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Trends in Financing Asian Agricultural Research

January 31, 1996

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TRENDS IN FINANCING ASIAN AGRICULTURAL RESEARCH

1. Introduction

Asian agriculture, like Asian economies more generally, grew at a healthy rate over the past several decades. AgGDP for many of the region's low-income countries increased by 3% per annum during the 1980s and over 4% per annum for countries such as China and Indonesia. This growth was a continuation of the green revolution gains that were reaped during the 1970s, albeit at a somewhat diminished pace compared with these earlier periods, coupled with a substantial shift in the pattern of production into higher-valued horticultural crops, livestock, fishery, and forestry output that grew faster than many staple cereals and root crops.

A sizeable share of the growth in Asian agriculture is due to the new technologies emanating from national agricultural research systems throughout the region and international agencies such as IRRI. But despite these past successes, new concerns are being raised about the region's ability to maintain these past gains (Byerlee and Pingali 1994), foster the future growth needed to feed and clothe the ### billion people that are expected to live in Asia by the year 2020, and to address the environmental consequences of agriculture in many land (and water) scarce Asian countries. Continued, and indeed expanded, investments in agricultural R&D are seen as crucial to meeting these pressing demands.

In this paper we assess the evolution and current status of investments in Asian agricultural R&D, highlighting in particular the differences between countries at different stages of economic development. The paper begins in section 2 with a brief review of the institutional development of agricultural research in Asia, followed by an overview of regional investments in agricultural research over the past 25 years. Various measures of national expenditures on agricultural research are presented and discussed. In the following section we briefly discuss the principles that determine the appropriate public role in agricultural R&D and reflect in particular on the changing role of industry in funding Asian agricultural research. In section 4 we describe in more detail some of the recent changes in funding agricultural research in three countries at different stages of economic development (China, Malaysia, and Australia). The experiences of these three countries highlight the diversity of developments regarding funding of agricultural R&D throughout the region. Section 5 concludes the paper.

2. Regional Review

2.1 *Institutional Development*

Botanical gardens were instrumental in the initial transfer and screening of tropical crops in Asia throughout the 19th century.[1] Building directly on these institutional precedents, formal agricultural research practices took root throughout the European (particularly British and Dutch) colonies at the turn of the century. The agricultural research structures that evolved were commodity oriented and commodity-specific cesses became a popular way of financing agricultural research. Menon (1971) maintained that this crop-specific approach, which continued well after the colonized countries in Asia gained independence, led to a considerable fragmentation of the national agricultural research effort, causing unnecessary duplication of effort and a neglect of research on food crops and environmental problems. Eventually, beginning around 1960, many Asian NARSs began to centralize and consolidate their agricultural research operations. For some countries this involved the establishment of an agricultural research council (e.g., India, Pakistan, Bangladesh) that assumed considerable managerial and financial responsibilities and often operated its own agricultural research entities. In other countries the various agricultural research activities were combined into a national agricultural research institute that undertook a comprehensive program of research, often with considerable autonomy from the ministry of agriculture to which it was ultimately responsible (e.g., MARDI in Malaysia and, to a lesser extent, AARD in Indonesia).

Since China, Japan, Korea, and Taiwan were never colonized by Europeans, their research systems have quite different beginnings. With the Meiji Restoration in 1868, Japan opened up to the rest of the world and within four years established its first agricultural experiment station. Agricultural experiment stations had only just begun to emerge in Europe. Several other stations followed and by the turn of the century Japan had a well developed research infrastructure by the standards of that time. Japan also introduced agricultural research to Korea and Taiwan, two countries it colonized during the period 1895-1945. In all three countries agricultural research was placed and remains directly under the Ministry of Agriculture. In addition, the NARSs have distinct national and provincial (or prefectural) research agencies that mirror each country's political structure.

China established its first agricultural experiment station in 1902. Despite this early beginning, China was a laggard in terms of developing a coordinated agricultural research infrastructure. Prior to 1940 only a few isolated agricultural research entities were in operation, reflecting the political instability and rather inward looking character of the country during the first half of this century. China's agricultural research developed considerably during the 1950s and 1960s, but suffered major setbacks during the Cultural Revolution (1966-76). Currently, the Chinese NARS is best described as a multi-ministry research system involving a series of parallel agencies at the national, provincial, and prefectural levels of government (Fan and Pardey 1992).

