The Managerial Revolution and the Developmental State: The Case of U.S. Agriculture

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A Public-Sector Managerial Revolution[1]

The dominant view among Americans is that government intervention into the operation of the economy can only result in inferior economic performance. It is a view, however, that is currently being questioned by a growing awareness of the successes of the developmental state in places such as Japan, Korea, and Taiwan [see Johnson, 1982; Amsden, 1989; Wade, 1990]. Yet many American academics and policymakers who recognize the accomplishments of the developmental state abroad still retain strong doubts about the applicability of such governmental intervention to the United States. However appropriate the developmental state may be for the late-developing nations, the skeptics argue, it is not suited to a nation such as the United States, which became highly industrialized a century ago on the basis of individualism and *laissez-faire*.

Such mistrust of the possibilities for an American developmental state reflects a misunderstanding of American economic history. No-

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where is the neglect of the historical record of the role of the government more evident than in the case of U.S. agriculture. Here was a sector of the economy that in 1890 represented 43 percent of the American labor force working on over four-and-a-half million farms [U.S. Bureau of the Census, 1961, pp. 72, 278]. In the aggregate, labor productivity in agriculture was somewhat higher than labor productivity in manufacturing in the 1890s. But low prices for agricultural commodities meant that the income generated from the products (including nonmarketed output) of these farms accounted for only 17.1 percent of national income [U.S. Bureau of the Census, 1961, p. 140]. The importance of agriculture to the national economy derived not only from the large numbers of people who were supported (even if barely) by it but also from the preponderance of agricultural products among U.S. exports. In 1890, agricultural products accounted for almost 75 percent of total U.S. exports, with cotton and grain products making up close to 50 percent of the agricultural export total [U.S. Department of Agriculture, 1891]. Especially in the context of a shrinking frontier of unutilized land, the discovery of new sources of productivity growth became critical to agriculture's ability to contribute to the economic development of the nation.

Acting as an individual enterprise, the family farmer had neither the financial resources nor the scientific knowledge to develop new technologies that could dramatically improve productivity. The agricultural machinery and implements sector--which included such giants as McCormick (soon to form the core of International Harvester) and John Deere--developed labor-saving mechanical technologies that increased the amount of land that could be tilled, planted, and harvested by a given number of labor hours. But, in addition, continued productivity growth in agriculture required scientific advances that could be embodied in the land and the products of the land to increase yields per acre.

To secure productivity gains from machines and scientific advances, farmers had to learn how properly to utilize these new technologies. In the transfer of knowledge to the farm, government, through the United States Department of Agriculture [USDA] and the state experiment stations, played the central role. The transfer of relevant knowledge also flowed from the farmer to the government agencies. Improvements in seeds, fertilizers, disease control, as well

as new product development, required that the scientific community, largely based in the USDA, land-grant colleges, and state experiment stations, receive information back from farmers concerning their experiences under widely varying climatic and geological conditions.

Finally, farmers had to have the financial resources to purchase these inputs. Yet, prior to the 1930s, volatile agricultural prices -- the consequence of unregulated competition in the sale of undifferentiated commodities -- meant that farmers rarely could rely on their own financial resources to invest in new technologies. Even when loans were available, many farmers were reluctant to borrow for fear of losing their land. Indeed, some farmers who did borrow to make significant capital investments ended up in bankruptcy and had their land foreclosed [Clarke, 1992].

The development of new agricultural products and processes, the diffusion of these technologies to the farmers, and the provision of financial incentives that could induce farmers to invest in the productivity-enhancing inputs had to be undertaken by some entities other than the farmers themselves. To some extent, private-sector businesses assumed these roles, especially in the development and diffusion of farm implements and machinery. The fact is, however, that in the economic development of U.S. agriculture, governments at the federal, state, and county levels became deeply involved in developing productive resources for agriculture and ensuring their effective utilization. Over the long run, moreover, the activities of the private and public sectors became inextricably linked in the development of U.S. agriculture.

An understanding of the roles of the government in the development of U.S. agriculture makes it difficult to argue that a successful developmental state is foreign to the experience of the United States. But the case of U.S. agriculture has even more profound implications for understanding the sources of successful economic development in the United States. The contribution of federal, state, and local governments in the United States to agricultural productivity represents one of the most successful examples in modern economic history of the beneficial impact of the developmental state on a single economic sector. In our view, an accurate understanding of the role of the government in the development of U.S. agriculture substantially undermines the "myth of the market economy" [Lazonick, 1991]. The

rediscovery of the history of the role of the government in American economic development during the twentieth century should compel a rethinking of how, as the "American century" nears its close, the United States should, and can, respond to ever-intensifying global competition.

The key to rethinking the role of the government in American economic history is, we shall argue, an understanding of the "managerial revolution" that occurred in the United States in roughly the half century from the 1880s to the 1930s. Our argument is that the managerial revolution occurred not only in manufacturing, as Alfred Chandler [1977, 1990] and others have amply documented, but also in agriculture. In manufacturing, the managerial revolution occurred primarily (although not entirely) within private-sector enterprises that came to dominate their industries. In agriculture, the managerial revolution occurred primarily (although not entirely) within public-sector organizations that defined the strategies and structures of the developmental state. We shall argue that the developmental state was central to technological change and productivity growth in U.S. agriculture from the late nineteenth century, and that the managerial revolution within the public sector was the essence of the developmental state.

The Managerial Revolution and the Family Farm

To begin to comprehend the role of the developmental state in U.S. agriculture, one must understand what made the managerial revolution such a powerful engine of economic development. As Joseph Schumpeter [1942] argued, economic development requires innovation -- the generation of higher-quality products at lower-unit costs than those goods and services that had previously been available. Innovation that is economically successful requires the development of new technology and its diffusion to producers who can generate high-quality products at low unit costs. The development of new technology requires that a specialized division of labor be coordinated to generate new knowledge that can be embodied in new productive inputs. The diffusion of new technology requires that the users of these productive inputs have both the incentive to invest in the new technology and the ability -- namely, knowledge that is complementary to the utilization of machines and scientific advances -- to

generate high-quality products at low-unit costs.

