Chapter 5

Korea: Growth, Consolidation, and Prospects for Realignment

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Introduction

The Great King Sejong initiated an active agricultural research and development (R&D) policy in Korea about 570 years ago. Famous for many scholarly and scientific achievements, including the creation of the Korean phonetic alphabet, he founded a national scholarly institute, known as the "Hall of Worthies," encouraging the most talented scholars in the country to conduct a variety of research activities (Eckert et al. 1990). Sejong's focus was on efforts to improve the welfare of the common people, including the promotion of agriculture to secure an adequate food supply. One part of his agricultural R&D effort was to transfer relatively advanced agricultural techniques used in the southern provinces to the north, where farmers were still using Chinese techniques that were not well suited to Korean conditions. King Sejong sent out officials from Seoul to study advanced agricultural technology and prepared a manual, "Straight Talk on Farming," designed to help advisers and farmers suit their agricultural practices to the agronomic and climatic conditions on the peninsula. Based on survey data, the king reported that the average farming household in the province around Seoul could produce "several times" more using better farming methods. Recognizing the importance of climate to farmers, the crown prince invented a rain gauge, which ranks among the major technological achievements of the period. Every village in the country was required to report rainfall and the amount of rain absorbed into the soil (Eckert et al. 1990). Despite this impressive start, for many reasons, Korean agricultural R&D, Korean agricultural progress, and the Korean economy all languished for much of the next 500 years.

While the ancient history of Korean agricultural R&D is a fascinating and understudied topic, this chapter reviews agricultural R&D policy in South Korea over recent decades. Our working definition of agricultural research and development is conditioned by the available data. It includes efforts to improve farm and related technology and practices by systematic investigation and dissemination of information and products that embody new knowledge. These efforts include all branches of the social, physical, and biological sciences and engineering. We devote most of our attention to research but include information on the formal agricultural extension system as well. We focus on agriculture, including both crop and livestock commodities, but much of the available data include forestry and fisheries in the totals for R&D funding and expenditures. We discuss further limitations on available information below. Before characterizing the R&D system, we attempt to place this information in context by discussing South Korean agriculture and agricultural policy.

Unfortunately, we have been unable to include information about agricultural R&D in North Korea. North Korea does conduct some agricultural research, but no reliable public data are available to describe the system or the extent of the efforts. We know of no systematic study of North Korean agricultural R&D. (Analyses of aspects of the North Korean economy and agriculture include Kim, Lee, and Sumner 1998 and Noland, Robinson, and Scatasta 1997).Therefore we concentrate on South Korea, and in what follows we use the terms *Korea* and *South Korea* interchangeably.

Overview of South Korean Agriculture in Recent Decades

South Korea's rapid economic transformation over the past several decades has been called an economic miracle (Lucas 1993). Per capita income grew from less than US$300 in 1971 to almost US$10,000 in 2000 (in 2000 dollars). In recognition of this transformation, South Korea became a member of the OECD in 2000. By many measures, South Korea is no longer a less-developed country. However, economic growth in Korea has been mostly associated with expansion of the industrial and service sectors. Agriculture has also modernized, but the vulnerable conditions in agriculture, including lagging per capita incomes, have caused Korea to continue to claim developing-country status before the WTO in negotiations on agriculture. Nonetheless, the rapid growth in the rest of the economy has shaped South Korean agricultural policy and changes in agricultural production.

Table 5.1 Korea: Patterns in agriculture, 1970–2000

Year	1970	1975	1980	1985	1990	1995	2000
Farm population (thousand)	14,422	13,244	10,827	8,521	6,661	4,851	4,032
Farm share of population (percent)	44.7	37.5	28.4	20.9	15.5	10.8	8.5
Land per farm household (hectares)	0.9	0.9	1.0	1.1	1.2	1.3	1.4
Total cultivated area (thousand hectares)	3,264	3,144	2,765	2,592	2,409	2,197	2,098
Percentage of cultivated area							
Rice	36.9	38.7	44.6	47.7	51.6	48.1	51.1
Barley	22.4	22.6	12.0	9.2	6.6	4.0	3.2
Soybeans	9.0	8.7	6.8	6.0	6.3	4.8	4.1
Wheat	3.0	1.4	1.0	0.1	0.0	0.1	0.0
Corn	1.4	1.0	1.3	1.0	1.1	0.8	0.8
Vegetables	7.9	8.0	13.6	14.1	13.2	18.3	18.4
Fruits	1.8	2.4	3.6	4.2	5.5	7.9	8.2
Meat production (thousand metric tons)	165	225	424	590	775	1,059	1,189
Percentage of meat production							
Beef	22.4	31.1	21.9	20.0	12.3	14.6	18.0
Pork	50.3	44.0	56.4	58.6	65.5	60.3	60.1
Poultry	27.3	24.9	21.7	21.4	22.2	25.0	22.0
Imports as percentage of total consumption							
Rice	6.9	5.4	4.9	0.0	0.0	1.0	2.0
Barley	0.0	8.0	42.4	36.3	2.6	33.0	53.1
Soybeans	13.9	14.2	64.9	77.5	79.9	90.1	93.6
Wheat	84.6	94.3	95.2	99.6	99.95	99.7	99.9
Corn	81.1	91.7	94.1	95.9	98.1	98.9	99.1
Beef	0.0	0.0	6.9	3.9	47.5	48.6	47.2
Pork and poultry	0.0	0.0	1.8	0.9	0.5	5.6	11.9

Source: MAF, various years.

Production Changes and Commodity Distribution

To provide an overview of South Korean agriculture, Table 5.1 presents summary statistics for the past three decades at five-year intervals. These data provide a context for the discussion of agricultural R&D and allow us to better understand the degree to which agriculture has been transformed.

As recently as 1970, almost 45 percent of the population lived on farms (the U.S. farm population, by comparison, was then less than 4 percent of the population). Three decades later, only 8.5 percent of the population lives on farms. The farm population fell from about 14.4 million to about 4 million as the national population rose from about 32 million to almost 50 million. For the same period, agricultural gross national product (GNP) as a percentage of total GNP declined from 27 percent to about 5 percent. The lower share of GNP indicates persistent income differences between farm and urban households and also some degree of part-time farming.