During the past decade, the institutional structure of most Asian NARSs has been relatively stable. While there have been ongoing internal re-organizations, very few countries have fundamentally restructured their research systems as was common practice throughout the 1960s and 1970s. Important exceptions to this generalization are the former Soviet states in Asia such

[1] Botanical gardens in the Asian colonies were established as early as 1768 in India, 1796 in Malaysia, 1810 in Sri Lanka, 1817 in Indonesia, 1822 in Singapore, and 1864 in Vietnam (Headrick 1988).

as Kazakhstan and Uzbekistan where the organization of agricultural research is currently in complete disarray. During the Soviet period nearly all applied agricultural research in these countries was conducted by state farms, while the more basic research was done by the academies of (agricultural) sciences. These national academies were linked to the "federal" Academy of (Agricultural) Science in Moscow. With the demise of the USSR, the national academies were no longer part of a functioning scientific network as existed during the Soviet period. In addition, the collapse of the planned economies in these countries has severely affected the operations of the state farms, including their research activities. Questions about how best to restructure the state farms (perhaps as private holdings) have yet to be resolved. Meanwhile, most research programs have ceased operations because of lack of funds and the existing research infrastructure is rapidly deteriorating.

2.2 *Expenditure Trends*

Investments in agricultural research for the 12 countries included in our sample have grown steadily for the past several decades (table 1)[2]. Total investments in public agricultural research more than doubled to over 6 billion (1985 PPP) dollars in 1990, more than two-thirds of which was spent by three countries, China, India, and Japan.[3] For low- and high-income countries alike, growth in agricultural research expenditures slowed during the 1980s compared with the 1970s. Two countries (Sri Lanka and Australia) even slipped into negative growth. In contrast, three of the four middle-income countries (South Korea, Taiwan, and Thailand) accelerated their rate of spending on agricultural research during the past decade; and, coincidently, their agricultural sectors outperformed most other Asian countries. Despite the overall slowdown in public R&D spending throughout Asia during the 1980s, for most Asian countries agricultural research expenditures grew faster than elsewhere in the developing world.

[table 1 here]

To obtain an internationally comparable measure of the amount of resources used for research, research expenditures were compiled in local currency units, then deflated to base year 1985 with a local GDP deflator, and finally converted to 1985 purchasing power parities (PPP) dollars using 1985 PPPs. PPPs are synthetic exchange rates that are designed to reflect the purchasing power of currencies. The PPP indexes used here are derived from the UN International Comparisons Program and published by Summers and Heston (1991) as the Penn World Tables (Mark 5). Using official exchange rates to convert local currencies to US dollar

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[2] These 12 countries accounted for 95 % of Asia's agricultural research expenditures in 1981-85 (including Australia, Japan, and New Zealand, but excluding the former Soviet states in Asia.) Our current sample does not cover the former Soviet states nor the Pacific islands states. Funding trends in these countries may have been quite different from those countries in our sample.

[3] These three systems are also among the world's largest NARSs. The United States spends more per annum on public sector agricultural R&D than any other country: 2.7 billion dollars per annum in 1993. In 1992, the latest year for which estimates are available, private spending on agricultural R&D in the United States totaled 3.3 billion dollars (Alston and Pardey 1996).

denominated spending aggregates gives substantial lower totals as well as lower regional rates of growth (table 1).

2.2 *Research Intensities*

Scaling a country's agricultural research expenditures by the size of its agricultural industry or by total government spending can be instructive.

2.2.1 *Research spending relative to agricultural output*

Table 2 tracks developments in agricultural research spending measured as a percentage of agricultural GDP, commonly called an agricultural research intensity (ARI) ratio. Several aspects of these ARIs are noteworthy.

[table 2]

Grouping the countries as we have in table 2 by "stage of development" stratifies them into discernably different investment classes that were not apparent when simple spending totals were used as indicators of investment (see table 1). There appears to be a fairly close association between research intensity ratios and "stage of development" or, more concretely, per-capita-income. The lower income group had ARI ratios that averaged 0.39% in 1990; some nine-fold lower than the corresponding ratios for the high-income countries. ARIs for the middle-income group fell between those for the high- and low-income countries. This result is consistent with the strong, positive relationship between ARIs and per-capita-income that Pardey, Roseboom, and Anderson (1991) found using a much larger, world-wide sample of countries. Growth in ARI ratios for the low-income countries has stalled since the late 1970s but contimued to increase markedly for middle- and high-income countries.

2.2.2 *Government spending intensities*

An alternative perspective on public agricultural research spending is given if such spending is expressed relative to total government expenditures. This is done in table 3. In contrast to the ARI ratios presented above, agricultural research expenditures relative to total government spending declined over time for most of the countries in our sample. Interestingly, government spending ratios declined most rapidly for the high-income countries and most slowly for the lower income countries; there is a negative relationship between the rate of *change* in government intensity ratios and per capita incomes. But, there is no clear relationship between per capita incomes and the intensity of government spending on agricultural R&D as was the case for the ARI ratios. This differs from earlier analysis based on a larger, world-wide sample of countries wherein government spending intensities declined when moving from low- to high-income countries (Roe and Pardey 1991).