The managerial revolution occurred to plan and coordinate the development and diffusion of those technologies that required large-scale investments in plant and equipment and sustained access to personnel with highly specialized complementary knowledge. In many manufacturing industries such as automobiles, consumer electronics, electrical machinery, and chemicals (among others), the technological possibilities for product differentiation and high throughput permitted individual business organizations that pursued innovative investment strategies to gain distinct competitive advantages in their industries. Those innovative enterprises that used the returns from innovation (in the form of retained earnings) to pursue a strategy of continuous innovation were often able to gain sustained competitive advantage and dominate their industries. This innovative investment strategy typically entailed not only technological innovation in products and processes but also organizational innovation in planning and coordinating complex specialized divisions of labor. Within major enterprises, these divisions of labor could include tens of thousands of highly trained individuals whose specialist activities often extended from the production of capital inputs to the sale of the final products. The managerial revolution enabled these manufacturing enterprises to develop their own technologies and diffuse them to their own production facilities around the nation and eventually around the world.

In agriculture, the technological limitations on product differentiation and throughput meant that it was very difficult for any individual business enterprise to gain a sustained competitive advantage. These limitations, along with the federal government policies of land distribution during the nineteenth century, resulted in the widespread persistence of the family farm in the twentieth century. As Table 1 shows, the number of farms in the United States reached 6.4 million in 1920.

Table 1 also shows that even as the number of farms in the United States dropped by two-thirds between 1920 and 1990, there was little growth in the number of acres in farms. Yet over this period, agricultural productivity per unit of input increased over two-and-a-half times [U.S. Bureau of the Census, 1976, pp. 498-99; U.S. Bureau of the Census, 1992, p. 657], while from 1920 to 1986 agricultural productivity per labor hour increased over fifteen times (see Table 2). How did this

Table 1
Total Farms and Acreage, United States, 1890-1990

	Number of Farms (1000s)	Land in Farms (1000 acres)
1880	4,009	536,082
1890	4,565	623,219
1900	5,740	841,202
1910	6,366	881,431
1920	6,454	958,677
1930	6,295	990,112
1940	6,102	1,065,114
1950	5,388	1,161,420
1960	3,962	1,176,946
1970	2,954	1,102,769
1980	2,440	1,039,000
1990	2,143	988,000

Sources: U.S. Bureau of the Census, 1976, p. 457; U.S. Bureau of the Census, 1991, p. 644.

Table 2
Farm Output per Labor-Hour, 1910-1986

Year	Output per labor-hour
1910	14
1920	16
1930	17
1940	21
1950	35
1960	67
1970	113
1980	191
1986	254

Sources: U.S. Department of Agriculture, 1954:458; U.S. Department of Agriculture, 1972, p. 540; U.S. Bureau of the Census, 1974, p. 614; U.S. Bureau of the Census, 1981, p. 709; U.S. Bureau of the Census 1989, p. 642.

remarkable productivity growth occur? Even when private-sector enterprises manufactured and marketed the productive inputs, the government did much of the research required to improve the productivity of the inputs and the training required to enable farmers to use these inputs more effectively. To develop and diffuse these yield-increasing technologies required the building up of extensive links between, on the one hand, state experiment stations and land-grant colleges and, on the other hand, millions of farmers.

The key actor in linking the research process with the production process was the county agent, a government employee who was an integral member of local farm communities. In 1924, ten years after the passage of the Smith-Lever Act, which established a nationwide cooperative extenstion service, there were 2,251 county agents in the United States, spread out over about three-quarters of the agricultural counties in the nation [McConnell, 1969, p. 46; see also Smith, 1926, pp. 4-5]. The cooperative extension service made the results of research at the USDA, experiment stations, and land-grant colleges and universities available and accessible to farmers. Supported by federal, state, and local funds (see Table 3), the main task of the county agents was to inform farmers about new agricultural practices [Rasmussen 1989].

Through cooperative extension services, the county agent took new methods of farming from the agricultural experiment stations and the USDA to groups of farmers in particular localities. The county agent also took back to the experiment stations information on the varying performance of new technologies under differing geological and climatic conditions as well as in combination with various other farming practices. This information then permitted the experiment stations to improve the technologies for use under different conditions.

The role of the county agents was, however, not only technological. They played central roles in organizing farmers on the local level for purposes of educating them collectively and sharing information among themselves.

The county agents were typically the key figures in organizing local farm bureaus -- organizations that when amalgamated into the American Farm Bureau Federation quickly became the most potent

advocates of the interests of commercial farmers on the national level [Kile, 1948, Pt. I; McConnell, 1969, ch. 5; Howard, 1983, ch. 10].

Table 3

Cooperative Extension Funds, by Source, 1915-1988

	Total (000 $)	Federal (%)	State (%)	County (%)	Private (%)
1915	3,597	41	29	22	8
1920	14,685	40	36	20	4
1925	19,250	36	37	20	7
1930	23,804	37	29	30	4
1935	20,042	45	25	26	4
1940	32,764	57	20	20	3
1945	37,836	50	24	23	3
1950	73,394	44	32	21	3
1955	100,617	39	36	22	3
1960	140,071	38	38	23	1
1965	188,884	38	39	21	2
1970	290,688	39	41	18	2
1975	448,334	40	41	18	2
1980	682,698	34	45	19	2
1985	996,629	33	46	18	3
1988	1,144,996	30	48	18	4

Source: Rasmussen, 1989, p. 252.

From the U.S. Secretary of Agriculture down through the state experiment stations to the army of county agents, an elaborate managerial organization evolved in the American agricultural sector between the late 1880s and the 1920s. Not by coincidence, it was during this very same period that the managerial revolution in manufacturing occurred. These decades witnessed a science-based industrial revolution in which the building of complex organizations was critical to the development and utilization of scientific knowledge. These decades also saw a transformation in the American system of higher education that developed highly educated personnel who were ready and willing to pursue careers in the complex science-based or-

ganizations. The potential for innovation and productivity growth through the application of science to industrial pursuits was enormous in agriculture as well as manufacturing. In both agriculture and manufacturing, a managerial revolution occurred.

