute of Agricultural Botany (not shown in Figure 1) which, amongst other activities, conducts varietal trials and produces lists of recommended seeds.

The statutory bodies are so-called because they operate under statutory authority and derive their resources from legislated mandatory levies on agricultural output. Currently, these bodies include the Home Grown Cereals Authority (HGCA), the Milk Development Council, the Horticultural Development Council, the British Sugar plc (now part of Associated British Foods), the Apple and Pear Research Council, the Meat and Livestock Commission (MLC), and

the Potato Marketing Board (PMB). The PMB is to be replaced by the British Potato Council on 1 July 1997 and an Egg Research Council is also to be created in the next two years. Whilst most of these bodies are relatively new (the HGCA and the MLC date back to the Agriculture Act, 1967, and are the successors to the marketing boards, set up in the 1930s), the British Sugar Corporation funded research from a levy on beet growers since the 1930s. British Sugar is now a fully commercial company, part of Associated British Foods. However, the levy-funding mechanism, which is operated by a statutory body called the Sugar Beet Research and Education Committee, is still in operation. As Thirtle (1996) showed, this adaptive research appears to be effective, in that TFP growth in sugar beet since 1954 has been about 1% per annum higher than the national average. These bodies are quasi-government organizations in that they operate autonomously and, through their boards of directors, are largely responsible to the industry, but depend on legislated levies from producers to secure their resource base. They have strong ties to commodity groups and food processors, as is indicated by the fact that several of them have mandates to implement marketing and promotion activities on behalf of their client groups. For example, a much larger share of the MLC's budget is dedicated to promoting livestock products than to research and some part of the newly-created Milk Development Council's budget will be allocated to promotional activities. The research sponsored by these organizations is almost always of a commodity-specific, 'near-market' nature.

As Figure 1 and Tables 10 and 11 show, the bulk of private agricultural research funds are spent by private input industry companies in their own in-house research laboratories. Some are considerable facilities, with a long history, such as Zeneca's (formerly ICI) establishment at Jealotts Hill, which in 1930 was the biggest research station in the UK, with a staff of 36 (Thirtle *et al* 1991). Private-sector expenditures for 1993/94 by in-house facilities are estimated to be about £284 million. Figure 1 and Table 10 show that the agro-chemicals industry is the dominant force, spending more than half this total. Farm equipment and machinery and animal health products account for a further £100 million, leaving £34 million of expenditures by the seed industry, animal breeders (pigs and poultry) and animal feed producers.

These estimates were obtained by a variety of methods. The expenditure on animal health R&D in 1993/94, of approximately £40 million, is about 21% of industry sales in 1994. This assumes that veterinary pharmaceutical producers have the same R&D intensity as the rest of the pharmaceuticals industry (the figure is from OST, 1995a). The other estimates were all made by industry insiders (whom we thank for contributing to this exercise), with the help of the trade associations and are more reliable. However, R&D expenditures by the

agro-chemical (fertilizer, herbicide and pesticide) companies may overstate the investment relevant to the UK , as ICI, which performs most of its research in the UK and is by far the biggest spender, is a multi-national corporation, with worldwide interests. The same is true of some companies in all the other input industry groups, such as Zeneca Seeds, Plant Breeding International and the tractor companies.

The food industry in the UK is dominated by a few large companies with a R&D expenditure of 1-2% of sales. The major firms supporting in-house R&D include Unilever, Associated British Foods and RHM. As might be expected, the activities of these companies are targeted, in part, towards international markets. Smaller companies tend to have lower research intensities and the BBSRC (1995) estimated expenditures at some £250-300 million. These figures probably include expenditures for product development, such as developing new recipes, so the lower figure is reported in Figure 1 and Table 10 as an estimate of current food industry research efforts.

3 Public agricultural science policy in the post-WWII period

INTRODUCTION

Major political changes in the governing of the UK since WWII have had important ramifications for science policy particularly because of the integrated nature of legislative and administrative functions within the British parliamentary system of Government (in which the Prime Minister and the Cabinet head both the legislative assembly and all central Government agencies). This Chapter therefore examines the history of public agricultural science policy in the UK in the context of the major changes that have occurred in general science policy and economic policy during the post WWII period. The Chapter relies heavily on material presented in Thirtle *et al* (1991) for the history of UK agricultural research policy prior to the mid-1990s and on Gummet (1991) and Cunningham & Nicholson (1991) for insights about general science and technology policy.

The postwar history of UK agricultural research policy can be divided into four phases:

1945-1956 A period of emphasis on a centralised agricultural research system under the control of the agricultural ministry. (The terms *ministry* and *agricultural research policy* are used extensively here to simplify the discussion because both the agricultural ministry and the agricultural research council were subject to name changes during the period 1945 to 1995.)

1956-1971 A period in which publicly funded agricultural research clearly operated under a dual funding system in which

public agricultural research was funded by the central Government both through the Ministry of Agriculture (in its various incarnations) and an Agricultural Research Council (also in various incarnations).

1971-1979 A period in which three important changes took place. First, as a result of a Government-wide review of general science policy, the Rothschild report, successive Conservative and Labour Governments reallocated resources towards the Ministry of Agriculture and away from the Agricultural Research Council. Second, partly spurred by UK entry into the European Economic Community, environmental interest groups began to question the benefits of agricultural research. Third, successive budget crises led to hiatuses in the rate at which public spending on agricultural research increased.

1979-1994 A period in which, within the context of a dual funding system, a more radically right-wing Conservative Government: cut total funding for agricultural research (as well as other scientific and technological research) in real terms between 1982 and 1987 and then, between 1987 and 1994, increased aggregate funding in real terms above its 1979 levels by expanding support for public interest and basic research; to some degree privatised the research functions of the agricultural ministry; legislated to allow the creation of statutory bodies to carry out 'near-market' research funded by levies on agricultural producers; and introduced greater competition among universities and independent research institutes for public agricultural research funds through expanded competitive grants programmes and by linking funding for academic departments in higher education institutions to periodic evaluations of their research productivity.

Below, we begin with a brief description of the UK agricultural research system in 1945 and then examine the changes that occurred in each of the four phases described above.

AGRICULTURAL RESEARCH POLICY IN 1945

In 1945, at the end of WWII, four organisations were involved in the administration of agricultural research in England and Wales: the Ministry of Agriculture and Fisheries; the Ministry of Food; the Development Commission; and the Agricultural Research Council (ARC). Prior to the 1930s, the ministry dispensed research funds under the direction of the Development Commission, which was established

in 1909 to administer a national agricultural research system and also administered its own budget. Snelling (1976) has noted that the division of tasks between the ministry and the Commission was ambiguous partly because, in contrast to other research areas, it was harder to draw a line between basic and applied research in agriculture. Thus, in 1931, the ARC was established to coordinate the activities of the two bodies. However, the ARC was not successful in accomplishing that goal, mainly because it was not given oversight authority over ministry or Commission agricultural R&D expenditures.

The independence of the ministry and the Development Commission was largely consistent with the recommendation of a 1918 Parliamentary Committee of Enquiry, chaired by General Sir Richard Haldane, which set up a broad framework within which all UK Governments have subsequently implemented general science R&D policy. The Haldane committee recommended that a dual funding system be established for all UK publicly funded science and technology research, arguing that research required by a Government department should be managed by that department but that research relevant to several departments should be funded by more autonomous research councils. The Haldane recommendations were accepted and became the basis for successive Governments' general science R&D policies. As a result, by 1949, four separate research councils had been established, including the ARC. (The others were the Department of Scientific and Industrial Research, the Medical Research Council and the Nature Conservancy which was responsible for resources and the environment.)

AGRICULTURAL RESEARCH POLICY, 1945-1956

The post-war Labour Government, led by Clement Atlee, viewed the crossed lines of responsibility for agricultural research between the Development Commission and the Ministry of Agriculture and Fisheries as inappropriate. Much more willing than the 1930s *laissez faire* Conservative Governments of Stanley Baldwin and Neville Chamberlain to have faith in the efficacy of centralised Government institutions, Atlee's Government almost immediately placed all administrative authority over agricultural research funding in the ministry's hands. In addition, in 1946, responding to the criticism that too little attention had been paid to linking agricultural research and advisory or extension functions within UK agricultural research, the Atlee Government also created the National Agricultural Advisory Service (NAAS). (In 1971, NAAS was renamed ADAS. In 1992, ADAS became an autonomous agency with a mandate to charge fees for services to private-sector clients.) NAAS was to supply agricultural advice and information through a system of regional field advisors

(roughly comparable to extension agents in the US). However, these advisors were to be supported by researchers located in a system of 13 experimental husbandry farms and horticultural stations. In Scotland and Northern Ireland, as is still the case, arrangements were slightly different. In Scotland, all publicly funded agricultural research became the responsibility of the Department of Agriculture and Fisheries for Scotland (DAFS - now SOAFD). In Northern Ireland, the Department of Agriculture for Northern Ireland (DANI) similarly was solely responsible for public agricultural research funds.

These institutional arrangements were maintained by successive Governments until 1956, when the agricultural research system in England and Wales experienced a substantial organisational change. However, the structure for funding public agricultural research in Scotland and Northern Ireland has not altered much since 1946.

One other important administrative change took place in this period. In 1955, as soon as food rationing in the UK ended, the Ministry of Food was closed and its functions integrated within the Ministry of Agriculture and Fisheries, which was then renamed the Ministry of Agriculture, Fisheries and Food (MAFF). This change may not have immediately affected MAFF's agricultural research agenda, but it is a part of the evolutionary process in which MAFF's emphasis on food safety research has increased very substantially.