[table 3 here]

3. Public Roles in Agricultural R&D

Governments the world over are raising questions about the public role in agricultural R&D. In this section we briefly introduce arguments in support of a continuing but, perhaps, substantially revamped role for government in (Asian) agricultural research. A key aspect of Asian agricultural R&D over the decades to come will be the emerging private-sector cum industry roles and the public policies designed to support these roles. A brief review of these aspects is included in the second part of this section.

3.1 *Rationale*[4]

Without government involvement, too little agricultural R&D would take place. Underinvestment by the private sector arises because of

- the nature of agriculture (typically there exists economies of size, scale, and scope in R&D so that individual farm businesses are too small to undertake effective R&D or farmers find it too costly to collectively fund the research)

- the nature of R&D (an inventor cannot fully prevent others from taking advantage of the invention -- i.e., the *free-rider* problem -- so the private costs and benefits from R&D do not coincide with the social costs and benefits, and the products of research are often *non-rival* in consumption so their use by one person does not diminish its value to others)[5].

These twin sources of *market failure* in agricultural R&D are endemic, but may be especially important in developing countries. Their effects on R&D may be exacerbated by other developing-country problems, such as pervasive distortions in commodity and capital markets. Uncertainty about the future in countries with unstable political regimes also discourages long-term investment in knowledge and other capital. Therefore appropriate government intervention is warranted to correct the market failure. This means promoting a more economic (usually greater) quantity and mix of agricultural R&D investments, especially in areas with relatively low private R&D incentives and relatively high expected payoffs.

This is usually interpreted to mean use of more taxpayer dollars to finance more public-sector R&D. But other government policies might also be used to improve the economic efficiency of agricultural R&D in terms of the total resources devoted to research, the allocation of those resources among research areas and research institutions, and the efficiency with which the resources are managed and utilized. Thus going beyond "more dollars" raises hard questions concerning the appropriate mix of private- and public-sector R&D activities, and the use of

[4] This section draws heavily from Pardey and Alston (1995).

[5] One of the reasons for the divergence between private and social costs and benefits from R&D is that there are unaccounted-for environmental side effects (externalities) from the implementation of particular research results.

economic principles in the management of resources in the least cost way and to allocate the resources to areas with the highest social payoff.

3.2 *Industry funding of Asian research*

There is a recent, and widespread, resurgence of interest in attracting additional industry support for (public) agricultural R&D as one way to address the underinvestment problem. But this is by no means a new form of financing research, especially in Asia. Much of the agricultural research initiated during the earlier part of this century in today's less-developed Asian countries was targeted towards commercial production of (exportable) crops. Funding for this research often came from commodity-specific taxes levied on or collected by processors, marketing organizations, or government customs agencies. It was common for these funds to be channeled through commodity boards or committees for the provision of marketing, advisory, and technology (including research) services to the respective industry groups. In addition, the processing or marketing of some commodities was controlled by state enterprises whose monopoly profits were used in part to finance commodity specific research. Such was the case for sugar research in Bangladesh, Indonesia, Sri Lanka, and Taiwan, where sugar processing is still monopolized by state-run enterprises, and for tobacco research in Taiwan and Thailand that have state marketing monopolies for tobacco. Table 4 provides an overview of commodities for which specific funding schemes were initiated.

[table 4 here]

Until 1966, the Indian NARS was predominantly financed by means of commodity-specific cesses and the Agricultural Produce Cess Fund. The AP Cess Fund was established in 1940 to provide revenue for the Indian Council for Agricultural Research (ICAR). An ad valorem tax of 0.5 percent was levied on a broad range of agricultural exports[6]. Between 1941 and 1966 this fund provided for about three-quarters of ICAR's total revenues (Rajeswari 1992). The commodity-specific research funds were administered by commodity committees or boards. Most of these boards operated their own research facilities although a few opted to fund research at state agricultural departments and universities.

However, these commodity-based financial and institutional arrangements were seen as impediments to efforts to develop a more centrally managed and nationally focused agricultural research system in India. Three successive reviews of the country's agricultural research system during the 1950s and 1960s all advised that ICAR exercise more direct management responsibilities for these commodity research activities. With the reorganization of ICAR in 1965/66, most of the commodity research institutes were placed under ICAR's management and the commodity check-off schemes were terminated. The exceptions were coffee, rubber, silk, and tea, whose commodity boards continued to administer their respective cess funds and

[6] These products were: bones, bristles, butter, cereals other than rice and wheat, drugs, fibre for brushes, fish, fruits, ghee, raw hides, manures, oilcakes, pulses, seeds, raw skins, spices, unmanufactured tobacco, vegetables, wheat, wheat flour, and raw wool.

directly manage the research these funds made possible. The AP Cess Fund was continued, but declined in importance as a source of funding for the newly established ICAR; the Fund presently accounts for less than 4% of ICAR's revenues.