Our purpose in the remainder of this paper is to describe the managerial revolution that occurred in U.S. agriculture from the Hatch Act of 1887 to World War II. In the conclusion, we shall indicate some of the implications of this managerial revolution for the growth of productivity in American agriculture subsequent to the legislation of the New Deal as well as for some major social problems that American society faces as we near the end of the twentieth century.

The Commitment of Finance to Agricultural Development

Economic development requires committed finance that enables those who make direct investments in productive assets to develop the productive capabilities of these assets until such time as they yield returns. Committed finance generally takes the form of retained earnings. For many farmers who did not make significant investments in farm equipment, such ongoing "financial" commitment was literally the seed corn that they planted. But in a business world of purchased inputs and sold outputs, the basic source of financial commitment for small family farms as well as giant corporations was (and remains) those revenues that are left over after workers, suppliers, landlords, owners, creditors, and governments have taken their shares. With the prospects of a steady stream of this "seed corn," the business enterprise can, if it so desires, secure additional finance through borrowing.

In the manufacturing enterprises that Chandler [1977] describes, retained earnings formed the basis for investments in not only plant and equipment but also research and development [see Brooks 1992]. In the agricultural sector, funding for research and development came from federal and state governments. In 1887, the Hatch Act allocated $15,000 per year to every state for the purposes of setting up and operating an agricultural experiment station. After the passage of the Hatch Act, the individual states took over more of the funding of the experiment stations, with the states' proportionate contributions rising steadily from 24 percent in 1896 to 36 percent in 1905 [True, 1937].

The passage of the Adams Act in 1906 bolstered the national movement to advance agricultural science within the state experiment station system. This act established a separate fund (initially $5,000 per year per state) of federal subsidies to support science-based research projects at experiment stations. The USDA and the Office of Experiment Stations [OES] also encouraged state governments to appropriate more funds to supplement federal aid to agriculture for station activities. Some states had previously made substantial contributions to stations, while others had provided no funds or had parsimonious records of funding station work. After the Adams Act, state appropriations expanded, with more states increasing their contributions to station work [True, 1937, pp. 138, 212]. In 1906, when the act was passed, nonfederal funding of experiment stations represented 41 percent of total station revenues. From 1912 until 1955, nonfederal funds amounted to anywhere from 60 to 80 percent of the total budgets of state stations [Huffman and Evenson, 1991, pp. 4-43].

The Smith-Lever Act increased the financial commitment of the federal government to agricultural research. The act authorized specific federal appropriations, with dollar-for-dollar state matching funds over an initial $10,000 per year per state, for cooperative agriculture and extension work. The act significantly enhanced the capacity of the experiment stations to diffuse knowledge to farmers.

The passage of the Purnell Act in 1925 further rewarded the USDA's efforts to increase federal appropriations for scientific research. The act authorized additional funds -- $20,000 per station in 1926, $60,000 by 1930 -- for research purposes (including some economic and sociological studies).

The Bankhead-Jones Act of 1936, similar to the Adams Act and Purnell Act, provided for project oversight by the OES [ESR 78, February 1938, p. 146]. The act also stipulated that states had to provide matching funds, similar to the Smith-Lever Act. The USDA only distributed 60 percent of the appropriation. It allocated the rest to regional laboratories that were often located near land-grant colleges and stations. The Bankhead-Jones Act was amended in 1946 with the passage of the Agricultural Research and Marketing Act which increased funding for basic research as well as marketing and distribution of agricultural products.

Not all land-grant colleges benefited equally from the public funding of agricultural experimentation. The "colleges of 1890" -- the separate black colleges set up under the Morrill Land-Grant College Act of 1890 -- got virtually none of the research funds. For example, in 1971, the "colleges of 1890" received just one-tenth of one percent of all the funds distributed to the land-grant colleges by the Cooperative State Research Service [Hightower, 1978, p. 12].

As the potential user of the new technologies, the family farm also needed finance to enable it to invest in new technologies. Volatile prices and mortgages of short duration, however, made it difficult, and often imprudent, for the farmer to invest in the new technologies. Clarke [1992] shows convincingly that New Deal legislation that remained in force after the 1930s vastly improved the prospects for financing high fixed-cost farm investments without setting the stage for high levels of farm foreclosures because of insufficient returns to these investments.

The pre-Depression cumulation of organizational capabilities that were the essence of the managerial revolution in agriculture were critical for securing the passage and implementation of the New Deal legislation. Central to these organizational capabilities were the United States Department of Agriculture and its Office of Experiment Stations, the land-grant colleges, the state experiment stations, and the cooperative extension service.

The Development of Agricultural Science

The Morrill Land-Grant College Act of 1862, which created a nationwide system of publicly funded state colleges for agriculture and mechanical arts, was not meant to provide critical institutional foundations for the managerial revolution. Rather, when it was passed, the act was aimed at upgrading the social standing of the farmer and artisan by providing these "industrial classes" with institutions of higher education that were on a par with existing elite universities like Harvard and Yale. Unfortunately for this Jeffersonian vision, farmers and artisans found little use for the land-grant colleges during the first quarter century of their existence, in part because of the underdevelopment of the secondary education system that was supposed to supply the colleges with students, and in part because of the irrelevance of a

four-year college degree for Americans who intended to earn their livelihoods as farmers and artisans [Lazonick, 1977]. It was only in the 1880s, with agricultural exports accounting for some three-quarters of all U.S. exports and with the limits to the American frontier rapidly being reached, that the federal government sought to make the land-grant colleges centers of agricultural research.

As already indicated, the critical legislation was the Hatch Act of 1887, for it marked the beginning of governmental actions to contribute to agricultural productivity. The USDA supported the establishment of an experiment station system to aid farmers nationwide, develop links with agricultural scientists across states, and raise funding for agricultural research. Each state in the Union, as a recipient of Hatch Act funds, had at least one central experiment station. In 1888 the Secretary of Agriculture established the Office of Experiment Stations as the administrative division of the USDA responsible for coordinating and monitoring the use and allocation of funds under the Hatch Act (see Figure 1).