AGRICULTURAL RESEARCH POLICY, 1956-1971

In 1956, a major change occurred in the public agricultural research system for England and Wales. Control over research funding was transferred to the ARC and the Development Commission gave up its agricultural research responsibilities. It is unclear why this change came about. However, Shattock (1991) has noted that during the 1950s a close relationship developed between the minister responsible for science research and all of the research councils and the universities. It was in this general environment that the ARC was given independent responsibility for agricultural research and MAFF's influence declined correspondingly. MAFF, however, remained in charge of substantial research funds through its mandate to provide applied research support for the NAAS. Thus the public agricultural research system still remained a dual system.

Public-sector agricultural research funding expanded rapidly between 1956 and 1971 although some administrative changes did occur. As part of the Wilson Labour Government's attempts to channel the 'white heat of science' into effective improvements in economic productivity, funding for all of the research councils was reorganised under the Science and Technology Act, 1965. (In the 1964 election campaign, Wilson (then leader of the opposition Labour party)

emphasised the need for an aggressive science and technology policy to prevent a 'brain drain' of talented researchers to the USA and to enhance economic productivity. In response, the Conservative Government established a committee of enquiry into the organisation and management of research chaired by Sir Burke Trend. The Trend Committee made several recommendations for reorganisation, including the creation of a science research council and a development authority to handle R&D applications. The Wilson Labour Government, elected in 1964, accepted most of these proposals but placed responsibility for industrial R&D in a new Ministry of Technology.) The Science and Technology Act transferred responsibility for these councils to the newly created Department of Education and Science (which later became OST). As a result, the dichotomy between the two components of Britain's agricultural research system became institutionalised; each was the clear responsibility of separate Government agencies. While, since 1970, decisions about funding have altered the relative importance of MAFF and the agricultural research council, no Government has chosen to rationalise the system under one agency.

AGRICULTURAL RESEARCH POLICY, 1971-1979

In 1971, a new parliamentary review, *The Organization and Management of Government R&D,* led to major changes in agricultural research funding (DES, 1971). This paper, generally known as the Rothschild report, was part of a comprehensive review of Government operations initiated by a newly-elected Conservative administration in 1970. The Rothschild report advocated that a *customer-contractor* principle be implemented for all science R&D. Under this principle, research would be orientated to the needs of the agencies commissioning the research on a customer-contractor basis. The report created a furore among leading scientists who claimed it was a threat to the flexibility and academic freedom of researchers. In fact, the report did not invoke any new principles for the 1918 Haldane report had argued that research councils should exist to fund research that spanned the interests of several departments but not that they should be entirely autonomous entities. In relation to agriculture, Rothschild argued that the ARC had been too divorced from the needs of its clients - the private agricultural community (such as farmers, agricultural input suppliers, and food processors) and the ministry (MAFF) - in its research agenda. This had important ramifications for the independent agricultural research institutes funded by ARC - apparently they also weren't adequately doing their job, at least as that job was perceived by influential UK agricultural lobby groups. Part of the ARC's 'public relations' problem was that it had to allocate

substantial funds to support basic research rather than applied research (Thirtle *et al* 1991). In addition, the bifurcation of responsibilities for research between ARC and MAFF had led ARC-funded agricultural research institutes to assume that MAFF's agricultural advisory service (NAAS) would be responsible for translating their laboratory results into useful inputs for agricultural producers (see Winnifrith, 1962 and also Ruttan, 1982).

The Rothschild report (DES, 1971) recommended that MAFF, acting as a customer on its own behalf and a more effective principal agent for the UK agricultural community, should be given a much larger direct say over the disposition of agricultural research funds for applied research. This implied that resources should be reallocated from the ARC to MAFF. As a result, within two years the ARC had lost a considerable proportion of its budget to MAFF, and MAFF then became an important client for the agricultural research institutes (Thirtle *et al* 1991). In addition, funding was increased for NAAS, MAFF's agricultural advisory service, which (with expanded responsibilities that included veterinary research and services) was reborn as ADAS in 1971. This single body was intended to handle all advice to farmers.

The Rothschild report also argued for institutional changes to improve communications between the ARC and MAFF (DES, 1971). Thus, a Joint Consultative Organization (JCO) was established to create links between the ARC, MAFF, and DAFS and DANI, all of which had R&D responsibilities. Within the JCO, five specialist advisory boards (for animals, arable crops and forage, horticulture, engineering and buildings and food science and technology) were created to provide advice on research policy and board members were drawn from user groups (farmers, agricultural input suppliers, and food processors) as well as civil servants and scientists.

This structure for the administration of research funds was maintained throughout the 1970s and into the 1980s. For most of the 1970s, agricultural research funding continued to expand although, as shown in Chapter 4, successive Government budget crises caused funding for all areas of research, including agriculture, to oscillate from year to year (see Table 4). Nevertheless, there were clear signs that public agricultural research funding would be less likely to expand in the 1980s, no matter which political party was in charge in Westminster. The change in the climate for public agricultural research funding was closely linked to widespread concerns about the need for reduced Government intervention in the economy and lower levels of Government spending in general (Thirtle *et al* 1991). However, there was also increasing scepticism about the potential benefits from additional scientific research. UK entry into the EU is relevant in this context.

The UK achieved full membership of the EU in the mid-1970s (after a transition period) and by 1976 was a full participant in the Common Agricultural Policy (CAP). The CAP generally guaranteed EU crop and livestock producers prices for their products that were well in excess of world market levels. Prior to UK entry into the EU, UK producers received lower prices than EU producers, especially for cereals. Under the CAP, however, UK crop producers immediately enjoyed sharp increases in prices and responded by adopting more intensive cropping practices. In response, fertiliser, herbicide, and pesticide use expanded rapidly and more land also came into production, often through the removal of hedges and walls. (See Thirtle & Bottomley (1992) for further details on inputs, outputs, and productivity patterns.) As a result, water pollution increased and the diversity and size of bird populations declined (Woods *et al* 1988). In addition, heavier grazing patterns were adopted for livestock that changed the rural landscape. These changes led influential environmental and conservation groups like the Royal Society for the Protection of Birds to question both the value of the CAP and the appropriateness of agricultural research that encouraged chemical-intensive agricultural production practices. Thus, under any administration, agricultural research was unlikely to expand as rapidly as in the past, and was more likely to involve a different set of research priorities and programmes which had gradually evolved.

AGRICULTURAL RESEARCH POLICY, 1979-1995

The election of a right-wing Conservative Government under Margaret Thatcher in 1979 had radical implications for many aspects of Government policy. With a perceived mandate to reduce the scale of Government, cut taxes, and lower the Government budget deficit, the Thatcher administration was willing to scrutinise carefully all aspects of public research funding. Thus, in 1982, budgets for all research councils were reduced and the ARC budget continued to decline throughout most of the 1980s (see Table 3 below). By 1987/88, public funding for all food and agricultural research had fallen in real terms by about 9.3% to £298.4 million from its peak 1982 level of £320 million, and the ARC's (by then called the Agricultural and Food Research Council - AFRC) funding had declined even more rapidly (by 23%, from £155.7 million in 1981/82 to £119.8 million in 1987/88). However, Thirtle *et al* (1991) argue that there is some confusion about the actual decline in real funding levels over this period because the AFRC's income has to cover expenditures on redundancy payments and pensions, which increased rapidly as the system was cut back.

The decline in public agricultural research funding was not simply due to a general decline in public funds for scientific research. The Conservative administrations of the 1980s and 1990s continually

argued that the Government should not do what the private sector could accomplish through the market place. This view led to policy innovations under which, during the late-1980s and 1990s, public sector organisations were amalgamated, privatised or closed down. Many agricultural research institutions were particularly susceptible on these grounds because of the applied or 'near-market' nature of their research and cuts in funding during the first part of the 1980s resulted in the amalgamation and consolidation of the research institutions funded by AFRC from 18 separate facilities to eight. Some were privatised in the late-1980s and early 1990s. In 1988, the government sold the National Seed Development Organization (previously operated by MAFF) and part of AFRC's plant breeding institute to Unilever. In 1989, the Liscombe Experimental Husbandry Farm (ADAS) was also transferred to the private sector. Between 1989 and 1990, several experimental horticultural stations operated by MAFF were closed and, in 1991, the AFRC Institute of Horticultural Research became Horticultural Research International, which was transferred to MAFF and thus became a non-departmental public body. It then had to obtain support for its work on a competitive, client-oriented basis from AFRC, MAFF, and the private sector.

Some important institutional changes in the management of public agricultural research were also made. The JCO, created in the 1960s to coordinate research by MAFF and the ARC, had been criticized as cumbersome and overly bureaucratic. In 1984, therefore, it was replaced by a Priorities Board. In its first report, released in 1985, the Priorities Board (whose membership explicitly included expanded representation for the food industry) identified the expansion of food research as a major priority for agricultural research. In response, in 1984, the ARC was renamed as the AFRC and funding for food research was increased sharply until, in 1988/89, food research accounted for 14.6% of the AFRC's budget. In part, this increase in funding reflected increased concerns for food safety among the general population—in the late 1980s, concerns had been raised in the UK about the use of Bovine Somatotropin (BST) in milk production and BSE in meat, as well as salmonella in eggs. It also reflected an increase in the political influence of the retail chains and the food processing and distribution lobbies. Thus, in 1989, the Priorities Board's membership was changed to include food retailing and consumer interests. This reflects both the growth of influence of the food industry and increased concerns over health on the part of both consumer groups and the grocers.