The average farm area grew during these three decades, but relatively slowly (increasing only 50 percent over a period in which income doubled every six years), and remains small, at less than 1.5 hectares per farm household. Most agricultural land in South Korea is cultivated. Pasture is relatively unimportant. The cultivated area has declined dramatically with urbanization and a rapid reduction in grain production. Since 1970, the share of land used for barley, soybeans, wheat, and corn has declined from about 36 percent to about 8 percent. These declines are all the more dramatic when we consider that the total cultivated areas declined by one-third. The area under fruit and vegetable production grew from less than 10 percent of the total cultivated area to almost 27 percent.

Rice has long been the staple of the Korean diet, and annual per capita consumption is more than 100 kilograms per person. Rice is also the mainstay of South Korean agriculture, as it has been for centuries. Indeed, the rice share of cultivated area actually grew from about 37 percent in 1970 to about 50 percent by 1985 and has remained stable since then. Rice also generates about 50 percent of total crop revenue and about 30 percent of total agricultural GDP, and it is cultivated on about 80 percent of crop farms (MAF, various years).

Along with rapid growth in per capita incomes has come rapid development of the South Korean livestock industry. Table 5.1 shows a sevenfold increase in meat production over three decades, with a gradual increase in the share of pork in the mix of meat production.

Commodity Policy and Trade

Agricultural policies in Korea have been directed toward two main objectives: self-sufficiency in rice and higher rural incomes. The dominance of rice in Korean agriculture was maintained mainly through high import barriers that allowed domestic prices to exceed border prices by a factor of four or five. Relatively tight import controls and high tariffs also applied to many other commodities, such as beef, citrus, and other horticultural crops. The most important goal of domestic agricultural policy was farm income support, and the main instruments were commodity procurement programs, input subsidies, and (to a lesser extent) loan subsidies.

Rice issues have dominated not only trade policy in agriculture but also domestic agricultural policy. Rice continues to account for more than 90 percent of the total aggregate measure of support for South Korean agriculture as calculated for implementation of the Uruguay Round Agriculture Agreement (URAA) (USDA 1999). The major instrument of the internal rice support program has been government procurement of a portion of national rice production. Each year the congress sets a government purchase price and a procurement target. Historically, the government price has been about 20 percent above the market price. The right to sell to the government is allocated to individual farmers through a kind of quota system. Under this system, the quantity procured by the government accounted for about 20 percent of the total crop. The government uses the rice it buys for military and other government purposes, or sells it back into the market at prevailing market prices. This program has been evolving rapidly.

The ban on rice imports was lifted and other barriers were lowered in 1995 as Korea began to comply with the URAA. The minimum-access provisions of the URAA required Korea to gradually expand imports of rice from 1 percent of base-period domestic consumption in 1995 to 4 percent by 2004. The minimum-access quantities themselves have been too small to have any measurable impact on the domestic market, especially as imports have been administered to favor the importation of rice for processing (Choi and Sumner 2000).

South Korean import data in Table 5.1 reflect the tight import controls on rice, the gradual relaxation of barriers for meat, soybeans, and barley, and the openness to importation of the other grains. South Korea is a major importer of agricultural products despite high protection for rice and several other commodities.

Agricultural Productivity Growth

In keeping with the goal of achieving self-sufficiency in rice, one major undertaking included the introduction of the high-yielding but low-quality variety *Tongil.* First introduced in 1975 with an intense government campaign, by 1985 it occupied half the total rice area. However, *Tongil* rice disappeared rapidly in the early 1990s, as incomes and demand for quality increased and government rules were relaxed.

In response to high price incentives and R&D efforts (discussed in detail in the following sections), rice yields increased by about 50 percent in three decades. Per-hectare yields of milled rice rose from 3.3 tons in 1970 to 5.0 tons in 2000. The annual rate of total factor productivity growth for rice from 1993 through 1997 was between 7 and 8 percent (Kwon and Lee 2001). Yet, despite yield and other productivity growth, the cost of producing rice has remained high. Korean production costs are about five times higher than those in California, which produces a similar quality of japonica rice (Cooperative Extension Service, University of California, Davis 1998). Implicit land rental costs account for 42 percent of production costs in Korea, and labor accounts for another 24 percent (Kwon and Lee 2001). Relatively high wages compared with most other Asian rice-producing countries, and high labor-to-land ratios compared with the United States and Australia, contribute to high costs relative to other major rice-growing regions. Of course, the very high land prices reflect high domestic prices relative to nonland variable costs.

Partial productivity measures also show rapid growth for other commodities over the past 30 years. For example, crop yields have increased rapidly, and milk yield grew from 5.0 metric tons per head in 1970 to 7.9 metric tons per head in 2000. Overall, the total real value of agricultural output grew by 110 percent over the 30-year period because of both productivity growth and a shift across commodities, while both land and labor use declined substantially. Real output per unit of land increased by 260 percent, and real output per unit of labor increased by 450 percent between 1970 and 2000.

South Korean Agriculture in Transition

The URAA stimulated many changes in South Korean agriculture. For the first time, the Korean rice industry has faced international competition. This shift in policy has had ramifications throughout agriculture as farmers attempt to improve productivity and search for commodities that may be competitive with imports. Some adjustments have been aimed at improving productivity in rice farming. The Korean government initiated a series of efforts to improve institutional arrangements in areas such as farmland ownership, domestic rice subsidy programs, marketing and distribution arrangements, and cooperatives. In 1992, Korea also began a decade-long rural restructuring project that allocated $40 billion to farmers and rural areas. This infusion of public resources into agriculture was significant. However, the most important impetus for transition came from individuals' anticipation of market opening and adjustments to meet that challenge (Sumner, Lee, and Hallstrom 1999). We now turn to how R&D fits into this picture of Korean agriculture in rapid transition.