Advocates of an experiment station system noted the advances that German agriculture had achieved because of sustained government support for agricultural research. Americans admired three characteristics of the German system: highly trained teachers and scientists, a commitment to high-caliber scientific investigations, and sufficient time and freedom to carry out research projects [Ferleger, 1990, pp. 12-13; Kerr, 1987, pp. 2-3].

One section of the Hatch Act specified that American experiment stations should make an effort "to conduct original researches or verify experiments . . . bearing directly on the agricultural industry of the United States" [Marcus, 1985]. USDA and experiment station proponents of original research rejected the idea that stations should function mainly as bureaus of information. Instead, they thought that the future of American agriculture depended on successful experimentation in the lab or field leading to scientific discoveries that were beneficial to the development of the industry. These innovations could then be disseminated to farmers through farmers' institutes and agricultural schools at the land-grant colleges.

Figure 1
Federal Agricultural Research Organizations, 1862-1953

Chemical and Biological Research — **USDA (1862)** — Statistics and Economics

Divisions:

Chemistry (1862)
Entomology (1863)
Botany (1868)

Bureaus/Offices:

Statistics (1863,1903)

Veterinary (1883)
Veterinary and Animal Industry (1884)

OES (1888)

Vegetable, Physiology, and Pathology (1890,1895)
Agricultural Soils (1894)
Agroscopy (1895)

Bureaus:
Soils (1901)
Plant Industry (1901)
Entomology (1904)

Crop Estimates (1914)
Markets (1917)
Farm Management and Farm Economics (1919)

Home Economics (1923)
Dairy Industry (1924)
Chemistry and Soils (1927)

Markets and Crop Estimates (1921)
Agricultural Economics (1922)

Entomology and Plant Quarantine (1934)
Plant Industry and Soils (1938)
Agricultural Chemistry and Engineering (1938)
Human Nutrition and Home Economics (1943)
Agricultural and Industrial Chemistry (1943)
Plant Industry, Soil, and Agricultural Engineering (1943)

Foreign Agricultural Service (1938)

Production and Marketing Administration (1945)

ARS (1953)

Agricultural Marketing Service (1953)

Sources: Huffman and Evenson, 1991, ch.2,47-48; Baker et al., 1963; Rasmussen and Baker, 1972.

For example, in 1890 basic research by the USDA's Bureau of Animal Industry revealed that cattle ticks transmitted from one animal to another a fatal disease that became known as tick fever. Subsequent public research on disease-producing organisms, particularly those borne by insects, built on the USDA's original investigations [Baker, et al., 1963, pp. 32-33; Moore, 1967, pp. 8-9].

The early directors of the OES attempted to define the objectives of research work at the stations. Because the OES had oversight responsibilities for the federal grants provided to states, it acted as a central clearinghouse for keeping track of the kinds of research projects that stations initiated as well as avoiding excessive duplication of experiments. OES staff, particularly the director, presented OES policy recommendations regarding agricultural research practices in, among other places, two critical forums: editorial exhortations and articles in the *Experiment Station Record* (*ESR*), and professional meetings of USDA/OES staff with scientists from land-grant colleges and experiment stations [Ferleger, 1990].

Meanwhile, some station directors faced tremendous pressure from various statewide groups to spend Hatch funds on nonresearch work. Some land-grant college administrators wanted station scientists to do more teaching rather than research. Some farmers who were skeptical about the merits of agricultural science wanted the stations to provide quick answers to isolated problems. Some political leaders who failed to appreciate the long-term benefits to their constituents of advances in agricultural science demanded that stations orient their work to solving immediate farm crises. Despite these conflicting pressures on the allocation of experiment station time and effort, by the end of the first decade of the twentieth century many stations had begun to focus their activities on original agricultural investigations that required fundamental research [Ferleger, 1990; Fletcher, 1937].

As stated by a Montana experiment station scientist in 1905, these investigations were defined as pure science or fundamental research when "scientific research is carried on for the acquisition of truth only and the mere sake of extending the boundaries of knowledge" [quoted in Eddy, 1957, p. 124; see also *ESR*, 18, January 1907, p. 413]. Under the joint leadership of James Wilson, Secretary of Agriculture from 1897 to 1913, and Alfred True, director of the OES from 1893 to

1915, the value of using public funds to extend basic scientific knowledge became firmly imbedded as the prime mission of the government.

Project review procedures contained in the Adams Act allowed the OES to exercise more control over expenditures and projects than was possible under the Hatch Act. The OES maintained that its review process enabled it to exercise effective influence over station work. The review process was critical, the OES argued, because expenditures under the Hatch Act were too often used for nonresearch work, such as enforcement of agricultural regulations, correspondence, and administrative tasks. The OES had repeatedly suggested that non-Hatch funds (that is, state appropriations) be used to cover nonresearch expenditures [Knoblauch et al., 1962, p. 112]. To avoid the confusion that had emerged under the Hatch Act regarding the uses of federal funds, Secretary Wilson, a vociferous proponent of agricultural science, sent instructions to the experiment stations on March 20, 1906, that explained that the Adams Act prohibited the use of federal funds for nonresearch work. He specifically indicated that "expenses for administration, care of buildings and grounds, insurance, office furniture and fittings, general maintenance of the station and animals, verification and demonstration experiments, compilations, farmers' institute work, traveling, except as is immediately connected with original researches in progress . . . and other general expenses for the maintenance of the experiment stations, are not to be charged to this fund" [Kerr, 1987, p. 44; Office of Experiment Stations, 1906, pp. 67-68]. This exercise of firm control over the use of federal funds forced the states to secure other funding to support the nonresearch expenditures of their experiment stations.

The evolution of USDA-OES control over this far-flung system of research says much about the public-sector managerial revolution that was taking place in the decades spanning the turn of the century. In 1895 the Secretary of Agriculture threatened to terminate appropriations for the experiment stations unless the stations agreed to a federal fiscal review of their expenditures. The stations, represented by the American Association of Agricultural Colleges and Experiment Stations (AAACES), agreed to submit their expenditures to the OES. In the same year Alfred True, director of the OES, visited 35 stations to review their work. True was concerned about the progress of not only particular projects but also "entire research programs." In 1899, upon

request of the OES, the attorney general of the United States ruled that Hatch funds could not be used for academic instruction. Similarly, in that year, James Wilson, the Secretary of Agriculture, told USDA scientists to stop making informal agreements with selected station scientists for joint cooperative research. Instead the secretary wanted all approved proposals for cooperative work to be monitored and implemented by the OES [Kerr, 1987, pp. 41-44]. These directives illustrate the USDA's resolve to manage the station's work by implementing the policies adopted by the OES -- policies that were formulated in consultation with the secretary of the USDA.