In the 1990s, John Major's Conservative Government continued to emphasize privatisation and reduced Government involvement in market-related activities, and these broad policy concerns continued to have important implications for agricultural research. In 1990, following the Priorities Board report, it was decided that all MAFF

funding for 'near-market' research should cease by 1991/92, resulting in a £30 million reduction in MAFF's applied research budget. Some of these funds were reallocated to the DES to fund higher levels of basic research at the universities and, through the AFRC, the agricultural research institutes. The 1990 Priorities Board recommendation that funding for near-market research should end was based on the 1987 Barnes report, an internal study commissioned by MAFF (Read, 1989). This report had recommended that MAFF funding for near-market research be cut by about £24 million. An earlier report by ADAS (MAFF, 1984) had also recommended that ADAS charge private sector users for services.

In 1990, the Priorities Board also recommended that the DTI's project LINK be supported. Under this project, the AFRC was to use some of its resources to fund joint research projects with industry. Thus, some of the funds from MAFF and the AFRC would be allocated to develop technology transfer projects. In 1995, 570 projects, with a total budget of about £300 million, were being jointly funded under the LINK program, but most of the support for these projects was provided by the private sector; the Government's contribution was only about £10 million.

Also in 1990, as part of a general initiative to reorganise the funding and management of Government, the Conservative administration announced that some Government departments would become executive agencies. In the past, these departments' agencies had dual roles, providing services to Government departments and also to private firms. Henceforth, instead of providing services to the 'public' for free, these 'executive agencies' would have to sell their services to the private sector and only receive part of their budgets from general Government revenues. Between 1990 and 1992, four research-related components of MAFF were given executive agency status; the Veterinary Medical Directorate (1990), the Central Veterinary Laboratory (1990), the Central Science Laboratory (1992), and the ADAS (1992). On being granted agency status, ADAS (the largest of these agencies) also experienced a 55% cut in MAFF funding for its research and technology transfer services. ADAS's commercial income rose by 40% between 1990 and 1994, but this did not compensate for the loss of MAFF funds and its work force declined from about 2900 people in 1991 to about 2500 people in 1994.

The reduction in the size of an agency such as ADAS does not necessarily imply that there has been a reduction in overall research effort. The extensive reorganisation of the system moved some reseach activities out of particular agencies and sometimes out of the public system. Thus, the creation of the Central Veterinary Laboratory and the Central Scientific Laboratory redistributed what had been ADAS employment and the privatisation of the Horticultural Research

Institute took other jobs out of the public domain. This trend has continued, so that by 1996 ADAS employment had fallen to 1700.

The private sector was 'expected' to pick up the slack in applied research created by the reduction in direct government support. In part, this was expected to occur through increased research funding by the statutory bodies. As discussed in Chapter 2, these agencies derive their resources from legislated mandatory levies on the output of specific commodities. Priorities for the use of these funds are established by each statutory body's governing board which largely consists of representatives of commodity groups or industry. MAFF and the scientific community are also usually represented on the statutory body of research funding committees.

In the UK, legislatively sponsored commodity and industry groups have had a long history of providing research support on commodity specific issues. However, between 1980 and 1995, largely because of EU policies, many of these groups were reorganised. In the 1960s, most of them operated as marketing boards with, in some cases, explicit mandates to maximise producer revenues through price discrimination. They also provided research funds to independent research laboratories and universities. Most of these boards' operations were incompatible with the EU's CAP regulations and, by 1994, even the Milk Marketing Board had been disestablished. This left an organisational vacuum with respect to research funding by commodity groups. Beginning in 1986, the Conservative Government moved to fill that vacuum through initiatives that created a series of new research and market development institutions. These include the Horticultural Development Council, and the Apple and Pear Research Council, (and founded in the 1980s) and, more recently, the Milk Development Council (founded in 1995), the British Potato Council (to be established in 1997), and the Egg Research Council (also to be established in 1997). In addition, the Government required some existing commodity groups such as the MLC to increase, or at least maintain, their research budgets. Thus, for example, MLC research expenditures increased by over 300% between 1986 and 1994 (from about £0.5 million to about £1.96 million). Total research funding from these bodies was expected to be about £22 million in 1994/95, a substantial increase over such funding in the mid-1980s.

The above changes in Government agricultural research policy represent a significant and interesting shift in emphasis. To some degree, between 1990 and 1995, in relation to agricultural research, the UK Government altered the customer-contractor principle for funding agricultural research that was emphasised in the Rothschild report. For some applied research, the policy sections at MAFF, in liaison with the Chief Scientist's Group, acted as customers, contracting with the MAFF agencies, the BBSRC, the universities and other research institutions.

But in 1990, the Priorities Board (1990) stated that "all government funding of near-market R&D ..... will have been withdrawn by 1991/92". While this goal was not entirely achieved, the Board's (and the Government's) view of the role of Government with respect to near-market research was unambiguously clear. For near-market research, the farmers and the food industry were to be the customers and were to contract with the providers by means of commodity-level statutory bodies. At the same time as cutting MAFF budgets for applied research, the Government increased funding for public interest research and the AFRC received more support for basic research.

The Government also implemented several organizational changes to increase the independence of the agricultural research councils. In 1994, the DES was reorganised as the OST and the research councils were reorganised into six new entities. In this process, the AFRC was subsumed within a more general Biotechnology and Biological

Table 3
Chronology of major changes in agricultural and food research

Year	Event/change	Comment/description
1971	Rothschild report	Customer/contractor principle: critical of ARC
1971	ADAS formed	Strengthen 'relevant' applied R&D and diffusion
1971	JCO formed	Link ARC, MAFF, Scottish and N. Irish Departments
1976/80	Funding stops growing	General cuts on public sector to control budget
1979	Thatcher elected	Government intent on reforming the public sector
1983/84	Budget cuts begin	Growth ceases: agricultural research targeted
1984	ARC becomes AFRC	Emphasis on food research due to value added
1984	Priorities Board formed	Replaces JCO to streamline the system
1985/88	AFRC restructuring	Closure and amalgamation of institutes: from 18 to 8
1987	ADAS extension charges	Services no longer free: increase in private advice
1987	Barnes Report	Industry to be the customer for near market R&D
1987	Privatisation	AFRC's PBI and NSDO sold to Unilever
1987	LINK Programme Supported	To encourage collaborative research
1988	BSE and Salmonella strike	BSE made a notifiable disease: Minister resigns over Salmonella
1989/90	ADAS horticulture cuts	3 Centres closed, 1 transferred to industry funding
1990	AFRC horticulture cuts	AFRC Institute now Horticulture International (mixed funding)
1990/92	Next Steps Agencies	4 MAFF and 1 SOAFD Executive Agencies formed
1991/92	Near-market funds cut	MAFF near-market R&D funding of £30M supposed to end
1992	OST Formed	Headed by Cabinet Minister to indicate importance
1993	Realising our Potential Report	First full review of S&T since the Rothschild Report
1994	AFRC incorporated in BBSRC	Broader Research Council to capture biotech synergies
1995	OST transferred to DTI	From Cabinet Office to Technology seen as wealth creation
1995/96	New statutory bodies formed	3 new bodies formed to raise levies on producers

Sciences Research Council (BBSRC) and the AFRC institutes were redesignated as Biotechnology and Biological Sciences Research Institutes (BBSRIs).

Conservative administrations of the 1980s and 1990s have argued that market competition improves economic efficiency and productivity. This view is consistent with and at least partly responsible for some important innovations in administration of public R&D funds. Since the mid-1980s, three important changes have been made. First, in 1987, the research outputs of all university academic departments became subject to periodic peer reviews and the outcomes of these reviews are now used to determine five-year 'block-grant' research funding levels. Second, a larger share of total R&D funds has been allocated through competitive grants programmes for which university, Government, and independent research institute scientists are eligible. Third, in higher-education institutions, independent research institutes, and Government laboratories, scientists are increasingly employed on the basis of short-term rather than long-term contracts. All of these trends have been reflected within agricultural research departments within universities, the Government and independent research institutes (Thirtle *et al* 1991; Scottish Crop Research Institute, 1993).

The major changes to the system are summarised in Table 3. There are some indications that the pace of change in UK public agricultural research policy and organisation has slowed. In 1995, in its annual review of public research organisation and funding, *Forward Look*, the Government stated that most of the recommendations for change in science policy developed in the early 1990s had been put into effect (OST, 1995a). In particular, the Prior Options Review, which is an ongoing Government assessment of public research, stated early in 1997 that privatisation of the Research Councils is not being considered. Nevertheless, in February 1997, it was announced that there was to be a management buy-out of ADAS, which was expected to operate as a private company.