Both East and West Pakistan inherited and maintained similar funding arrangements after being separated from India in 1948. However, the Pakistani-based commodity committees administering these funds lost access to the various research facilities located in India. Local research institutes were established for several commercially important crops; jute, silk, sugar, and tea in East Pakistan, and cotton and tobacco in West Pakistan. Checkoffs levied on coconut, lac[7], and oilseeds were earmarked for the Pakistan Agricultural Research Council (PARC) and together with the AP Cess Fund constituted a substantial part of PARC's total revenues. But, when PARC was reorganized in 1980 the government abolished all cess funds over the objections of Council management which recommended expanding such funding arrangements. In Bangladesh the jute cess scheme was terminated in 1973.

Industry-based funding is also an important feature of agricultural research in Indonesia. During the colonial period several large companies, which owned plantations throughout the country, operated their own research facilities, while smaller plantation owners funded joint research facilities (e.g., the Sumatra Planters Association). As a consequence of the nationalization of most Dutch-owned plantations in the 1950s, the Indonesian government now owns and operates a large number of estate enterprises (PNPs) through its Ministry of Estate Crops. The research facilities servicing these estates were continued and funded by the PNPs.

When the public-sector Agency for Agricultural Research and Development (AARD) was established in 1974, most of the estate crop research entities initially remained outside AARD. However, in 1979 a Board of Management was established to coordinate the activities of these research agencies. Over the following six years, management of the estate crops research institutes was gradually consolidated under this Board. The Board, chaired by the Director General of AARD, is affiliated with but not directly controlled by AARD. In 1986, the Board was divided into two entities -- one for sugar and one for the remaining estate crops. The latter was recently renamed the Indonesian Planters Association for Research and Development (IPARD). These institutional changes were done in such a way that industry funding has remained the most important source of revenue for estate crops research in Indonesia. In 1990, industry funds accounted for 92% of the estate crops research resources. Because estate crops research constitutes just 20% of total research spending, the industry share of the country's total research expenditures was less than 18% in 1990. The remaining 82% came from general government revenues and from grants and loans provided by donor agencies.

This brief review shows that industry-based funding arrangements, once quite common throughout colonial Asia, became much less so after independence, with few new schemes being initiated in more recent years. However, quite a number of such schemes are still in place, but

[7] Lac is a resinous substance secreted on certain Asiatic trees by insects and is the source of shellac.

for most Asian countries industry contributions currently account for less than 5% of total public agricultural research revenues. Indonesia, Malaysia, and Sri Lanka are the only countries with any substantial amount of industry funding; estimated at up to 18%, 29%, and 40% respectively.

Commodities for which industry based funding arrangements persist usually have highly concentrated production, marketing, or processing sectors. This high degree of concentration lowers the transactions costs involved in collecting industry taxes and ameliorates the free-rider problem; the fewer numbers of beneficiaries makes it less likely that an individual or group of individuals will attempt (or, indeed, be able) to benefit from the R&D without contributing to its cost. Moreover, many of these commodities are exported in small quantities relative to total world trade so world prices are invariant to any research-induced shifts in a country's output of that commodity. This means that domestic producers are likely to be the primary beneficiaries of any research-induced reductions in their cost of production (or increases in outputs and exports) so self interest dictates there is economic virtue in the industry taxing itself to fund R&D on its particular commodity.

4. Country Cases

4.1 *China*

The Chinese agricultural research system is one of the largest in the world, currently employing more than 60,000 researchers. China's investments in agricultural research grew steadily during the 1970s and 1980s (table 2). However, this growth slowed during the 1980s and failed to keep pace with the rapid expansion of agricultural production. As a result, China's agricultural research intensity ratio declined significantly after peaking at 0.54% in 1978 (table 2). In comparison with other low-income countries in Asia, China moved from investing relatively more than average during the 1970s to about average at present.

Funding support for most research institutes in China consists of both core and project funds. Core funds are mainly used for salaries and are allocated to various organizations by central and local finance departments at the various levels of government, on the recommendations of their counterpart Science and Technology Commissions. Project funds are allocated in accordance with the research program specified in the country's five-year plan.

Until the early 1980s, most of the funding for agricultural research was provided by government. Only a small share of the revenues came from other sources such as the sale of agricultural produce and services. However, with the introduction of the economic reforms in the early 1980s, government policies regarding the financing of agricultural research were radically revised. The national government strongly encouraged public research institutes to become less reliant on government funding. As a result, agricultural research institutes got increasingly involved in income-generating activities. Some of these activities draw upon the scientific expertise available in house (e.g., laboratory analyses and seed production and sales), but others bear little or no relationship to agricultural research (e.g., provision of taxi services). In an effort to stimulate income-generating operations the government also encouraged greater links between research agencies and their clients.

Since the introduction of these new funding policies, commercial activities by public research agencies have boomed. In 1987, 70% of the total funding for agricultural research still came from direct government support and 24% from own sources, principally commercial operations (table 5). By 1993, however, direct support from the government had dropped to 47% of total revenue while own income had increased to 40%. Although total research expenditures have continued to increase in real terms, the total amount of direct government support to agricultural research declined from 732 million (1985) yuan in 1987 to 695 million (1985) yuan in 1993 -- a decline of 5.3%.

