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Designing an Effective Federal Biomass Program

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Abstract

This article addresses two questions: Has the effectiveness of the US government's federal research and development (R&D) spending suffered from the post-1980 strategic change from freely shared and publicly owned to privately owned scientific advances? What criteria would a federal R&D program use to design a strategy that most effectively enhances the well-being of farmers and rural communities? Several studies found that the pre-1980 US Department of Agriculture research strategy was very effective. No comparable studies have analyzed the comparative effectiveness of the post-1980 strategy of restricting access to the results of public research. Recent experience and several analytical studies suggest that to significantly enhance the health of rural economies from an expanded use of plant matter as an industrial material, federal policy should channel scientific and engineering research into small- and medium-sized production and processing technologies and should encourage farmer-owned, value-added enterprises.

Index Entries: Ethanol; scale; ownership; research and development; effectiveness.

Introduction

One of the twentieth century's greatest scientists and thinkers, Albert Einstein, observed, "Perfection of means and confusion of ends seem to characterize our society." Are the US government's federal programs supporting industrial uses of biomass an example of such thinking?

The ends of the federal biomass programs are clear enough: enhanced national security, improved environmental protection, stronger rural economies. Research is a means to these ends. Are the federal biomass programs designed to most effectively achieve these ends?

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Federal programs and policies channel scientific genius and entrepreneurial energy and investment capital in specific directions. Regarding biomass, the overall impact of direct spending and tax incentives is not insubstantial.

The federal government spends more than $200 million annually directly on research and development (R&D) directed toward expanding industrial uses of biomass. Assuming a three- to one-average private-to-public investment match, this federal direct spending attracts an additional $600 million in private spending. Federal biomass-related tax incentives presently “spend” more than $1 billion per year. This in turn attracts several billion dollars of private investment in these areas. The vast majority at present goes into expanding ethanol production.

This article examines some aspects of federal R&D efforts in the biomass area. It raises two areas of question. One is whether the post-1980 changes in the way the federal government conducts biomass research has made the biomass R&D effort more or less effective in achieving its stated goals. The observations are primarily directed toward the Department of Agriculture because the vast majority of its research is conducted in-house by permanent scientific staff.

The second area of question focuses on one of those goals, improving the well-being of America’s farmers and rural communities, and suggests that social criteria can and should inform and guide engineering research strategies. The observations are primarily directed toward the Department of Energy (DOE), although they are broadly applicable to agency heads and policy makers.

Public vs Private Knowledge

Before 1980, the results of federal agricultural research were freely available and widely shared. Virtually all of the research was directed toward improving crop production and yields as well as harvesting and storage costs of crops intended for food and feed markets.

There are considerable uncertainties regarding cost-benefit analyses. Nevertheless, it is instructive that the many studies done both inside and outside the United States Department of Agriculture (USDA) found its pre-1980 R&D efforts very effective and influential.

USDA economists found that publicly funded agricultural research earned an annual rate of return of at least 35 %.[1] A 1966 study by the Agricultural Research Service (ARS) on the impact of its research from 1941 to 1966 concluded that 109 products and processes developed by ARS had been commercialized and 26 represented major contributions in basic research. Their value was estimated by the ARS at more than $6 billion, 20 times the $309 million spent by the ARS laboratories during this period.[2]

A 1980 study by the Congressional Office of Technology Assessment on the benefits stemming from agricultural research concluded that, “the range of estimated rates of return is from a low of 23 percent to a high of 100 percent."[3] A 1992 study by Chapman and Associates *(1)* examined 178 cases of ARS research projects completed from 1980 to 1990 (including cooperative programs or joint programs with State Agricultural Experiment Stations). Of the 178 cases, benefits data were identified for 87, resulting in $14.8 billion in sales or savings. These savings were greater than the total amount spent on the ARS during that time period *(1)*.

Another study *(2)* found that although the ARS had a relatively small number of patents compared to the private sector in agricultural-related areas, the ARS patents were cited more often than private patents. Thus, the ARS patents were considered more often "key" patents marking significant advances in knowledge *(2)*.

Despite these successes, in the late 1970s there was a growing and increasingly influential school of thought that a focus on more basic research and the nonexclusive sharing of the fruits of such research was not encouraging the levels of private investment sufficient to commercialize new technologies. Many potentially valuable scientific advances were therefore remaining in the laboratories. Commercialization would occur only if private investors could be guaranteed exclusive access to the knowledge generated from what would increasingly become investments in federal research efforts made by both private and public sectors.