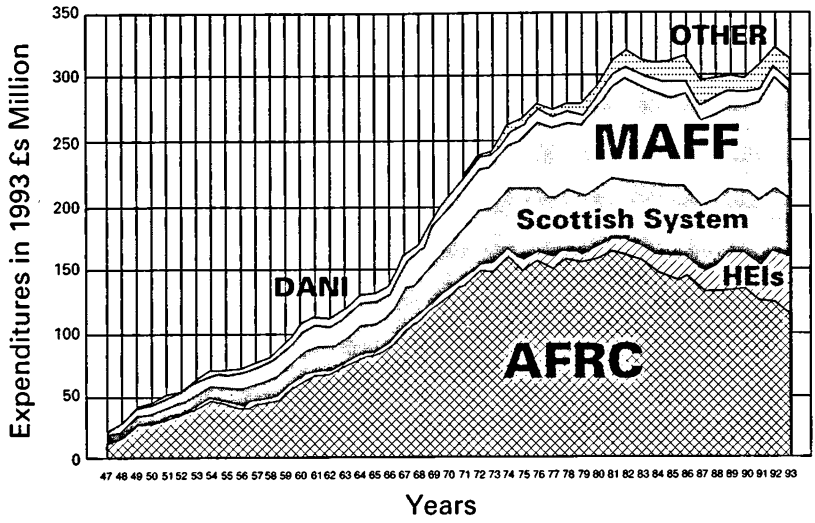
4 Post-war trends in public agricultural R&D expenditures and funding

EXPENDITURES

Although it is not possible to find annual data on all the diverse elements of the system portrayed in Figure 1, Thirtle (1989) estimated the expenditures of the AFRC, MAFF, DAFS, DANI and the universities, which accounted for 99% of the total up until 1972/73. From that date, these series still account for at least 92% of expenditures and there is data on the 'other' expenditures of the system. These data are plotted in Figure 2, which shows that the system grew rapidly in real terms from 1947/48 to 1976/67, at a rate of almost 8% per annum. Total expenditures, measured in real 1993 prices, increased by 1100%, from £25 million to £282 million. However, during the inflation of the early 1970s, following the oil price rise, the public sector share of GDP rose from 42% to 49% (Griffiths & Wall, 1993) and the Government reacted by curbing public spending. Thus, expenditure growth ceased in the late-1970s, but resumed in the early 1980s. Expenditures peaked in 1982/83, declined and then recovered after 1987/88.

The changes since 1972/73, for which more complete data are available, can be assessed using Table 4, which includes the category entitled 'other' shown in Figure 2. 'Other' is made up of the DES direct grant to NERC and MAFF's external commissions with NERC, the food research associations (treated here as 'public' research), and other contractors, which include other Government departments, the HGCA, NIAB and the Eggs Authority. Although this category is relatively small, it grew as the system was diversified and was rising fast enough to make a difference at the time of the cuts, partly due to increases in

Figure 2
Major public R&D expenditures in the UK, 1947/48-1993/94



The variables are also defined as in Table 4.
Sources: Prior to 1972/73 from Thirtle (1989), then as for Table 4.

food research. Table 4 shows that the agricultural and food R&D system was spending £320 million at its peak, in 1982/83, and was cut to £298 million by 1987/88, which is a reduction of only about 7% and by 1992/93 expenditures were back at the peak level. However, it can be seen in Chapter 5 that this recovery in R&D expenditures has been cancelled out by the rapid reduction in MAFF's technology transfer budget. The penultimate column reports the food research expenditures of the AFRC and MAFF, but similar figures are not available for DAFS and DANI. The figures show that food research doubled in the 1980s, from a low base. Thus, the last column shows total agricultural R&D (total minus food), which peaks in 1982/83, falls by 12% by 1988/89 and then recovers to within 6% of its peak level.

The changing shares of the institutions are also apparent in Figure 2 and Table 4. The AFRC expenditures, which are concentrated on basic scientific research, peaked at £163 million in 1981/82, but by 1993/94 had fallen by 30%, to £112 million. However, much of the decline is due to the increase in AFRC contract research with the universities, which also gained funding from MAFF. Thus, over the same period, their expenditures grew from £9 million to £46 million, which almost compensates for the fall in AFRC spending. With the expenditures of the Scottish system, which are largely for basic research, remaining

Table 4
Expenditures of the public agricultural research system, 1972/73-1993/94, £ million[1]

Year	AFRC[2]	MAFF[3]	DAFS[4]	HEIs[5]	DANI[6]	Other[7]	Total R & D	Food[8]	Total Agriculture
1972/73	146.6	32.0	42.6	6.5	9.0	2.9	240.0	19.7	220.3
1973/74	148.2	33.2	42.8	6.7	9.0	2.9	243.0	24.6	217.4
1974/75	159.9	35.2	45.9	5.9	9.0	5.3	261.0	26.7	234.3
1975/76	150.6	38.1	57.4	5.9	9.0	5.4	266.0	29.3	236.7
1976/77	156.6	52.5	48.8	6.7	9.0	5.1	279.0	22.6	255.4
1977/78	151.3	55.3	44.8	7.3	9.0	4.5	272.0	15.3	256.7
1978/79	156.5	52.8	46.2	7.2	9.0	4.9	277.0	16.6	260.4
1979/80	153.6	53.9	45.4	7.2	9.0	7.5	277.0	19.3	257.7
1980/81	157.1	61.9	46.8	8.0	9.0	8.4	291.0	20.4	270.6
1981/82	162.9	70.2	47.4	8.9	9.0	12.6	311.0	25.4	285.6
1982/83	160.2	79.3	47.6	11.1	8.6	13.0	320.0	28.2	291.8
1983/84	156.5	74.6	47.7	11.9	9.8	11.0	311.5	29.4	282.1
1984/85	146.9	69.3	55.0	14.4	10.3	13.2	309.2	30.1	279.1
1985/86	144.4	68.9	53.9	15.2	11.3	16.9	310.5	34.6	275.9
1986/87	145.2	72.6	52.2	15.2	10.5	18.2	313.8	37.3	276.5
1987/88	131.6	65.7	49.6	16.2	11.6	23.6	298.4	36.7	261.7
1988/89	132.1	68.8	50.5	18.0	11.5	18.6	299.4	44.0	255.4
1989/90	134.1	65.0	49.3	26.0	12.8	14.3	301.6	38.6	263.0
1990/91	132.5	65.1	49.2	27.4	11.3	13.2	298.7	40.4	258.3
1991/92	123.0	74.9	49.5	29.6	11.2	17.0	305.3	40.7	264.6
1992/93	122.1	88.3	46.5	41.2	8.6	13.6	320.4	43.1	277.3
1993/94	112.6	84.4	45.2	45.8	8.3	14.4	310.7	37.8	272.9

[1]In 1993 prices.
[2]AFRC income, plus income to the institutes, minus pensions.
[3]MAFF in-house, including Kew Gardens, minus fisheries research.
[4]Core funding from DAFS/SOAFD only, minus fisheries research.
[5]Contracts from the AFRC and MAFF, but not other institutions, or HEFC.
[6]DANI in-house, minus fisheries research: prior to 1981/82, estimates from Thirtle (1989).
[7]All MAFF commissions, except for fisheries research and with the AFRC and the HEIs. In later years, the AFRC commissions are subtracted from the totals for the councils shown in *Forward Look* (OST, 1995a).
[8]Food research including all commissions up to 1985/86. Then AFRC and MAFF only, plus estimates for DAFS and DANI.

Sources: AFRC and ARC (various years) *Annual Reports*; MAFF (various years) *Report on Research and Development*; Cabinet Office (various years) *Annual Review of Government funded R&D*; OST (1990,1992 & 1995a).

roughly constant, this suggests that real expenditures for basic scientific research have fallen by about £16 million, which is about 7%. This decline becomes a possible increase when the changes in the research portfolios of the institutions are taken into account. In 1981/82, 47% of the ARC's expenditures were classified as 'improvement of technology', whereas in 1993/94, 98% were listed in the most basic category (ARC, 1984; OST, 1995a). This would imply a £20 million increase in basic research, but the categories were changed between the two periods. However, since the literature unambiguously suggests that the AFRC system was moving towards more basic

research, it is safe to conclude that expenditures on basic scientific research rose by an indeterminate amount. The most obvious change in Figure 2 and Table 4 is the rapid increase in the intramural expenditures of MAFF (including Kew Gardens), which since 1972/73 have grown by over 260%, from £32 million to £84 million. The growth in the 1970s may be partly attributed to MAFF benefitting from the Rothschild Report's recommendations (DES, 1971). MAFF's expenditures peaked with the rest of the system in 1982/83, at £79 million and had fallen by 17%, to under £66 million, by the time the system reached its lowest level in 1987/88. At this point the AFRC's expenditures had also been cut by 19%, reflecting the Thatcher Government's determination to reduce the size of the public sector.

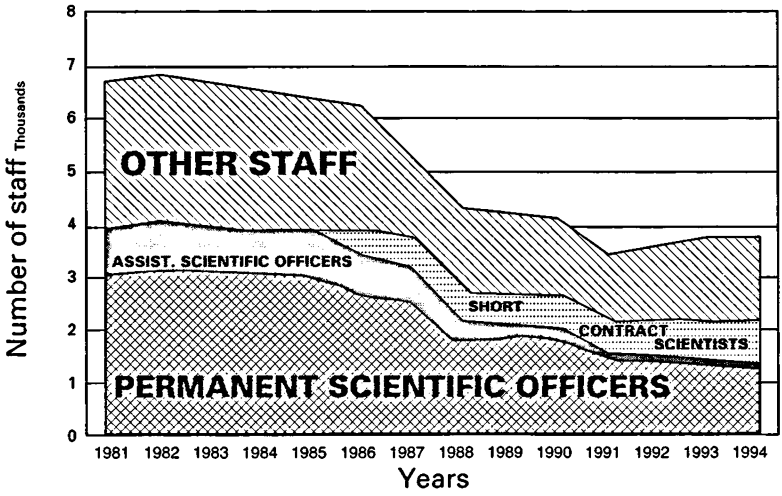
The removal of Government funding for MAFF's 'near-market' research, which was recommended by the Barnes Report (see Chapter 3), was expected to reduce MAFF's budget by a further £30 million, or 30% in the early 1990s (Webster, 1989). Although MAFF has cut its activities in this area, it is unlikely that it has succeeded in withdrawing totally, since the statutory bodies, which were supposed to take responsibility, had raised only an extra £6 million by 1993/94. (The projected cuts would be worth £30 million in real 1993 prices, so the deficit is still £24 million. The statutory bodies are further discussed in Chapter 5.) This failure, combined with a rapid increase in 'public interest' research (on food safety, diet, pollutants and preserving the rural environment) caused MAFF's expenditures to rise by 28% by 1993/94, to £84 million. These recent changes are discussed in the next Chapter.