Institutional Arrangements for Agricultural R&D

The modern Korean agricultural R&D system is about 40 years old. There have been a number of changes over time, but the basic structure has remained in place. Agricultural research and development follows many of the familiar patterns of funding and performance seen in other countries. However, compared with most other OECD members, the South Korean institutions are relatively new, and the R&D situation, as with much else in South Korean agriculture, has been evolving rapidly.

Public funding for agricultural research now follows three channels:

1. The Office of the Prime Minister provides funding through research councils that support the basic staff and core expenditures of the government-supported research institutions.

2. Specific ministries, mainly the Ministry of Agriculture and Forestry (MAF), and administrations, mainly the Rural Development Administration (RDA), support their own intramural research institutions and provide project funds for government-supported institutes, universities, and private research institutions.

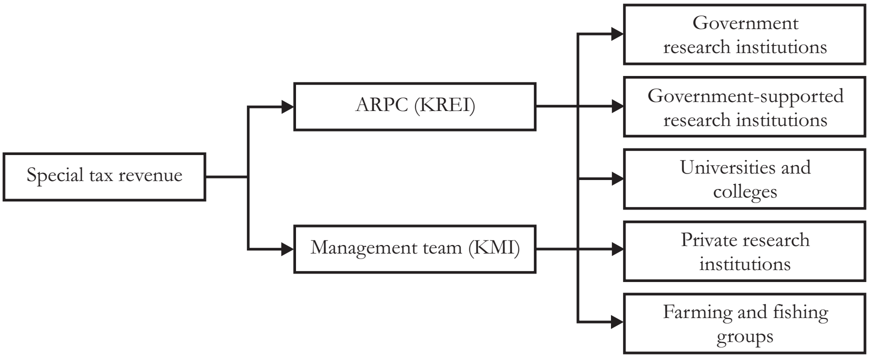
3. Science funds not tied directly to agriculture are provided to universities and public and private research institutions for more-basic research.

The RDA is the largest source of public funding for agricultural R&D. It was created in 1962 and is a separate, autonomous unit within MAF. MAF, together with the Ministry of Maritime Affairs and Fisheries, sets general directions for agricultural R&D, then MAF and RDA request funds for the research budget, and the Planning and Budget Agency modifies the request and coordinates the overall Korean government budget.

Government research institutions in agriculture, forestry, and fisheries include 46 national and public research institutions and 4 government-supported research institutions (Ministry of Science and Technology 2001). RDA, the largest R&D agency in the agricultural sector, operates 10 intramural research institutes. When the RDA was established in 1962, it had 12 intramural research institutes; this number reached 19 by the early 1990s but fell back to 12 with reform in 1994. The most significant consolidation in 1994 was the creation of the National Institute of Agricultural Science and Technology through the merger of 4 independent institutes (the Institute of Agricultural Science, the Agricultural Chemicals Research Institute, the Agricultural Genetic Engineering Institute, and the National Sericulture Entomology Research Institute).

South Korean data distinguish between units of the government that are under the direct supervision of a specific ministry, such as the intramural institutes under the RDA, and other publicly funded units that are collectively known as public nongovernmental enterprises. Before 1999, each institute had belonged to the corresponding ministry. Since then, government-supported research institutes have been placed under the Office of the Prime Minister rather than under individual ministries. This reform was designed to enhance the independence of the institutes, encourage joint research, and facilitate the sharing of information among institutes. Under the new system, each government-supported institution competes with external research institutions, such as universities or private research bodies, for project funds other than basic salaries and basic costs, which are provided by the government. The Korea Rural Economic Institute, the Korean Maritime Institute, the Food Research Institute, and the Korean Research Institute of Bioscience and Biotechnology all report to the Office of the Prime Minister.

Figure 5.1 Korea: Distribution of research funds from the special tax for agricultural and rural development



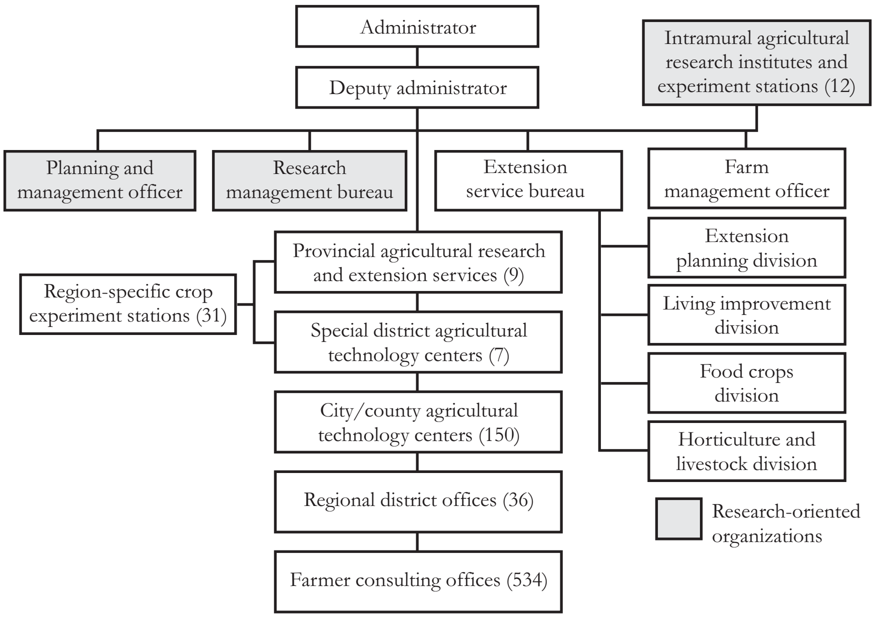
Source: Compiled by authors.

MAF provides some research funds directly to the research entities that are separate from RDA's budget. MAF's research fund is allocated competitively, and the government-supported research institutes win the largest share of these grants. Since 1994, MAF has provided additional competitive research grants drawn from the special tax for agricultural and rural development, administered by the Agricultural R&D Promotion Center (ARPC), an affiliate of the Korea Rural Economic Institute.[1] Figure 5.1 shows the flow of funds from the 1994 special tax.