[table 5]

The source of funds and their relative importance in an institution's funding base varies depending on the particular institution and the region involved. National institutes rely more on government funding than provincial and prefectural institutes. Most of the own income is used to augment the salaries of researchers and provide other fringe benefits. Only a small proportion is used to meet the operational or capital costs of R&D.

There are increasing concerns about the conflicts of interest between the research responsibilities and the income-earning activities of the research institutes. Both human and financial resources are diverted away from research in order to generate additional income and top up salaries. The anecdotal evidence suggests this is having a detrimental effect on the quality and the amount of research. In addition, the research agencies at the prefectural and provincial level that conduct applied and adaptive research have been more successful in diversifying their funding base than the national agricultural research agencies that conduct more basic research. Hence these new policies appear to be undercutting the country's basic research capacity and shifting the emphasis of its agricultural R&D in ways that could be detrimental in the longer run.

4.2 *Malaysia*

The Malaysian Agricultural Research and Development Institute (MARDI) was established in 1969 as a statutory agency under the Ministry of Agriculture and is now the country's largest agricultural R&D agency undertaking research on a broad range of crops and livestock. In addition, there are three research entities directly managed by statutory commodity boards operating under the auspices of the Ministry of Primary Industry. They are the Rubber Research Institute of Malaysia (RRIM), established in 1925 and managed by the Rubber Research and Development Board; the Palm Oil Research Institute of Malaysia (PORIM), established in 1979 and managed by the Palm Oil Research and Development Board; and the Research Department of the Malaysian Cocoa Board (MCB), established in 1989. The Ministry of Primary Industry also administers the Forest Research Institute of Malaysia (FRIM), that prior to 1985 operated as a research unit within the Department of Forestry.

A decade ago most of the funding for MARDI and FRIM was directly provided from general government revenues, while RRIM and PORIM were almost wholly funded by commodity-specific taxes (table 6). There is a cess of M$0.0385 per kg of exported rubber collected by government customs agents, 70 percent of which is earmarked for research conducted by RRIM. Industry support for PORIM research comes from a M$5.00 per ton cess on all the crude palm oil and palm kernel oil produced in Malaysia, irrespective of whether it is consumed domestically or exported. The levy is collected directly from oil millers. MCB, established in 1989, is almost wholly financed from general government revenues. Although there is a provision in MCB's act of establishment that allows for research funds to be generated by taxing the industry, it has yet to be implemented.

[table 6 here]

During the past decade, the sources of support for agricultural research in Malaysia have changed considerably. In 1987 the government created a special fund for R&D under its so-called Intensification of Research Priority Areas (IRPA) program. This program, which is operated by the Ministry of Science and Technology, is essentially a competitive funding scheme. All research institutions and universities can bid for research funds from this scheme. Five panels, covering agricultural, industrial, medical, strategic, and social science research, screen proposals for compliance with government policies and objectives, the perceived needs of end users (e.g., industry), and funding availability. A substantial amount of government support is currently channeled through the IRPA program (table 6).

Another significant change has been the dramatic contraction in the amount of cess income coming from rubber exports whose volume declined in response to increases in domestic consumption coupled with declines in domestic production. Industry funding for RRIM research dropped from M$ 59 million in 1986 to just M$ 35 million in 1992. The shortfall has been met by direct government payments and additional public funds channelled through the IRPA program (table 6).

4.3 *Australia*[8]

The Australian public-sector agricultural R&D system is particularly interesting for several related reasons. First, Australia invests relatively heavily in public-sector agricultural R&D (nominal research intensities are quite a bit higher there than in most other industrialized countries). Although Australia provides little direct assistance to its agricultural sector, it provides more support than most countries for public-sector agricultural R&D; most developed countries provide more total assistance but mainly through price supports and other direct

[8] The material summarized in this section is dealt with in much more detail by Alston et al. (1995).

interventions in commodity markets that have become quite unimportant in Australian agriculture[9].

Second, mechanisms have progressively developed -- from the 1930s to the present -- to facilitate a growing role for industry in providing funds and, perhaps to a lesser extent, in setting research directions. In the beginning, the industry R&D funding arrangements were relatively informal. These arrangements were partial, having evolved in a fragmented manner, and they lacked a coherent rationale. The past ten years have seen a dramatic redesigning of Australia's rural R&D system with the intent of formalizing and strengthening the private sector's role in R&D, both as a source of finance and as a determinant of where the R&D effort should be directed.