Table 4 also shows that the regional systems have had their expenditures reduced from the peak levels of the mid-1980s, so that by the end of the period the Scottish system was spending only 82% of its peak level and DANI only just over 70%. The 'other' category rose substantially in the mid-1980s and returned to the early 1980s level by the end of the period. In summary, Table 4 and Figure 2 show that the total expenditures of the whole system were never cut by more than 7% and that by the last years expenditures had recovered to the previous peak level of 1982/83. However, these figures do not include MAFF's technology transfer budget, which has only been published since 1987/88. This item fell from £37.7 million in 1987/88 to £19.4 million in 1993/94, as Table 6 in the next Chapter shows. If this reduction is taken into account, the total science and technology expenditures of the system at the end of the period were still 2% below the 1987/88 trough.

Although it is not possible to assemble data on the total numbers of researchers in the system, staff figures are available for the AFRC (and its predecessor) and provide another measure of the reduction in research activity. From 1948 to 1982, the AFRC's complement of

research officers (and higher grades) rose by over 600%, from 500 to 3085. By 1982, the science staff, including assistant research officers had reached 4032, out of a total staff of 6796. From 1982 to 1994, expenditures fell by 30%, but total and scientific staff fell by 45%, to 2190 and 3716 respectively, as Figure 3 shows. The Figure also shows that 825, or 38% of the science jobs, were on short-term contracts, rather than permanent posts, reflecting Government policy on hiring. Since the policy was to protect as many science jobs as possible, the reduction in support staff was considerably more drastic. The reduction in employment was more severe than the expenditure cuts because scientific research was becoming increasingly capital intensive, due to the growth in biotechnology and other sophisticated techniques that require expensive capital equipment.

Figure 3
Scientific and other staff of the AFRC, 1981-94



Source: AFRC Annual Reports. Up until 1984 these figures are actual numbers employed. From 1985 they are posts including vacancies.

FUNDING

The reduction in expenditures and employment would have been greater if all the funding was programme grants from traditional sources, which was largely true until the late 1960s. From 1972/73, it is possible to make reasonably accurate estimates of contract funding for projects, which includes a considerable proportion of private funding. Table 5 and Figure 4 show the AFRC's (and its predecessor's) science grant, net of its growing burden of pensions, MAFF's commissions with the AFRC, MAFF's intramural and external funding, net of fisheries

research expenditures and AFRC commissions, and the public funding going to DANI and DAFS. By 1972/73 core programme funding stood at £229 million, which with expenditures running at £240 million means that core public sources accounted for 95% of expenditures. By 1982/83, core funding had increased by a further 31%, to £300 million, but it fell to a low of £260 million in 1989/90, a reduction of 13%. Table 5 and Figure 4 show that by 1993/94 the figure was £268 million, which is up 3% from the trough, but still only 90% of the peak level of 1982/83.

Table 5
Core public funding of agricultural research and new contract funding, 1972/73-1993/94, £ million[1]

Year	AFRC Science grant minus pensions	MAFF commissions with the AFRC	AFRC Total	MAFF internal and external (not AFRC)	DAFS	DANI	Total core funding	Total expenditure	New contract funding
1972/73	142.2	0.0	142.2	35.4	42.6	9.0	229.2	240.0	10.8
1973/74	102.9	40.5	143.5	38.7	42.8	9.0	233.9	243.5	9.7
1974/75	91.1	62.5	153.6	42.7	45.9	9.0	251.2	263.2	12.0
1975/76	60.0	80.0	140.0	44.4	57.4	9.0	250.8	270.4	19.6
1976/77	66.7	81.3	147.9	59.0	48.8	9.0	264.8	281.9	17.1
1977/78	63.2	79.0	142.1	61.4	44.8	9.0	257.3	274.1	16.8
1978/79	71.1	76.9	148.0	59.1	46.2	9.0	262.4	278.1	15.7
1979/80	68.0	76.2	144.2	62.4	45.4	9.0	261.0	279.6	18.7
1980/81	71.2	78.5	149.7	68.2	47.0	9.0	273.9	295.9	22.0
1981/82	72.3	83.4	155.7	80.4	48.6	9.0	293.6	311.0	17.4
1982/83	67.4	85.1	152.5	91.9	47.6	8.6	300.5	319.9	19.3
1983/84	64.5	85.2	149.7	87.1	47.7	9.8	294.3	311.5	17.2
1984/85	57.7	73.0	130.7	101.4	55.0	10.3	297.5	309.2	11.7
1985/86	56.1	77.6	133.7	86.2	53.9	11.3	285.1	310.5	25.4
1986/87	63.1	69.8	132.9	87.4	51.0	11.9	283.2	313.8	30.6
1987/88	58.5	61.3	119.8	83.0	49.6	11.6	264.2	298.4	34.3
1988/89	59.3	60.7	120.0	81.9	50.5	11.5	263.8	299.4	35.6
1989/90	69.8	56.2	126.0	73.6	47.3	12.8	259.7	301.6	41.9
1990/91	78.7	51.8	130.5	78.3	47.3	11.3	267.3	298.7	31.4
1991/92	81.5	37.2	118.7	90.8	47.5	11.2	268.2	305.3	37.1
1992/93	88.2	36.5	124.7	91.4	46.5	8.7	271.3	320.4	49.1
1993/94	89.4	36.0	125.4	89.3	45.2	8.4	268.3	310.7	42.4

[1]In 1993 prices.

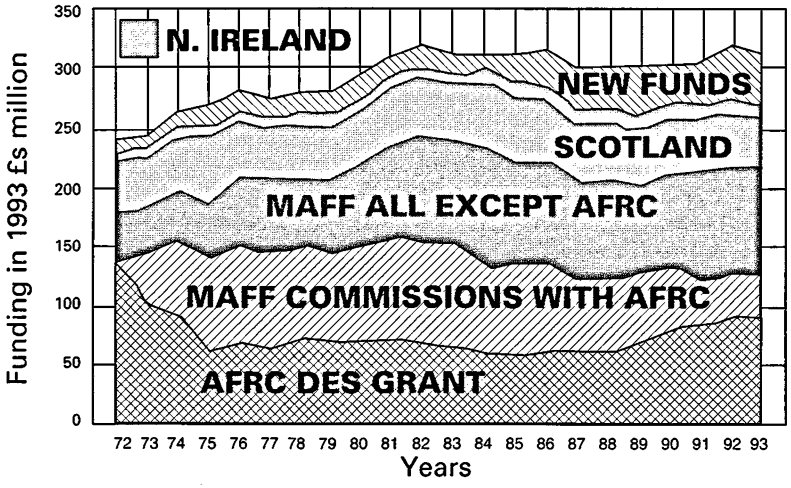
Sources: As for Table 4.

Notes: As for Table 4 except that MAFF includes DES direct grants to NERC up till 1980/81. For the early part of the series, to 1980/81, the new funding column is really new ARC funds plus the HEI's expenditures, which are almost constant. It it not really possible to record core funding, but it is almost synonymous with expenditures, except in the case of the AFRC. From 1981/82 the calculation really is AFRC, MAFF, DAFS and DANI's public funding from the Cabinet Office's *Review of Government Funded R&D* and from the OST's *Forward Look*. This part of the series covers the important changes.

The penultimate column of Table 5 shows total expenditures and the gap between these and the core funding is the new contract funding for specific projects, from public and private sources, reported in the last column of the Table and top layer of shading in Figure 4. The importance of these new sources of funds has approximately doubled

since the beginning of the 1980s, reflecting the pressure that the Government has put on all the institutions to diversify their funding sources and compete for research contracts.

Figure 4
Core public R&D funding and new contract funding, 1972/73-1993/94



Sources: As for Table 5: the same is true of variable definitions.

Figure 4 and Table 5 also show the changing fortunes of the institutions in terms of their allocation of core funding. Thus, the first column reports the AFRC's direct grant minus the cost of pensions and compensation for redundancies. These payments were insignificant in 1972/73, at £2 million in real 1993 prices, but as the AFRC was forced to contract, they grew to £23 million in 1985/86, which severely reduced the funding available for research.

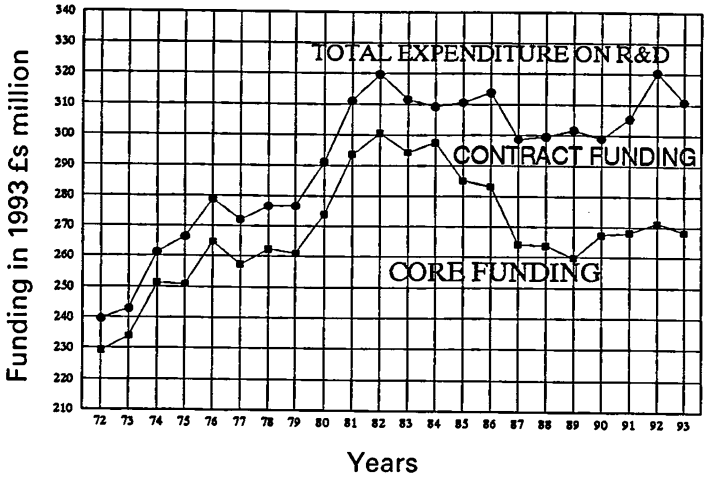
As the first year shows, the customer/contractor principle, recommended by the Rothschild report (DES, 1971), had not been implemented and the ARC controlled all its core funding. In the next year its direct grant, in round figures, fell by £40 million and it received £40 million in commissions from MAFF, the customer under the new scheme. (For the ARC's view of the changes see Chapter 5 of Henderson's personal history of the ARC, in Cooke (1981).) By 1975/76, MAFF controlled the major share of the ARC's core funding and this remained true until 1989/90, when the policy changes of the mid-1980s came into effect.