The Ministry of Maritime Affairs and Fisheries now guides research policy for fisheries and maintains the Korea Maritime Institute (KMI), which also funds competitive grants. The Forestry Administration, within MAF, operates two intramural research institutes.

Rural and agricultural extension services have been provided primarily by the RDA rather than by universities or by state or local governments. The extension service was introduced in the late 1950s to promote the dissemination of agricultural production technology. RDA took over the extension role when it was established in 1962. The rate of adoption of modern agricultural practices was very low throughout the 1960s and 1970s, and extension was an important tool for increasing productivity. Because the government's focus during this period was on increasing rice self-sufficiency, the extension service concentrated on disseminating new high-yielding varieties and other high-productivity technology. The extension service still accounts for a major part of the RDA budget. Figure 5.2 illustrates the basic organization of agricultural extension in South Korea.

Figure 5.2 Korea: Rural extension organizations—Rural Development Administration, 2000



Source: Compiled by authors.

Note: Figures in parentheses indicate number of stations, centers, offices, or services.

The National Agricultural Cooperative Federation (NACF) has also exerted a significant influence on agricultural R&D. NACF operates as a major marketing cooperative, but it is also a farm input supplier, a financial institution, and an insurance company. It has been a powerful political force and has had quasi-governmental authority in implementing farm programs. NACF also operates an agricultural college and has performed extension services. However, NACF has not been as influential in extension as RDA.

The role of universities in Korean agricultural R&D resembles that of institutions in Australia and several European countries more closely than that of universities in the United States. The total number of universities conducting agricultural research is not available, but about 35 university research institutes are devoted to agriculture, forestry, or fisheries (Ministry of Science and Technology 2001). University funding for agricultural research is limited, staff teaching loads are high, and support for research must be garnered from relatively short-term grants. As is discussed below, there have been some increases recently in the competitive funds available from government sources for university research related to agriculture, but these funds remain small relative to the funding for government researchers.

Private companies are important in certain parts of the formal R&D effort, but we have relatively little information about their work; thus they are necessarily underrepresented in the discussion that follows. Overall, companies in the agriculture, forestry, and fisheries sectors operate ten formal research institutes (Ministry of Science and Technology 2001). Companies account for a significant share of the total formal outlays on agricultural R&D—about 16 percent. (For information on private agricultural R&D in other parts of Asia, see Pray and Fuglie 2001.) Individual farms and small local entrepreneurs devote much effort to innovation in agriculture. As farm size, crop mix, costs of labor, and other aspects of agriculture have changed rapidly, farmers have invested in, developed, and adopted innovations. Such innovation requires sustained investment of resources, but unfortunately such R&D on farms is difficult to measure, and we have not been able to document it thoroughly.

The Provision of Agricultural R&D Services

This section reviews evidence on budget trends and a number of other characteristics of Korean R&D providers. Because of data limitations, we focus more on government and university providers than on the private sector.

Expenditures of R&D Providers

Agricultural R&D in Korea is performed by several types of research organizations: government agencies and government-supported research institutions, public and private universities and colleges, and private companies, including cooperatives.

Table 5.2 provides shares of R&D expenditures by research provider from 1995 to 2000. Since 1995 the university and college share has grown from about 12.1 percent to almost 20.8 percent of the total, while the share of companies has fallen from 17.5 percent to 12.6 percent. Government R&D organizations and government-sponsored institutes have conducted the bulk of the research every year, ranging from 70.4 percent in 1995 to 63.7 percent in 1999 before increasing to 66.6 percent in 2000. Company data are not available prior to 1995, so it is not possible to calculate comparable shares for earlier years.

Table 5.3 contains more detail on R&D expenditures since 1978 for government and university research. Table 5.3 provides the data in Korean won; Appendix Table 5A.1 converts data to international dollars using a purchasing power parity exchange rate. The data are complete for government and government-supported research institutes for this period and provide information on university

Table 5.2 Korea: R&D expenditures on agriculture, forestry, and fisheries by type of research entity, 1995–2000 (percent)

Year	Government institutes	Universities and colleges	Companies	Total
1995	70.4	12.1	17.5	100
1998	67.4	17.3	15.3	100
1999	63.7	20.1	16.2	100
2000	66.6	20.8	12.6	100

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

expenditures from 1978 to 1988 and from 1995 to 2000. R&D expenditures, expressed in real terms using the GDP deflator, have risen substantially. The bulk of research has always been conducted at national and public research institutes, especially the RDA. The government-supported institutes, which have more autonomy from MAF, have accounted for an important part of the research expenditures. Over the period shown in Table 5.3, the share of government research done by the national and public institutes has fluctuated, but it remained around 15 percent before declining to about 11.5 percent for the last three years in our series.

University expenditures grew from about 13.5 billion won for the 1978–79 average to about 35 billion won in 1988, while R&D expenditures in government research institutes were comparatively stagnant in real terms. (We find the huge measured drop in public university expenditures from 1978 to 1979 inexplicable and therefore use an average of the two years.) Overall, the share of research expenditures by universities doubled from about 10 percent of the (noncompany) total during the 1978–79 average to about 20 percent in 1988.

The decade from 1988 to 1997 saw very rapid overall growth in university and government research, with university expenditures remaining a relatively constant proportion. Reflecting URAA initiatives, government expenditures doubled in real terms from 1991 to 1993 and continued to grow gradually thereafter. Even the financial crisis of 1998 did not curtail research substantially.