This evolution has culminated in the creation of a system of Research and Development Corporations (RDCs) that are funded by commodity checkoffs (or taxes) matched on a formula basis with grants provided by the federal government. The RDCs are now responsible for around 30 percent of total public-sector agricultural R&D in Australia. The RDC model is a mechanism by which the factors that lead to underinvestment -- public-good characteristics of research, the difficulty of excluding free riders, and the non-rival use of research findings -- can be ameliorated to allow industry, the principal beneficiaries, to take more responsibility for the funding and direction of research.

The rationale for introducing the new RDC arrangements in 1985 (and revisions in 1989) was

- to increase the resources available for agricultural research
- to increase industry support for agricultural research and
- to provide greater opportunities for industry to influence the direction of research.

In fact, the RDCs have not succeeded in increasing the public resources available for agricultural research. Since 1985, while nominal expenditure has continued to rise, real expenditure has remained constant and research intensities have slightly declined (table 1 and 3). But there is no evidence that the RDCs have crowded out other sources of funds for public-sector agricultural R&D: without rising contributions from the RDCs, total funding for agricultural R&D would have fallen faster in nominal and real terms.

The RDCs have been successful in increasing *industry* support for research. Expenditure by the RDCs rose from A$56 million in 1985 to over $280 million in 1994-95. R&D expenditures by business has also risen markedly. Some of this can be attributed to the RDCs but some is a response to the 150 percent tax concession for research expenditure. However, the increase in research expenditure has not been enough to maintain the share of agricultural research in the

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[9]Specifically, Alston and Pardey (1994) pointed out that using a measure of the nominal rate of producer protection, Australia ranked in the bottom six of 32 nations in terms of producer protection to agriculture. They also pointed out that Australia ranked in the top four in terms of research intensity within the same set of countries.

total research budget or relative to agricultural GDP.

In addition, there seems to have been a sizeable shift away from basic research towards applied rural research, which may not be appropriate. The greater applied nature of rural research in public institutions has come at the expense of more basic research presumably, which has a higher public good component. No doubt the RDCs are responsible for some of this shift, and the fact that RDC funding attracts additional public funding adds to the RDC influence and prompts the question whether the "tail" of RDC funding is "wagging the dog" of public-sector agricultural R&D expenditures too much. Potential conflict of interest raises issues about the governance structures for RDCs. Thus Alston et al. (1995) conclude that on balance, the rising role of RDCs has been beneficial for the Australian economy, but not without some drawbacks.

5. Conclusion

Spending on public agricultural R&D for low-income countries in Asia is now over three-fold higher than in 1970; for middle-income countries there was almost a five-fold increase over this same period. But, growth during the 1980s, while still substantial, was slower than the previous decade. And, research spending relative to the size of the industry stalled in low-income countries in Asia (and for some, like China, it even shrank) during the 1980s given the substantial growth in agricultural output that was common among such countries. Middle-income countries in Asia increased their agricultural research intensity ratios, as did the slower growing agricultural economies of the region's high-income countries.

Government spending ratios that express public agricultural R&D expenditures as a share of total government spending give an alternative perspective on support for public R&D. While agricultural R&D spending relative to overall public expenditures is now roughly equal across countries grouped by income class this has not always been so. Twenty years ago low-income countries spent considerably less on agricultural R&D relative to total government spending than high-income countries. However, these government spending ratios trended down for the middle- and high-income group of countries, but not for the low-income country group for which the ratio remained relative constant.

Taxpayers still foot most of the bill for funding agricultural R&D done by public agencies in most Asian countries. Nonetheless, a variety of alternative funding mechanism are in place and there seems to be a fairly widespread trend toward greater private participation in public agricultural R&D. Funding by industry using commodity checkoff schemes (with matching public funds in some cases), export taxes, and various fee-for-service approaches are being tried for a number of commodities in a number of countries. The degree to which industry is gaining a greater say in the way these funds are spent and the mechanisms by which they oversee the R&D varies markedly across countries and across institutions within a country. The impression is that these organizational and management issues may matter just as much as the amount of resources earmarked for research in terms of its economic effectiveness.

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Appendix A: Data sources and construction notes.

The expenditure data presented in this chapter were derived mainly from secondary sources and build upon earlier work reported by Pardey and Roseboom (1989) and Pardey, Roseboom, and Anderson (1991). Although our aim was to report expenditures on all agricultural research performed within the public domain this has not always been possible. In particular, the coverage has been less than complete on research expenditures by the university sector. We have, however, been reasonably successful in achieving consistent coverage over time. Expenditures generally include all salary, operating, and capital costs, irrespective of the source of funding. Our estimates include spending from donor-sourced funds, although no specific effort was made to estimate donor contributions in-kind (e.g., technical assistance). Agricultural research defined here includes all crop, livestock, forestry, and fisheries research.