MAFF was judged to have operated the customer/contractor principle poorly, and control of core funding was to be returned to the AFRC. Thus, MAFF's commissions have continued to shrink in the 1990s and

the AFRC's direct grant has increased. However, as the third column shows, the AFRC has increased control over a total core budget that has declined by 20% from its peak in 1981/82.

MAFF's remaining income covers intramural expenditures and all external commissions except the AFRC. These expenditures peaked at over £100 million in 1984/85, when the cuts at the ARC had already begun, but by 1989/90 had been cut by 17%. However, in the early 1990s, the cessation of funding for 'near-market' research was expected to reduce MAFF's budget by a further £30 million (Read, 1989; Webster, 1989). Instead, the BSE crisis, outbreaks of salmonella and increasing concern over pollution and the rural environment led to rapid increases in public interest research, all of which fell in MAFF's domain. (Far from dying down, concern over BSE reached a new height in March 1996. For some years the Government had dismissed the link between BSE and Creutzfeldt-Jakob disease (CJD) in humans as unproven, but on March 20th, Stephen Dorrell, the Health Secretary said "The most likely explanation is that these cases (of CJD) are linked to exposure to BSE before the offal ban in 1989". The Government has reacted to the BSE crisis by announcing that a Chief Scientist will be appointed to advise on food issues.) Thus, far from falling, MAFF's expenditures rose by 21%, although at the end of the period they were still only at 89% of the peak level.

Figure 5
Core funding and total public R&D expenditures, 1972/73-1993/94



Nothing further needs to be said of the regional funding to DAFS and DANI, since their expenditure series, discussed above, are the same as their core funding, due to lack of data on income from contract research. The next Chapter will report this information for the key years of 1987/88 and 1993/94.

The difference between the figures for total public R&D expenditures, shown in Table 4 and Figure 3, and the figures for core public funding shown in Table 5 and Figure 4, gives a measure of how far the system has succeeded in broadening its financial base. Thus, Figure 5 shows that funding of public R&D by competitive contracts, with both public and private institutions, has increased from £10 million, or 4% of total expenditures, in 1972/73, to £40 million, or 15% of total expenditures, by 1993/94.

5 Recent changes in agricultural and food R&D including the private sector

INTRODUCTION

Since the late 1980s, public expenditures and funding for agricultural R&D and employment levels for scientific researchers within the AFRC institutes have all stabilized. As was discussed in Chapter 3, two countervailing policy forces were at work over this period. On the one hand, the Conservative initiatives to devolve 'near-market' research activities and technology transfer to the private sector tended to reduce funding levels. On the other hand, a renewed emphasis on the importance of scientific and technological research led the Government to maintain funding for basic research. The recovery in research expenditures has been caused by the rapid growth in public interest research and the increase in contract funding.

Chapter 3 provided a detailed account of general science and agricultural research policy in the UK and in Chapter 4, using relatively complete measures of aggregate agricultural research expenditures and funding, we examined the changes since 1972/73. Both analyses showed unambiguously that major 'structural' changes took place in the public agricultural research system in the 1980s and 1990s, but the lack of data prevented discussion of changes in private sector R&D.

This Chapter provides a more complete analysis of the recent past by comparing Figure 1 with a similar flow of funds diagram for 1987/88 from Thirtle *et al* (1991), which was updated with new information and converted to real 1993 prices. Throughout the discussion, to be consistent with the information presented in Figure 1, the current names of the institutions are used.

RECENT CHANGES IN PUBLIC SECTOR EXPENDITURES AND FUNDING

Table 6 compares the expenditures of the public sector research agencies in 1987/88 and 1993/94. In real terms, the first total shows that expenditures on agricultural and food research increased by 5% from £296 million to £311 million. (It should be pointed out that the data presented in Figure 2 and Table 4 are slightly different because the time series omits some items in the interests of consistency. For instance, privately funded research in the Scottish system is missing

Table 6

Expenditures of the public agricultural research system[1]

Organization	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
BBSRC[2]	133.0	44.99	113.0	36.39	84.96
MAFF[3]	58.5	19.79	75.1	24.19	128.38
Kew Gardens	7.6	2.57	9.4	3.03	123.68
SABRIs	39.5	13.36	34.0	10.95	86.08
SAC	11.6	3.92	13.3	4.28	114.66
SOAFD	2.8	0.95	5.0	1.61	178.57
DANI	11.8	3.99	8.4	2.71	71.19
Universities	16.3	5.51	45.8 (54.8)[4]	14.75	280.98
Other[5]	14.5	4.91	6.5	2.09	44.83
Total R&D	*295.6*	*100.00*	*310.5 (319.5)*	*100.00*	*105.04*
MAFF Technology Transfer	*37.7*		*19.4*		*51.46*
Total Science and Technology	*333.3*		*329.9 (338.9)*		*98.98*
Of which Basic Science	*208.0*		*215.50 (224.5)*		*103.61*
Of which Applied R&D	*87.6*		*95.0*		*108.45*

[1] In 1993 prices.
[2] The BBSRC was called the AFRC in 1987/88.
[3] Intramural expenditures, minus fisheries research, minus Kew Gardens.
[4] Including funding from HEFCs: no equivalent figure is available for 1987/88.
[5] For these items see Figure 1.

Sources: AFRC (1989 & 1995); Cabinet Office (1990); OST (1995a).

and so is MAFF's technology transfer budget. Conversely, MAFF's expenditures with the food research associations (RAs) were included as public research, whereas here the full expenditures of the food RAs are included under private research.) However, MAFF's technology transfer budget was a victim of the cuts in near-market research, and was practically halved, so that total science and technology (S&T) expenditures fell by 1%. If the R&D carried out by MAFF and DAFS and DANI is taken to be of an applied nature and all the rest is considered to be basic research, the increase in basic science is 3.6%, or £7 million. Since in 1987/88, 32% of the AFRC's expenditures were classified as 'improvement of technology', whereas in 1993/94, 98% were listed in the most basic category (AFRC, 1984; OST, 1995a), this would imply a substantial increase in basic research, but for the categories changing between the two periods, as was noted in the last Chapter.

The first row of Table 6 shows that BBSRC expenditures have fallen by £20 million, but this is due to the BBSRC increasing its spending with the universities from £12.5 million to £35.5 million, to bring it into line with the other research councils. Thus, with MAFF also increasing its contract research, from £6 million to £10.3 million, universities' expenditures increased by 280%, although from a low base. The figure in brackets is total university R&D expenditures, but it is not used in the comparisons because it includes the HEFC research income awarded to the universities under the category 'agriculture and food' and no figure was available for 1987/88. The rapid growth of university research (including the SAC) is enough to offset the fall in expenditures of the SABRIs and the components of the 'other' category, so that total basic science expenditures increased by £7 million.

The increase that has offset the cuts in near market activities and has pushed the 'applied' research total up by 8% is for public interest research, particularly on the environment and food safety. Research of this nature falls under MAFF's remit and is the cause of MAFF's increase in expenditures of £17 million, show in the second row of Table 6. In real 1993 terms, food safety research accounted for only £5 million in 1983/84, but by 1993/94 food safety research was costing about £20 million and with research on BSE, almost £30 million. By 1993/94, over 60% of MAFF's public funds were spent on research to protect the public (£55 million), to protect farm animals (£4 million) and to enhance the rural environment (£20 million), leaving only £49 million for research to improve economic performance (MAFF, 1994). The other departmental research expenditures are for DANI, which fell by £3.2 million and SOAFD, which showed an increase of £2.2 million due to its 'next step' agencies' deficit.

Decomposing the funding, disbursements and expenditures of the BBSRC shows what lies behind the fall in intramural expenditures in the first line of Table 6. Thus, Table 7 shows that the increase in the

direct grant to the BBSRC was practically offset by the reduction in MAFF commissions, but with a slight increase in contract funding, total funds rose by almost 5%. However, the increase in contracts to the HEI's, which was a response to Government policy and the increase in pensions practically doubled disbursements, leaving a 15% reduction in intramural expenditures by the BBSRC institutes.

Table 7
Funding, disbursements and expenditures of the BBSRC[1]

	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
Funding					
OST Science Grant	76.9	47.17	109.4	64.05	142.26
MAFF Commissions	61.9	37.98	36.0	21.08	58.16
Other Council Funds	9.5	5.83	10.8	6.32	113.68
Other Institute Funds	14.7	9.02	14.6	8.55	99.32
Total Funding	163.0	100.00	170.8	100.00	104.79
Disbursements					
To HEIs	12.0	40.27	35.5	61.42	295.83
Pensions	17.8	59.73	20.0	34.60	112.36
Other Councils and Departments	0.0	0.00	2.3	3.98	NA
Total Disbursements	29.8	100.00	57.8	100.00	193.96
Intramural R&D Expenditures	133.2		113.0		84.83

[1] In 1993 prices.

Sources: AFRC (1989 & 1995).