In rapid fashion, beginning in 1980, the federal government dramatically changed its R&D strategies to encourage one in which private interests would become increasingly influential in directly assisting public research:

1. The University and Small Business Patent Procedure Act, commonly known as the Bayh-Dole Act of 1980, gave nonprofit organizations such as universities as well as small businesses the right to retain patents for technology developed with government funds.
2. The Stevenson-Wydler Technology Innovation Act of 1980 provided federal departments, agencies, and affiliated laboratories with a legislative mandate to pursue technology transfer activities. Each agency was to make available not less than 9.5% of its R&D budget for technology transfer activities.
3. In 1983, an Executive Order extended the coverage of the Bayh-Dole Act to all government contractors. The Act also granted federal agencies the right to offer exclusive or coexclusive licenses to patents on inventions made by laboratory employees considered necessary for the commercialization of the invention.
4. The Federal Technology Transfer Act of 1986 allowed federal laboratories to enter into Cooperative Research and Development Agreements (CRADAs) with private firms. A CRADA confers two important rights to businesses: First, the right of first refusal of an exclusive license on any patentable inventions that arise from the research partnership; and, second, the right to keep research findings secret for 5 yr. The Act also permitted royalty income from

> patent licensing and assignment to be distributed directly to the inventors. The 1986 Act also made technology transfer a responsibility of every laboratory scientist and engineer. It required at least one full-time equivalent technology transfer position for every laboratory having 200 or more full-time scientific, engineering and related positions.

Today much if not most federal research, including biomass-related research, is done in partnership with private companies that have the right to exclusively own the intellectual property generated from that collaboration.

How effective has the post-1980 approach been compared to its predecessor?

Unfortunately, there are few if any studies that adequately address this important question. Vast changes in agricultural technologies have occurred over the last 20 yr, especially in the area of biotechnology in crops and animals. Yet, in this area federal R&D spending may have played a modest role that largely followed the massive amounts of venture capital that flowed into the biotech sector.

Efforts to compare the pre- and post-1980 R&D strategies are confounded by the fact that the metrics used to evaluate the performance of federal research have changed. In the older period, the measures used largely reflected the impact on the country and the countryside, such as the number of acres planted in the new hybrid and the rate of adoption of a new technology by farmers or processors. The new approach largely measures the impact on the agency or its private partner, considering factors such as the number of patents issued, the number of licenses issued, and the amount of royalties received.

It is now more than 20 yr since the federal government adopted a dramatically different approach to R&D by emphasizing technology transfer, private partnerships, and exclusive licensing. This is sufficient time to allow evaluation of the comparative effectiveness of both approaches.

Impact of Federal Biomass R&D on Rural Communities

One of the principal objectives of the federal biomass program is to improve the lot of farmers and rural communities. History teaches us that simply expanding demand for plant matter will not automatically benefit the cultivators of that plant matter. As farmers are aware more than anyone, expanded markets in the past have not resulted in increased net income to the farmer. This is because, as John F. Kennedy once observed, "The farmer is the only man in our economy who buys everything retail, sells everything he sells wholesale and pays the freight both ways."[4]

In 1910, of every dollar generated by agriculture, the farmer received 41¢. By 1990, the farmer's share had dwindled by more than 75%, to just 9¢. And today it is closer to 7¢. Yet this reduction in the farmer's income has not resulted in a reduction in the retail prices of the products made from the farmer's raw materials. The price of a pound of corn flakes has gone up some 50% in the last 15 yr while the price of a pound of corn has gone down.[5] What this means is that for the farmer to significantly benefit from federal biomass policies, these policies must enable the farmer to gain an income from the value-added steps in converting the commodity crop into a wholesale and retail product.

I serve on a congressionally created committee that advises the Secretaries of Energy and Agriculture on biomass R&D efforts. In 2002, the Biomass R&D Technical Advisory Committee delivered its first annual report, which acknowledged, "Expanding the use of biomass for non-food and feed purposes will benefit farmers and rural areas only indirectly and modestly. A more significant development would occur if farmers themselves were able to produce the biofuels or bioproducts, either on the farm or as owners in a local production plant."[6]

Consider the emergence of bioethanol as an instructive example. The federal excise exemption for ethanol plus Clean Air Act regulations has created a 2.5 billion gal/yr ethanol industry. Evidence from Minnesota and Missouri indicates that this has increased the price that farmers are getting for their corn from local ethanol plants by 5–10¢/bushel.[7]

However, if farmers own the ethanol plant, they receive the additional price that results from increased markets plus they receive a part of the profit generated at the manufacturing level. Information on returns on ethanol investments is closely guarded and the returns vary dramatically from year to year and from plant to plant. Nevertheless, it is not unusual for the dividend in an average year to be 25–50¢/bushel. One unreleased study of the farmer-owned Minnesota Corn Processors ethanol plant found that farmer-investors earned about 18% annually over the 20-yr life of the plant as a cooperative.

Scale: The Minnesota Lesson

Unlike the federal government, several states have altered their biomass incentives to enhance the positive impact on rural communities. The Minnesota experience, often called the Minnesota Model, is instructive.

In the early 1980s, Minnesota's state ethanol incentive mirrored that of the federal incentive—a partial exemption from the gasoline tax. That incentive succeeded in making the price of ethanol competitive with other gasoline additives. The demand for ethanol-blended gasoline soared. But the demand was met entirely by ethanol imported into the state from out-of-state, large manufacturing facilities owned by one multinational corporation. Minnesota farmers and Minnesota's farming communities did not benefit from the expanded consumption of ethanol inside the state.