Research Orientation

It is always difficult to classify R&D projects. Classification into "applied" versus "basic" research or "development" efforts is to some degree arbitrary. Here we report the classifications used by the institutions themselves. The research expenditures by public research institutions in agriculture, forestry, and fisheries in 2000 suggest that about half of all research is applied. The remaining half is divided almost evenly between basic and development research. Government-supported agricultural research institutions spend a higher proportion of their funds on development research than do the national and public research institutions (Ministry

Table 5.3 Korea: R&D expenditures on agriculture, forestry, and fisheries by type of research entity, 1978–2000 (billion 1999 won)

	Research institutes			Universities and colleges			Companies			
Year	Total	National and public	Government-supported	Total	National and public	Private	Total	Government-invested	Private	Total
1978	107.4	99.6	7.8	21.0	18.1	2.9	NA	NA	NA	128.4
1979	150.0	129.8	20.2	6.6	4.3	2.3	NA	NA	NA	156.6
1980	114.6	95.5	19.1	12.5	10.7	1.8	NA	NA	NA	127.1
1981	93.0	74.7	18.3	7.7	7.1	0.7	NA	NA	NA	100.7
1982	112.9	95.3	17.6	18.3	14.6	3.7	NA	NA	NA	131.2
1983	93.0	86.2	6.8	15.8	11.9	3.9	NA	NA	NA	108.8
1984	107.9	87.9	20.0	23.1	17.9	5.3	NA	NA	NA	131.0
1985	106.2	88.2	18.0	21.3	17.6	3.7	NA	NA	NA	127.5
1986	118.8	99.9	18.9	36.5	29.4	7.1	NA	NA	NA	155.3
1987	133.1	113.9	19.2	32.1	23.5	8.5	NA	NA	NA	165.2
1988	136.3	115.1	21.2	35.4	30.1	5.3	NA	NA	NA	171.7
1989	142.7	121.2	21.5	NA	NA	NA	NA	NA	NA	NA
1990	166.6	130.8	35.8	NA	NA	NA	NA	NA	NA	NA
1991	166.7	132.2	34.5	NA	NA	NA	NA	NA	NA	NA
1992	202.0	168.6	33.4	NA	NA	NA	NA	NA	NA	NA
1993	327.2	290.1	37.1	NA	NA	NA	NA	NA	NA	NA
1994	293.8	252.2	41.6	NA	NA	NA	NA	NA	NA	NA
1995	335.5	296.9	38.6	57.7	35.1	22.7	83.5	8.0	75.5	476.7
1996	346.5	299.0	47.5	86.5	44.0	42.5	NA	NA	NA	433.0
1997	372.3	321.9	50.4	83.2	45.1	38.1	97.1	8.3	88.8	552.6
1998	336.3	295.4	40.9	86.5	52.5	34.0	76.1	10.5	65.6	498.9
1999	309.9	278.4	31.5	102.8	65.9	36.9	83.1	12.5	70.7	495.8
2000	330.4	287.9	42.5	103.4	65.2	38.2	62.7	NA	NA	496.5

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

Notes: Data were converted to 1999 won using a GDP deflator. NA indicates data not available.

of Science and Technology 2001). We have no information on how the Korean classification system compares in practice with those in other countries.

Consistent with national agricultural policy, research on rice has been the central focus of agricultural R&D in South Korea. As a result, a number of high-yielding cultivars have been developed. In 2000, 99.2 percent of all paddy land was planted to cultivars developed by RDA (Rural Development Administration 2000). Research on rice, however, declined as a share of total research in the 1990s. Research on nonrice crops, including fruits and vegetables, specialty crops, livestock, and flowers, has increased (J. Park et al. 2000).

The amount of research devoted to each commodity may also be observed from an analysis of research papers written by the RDA staff. In 1958, about 53 percent of these research papers were devoted to grains (37 percent to rice and another 16 percent to other grains). This percentage fell to about 33 percent in 1970 and then rose back to about 45 percent in 1980 and 1990 (Table 5.4). It declined to about 40 percent by 1995 and to 31 percent by 1998. Considering rice alone, the share of research papers increased from about 21 percent in 1970 to 30 percent in 1980 before falling back to about 17 percent in 1998. The continuing high publication share for nonrice grains is puzzling, given the unimportance of those crops in South Korean agriculture. It may be driven by three factors: the relevance of research on other grains to rice applications; a prevalence of researchers trained in an era when other grains were more important; and the fact that many researchers have studied in places such as the United States or Australia, where other grains are important, and thus their early publications relate to these other crops. There is considerable variability in some of the data on other crops, but two other trends stand out in Table 5.4. First, the share of publications on livestock research dropped substantially, from a high of almost 35 percent in 1970 to less than 20 percent in 1998. Second, the share of publications devoted to vegetable crop research increased from about 6 percent in 1970 to 15.5 percent in 1998.

Table 5.4 Korea: Percentage of RDA research papers by commodity group, 1970–98

Year	Rice	Grains	Specialty crops	Vegetables	Fruits	Livestock	Flowers	Forestry	Other
1970	21.1	11.5	1.9	5.8	12.0	34.6	3.8	0.0	9.3
1980	30.3	15.2	4.3	8.7	4.3	26.1	4.3	0.0	6.8
1990	26.0	20.0	7.3	7.3	4.0	22.7	5.3	2.0	5.4
1995	21.5	18.1	5.1	14.7	11.0	20.9	4.0	0.6	4.1
1998	17.0	13.7	8.2	15.5	9.5	19.5	8.6	0.3	7.7

Sources: Complied by authors from Rural Development Administration 1999 and S. Park et al. 2000.

Another indicator of the current orientation of R&D in Korea is the distribution of ARPC funds. About half of these funds are allocated to projects classified as "advanced technology," with a quarter allocated to overtly applied projects in the field or projects involving farmers; the final quarter goes to projects classified only as "national priority." The precise meanings of these categories are difficult to discern, but the general thrust is that at least half these funds are allocated to relatively basic research efforts as opposed to field studies (MAF 1999).

Agricultural R&D Personnel Qualifications and Orientation

The total number of researchers and other staff at government agricultural research institutions in South Korea has changed little since 1978. The total number of staff was about 4,546 in 1978 and grew to 5,108 by 2000. However, the proportions of staff in each job classification changed substantially. In 1978 there were 0.72 technicians and 0.87 support staff per researcher. By 1999 those ratios had fallen to 0.5 technicians and 0.33 support staff per researcher (Ministry of Science and Technology 2001).