Table 8 presents a similar decomposition for MAFF. Between 1987/88 and 1993/94 the decrease in core funding and the technology transfer budget was only partly offset by the increase in receipts, so funding fell by 15%. However, substantial changes took place in the way in which MAFF allocated its disbursements. Commissions with the BBSRC fell by 42% (from £61.9 million to £36 million). Conversely, support for the HEIs increased by 240% from £4.3 million to £10.3 million. These changes reflected policy decisions on the way in which the agricultural research institutes and the universities were to be funded. Basic research was to be supported through OST grants to the BBSRC (that is, the basic research agenda would be managed by scientists) and MAFF was encouraged to increase commissions with the universities and contracts with other research councils and Government departments. Contracts with private industry, public corporations and other agencies fell largely because 1987/88 was an abnormal year (see Table 4), and support for Kew Gardens (treated as

intramural in Table 4) was increased. The overall outcome was a 28% reduction in disbursements, which offset the reduction in funding to the extent that science and technology expenditures fell by only 2%. Indeed, if the technology transfer budget is ignored, R&D expenditures actually rose by 28%.

Table 8
Funding, disbursements and expenditures of MAFF[1]

	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
Funding					
From the Exchequer	145.7	75.18	125.3	76.12	86.00
MAFF Receipts	10.4	5.37	19.9	12.09	191.35
Technology Transfer Budget	37.7	19.45	19.4	11.79	51.46
Total Funding	193.8	100.00	164.6	100.00	84.93
Disbursements					
To BBSRC	61.9	63.42	36.0	51.36	58.16
To HEIs	4.3	4.41	10.3	14.69	239.53
Kew Gardens	7.6	7.79	9.4	13.41	123.68
Other Councils and Departments	6.7	6.86	7.0	9.99	104.48
Private Industry, Public Corporations and Other	17.1	17.52	7.4	10.56	43.27
Total Disbursements	97.6	100.00	70.1	100.00	71.82
MAFF & Agencies S&T Expenditures	96.2		94.5		98.23
MAFF & Agencies R&D Expenditures	58.5		75.1		128.38

[1] In 1993 prices.
Sources: Cabinet Office (1990); OST (1995a).

This redirection of resources towards the universities and away from the agricultural research institutes represents the outcome of three policy initiatives introduced by the Conservative Government in the 1990s to open the BBSRC funds to competition. The first initiative is the drive towards an increased allocation of public funds for basic research; the second is a movement away from public support for research into traditional agricultural production issues; the third is an attempt to increase competition among public agencies for public research funds. Another reason for this reallocation may be that the nature of scientific research relevant to improving agricultural production has also changed over the past 10 years as genetic and other laboratory-based microbiological research activities have become more important.

For the Scottish and Irish systems, there are no time series data on expenditures, so they were treated as being synonymous with core funding. Similar trends are exhibited in SOAFD's allocation of research funds to those observed for MAFF. Table 8 shows that the SABRIs experienced a large decline in public funding and despite having doubled the amount of contact funding, shown in the penultimate row (almost all of the new funding is for the SABRIs), their expenditures fell by some 13% from about £39 million to about £34 million. The in-house expenditures of SOAFD are up over £2 million because its newly-formed executive agency (the Scottish Agricultural Science Agency) was running well over budget. The SAC has been reorganised and has increased core funding and expenditures. The last line of Table 9 shows that funding for DANI was also reduced by over 20% although a detailed breakdown of changes in the distribution of that budget is not available.

Table 9
Funding, and expenditures of the SOAFD and DANI[1]

	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
Expenditures					
Scottish Agricultural and Biological Research Institutes	39.5	73.28	34.0	65.01	86.08
In-house Research and Royal Botanical Gardens	2.8	5.19	5.0	9.56	178.57
SAC	11.6	21.52	13.3	25.43	114.66
Total Expenditures	53.9	100.00	52.3	100.00	97.03
Core Funding from SOAFD	50.4		45.2		89.68
Funds from new contracts	3.5		7.1		202.86
DANI: In-house and Queen's University	11.8		8.4		87.29

[1] In 1993 prices.
Sources: Cabinet Office (1990); OST (1995a); Annual Reports of the Insitutes and SAC.

RECENT CHANGES IN PRIVATE SECTOR EXPENDITURES AND FUNDING

Lack of time series data has prevented analysis of the considerable expenditures of the private sector in the last Chapter. Here, it is possible to compare 1987/88 and 1993/94 in some detail. The private

sector expenditures, reported in Figure 1, are estimates made by those within the industries and whilst an improvement on previous efforts, they are still subject to greater errors than the public materials, because of the paucity of published data on firm-level R&D in the UK. The data for 1987/88, from Thirtle *et al* (1991), have been corrected with similar estimates and in the light of comments, to allow the construction of Table 10. The first section shows the expenditures of the input industries. The vast majority of private sector agricultural research (£284 million in 1993/94) is conducted in the laboratories of the firms that constitute the agricultural input industries, although at least £6 million was spent with the BBSRIs. The information on private sector expenditures in earlier periods is limited to occasional estimates. For 1975/76 MAFF (1976) suggested that, apart from work on product development, private industry spent £15 million on "agricultural R&D of importance to national progress". This is worth £63 million in real 1993 prices, as compared with public expenditures of £237 million. Of course, this figure is not comparable to the figures reported here, which include all R&D expenditures.

Table 10 shows the breakdown for animal health research, the agrochemicals industry, farm equipment and machinery, seed producers, feed producers and pig and poultry breeding, for the two periods. The first line shows that the R&D expenditures of the agrochemical (fertilizer, herbicide and pesticide) companies have increased by £10 million, to £150 million. (The figure for 1987 reported in Thirtle *et al* (1991) was based on the finding that there were 2 300 R&D staff employed by the agrochemical companies. Here, we use a considerably higher estimate from industry sources.) However, this figure overstates investment in R&D for the UK, in the sense that by far the largest agrochemical company is ICI, a multinational corporation that bases much of its agricultural and food research operations in the UK, but which has worldwide markets. The second largest item is the R&D outlays for farm machinery and equipment producers, which were estimated at £60 million. This represents a decline of 13%, which the industry attributes to poor sales, due to the depressed state of UK agriculture over the last few years. The 1987/88 estimate assumed that producers of farm machinery and equipment spend 4% of the value of sales revenues (estimated at £1.5 billion) on R&D. Rothwell (1978) estimated that equipment producers allocate 1-3% of sales revenues for R&D and tractor manufacturers spend 5-10% of revenues on R&D. However, economic conditions have not been good for some time and the current estimate is that the figure for UK companies is less than 5%. The other large item is for the animal pharmaceuticals industry, which by 1993/94 was spending approximately 21% of total sales on R&D (OST, 1995b) and on this basis, if veterinary pharmaceutical companies spend a similar proportion of revenue on R&D, their

expenditures would be at least £40 million. This is an increase of 33% on the earlier period, when the research intensity was 13% (OST, 1995b).

Feed, seed and animal breeding complete the list. Thirtle *et al* (1991) provided evidence that feed producers operate some in-house research facilities. The annual cost of these activities is relatively small and was assumed to be about £7 million in 1987/88. By 1993/94 this had fallen to an estimate of £4 million, based on the R&D expenditures of major firms and their market shares, again probably due to low profitability in the UK agricultural sector. Thirtle *et al* (1991) estimated R&D investment by the seed sector on the assumption that seed companies allocated about 15% of sales revenues to research (Cooke, 1981). With more information from the industry, the 1988 figure was about £30 million which has fallen to less than £20 million because of low profitability.

Cereals, pulses and potatoes account for £18.6 million (according to the British Society of Plant Breeders) and seed sales of open pollinating crops such as wheat and barley offer a poor return, partly because they can be reproduced by farmers. The allocation of funding to research related to vegetable production is barely £0.5 million and only two companies are engaged in this activity. The majority of vegetable seed is imported from the Netherlands, the USA, Japan and Denmark. (It is probably not coincidental that horticulture was the first area to be severely cut by the public research system in the 1980s.) To put these figures in perspective, the top twelve multinational seed companies are spending about £250 million a year, mostly on hybrid maize, sugar beet, sunflowers, oilseed rape, sorghum and cotton.

Finally, pig and poultry breeding companies continue to be involved in research, but have reduced their expenditure in this area from 1987/88, due to the depressed state of these branches of agriculture. Expenditures are now estimated to be about £10 million, a reduction in real terms of one third. (One appropriate aim of Government technology policy, stressed by Nelson (1982), is to institute policies that ensure that R&D is not the first casualty of poor business conditions.) Thus, total expenditures have fallen by about £16 million, or 5%, and the very small in-house expenditures of the statutory bodies is not significant yet. Thus, in an era when Government policy required the private sector part of the partnership to take greater responsibility, expenditures have fallen due to poor economic conditions. To the extent that the private sector is now considered to be largely responsible for productivity enhancing R&D this is most unfortunate and suggests that the Government needs to consider policies to encourage private R&D investment. This has always been an issue and the possibilities were discussed as the reforms progressed (ABRC, 1986).

The lower part of Table 10 covers the food industry and suggests that food industry laboratories spent as much as £250 million in 1993/4. The BBSRC (1995) recently asserted that "about 0.5% of sales revenue is spent on R&D, amounting to some £250-300 million per annum (based on Food and Drink Federation Data) ..... by UK food companies". The lower bound is reported in Figure 1 and Table 10 as a 'best guess' about current food industry research efforts. The real number, however, is probably much smaller, in that the food industry particularly raises the problem of defining research. Whereas the seed and animal pharmaceutical companies do significant amounts of research, some of a quite basic nature, at the other end of the spectrum, food companies can define the development of new recipes as research. Thus, the huge increase in food research, of 78%, relative to the earlier estimate by MAFF (1990), should be treated with care.