The Adams Act stipulated advance reviews of station work, thus allowing the OES to make recommendations about the scope and nature of project outlines before investigations began. The OES also had legislative power to recommend curtailment of Adams funding for a station that did not abide by the OES's standards for scientific investigations; and during the first three decades of this century several stations did have their funding cut off temporarily [Kerr, 1987, pp. 58-61, 66-68]. As a result, the review process, known as the "project system," gave the OES a powerful managerial mechanism to oversee scientific work under the Adams Act. In subsequent years *all* reviews occurred under this system irrespective of source of funding. In sum, according to Edward Eddy, with the Adams Act "for the first time in Land-Grant College history a Federal Department had been given direct authority over state units" [Eddy, 1957, p. 125].

The OES, in its advisory capacity, recognized that station autonomy over research projects remained a politically explosive issue, one in which station directors had to contend with various constituencies while also conforming to scientific standards set by the OES for funding under the Adams Act. The act enabled the USDA, through an administrative unit, the OES, to formally monitor federal subsidies for research work. As a result, the USDA had a mechanism to strengthen scientists' commitment to basic research within an organizational structure that would, they believed, enhance future opportunities for fundamental discoveries leading to innovations.

Alfred True sent a memorandum to station directors on April 30, 1906, describing in minute detail how a project outline should be submitted to his office. He included a sample project outline that explicitly specified the scope and character of the study to be carried

out, and a budget that broke down estimated expenses by, among other items, employee function (for example, salary of expert in charge, salary of analyst) [*Annual Report*, 1906, pp. 68-70]. To handle the burgeoning number of projects that had to be examined, True's staff at OES grew rapidly from 38 in 1897 to over 200 in 1912 [Kerr, 1987, p. 45].

In the OES's annual report to Congress of Adams work completed in 1907, True remarked that "the system . . . of having projects outlined by the stations and passed upon by the Office in advance of beginning work . . . has worked very satisfactorily" [quoted in Knoblauch et al., 1962, p. 164]. In practice, under this project approach, experimentation on a project could not begin without meeting what came be to be known as the "True Standard." How original did a project have to be to conform to this standard? Although True was not a scientist, he understood the complexities that pure agricultural science research projects entailed. In his evaluations of projects, he did not require complete originality. Instead he wanted some aspect of the work to involve science-based principles. Knoblauch et al. state that True was "more intent on measuring station projects for their scientific caliber than for their academic uniqueness, [and he] relied on the certainty that a scientific investigation, planned and conducted in conformity with the project system, would achieve prior to its termination a significant penetration in depth." True believed that 'originality' in accomplishment, gained by an assault against the unknown, would unfailingly emerge" [Knoblauch et al., 1962, pp. 164-65].

An AAACES commission report in 1908 emphasized a mission-directed approach to promote agricultural research in the United States. The five-person commission (which included, in addition to two prominent agricultural researchers and a representative of the USDA, Carroll D. Wright and David Starr Jordan) had been set up in 1906 to evaluate how successfully federally funded agricultural research had been carried out. They also made recommendations on the nature and types of research on which experiment stations and the USDA should concentrate their efforts. The report spelled out the functional relationship between the USDA and experiment stations, thus reinforcing the already evident central role that the USDA played as manager of the nation's agricultural research agenda. In particular the report noted:

> There should be a clearer definition of the relative fields of work of the United States Department of Agriculture and the experiment stations. The dominance of the stations within their respective fields should be preserved and their growth fostered, as agencies for the investigation of local questions and of the more individual scientific problems. The Federal agency, on the other hand, should cultivate the almost limitless field offered by questions having national or interstate relations, and by those broad scientific problems requiring heavy expenditures, elaborate equipment, long continued study, and the correlation of the results of many investigators, which efforts are usually beyond the means of an individual station. On many questions the harmonious cooperation of the two agencies is essential to the highest efficiency of effort . . . . Research work, both national and state, should be provided for by separate, lump-sum appropriations, to be distributed according to the discretion of the responsible executive head of each agency . . . . An advisory board is suggested consisting of members appointed by the Secretary of Agriculture and by the Association of American Agricultural Colleges and Experiment Stations, respectively, which shall confer with the Secretary of Agriculture regarding the mutual interests of the Department and the Stations and shall consider the promotion of agricultural investigation in general. [Knoblauch et al., 1962, p. 125]

Prior to the passage of the Adams Act, the AAACES recognized that it needed a new committee to coordinate "operational harmony" with other administrative units [Knoblauch et al., 1962, p. 107]. The Experiment Station Committee on Organization and Policy (ESCOP) included representatives from other administrative units engaged in agricultural research, in particular the USDA. Within the USDA's organizational hierarchy, the ESCOP played a critical role in resolving administrative disputes among different units while preserving organizational harmony and cohesion.

By the first decade of the twentieth century the USDA had in place a managerial organization to enhance the nation's capability to promote agricultural science. Greater appropriations to the USDA during the sixteen years (1897-1913) in which Secretary Wilson headed the department meant that the USDA could expand its research programs. Moore provides a succinct summary of Wilson's vital role: "His sixteen years in the Cabinet . . . established a record for unbroken service that has never been equaled. His interest in scientific work made him a frequent visitor in the Department laboratories. He knew all the scientists and what they were doing" [1967, p. 16]. Secretary Wilson's emphasis on strengthening the department resulted in larger USDA appropriations, jumping from about 3 million dollars in 1897 to close to 25 million dollars in 1913. During Wilson's term, the USDA hired hundreds of scientists, developed new lines of inquiry, especially in the fields of entomology and animal and dairy husbandry, purchased equipment, and modernized facilities. It also expanded research and regulatory work on plants, soils, and nutrition [Kerr, 1987, pp. 44-45; Baker et al., 1963, pp. 42-51; Moore, 1967, p. 16].