Between 1978 and 2000, however, there were large shifts in the reported numbers in each classification. Some of these changes likely occurred as a part of institutional reorganizations. For example, the total reported staff increased from 5,597 in 1992 to 8,184 in 1993. This change is consistent with the increase in R&D expenditures for those years, shown in Table 5.3. However, personnel data show that the staff numbers declined to 6,399 in 1994. By 1996 the total number of staff had fallen by another 20 percent, with the number of researchers accounting for about half the decline. Another drop of about one-sixth of the total staff occurred in 1997, but on this occasion most of the staff cuts were in the technician category. Expenditures grew during this period; even allowing for real salary increases and additional budgets for supplies and equipment, it is difficult to understand how the staff reductions are consistent with the expenditure increases. Thus, reported staff numbers do not seem to reflect reductions in the actual amount of research effort.

Table 5.5 summarizes the share of researchers, including support staff, across research institutions for 2000. These data show that university and college researchers account for a significantly higher share of total research personnel than of total R&D expenditures (Table 5.3). This disparity reflects the part-time nature of academic research and a relative lack of research facilities.

In 1978 only about 5 percent of researchers held Ph.D.s and another 15 percent held master's degrees. By 1999, 38 percent of researchers held Ph.D.s, and another 49 percent held master's degrees (Ministry of Science and Technology 2001).

Table 5.5 Korea: Agricultural researchers by type of research entity, 2000

Type of research entity	Number of researchers	Percentage of total researchers
Government research institutes	5,108	53.3
Universities and colleges	3,255	34.0
Companies	1,216	12.7
Total	9,579	100.0

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

Data on numbers, broad topics, and qualifications of agricultural researchers in colleges and universities and in companies are provided in Table 5.6. Universities and colleges had 3,255 staff members who devoted some time to agricultural research in 2000. Of these, two-thirds were classified as crop agriculture and forestry researchers, and another 20 percent, approximately, as animal husbandry researchers. About two-thirds of these researchers have Ph.D.s, and almost all the rest have master's degrees. One concern with the data on university and college researchers is that we do not know the extent of their research commitment. For example, we do not know what portion of their time these individuals devote to research relative to teaching and other responsibilities. Nor do we know how their research is directed to specific topics.

Of 1,216 company researchers, about two-thirds work in crop agriculture and forestry, with another one-sixth in animal husbandry. However, only 15 percent of the company researchers have Ph.D.s, and only about half have any type of graduate degree. These differences in qualifications suggest significant differences in the nature of academic and company research.

Table 5.6 Korea: Education levels of agricultural researchers in universities and companies, 2000

Research focus	Ph.D.	M.Sc.	B. Sc.	Other	Total
Universities and colleges					
Agriculture and forestry	1,490	560	140	41	2,231
Animal husbandry	430	121	8	13	572
Fisheries and marine	273	37	5	0	315
Other	99	34	1	3	137
Total	2,292	752	154	57	3,255
Companies					
Agriculture and forestry	116	294	382	28	820
Animal husbandry	30	96	73	2	201
Fisheries and marine	6	10	18	1	35
Other	7	30	88	35	160
Total	159	430	561	35	1,216

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

As noted earlier, the extension service in Korea has been a branch of the RDA for about four decades. The number of extension personnel was relatively stable (between 6,000 and 8,000) from 1965 through 1997. The size of the extension staff doubled from 1963 to 1965 as the result of a presidential intervention. President Park, who took an active personal interest in rural issues and food security, decided that about 3,000 individuals who had been employed under contract to distribute *Tongil* rice varieties to farmers should be incorporated into the extension service. This shift more than doubled the number of extension workers in a two-year period. However, in 1997, most extension workers employed by the central government were transferred to local government appointments. The number of extension workers dropped from 6,839 in 1997 to 5,545 in 1998 and 5,032 in 1999, a 27 percent decrease in two years (Rural Development Administration 1998, 1999, and 2000; KREI 1999).

Funding of Agricultural R&D in Korea

Funding for agricultural R&D in Korea has grown dramatically in both nominal and real terms over three decades, but with some fluctuations. Research institutions evolved significantly in the 1990s as substantial new resources were added.

Agricultural R&D Intensity

We do not have a complete history of total R&D expenditures for South Korea because data on research by companies are limited. However, using the data from Table 5.3 together with agricultural GDP data, we find that agricultural R&D intensity has grown rapidly for many years. The sum of university and government R&D was 0.68 percent of agricultural GDP in 1988, growing to 1.68 percent by 1995 and to 1.82 percent in 1997. This measure of research intensity has changed little since. Government agricultural R&D has also grown rapidly. In particular, from 1992 to 1995, in response to the pressure created by URAA, government agricultural R&D rose from 0.81 percent to 1.44 percent of agricultural GDP.

Table 5.7 shows two measures of relative intensity of agricultural R&D since 1994. Total R&D expenditures have risen from about 9 trillion won in 1994 to over 14 trillion won in 2000 (in 1999 prices). After a dip during the financial crisis in 1998, total R&D expenditures jumped by 2.9 trillion won in 2000. Agricultural R&D followed a similar pattern, except that the dip in 1998 was less severe, and expenditures actually declined in 2000 even in nominal terms. Agricultural R&D remained at around 4.5 percent of total R&D (except in 1996) before falling to 3.5 percent in 2000. This percentage is far less than the share of agriculture in the South Korean economy. Agriculture, forestry, and fisheries accounted

Table 5.7 Korea: Agricultural R&D expenditure and research intensity, 1994–2000 (1999 prices)

	R&D expenditure on agriculture, forestry, and fisheries			Gross domestic product of agriculture, forestry, and fisheries			Total R&D expenditure	
Year	Billion won	Million U.S. dollars	Percentage of total R&D expenditure	Billion won	Million U.S. dollars	Percentage of total R&D expenditure	Billion won	Million U.S. dollars
1994	414.4	349	4.4	25,037.0	21,060	1.7	9,366.8	7,879
1995	476.7	401	4.6	25,865.2	21,757	1.8	10,456.0	8,795
1996	433.0	364	3.7	26,053.8	21,916	1.7	11,597.2	9,755
1997	552.6	465	4.4	25,072.4	21,090	2.2	12,595.1	10,595
1998	499.0	420	4.5	21,621.5	18,187	2.3	11,152.8	9,381
1999	512.4	431	4.3	24,481.5	20,593	2.1	11,921.8	10,028
2000	496.6	418	3.5	24,241.3	20,391	2.0	14,065.3	11,831

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

Note: Data were converted to 1999 won using a GDP deflator, and to U.S. dollars using a 1999 purchasing power parity (PPP) exchange rate ($1=1,188.82 won).

for 6.2 percent of the national earnings in 1995 and 4.6 percent in 2000. As a share of the labor force, agriculture is even more important. Agriculture accounted for 12.4 percent of the labor force in 1995 and 10.9 percent of the labor force in 2000.