Table 10
Expenditures of the private agricultural research system[1]

	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
Input Industries Expenditures					
Agrochemicals	140.0	46.51	150.0	52.45	107.14
Animal Breeding	15.0	4.98	10.0	3.50	66.67
Animal Feedstuffs	7.0	2.33	4.0	1.40	57.14
Animal Health Inputs	30.0	9.97	40.0	13.99	133.33
Farm Machinery & Equipment	78.0	25.91	60.0	20.98	76.92
Seed Industry	30.0	9.97	20.0	6.99	66.67
Input Industries Total	300.0	99.67	284.0	99.30	94.67
Statutory Bodies In-House	1.0	0.33	2.0	0.70	200.00
Total Agricultural Research	301.0	100.00	286.0	100.00	95.02
Food Industry Laboratories	140.0	91.74	250.0	91.91	178.57
Food Research Associations	12.6	8.26	22.0	8.09	174.60
Food Industry Total	152.6	100.00	272.0	100.0	178.24
Total Agriculture and Food	453.6		558.0		123.02

[1] In 1993 prices.
Sources: All figures are unpublished estimates, except for the expenditures of the Food Research Associations, which are from Annual Reports.

The food RAs issue annual reports that give expenditures and they have benefitted from the increased public sector interest in food safety and quality. Their expenditures were about £22 million in 1993/94, as compared with a real 1987/88 figure of £12.6 million. The Campden Food and Drink RA had a turnover of £7.1 million by 1993/94 and BIBRA had an income of £3.8 million. The Leatherhead Food RA had a

1993/94 turnover of £8.7 million and the Flour Milling and Baking RA (now merged with the Campden Food and Drink RA) had a turnover of £2.6 million. The funding sources have become more diverse as MAFF has provided less directly, but has encouraged joint EC projects, which are becoming an important source of funds (Leatherhead Food Research Agency, 1993). The Campden Food and Drink RA (1994) reported that MAFF funding was down to 12% of total turnover, from 26% three years earlier.

In addition to its own expenditures, the private sector funds a significant amount of research conducted by public institutions. The figures for new funding sources in Table 5, which included contract work for public agencies, never exceeded £50 million, but greater detail is available for these two years, collected from the annual reports of the institutions. Thus, the totals in Table 11 show private funding of the public system increasing from £40 million to £48 million, which with the expenditures of the private system adds to the figures for total private funding, shown in the last line. These indicate that private funding of R&D has risen by 23%, but even if all the transfers to the public sector were for agricultural research, the private total is still £7 million below the 1987/88 level. So, private food research has increased, but there is no evidence at all of the private sector taking responsibility for productivity enhancing and near market research to make up for the public sector cuts.

Table 11
Private funding of public agricultural research[1]

	1987/88		1993/94		1993/94 as % 1987/88
	£ million	*Share(%)*	*£ million*	*Share(%)*	*Proportion(%)*
From Statutory Bodies	15.8	39.50	20.4	42.24	129.11
Input & Food Industries to AFRS	9.6	24.00	6.0	12.42	62.50
Trusts & Foundations to AFRS	4.2	10.50	2.0	4.14	47.62
MAFF Receipts	10.4	26.00	19.9	41.20	191.35
Total Funding of Public R&D	40.0	100.00	48.30	100.00	120.75
Total Private Funding	493.6		606.30		122.83

[1] In 1993 prices.
Sources: AFRC Annual Reports (1989 & 1995); Cabinet Office (1990); OST *Forward Look* (1995a), plus various Annual Reports and unpublished estimates.

In line with Government policy of charging for services, MAFF has almost doubled its receipts, but funding from industry, trusts and

foundations is down 40% and although the statutory bodies have raised almost 30% more, the amount is not sufficient to replace the near market budget MAFF was to lose. Funding for research by the statutory bodies was discussed in Chapters 2 and 3. These organizations obtain funds to support applied research for commodity producers, but not all areas are covered yet and the funding is only growing slowly. Thus, the private part of the research partnership appears to have similar problems to the public element.

REVIEW OF THE REFORMS

The Rothschild Report of 1971 raised the issue of 'value for money' in scientific research and led to changes intended to improve responsibility and accountability (DES, 1971). The main mechanism introduced was the customer-contractor principle, but Ruttan (1982) raises the possibility that this had turned into "a cosy bilateral monopoly relationship between customer (MAFF) and supplier (ARC)" and suggests that the critics of the system felt it was time for a new review. In fact, a review of the entire science budget had begun (ABRC, 1982) which led to the substantial changes described above. The White Paper *Realising our Potential* (OST, 1993) was the first full review of science policy since Rothschild and it provides an *ex-post* rationalization of Government policy. An economic interpretation of the reforms and a brief appraisal is given below.

To ensure that R&D makes a maximum contribution to wealth creation it is necessary to ensure that the public and private research portfolios produce a suitable quantity of economically appropriate technologies in the most efficient manner possible. (The *Technology Foresight* (OST, 1995a & b) documents, which are a key policy initiative emanating from the White Paper, are sub-titled 'Progress Through Partnership' and embrace the dual themes of partnership and wealth creation.) The recent changes were driven by Government initiatives founded on the belief that competitive markets are the key to achieving both these goals, except in special cases where the market fails and public intervention is required. The sceptics have noted that neither agriculture nor food appear in the title of the new research council and with only a minor proportion of MAFF's budget available for productivity enhancing research, support for the holistic activity called agriculture must be even lower than when Spedding (1984) complained that there really was no "agricultural research" in the UK.

While the reforms make economic sense, it should also be recognized that creating a market in agricultural technology may be counter-productive because the transactions costs incurred could be greater than the productivity gains. The trade-off is between the increased incentives and accountability versus the amount of time

spent applying for grants and completing evaluations rather than actually doing research. Pushed too far, the reforms could reduce productivity rather than increase it. There is also a danger of short-termism, in that the market does not handle projects with long gestation periods well and much scientific activity is long-term. Research teams that took long periods to build have been dismantled and can never be reassembled, especially in a climate within the institutions that is not attractive to quality entrants, who can see better prospects in other areas.

The historian's version of endogenous growth theory (Crafts, 1996) suggests that France failed where Britain succeeded, in the 18th century, because the most able Frenchmen chose to be bishops, generals, lawyers and civil servants, rather than entrepreneurs and scientists. Right now, many scientific researchers would welcome the opportunity to join the rent seekers, by taking holy orders or studying for the bar. This element of the incentive system does seem to have been overlooked in the recent reforms, but has been noted by Professor John Hillman, the director of the SCRI and chair of the Technology Foresight Panel for Agriculture, Natural Resources and Environment (SCRI, 1993).

6 Conclusions

The funding, governance, and institutional structure of agricultural research in the UK have all changed substantially since WWII. To understand the reasons for these changes in research policy, they have been placed in a broader policy context, making it possible to distinguish changes in agricultural research policy that were specific to that sector from those that reflected broader trends. Some regional differences between Scotland, Northern Ireland, and England and Wales, were also noted.

In the immediate postwar period (1945-56) agricultural research was controlled by the agriculture ministry, but in 1956, a dual funding system was introduced, in which 'near-market' agricultural R&D was the responsibility of MAFF, while more basic research was the domain of the ARC. Funding for both types of research grew substantially during this period and the dual system has survived to the present, but there have been major changes in emphasis between the two lines of research and the ways in which they are managed, financed, and executed.

Two important changes took place in the 1970s. The Rothschild report of 1971 continued to uphold the principle of a dual funding system but also advocated that the customer-contractor principle be adopted. The report argued that the ARC had become too distant from its client groups in the agricultural industry and even from MAFF. MAFF was viewed as a more effective customer to represent the industry, so control of over one quarter of the ARC's funding was given to MAFF, whose own expenditures also increased because a higher priority was placed on applied, near-market research funding for MAFF research (both in-house and contracted).

The most recent major shift in research policy began in the early 1980s, with the Thatcher Government's initiatives to reduce the size of the public sector and allow market forces to play a greater role in the UK economy, including the allocation of agricultural research resources. Six major developments have been identified above. First, the Government has redefined the roles of the public and private sectors, with productivity-enhancing research, near-market research and technology transfer activities becoming the responsibility of the private sector. Public R&D is now concentrated on broadly-based basic scientific research (culminating in the restructuring of the research councils, in which the AFRC was incorporated in the BBSRC) and public interest research. Second, this led to reductions in the expenditures of the public system of 7% and cuts in core funding from taxation of 13%. Third, charges have been introduced where possible, statutory bodies created to fund commodity R&D with levies on producers and institutions have been privatized, closed and amalgamated. Fourth, to create a competitive market in research, a greater role has been given to the universities and other institutions, and competitive bidding for research projects has, to an extent, replaced automatic programme funding. Fifth, to extend market incentives to within the organizations, accountability has been increased by the formation of executive agencies, monitoring and evaluation procedures have been strengthened and increasing numbers of staff have been hired on short-term contracts. Sixth, the Government has committed itself to providing clear policy leadership and improving information flows, by means of publications, improved management structures and increased collaborative research. The establishment of the OST, under a cabinet minister, reflects the Government's commitment and the relocation of the OST, from the Cabinet Office to the DTI is an indication that the central role of science is now seen as wealth creation.

Similar developments have also taken place in agricultural science policy and funding patterns in the Netherlands and in Australia. Although important details differ, common threads include reduced growth in total public-sector funding, a shift in emphasis toward more 'public-good' uses of public funds, and an increasing use of public authority to encourage greater private-sector support for public research where the spillovers beyond agriculture are relatively small, instituting schemes such as producer levies. In the UK, after an extremely painful and messy period of adjustment, agricultural science policy has stabilized and so has public funding and expenditures on R&D, at 1987/88 levels. However, private agricultural R&D has fallen further.

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