Australia: Includes all state departments of agriculture, universities, and CSIRO. (Source: Alston et al. 1995)

Bangladesh: Includes BARC, BARI, BRRI, BINA, SRTI, SRDI, BTRI, BLRI, FRI, and BFRI. Universities are excluded. (Source: various published and unpublished BARC reports)

China: Includes all agricultural research expenditures at the national, provincial, and prefectural level by both government institutes as well as universities. (Source: Fan and Pardey 1994)

India: Includes agricultural research expenditures federal and state agencies. Expenditures by universities are included. (Source: Science and Technology Indicators, Government of India, various issues)

Indonesia: Includes research expenditures by AARD as well as the estate crop research institutes. Universities are excluded. (Source: various AARD published and unpublished documents).

Japan: Includes research expenditures by the Ministry of Agriculture, Forestry and Fisheries, prefectural institute, and universities. (Source: MOAFF and OECD)

Malaysia: Includes research expenditures by MARDI, RRIM, PORIM, and FRIM. Excluded are the Fisheries Research Institutes, the Veterinary Research Institute, and the Malaysian Cocoa Board, as well as the universities. (Source: Hashim 1992, and Kadir 1994)

Pakistan: Includes research expenditures by most national as well as provincial agricultural research entities in both the government and the university sector. (Source: ???).

South Korea: Includes research expenditures by RDA, IFG, and FRI. Excluded are expenditures by a few (relatively minor) government institutes as well as the universities. (Source: personal communication)

Sri Lanka: Includes agricultural research expenditures by almost all government research institutes. Universities are excluded. (Source: ???)

Taiwan: The coverage of the reported data series is not specified but it seems these data include government, university, as well as private-sector agricultural research expenditures. (Source: Statistical Yearbook of the Republic of China 1994)

Thailand: Includes agricultural research expenditures by both the government and the university sectors. There are several different departments under the Ministry of Agriculture and Cooperatives (MOAC) that conduct research. They all combine research with other activities and it is difficult to isolate the research component. We have estimated research expenditures of the various government departments for the more recent years using the relevant research shares from the early 1980s reported in various Government Expenditure Yearbooks.

Table 1: *Agricultural research expenditures*

Countries	Agricultural research expenditures					Annual growth[a]	
	1971-75	1976-80	1981-85	1986-90	latest year	1971-80	1981-93
	(million 1985 PPP dollars)					*(percentage)*	
Bangladesh	51.7	68.8	111.2	131.0	132.8[c]	6.8	2.7
China	576.9	842.5	1165.3	1460.0	1867.6[d]	8.4	4.8
India	404.4	657.6	874.6	1296.5	1561.8[b]	9.9	7.5
Indonesia	61.6	108.0	147.2	202.4	208.2[b]	9.5	6.2
Pakistan	74.6	111.6	165.7	201.8	198.3[c]	8.5	3.5
Sri Lanka	19.4	31.8	37.3	31.3	35.5[d]	9.6	-1.3
Low-income	*1188.5*	*1820.3*	*2501.4*	*3323.0*	*3845.3*[b]	*8.9*	*6.0*
Malaysia	42.7	91.2	124.5	151.0	170.5[c]	16.1	3.6
South Korea	44.3	53.2	73.9	91.8	127.2[d]	3.6	6.0
Taiwan	71.8	101.9	145.0	211.9	316.1[c]	7.2	7.4
Thailand	119.4	143.8	196.9	245.6	428.0[d]	3.9	8.3
Middle-income	*278.3*	*390.0*	*540.3*	*700.3*	*1039.3*[c]	*6.8*	*6.4*
Australia	239.0	271.7	299.7	290.0	302.0[d]	2.1	-0.3
Japan	974.0	1101.2	1239.9	1306.5	1409.6[d]	2.7	1.3
High-income	*1213.0*	*1372.8*	*1539.6*	*1596.5*	*1711.6*[d]	*2.6*	*1.0*
TOTAL	*2679.7*	*3583.2*	*4581.3*	*5619.8*	*6039.6*[b]	*6.0*	*4.3*
	(million 1985 US dollars)					*(percentage)*	
TOTAL	*1541.8*	*1908.5*	*2307.7*	*2659.4*	*2824.8*[b]	*4.4*	*2.9*

Note: For details about institutional coverage see appendix A.

[a] Growth rates were calculated using a least squares regression method.
[b] Latest year: 1990
[c] Latest year: 1992
[d] Latest year: 1993