One interpretation of these figures is that Korea has underinvested in agricultural research relative to other sectors of the economy. However, such a conclusion would be premature without information on the actual or prospective rates of return to investments in agricultural R&D relative to R&D in other parts of the economy. There are two reasons why agricultural R&D may offer lower rates of return than R&D in other sectors for a given level of current intensity. First, given the difficulty in appropriation of benefits from agricultural R&D oriented to farm production, there is an in-principle case for much of this research to be supported by public funds. However, government funding makes it harder to link funding to performance relative to investments by private firms for their own expected profit. Thus, even though the *potential* payoff may be higher, the *realized* payoff to agricultural R&D may be lower, and the lower research intensity follows as an appropriate consequence. These theoretical arguments notwithstanding, evidence generally supports the view that public agricultural R&D has a comparatively high payoff (Alston et al. 2000). Second, because the payoff to R&D investments is achieved only with a significant time lag, it may be more appropriate to compare R&D investments now to the projected future size of the agricultural economy. That is, investments in R&D in 2005 are likely to be applied in Korea in 2010 or later. This makes the relative research intensity measures misleading for industries in which the projected relative shares are changing rapidly.

Agricultural R&D Funding Sources and Flows

Data on company funding of R&D are not available, but Table 5.3 provides the data on company performance of R&D, and we believe that almost all of those funds spent by private research institutions were provided by private companies themselves. Also, recent data show that little company funding now flows to government institutions (Ministry of Science and Technology 2001).

The composition of funding for government agricultural research institutions had one major fluctuation in the past 30 years. From 1984 to 1996 a significant share of the cost of the research performed by these organizations was covered by private funds. Private support for research at government institutions grew from almost nothing in the early 1980s to between 10 and 20 percent for a decade before declining gradually to almost zero again by 1997 (Ministry of Science and Technology 2001).

MAF, RDA, and ARPC are now the three main agricultural funding agencies for agricultural R&D projects. In addition, the Ministry of Maritime Affairs and Fisheries and the Ministry of Finance and Economy provide funds to the R&D institutions with mandates in the corresponding areas.

MAF finances mainly policy-oriented R&D in agriculture. Previously the research funds from MAF were available solely to government-supported research institutions such as the Korea Food Research Institute (KFRI) and the Korea Rural Economic Institute (KREI), but these funds are now allocated through competitive grants among government-supported research institutions, universities and colleges, and private companies. Most of the RDA's research budget is allocated to ten intramural research institutions under RDA. However, a small share is distributed to other public and private research institutions and to universities and colleges in the form of long-term joint research projects with RDA. The Forestry Administration mainly provides research funds to its own research arms—the Forestry Research Institute and the National Arboretum. Forestry research is also conducted by the KREI. The Ministry of Maritime Affairs and Fisheries research funds are made available to the Korea Ocean Research and Development Institute and the KMI.

As noted above, the significant changes in agricultural R&D policy that took place in 1992 and 1994 were motivated by international trade issues. As it became clear that the URAA would create some additional pressure to import, the Korean government responded with substantial new agricultural R&D funding. Two new programs were initiated, with the stated goals of strengthening agricultural competitiveness and improving the quality of rural life. The Agricultural and Rural Structural Improvement Program, which ran from 1992 to 1998, devoted 33,400 billion won to R&D. Of this total, about 6 percent each was devoted to forestry and fisheries, about 35 percent was devoted to rice, and about 12 percent to livestock R&D. Only 4 percent of the funds were devoted to horticulture (MAF 2000). This allocation can be understood as a response to the real threat that potential imports might pose for domestic rice production, but it was not consistent with the ever-growing importance of horticulture in Korean agriculture. Given that Korean rice prices are about four times higher than border prices, R&D could do little to protect domestic rice production and land prices that rely on high domestic prices if the border were opened significantly. Competitiveness is different for significant parts of the Korean horticultural industry. Given the premium on freshness, the uniqueness of the Korean market, and the high cost of transportation, R&D has the potential to help some segments of the Korean horticultural industry to compete effectively with imports.

The second response to the URAA was the special tax for rural and agricultural development, which was scheduled to provide about $45 billion won for R&D until 2004. The agricultural research fund is managed by the ARPC. With the establishment of the Ministry of Maritime Affairs and Fisheries in 1997, the fisheries section of ARPC was transferred to an R&D Management Team for Fisheries under the Korea Maritime Institute. These funds are allocated to government-supported research institutions, private research institutions, and universities and colleges.

Interestingly, the ARPC was created as a unit under KREI in 1995 and is staffed and managed mainly by economists. The idea behind this institutional arrangement, under which the allocation of scientific R&D funds was explicitly the role of economics staff, was to tie the allocations of R&D funds more directly to the economic issues of importance to agriculture in Korea (KREI 1997). Furthermore, one might expect that formal economic principles and analysis would play a more significant role in the allocation of funds. However, it is not clear that such approaches are in fact used in the allocation process. The procedures used by ARPC seem to be much the same as other peer-reviewed competitive research programs.

Summary and Conclusion

The Rural Development Administration is both the largest funder and the largest provider of Korean Agricultural R&D and extension. Rice-related technological development continues to receive substantial research resources. Over the past 30 years, with strong financial and political support, the RDA bred a number of high-yielding rice cultivars that have been widely used in Korea.