In the years after the Adams Act, federal-state relations regarding agricultural research proceeded relatively smoothly. ESCOP played a mediating role in resolving those jurisdictional or administrative disputes that did arise. Federal-state relations were characterized by collusion, compromise, and cooperation, with the USDA encouraging agreements among competing research units so as to maintain public support for agriculture [Baker and Rasmussen, 1971]. Over the years many joint committees were set up to coordinate policies among AAACES, the OES, and the USDA.

An important force for the organizational integration of the nationwide system of agricultural research was the movement of agricultural scientists over the course of their careers between the public and private sectors and between state and federal public institutions. In earlier years some station scientists (so-called "research entrepreneurs") cultivated relationships with various client groups in order to ensure political support for their work [Rosenberg, 1971; Danbom, 1988, pp. 21-22]. These clients included private agricultural firms and commercial farmers who needed research done in a specific area related to monoculture agriculture.

Scientists at the USDA also cultivated similar relationships. In Ruttan's words: "The major research bureaus of the USDA were initially established in a manner to take full advantage of the link between the bureau's mission and its clientele interests both within and outside of the Congress" [Ruttan, 1980, p. 530]. Station scientists did change their affiliations, with many department heads departing for positions with the USDA, land-grant colleges, or private firms. One glimpse of the problem is captured in a study of the 1914-1919 period that found that stations experienced an 80 percent turnover rate, with some leading scientists leaving the station system. In particular, the OES reported that "370 department heads and leaders of special lines [departed] . . . . Of this expert class, upward of 150 went into industrial or commercial lines, . . . 50 into extension work, [and] an equal number to the National and State departments of agriculture . . ." [True, 1937, p. 237; Kerr, 1987, pp. 62-63].

High turnover rates could delay or slow ongoing station projects. But they also provided the USDA and private agricultural firms with a readily available pool of trained scientists [see Huffman and Evenson, 1991, ch.3]. Those scientists who moved back and forth between government and industry established key public-private links that contributed to the improvement of technologies.

As the main coordinating force, the USDA maintained its mission of directing the various centers of basic agricultural research. Between the Smith-Lever Act of 1914 and the Purnell Acts of 1925, the USDA reorganized its departments to streamline operations (see Figure 1). New departments were established to respond to changing economic conditions, particularly falling prices caused by overproduction. One new department, the Bureau of Agricultural Economics, carried out studies to help farmers market and distribute farm products.

The OES maintained its historical position as a separate unit within the USDA. Its chief of operations also assumed the title of assistant director of the Office of Scientific Work, reporting directly to the USDA's director of Scientific Work [Baker et al., 1963, pp. 64-67]. OES's project system was firmly in place in the 1920s, so that few proposals were turned down, though many were substantially revised. The review process involved an examination of the project by an OES scientist in a particular specialization (for example, field

crops) and consultation with scientists within the USDA. The OES project system was not a pro forma process, although, as in the case of USDA reviews of proposals, the OES deliberately attempted to reformulate the objectives of a project rather than reject it outright [Key, 1937, pp. 43-44]. Kerr [1987, p. 67] states that in 1928 "only twenty-three of the nearly 400 proposals were turned down. Yet in the same year, Washington reviewers insisted upon substantial modifications in another 105 of those proposed projects in an attempt to promote scientific productivity in the state agricultural experiment stations."

Thus, the OES continued its role of coordinating the expenditures and projects of the state experiment stations while promoting cooperative research efforts between the USDA and the stations. Cooperative research projects grew over the 1920s, as was noted at the 1930 AAACES meeting, where the Joint Committee on Projects and Correlation of Research reported that almost 1,100 USDA-experiment station projects were currently under way, about 200 more than the previous year. Finally, state agricultural departments absorbed some regulatory functions previously carried out by stations while appropriating more state funds for experiment work [*ESR* 60, 1930, pp. 103-04].

Experiment station scientists published the results of their research in many places, including popular publications and scientific journals. Scientific discoveries irrespective of field were published in the *Journal of Agricultural Research*, edited by USDA and AAACES scientists. The journal, published from 1913 to 1949, reported important scientific findings of agricultural scientists for the public and private scientific communities.

In 1931 an ESCOP special commission survey of the experiment stations noted that the "role of the Department [of Agriculture] in a national system for agricultural research should be that of advisor, contributor, and coordinator, rather than administrator . . . . The Department, . . . because of its detachment from local influences, could be expected to bring into cooperation broad and unbiased views of the purposes and relations of research projects. It is in the position to coordinate the net results of all local research and translate them into the broadest and most fundamental meaning." The commission also suggested that "the United States Department of Agriculture [should] establish and operate field stations or laboratories in any state only in

definite cooperation with the state experiment stations" [Knoblauch et al., 1962, p. 127]. In addition, various AAACES committees examined the nature of cooperative research projects. In 1931, for example, a special committee report on federal-state relations remarked that the "fundamental finding of the committee [is] that in general mutually cordial and helpful relations exist between the Federal and State agencies, and there is constant improvement in the administration of the details of cooperative research" [*ESR* 66, February 1932, p. 107 and *ESR* 68, February 1933, p. 139].

The 1931 ESCOP special commission survey contributed to the passage five years later of the Bankhead-Jones Act which appropriated additional funds for state stations and the establishment of regional research laboratories to support cooperative research. Each laboratory worked on a specific problem: for example, poultry in Michigan or swine breeding in Iowa [Kerr, 1987, pp. 74-75].

These laboratories represented another significant step in the USDA's efforts to contribute, through research, to the alleviation of the problems of American agriculture. During the 1920s and 1930s, one of the most pressing and persistent problems was overproduction. With large agricultural surpluses flooding depressed markets during the 1930s, President Roosevelt signed the Agricultural Adjustment Act of 1938. This act committed federal funds to establish and operate four regional laboratories that would investigate new uses of farm products [Moore, 1967, p. 22].