Table 2: *Agricultural research intensity ratios*

Countries	Agricultural research expenditures relative to AgGDP				
	1971-75	1976-80	1981-85	1986-90	latest year
			(percentages)		
Bangladesh	0.13	0.16	0.25	0.26	0.25[b]
China	0.40	0.48	0.41	0.38	0.43[c]
India	0.21	0.33	0.38	0.48	0.52[a]
Indonesia	0.13	0.21	0.26	0.27	0.27[a]
Pakistan	0.39	0.52	0.58	0.59	0.47[b]
Sri Lanka	0.40	0.53	0.50	0.37	0.36[c]
Low-income	*0.27*	*0.37*	*0.39*	*0.40*	*0.39*[a]
Malaysia	0.51	0.85	1.04	1.08	1.06[b]
South Korea	0.27	0.26	0.36	0.39	0.56[c]
Taiwan	1.41	1.70	2.34	3.03	4.65[b]
Thailand	0.73	0.65	0.89	0.94	1.40[b]
Middle-income	*0.60*	*0.65*	*0.89*	*0.94*	*1.34*[b]
Australia	2.56	2.93	3.51	3.11	3.54[b]
Japan	1.97	2.24	2.81	3.03	3.36[b]
High-income	2.06	2.33	2.92	3.04	3.29[b]
TOTAL	*0.48*	*0.58*	*0.60*	*0.59*	*0.58*[a]

Note: For details about institutional coverage see appendix A.

[a] Latest year: 1990
[b] Latest year: 1992
[c] Latest year: 1993

Table 3: *Government research spending intensities*

Countries	Research spending as a share of government expenditures				
	1971-75	1976-80	1981-85	1986-90	latest year
			(percentages)		
Bangladesh	0.90	0.74	0.84	0.76	0.66[a]
China	0.45	0.51	0.60	0.51	0.54[c]
India	0.63	0.64	0.61	0.59	0.66[a]
Indonesia	0.28	0.27	0.27	0.31	0.29[a]
Pakistan	0.63	0.63	0.67	0.53	0.41[b]
Sri Lanka	0.45	0.44	0.39	0.28	0.29[c]
Low-income	*0.50*	*0.53*	*0.57*	*0.52*	*0.53*[a]
Malaysia	0.53	0.72	0.56	0.66	0.57[b]
South Korea	0.43	0.26	0.25	0.23	0.21[c]
Taiwan	0.91	0.71	0.67	0.62	0.53[b]
Thailand	1.25	0.94	0.82	0.86	1.10[b]
Middle-income	*0.77*	*0.62*	*0.56*	*0.55*	*0.55*[b]
Australia	0.77	0.63	0.59	0.49	0.42[a]
Japan	0.82	0.59	0.52	0.48	0.47[a]
High-income	*0.81*	*0.59*	*0.53*	*0.48*	*0.47*[a]
TOTAL	*0.63*	*0.56*	*0.55*	*0.51*	*0.51*[a]

Note: For details about institutional coverage see appendix A.

[a] Latest year: 1990
[b] Latest year: 1992
[c] Latest year: 1993

Table 4: *Commodities with specific funding arrangements for research*

Commodity	Bangladesh	India	Indonesia	Malaysia	Pakistan	Philippines	Sri Lanka	Taiwan	Thailand
Arecanut		†1966							
Cashew									
Cocoa			X	X (a)					
Coconut		†1966			†1981	X			
Coffee		X	X						
Cotton		†1966			X				
Jute	†1973	†1966							
Lac		†1966			†1981				
Oilseeds		†1966			†1981				
Palm oil			X	X					
Rubber		X	X	X			X		X
Silk	X	X							
Sugar	X	†1969	X			X	X	X	X
Tea	X	X	X				X		
Timber						X			
Tobacco		†1966	X		X	X		X	X
Agricultural produce		X			†1981				

Note: This overview is not necessarily exhaustive as it was not always possible to trace down the old cess schemes that are no longer operational. X means industry funding scheme in place and † means that such a scheme was ended.
(a) Legal provision for collecting a cess exists but has not been implemented yet.

Table 5: *Sources of income for Chinese agricultural research*

Year	Level	Share of funds from				Total
		Government	Own income	Loans	Other	
				(percentages)		
1987:	National	86.2	12.8	0.2	0.7	100
	Sub-national	66.7	26.5	4.2	2.5	100
	Total	*70.5*	*23.9*	*3.4*	2.2	*100*
1993:	National	68.1	26.2	3.4	2.3	100
	Provincial	45.2	44.1	7.3	3.4	100
	Prefectural	42.8	39.2	13.8	4.2	100
	Total	*47.1*	*40.2*	*9.1*	*3.6*	*100*

Source: Agricultural Science and Technology Statistical Materials, various issues

Table 6: *Sources of income for Malaysian agricultural research*

Year	Level	Share of funds from Government	IRPA	Cess	Other	Total
				(percentages)		
1986:	MARDI	89.2	0	0	10.8	100
	RRIM	0	0	92.3	7.7	100
	PORIM	0	0	100.0	0	100
	FRIM	97.3	0	0	2.7	100
	Total	*46.1*	*0*	*46.4*	*7.5*	*100*
1993:	MARDI	70.0	25.5	0	4.5	100
	RRIM	17.2	22.7	52.6	7.5	100
	PORIM	0	7.1	92.9	0	100
	FRIM	71.3	14.2	0	14.4	100
	Total	*44.5*	*20.7*	*29.2*	*5.7*	*100*

Source: Kadir (1994).