More recently, in response to URAA, the government created a new funding source and a new agency, APRC, for agricultural R&D. The special tax for rural development funds was scheduled to end in 2004 but was recently extended until 2014. Many countries, including the United States, have responded to competitive pressures in agriculture with additional commodity subsidies and attempts to increase protection. Faced with WTO limits on direct subsidies and with declining border protection, Korea opted to devote substantial new resources to R&D and other productivity-enhancing public-good investments.

The additional funds available through ARPC provided universities and the private sector an expanded opportunity to participate in agricultural research. A growing problem, however, is coordination in setting research goals and priorities. This issue applies in most countries, and is probably even more troublesome in places such as the United States, where much agricultural R&D is funded by states and performed by individual universities.

As Korea grapples with the lack of international competitiveness of some important industries, it must look to rapid changes in farm size, the commodity mix on farms, demographic and human capital transformations, and innovative technologies. Obviously, these issues are not unique to Korea, but Korea may be ahead of most other countries in facing these questions in the context of an incredibly rapid transformation of the economy. By all accounts, Korean farm leaders expect the border to open, and they expect major changes.

Given the major adjustments facing Korean agriculture, the potential payoff for some new R&D investments is less clear. R&D investments must be applicable to those commodities, farm sizes, organizations, and regions that are likely to remain viable for 5 or 10 years from the time of the investments. Careful economic analysis may show that R&D investments would have a higher payoff if they ignored some of the productivity concerns of hundreds of thousands of small rice farms that might be already gone by the time research results were available for adoption. Furthermore, given terrain that makes tiny plot sizes the only possibility in much of the country, the payoff might also be higher for R&D investments that focused mainly on regions of the country that are likely to remain in commercial agriculture. It may be counterproductive to dilute the Korean R&D budget by investing in marginal areas that are unlikely to remain in agriculture and can never be made competitive in rice production. The challenge is how to maintain a political consensus to support agricultural R&D if it opts to neglect parts of the country and many of the current farms.

The objective of a more productivity-based R&D policy may be achieved by tying agricultural R&D funding measures to broader funding for aid in the transition out of farming or to shifts to other commodities. A budget for aid to rural areas and residents could be made broadly available, with self-selection into various arms of a program that included agricultural R&D, aid for rural schooling and other human capital development, and aid for rural nonfarm infrastructure. This effort could smooth the process of adjustment to more open markets for farm commodities and mitigate losses for some commodities and regions.

The transition facing Korean agriculture suggests that, more than in most countries, effective R&D investment policy must be developed in the context of economic analysis of the effects of changes in other economic policy that affect agriculture. Korean officials recognize this fact, but implementation remains a challenge.

Appendix Table 5A.1 Korea: R&D expenditures on agriculture, forestry, and fisheries by research entity, 1978–2000 (million 1999 international dollars)

	Research institutes			Universities and colleges			Companies			
Year	Total	National and public	Government-supported	Total	National and public	Private	Total	Government-invested	Private	Total
1978	90.4	83.8	6.6	17.7	15.2	2.4	NA	NA	NA	108.0
1979	126.2	109.2	17.0	5.6	3.7	1.9	NA	NA	NA	131.8
1980	96.4	80.3	16.1	10.5	9.0	1.5	NA	NA	NA	106.9
1981	78.3	62.9	15.4	6.5	5.9	0.6	NA	NA	NA	84.8
1982	94.9	80.1	14.8	15.4	12.3	3.1	NA	NA	NA	110.3
1983	78.2	72.5	5.7	13.3	10.0	3.3	NA	NA	NA	91.5
1984	90.8	74.0	16.8	19.4	15.0	4.4	NA	NA	NA	110.2
1985	89.3	74.2	15.1	17.9	14.8	3.1	NA	NA	NA	107.2
1986	99.9	84.0	15.9	30.7	24.8	5.9	NA	NA	NA	130.6
1987	119.9	95.8	16.1	27.0	19.8	7.2	NA	NA	NA	138.9
1988	114.7	96.8	17.9	29.7	25.3	4.4	NA	NA	NA	144.4
1989	120.1	102.0	18.1	NA	NA	NA	NA	NA	NA	NA
1990	140.2	110.1	30.1	NA	NA	NA	NA	NA	NA	NA
1991	140.2	111.2	29.0	NA	NA	NA	NA	NA	NA	NA
1992	169.9	141.8	28.1	NA	NA	NA	NA	NA	NA	NA
1993	275.2	244.0	31.2	NA	NA	NA	NA	NA	NA	NA
1994	247.1	212.1	35.0	NA	NA	NA	NA	NA	NA	NA
1995	282.2	249.8	32.4	48.6	29.5	19.1	70.2	6.7	63.5	401.0
1996	291.5	251.5	40.0	72.8	37.0	35.8	NA	NA	NA	364.3
1997	313.1	270.7	42.4	70.1	37.9	32.0	81.7	7.0	74.7	464.9
1998	282.9	248.5	34.4	72.8	44.2	28.6	64.0	8.8	55.2	419.7
1999	260.7	234.2	26.5	86.5	55.4	31.1	70.0	10.5	59.5	417.2
2000	278.0	242.2	35.8	87.0	54.8	32.2	52.7	NA	NA	417.7

Source: Ministry of Science and Technology and Korea Institute of S&T Evaluation and Planning 2001.

Notes: Data were converted from Korean won to U.S. dollars using a 1999 purchasing power parity (PPP) exchange rate ($1=1,188.82 won). NA indicates data not available.

Note

1. The special tax for agricultural and rural development (first introduced in 1995 for a 10-year period but now extended to 2014) is a tax earmarked for agricultural development, the enhancement of agricultural competitiveness, and the improvement of rural living conditions and rural welfare. It was implemented as a surtax or surcharge on a number of existing taxes such as income tax, corporate tax, and import tariffs. The surcharge is typically in the range of 20 percent, such that if the income tax rate, for example, is 30 percent, the special tax constitutes a further 6 percent. The total annual revenue target for the tax is around 1,500 billion won (about US$1.5 billion).

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