These laboratories centered their work on chemical and engineering research in order to improve the range of uses of agricultural products, especially by-products. Each research center focused on regional crops; for example, the Southern laboratory concentrated on cotton, peanuts, and sweet potatoes, while the Northern laboratory carried out research projects on corn, wheat, and soybeans. Especially during World War II, these research laboratories contributed to the development of many new industrial and agricultural products, including rubber substitutes from dairy products (Northern), drugs from tobacco and buckwheat plants (Eastern), tire cord from cotton (South), and dried food products from fruits and vegetables (West) [Harding, 1947, pp. 53-57].

In 1947 the Secretary of Agriculture reorganized the research departments of the USDA (including the OES) and put them under the authority of the Agricultural Research Administration (renamed the Agricultural Research Service [ARS] in 1953). The USDA streamlined its operations again in the 1950s after all funding for research purposes was consolidated in the Act of 1955 Consolidating the Hatch Act and Laws Supplementary Thereto. As had been the case in earlier reorganizations dating back to the days of James Wilson and Alfred True, the 1955 reorganization of the USDA was a basis for realigning its administrative structure to manage more effectively its new and varied activities [Ruttan, 1980].

During the first half of the twentieth century, research by agricultural scientists at experiment stations and the USDA contributed enormously to the productivity of American agriculture. Robert Evenson, Paul Waggoner, and Vernon Ruttan [1979, p. 1103] have documented the enormous returns to investments in agricultural research (often on the order of 30-40 percent per year, and in some cases much higher) in the United States and abroad throughout the twentieth century. Specifically, they estimated an annual rate of return on U.S. agricultural research expenditures of 65 percent for the period 1868-1926 and of between 95 and 110 percent for the period 1927-1950. According to the estimates of Evenson et al. [1979, p. 1102], federally sponsored research accounted for productivity growth rates of 1 percent per year from 1870 to 1900, and over 1 percent per year since 1925.

Underlying these remarkable productivity results were sustained scientific advances over a wide range of crops and applications. The USDA and station scientists recorded notable successes in fending off damaging insects, particularly two formidable pests: the Hessian fly that infested wheat and the boll weevil that infested cotton [Harding, 1947]. Coordinated work between the USDA and stations successfully eradicated or reduced the impact of particular plant diseases--for example, black rot that damaged sweet potatoes and wilt diseases that harmed cotton and other crop plants. Besides plant disease work, USDA and station scientists carried out plant-science research directed toward developing geographically specific soybean, wheat, cotton, orchards, and tobacco varieties. In later years other research projects expanded the market for cotton by developing new uses for the raw

material, such as wash and wear cottons, stretch cottons, and flame-proof cottons. Soybean projects that focused on improved methods of processing the crop resulted in soybean oil and high protein meal from soya [Moore, 1967, p. 24].

The Developmental State: Past and Present

The story that we have told about the managerial revolution in the developmental state has focused on the role of the USDA and OES in planning and coordinating the production of knowledge in the land-grant colleges and experiment stations in the United States. This managerial organization in the public sector is analogous to that which exists in the private sector, where the corporate headquarters of industrial enterprises plan and coordinate the activities of their divisions [on the historical evolution of the multidivisional organizational structure, see Chandler, 1962]. From the late 1880s, the federal government had a strategy to develop American agriculture, and over the next half century or so put in place an organizational structure to generate the productive resources that economic development required. To be sure, numerous interested parties on the state and local levels influenced the evolution of the strategy and structure of the developmental state in American agriculture. But, as in the cases of the public-sector American Association of Agricultural Colleges and Experiment Stations or the private-sector American Farm Bureau Federation, state and local interests quickly built national organizations that could interact with the federal government in shaping the nation's agricultural strategy.

Some economists have stressed the role of decentralized decision making in the successful development of American agriculture. For example, Zvi Griliches [1957] emphasizes the role of investment decisions at the farm level in response to market incentives in the diffusion of hybrid corn, although, in a subsequent article [Griliches, 1958], he also calculates enormously high returns to the public-sector research that generated the technology.

Farmers did respond to market incentives in adopting the new technologies. But as Clarke [1991, 1992] has argued persuasively, it was the political process, and in particular the New Deal legislation of the 1930s that stayed in place in the following decades, that structured market forces to induce farm investment. New Deal legislation that

supported farm prices and that provided low-cost and secure farm credit made it possible for farmers to adopt high-fixed cost technologies like tractors that yielded substantial productivity gains and sharp declines in farm foreclosures [Clarke, 1992]. Although Clarke analyzes the case of tractors, an agricultural input produced in the private sector, she also recognizes that scientific advances coming mainly from the public sector increased yields per acre, which in turn increased the potential productivity gains that could be derived from mechanization that could decrease the number of labor-hours per acre. The perspective that we have presented suggests that it was the managerial revolution within the developmental state prior to the 1930s that made it possible for the government to restructure markets effectively during the crisis of the Great Depression.

Evenson, Waggoner, and Ruttan [1979], whose productivity figures on the returns to agricultural research we have already cited, have focused on the role of the public sector in the development of technology but have emphasized the decentralized character of the system of land-grant colleges and experiment stations as the key to the success of what we have called the developmental state. Specifically, Evenson et al. [1979, p. 1105] argue that the distribution of agricultural researchers across many different regions of the nation "exposes scientists to the problems of farmers, gives farmers and extension workers easy access to specialists and their libraries, spins off talent and ideas to a locality and gives a region the technological capacity essential to development."

We recognize the importance of this decentralized structure for diffusing and improving agricultural technology but view its evolution as the outcome of a national strategy to increase agricultural productivity. The very existence of scientific advances to be diffused and improved as well as the very existence of the land-grant colleges, experiment stations, and cooperative extension services to do the diffusing and improving can only be understood in terms of the historical evolution of a national system of agricultural innovation [on national systems of innovation more generally, see Nelson, 1993].

The events leading up to the federal funding of cooperative extension services is a case in point. In 1913 the Joint Committee on Projects and Correlation, composed of representatives selected by the AAACES and the Secretary of Agriculture, analyzed federally funded

work of the USDA, agricultural colleges, and experiment stations. Their report noted the need for an expansion of extension services. The committee's report contributed to the passage in 1914 of the Smith-Lever Act, which funded the diffusion of knowledge to farmers through extension services provided by the land-grant colleges and the experiment stations. Commenting on the Act in 1914, David F. Houston, the Secretary of Agriculture noted: "We are in reality one family, working in different jurisdictions to serve the same people" [Knoblauch et al., 1962, p. 113].

The extension service would now be responsible for all rural farmer educational activities, including demonstration farms, adult education programs, and farmers' institutes. Many local substations were set up to bring experiment station scientists in closer contact with farmers. The service's task, carried out by a multitude of county agents, was to inform farmers of the latest agricultural improvements generated by publicly supported research [Rasmussen, 1989; Huffman and Evenson, 1991, ch.2, pp. 52-53].

By the 1920s, on a nationwide basis in agriculture, a highly integrated, committed, and productive public-sector organization for developing knowledge was complemented by a highly integrated, committed, and productive public-sector organization for diffusing knowledge. In The *Wallaces of Iowa*, Russell Lord [1947, pp. 380-81], a prominent farm journalist and associate of Henry A. Wallace, summed up the organizational revolution that had occurred in middle and lower management of the developmental state:

> When we lament, as we often do in this republic, the lack of a college-trained group of civil servants specifically trained in tasks of administration and statesmanship, we overlook the fact that in one important particular we are well supplied. The Land Grant Agricultural Colleges, established in the states in the time of Lincoln, have been turning out year by year not only thousands of trained technicians in the special branches of agriculture, but economists, sociologists, and administrators whose approach to events is trained and generally realistic. And the in-service training which many such men and women acquire after graduation in the Agricultural Extension Service, as county

> agents, state supervisors, and state or regional administrators, for instance, inclines to instill a considerable degree of skill and competence in public affairs. These men and women customarily work facing real people, out on the ground. One reason that Triple-A was able to forward its programs, it may well be argued, where NRA so largely failed, lies in the fact that Triple-A could be and was staffed from the very first with specifically trained and, on the whole, educated people [Lord, 1947, pp. 380-81].

Particularly at the lower management level of agricultural extension, the contribution of the public-sector organization to the success of the New Deal legislation was organizational as well as technological. From the 1910s, county agents had become key figures in organizing private-sector farm bureaus that brought together local farmers for educational and political purposes. In 1919 these local farm bureaus quickly amalgamated to form the American Farm Bureau Federation, a private-sector organization that became the most powerful advocate of the interests of commercial farmers over the following decades [Kile, 1948; McConnell, 1969; Howard, 1983]. Those interests, they understood, were served by the federal government through a national system of innovation designed to develop and diffuse technology to farmers. During the crisis years of the 1930s, the county agents, in conjunction with the farm bureaus, were called upon not only to diffuse technical knowledge to farmers but also to implement New Deal programs such as crop reduction [see, for example, Kirkendall, 1966].

With the passing of the Great Depression, however, there was a growing concern that public-sector employees in agriculture were becoming the servants of only the wealthier segment of the farm population rather than of the farm population as a whole. Early in the New Deal, in an address to the American Economic Association, M. L. Wilson, a major agricultural economist in the Roosevelt administration, had recognized the dangers of an "engineered agriculture" as opposed to a "living agriculture" for a large segment of the agricultural population.

> An engineered agriculture is going to require much fewer workers than a mode of living agriculture. It has

> been estimated that we could easily release two million of the six million farm families now on the land for other productive industry and thereby improve both the status of the four million families remaining on the land and increase the productivity of society as a whole. The question arises, where will the two million families go, especially as we have now between eight and ten million unemployed? How can they be fitted into new walks of life without great human sacrifice? This comes very near to the crux of the agricultural problem [Quoted in Lord, 1947, p. 370; see also Kirkendall, 1966].

Subsequent history would show that the reduction of two million farms of which Wilson spoke in 1933 would take about two decades, with another reduction of two million farms taking about two decades more [U.S. Bureau of the Census, 1976, p. 457]. As an "engineered agriculture" took hold, the farm sector became much more productive and much less populous.

By the second half of the twentieth century, there was reason to argue that private-sector interest groups -- the Farm Bureau in Grant McConnell's *The Decline of Agrarian Democracy* [1969; originally published in 1953] and agribusiness in James Hightower's *Hard Tomatoes, Hard Times* [1978; originally published in 1972] -- dominated the agricultural sector, including the land-grant colleges and the experiment stations, in pursuit of their own ends. In the aftermath of the New Deal, poor (or what the USDA called "non-commercial") farmers had little future in agriculture, while the richer ("commercial") farmers as well as the private-sector suppliers of agricultural equipment, implements, fertilizers, and seeds had privileged access to highly effective public-sector organizations for developing and diffusing technology.

In the process, the developmental state in American agriculture was a success in introducing new technology and raising productivity in American agriculture. The developmental state has also been important in opening up and expanding global markets for U.S. agricultural exports [Vogel, 1985, ch.8]. In the late twentieth century, the agricultural sector remains of prime importance to American economic prosperity. In 1989, primary agricultural products were 11.6

percent of all U.S. exports, with grain products, soya products, and cotton making up over half of the value of the agricultural exports. In these products and many others, the United States outstrips the productivity levels of every other nation in the world.

But the American-style developmental state also was exclusive in the sense that, with the passing of the New Deal and its coterie of social reformers close to President Roosevelt, little attention was paid to the fate of the millions of farm families who could not continue to make a living in agriculture. No comparable developmental state existed in industry where the vast majority of the displaced farmers had to find work in blue-collar jobs that demanded little in the way of skills [see Lazonick, 1990, ch.7-9].

This legacy of unskilled shop-floor work, as well as a more recent decline of concerted commitments to scientific research, are now pressing problems facing American industry in its attempts to be internationally competitive. The case of American agriculture shows that the developmental state is not alien to the nation. For developing and utilizing productive resources, moreover, the organizational principles of an effective developmental state are analogous to the organizational principles of an effective business organization in the private sector. The lessons of the past in agriculture suggest that the United States can build a developmental state in its efforts to be a world industrial leader. The demands of the present for a highly skilled work force suggest that the developmental state that is put in place will have to be more inclusive in its distribution of productive capabilities than the developmental state that gave the nation the world's most productive agricultural sector.

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