To remedy this problem, in the mid-1980s, Minnesota converted its state ethanol incentive from a consumer-oriented excise tax exemption to a producer-oriented direct payment. Instead of reducing state gasoline taxes by a couple of pennies for a 10% ethanol blend, the state paid 20¢/gal for ethanol produced within the state. To encourage the construction of many plants in different parts of the state, the incentive, which ran for 10 yr, applied only to the first 15 million gal produced.

Some argued that by encouraging many small biorefineries, the government was encouraging higher-cost and more inefficient biorefineries because of the engineering economies of scale involved. Indeed, an internal study by the Institute for Local Self-Reliance concluded that a 150 million gal/yr ethanol facility had unit costs about 15–20¢/gal less than those of a 15 gal/yr facility.

Thus, the 20¢ incentive made up for the difference between small and large biorefineries. The result was that rather than one or two 100 million gal/yr plants, by 2002 Minnesota was home to 15 ethanol plants, the average capacity of which was 15 million gal/yr. The scale of the plants also encouraged farmer ownership. In 2002, 12 of the 15 plants were owned by more than 9000 grain farmers. These plants provided almost 10% of the transportation fuel sold in the state.

The proliferation of small plants led to an unanticipated technological dynamic. Because of the large number of plants built, several engineering firms competed with each other to design and build the least expensive and most efficient facility. Yields of ethanol in dry mills quickly rose from 2.5 to >2.8 gal/bushel. The large number of plants, coupled with equal numbers of plants being built in surrounding states, accelerated the engineering and operational learning curves. The result was to rapidly reduce the cost of ethanol produced from small dry mills.

A 1998 study by the USDA, a follow-up to a 1987 ethanol plant survey, examined the comparative economics of small- and medium-sized dry mills and large wet mills. In 1987, small- and mid-sized dry mills had cash operating costs of 50¢/gal. Large wet mills had a cash operating cost of 47¢/gal. By 1998, dry mills had dropped their operating costs to 41.7¢, whereas wet mills had dropped theirs only marginally, from 47.2 to 46¢. The 1998 report concluded, "Wet mill variable costs appear to have remained very stable at about 46 cents per gallon. Improved energy cost management was offset by several factors, including waste management and overhead... In contrast, dry mills have experienced a l5-percent reduction in operating costs, due to the effects of reduced energy, labor and maintenance expenditures and possibly economy of scale" *(3)*.

Scale: The Federal Challenge

Can federal research efforts focus on technologies applicable for smaller facilities? What would such research look like? This is a key challenge for researchers and policy makers. Engineering economies of scale do exist, as do management and marketing economies of scale. However, there are technologies that lend themselves more to modular expansion. Technologies should as much as possible allow the farmer to capture the value added from storing, preprocessing, and perhaps even processing the crop on site.

In the late 1970s, the DOE launched its wind energy initiative. Wind energy has dramatic economies of scale. The power output varies by the square of the diameter of the turbine's blades and by the cube of the increase in the wind speed. The DOE focused on building very large-diameter wind turbines. These megaturbines contributed relatively little to the technological advances in the wind energy field. Much more important for wind energy development was the design of buyback tariff structures in California in the early 1980s and the wind energy mandate in Minnesota in the mid-1990s.

As the wind energy industry grew, advances in the electronics and construction design of wind turbines grew even more rapidly. As they did, wind turbines became larger in a more organic way, moving from the 200-kW machines of the early 1980s to the 750-kW machines of the late 1990s to the new 1.5-MW machines.

In 2001, the DOE launched a small wind turbine initiative. The objective was to make wind energy economical in the many areas of the country that have lower wind speeds. This initiative is a 180° turn from the wind energy program of the late 1970s. It is too early to evaluate its results.

Regarding biomass, the DOE favors larger facilities, again because of their engineering economies of scale. The biomass program's orientation to the scale of production systems mirrors that of the fossil fuel and nuclear programs. Yet biomass has characteristics that may lend itself to a different orientation. The cost of transporting biomass, e.g., is much higher than the cost of transporting fossil fuels or uranium. In addition, the farmer-oriented and rural economy objectives of the biomass program are not part of the fossil fuel or nuclear development program.

Both DOE and the Department of Agriculture are conducting research in biochemical production. How would a focus on smaller scale and modular production units affect the research done under these programs?

The DOE and, to a lesser extent, the Department of Agriculture, have largely ignored questions of scale and ownership in their R&D efforts. The result could be that success in dramatically increasing the use of biomass for energy and industrial purposes may well not translate into higher farmer income or healthier rural communities. Yet these are formal objectives of both agencies' missions. Taking these socioeconomic factors into account could well encourage a different R&D and commercialization strategy by the federal agencies in charge of the biomass program.

Notes

1. Catherine E. Woteki, Deputy Undersecretary, Research, Education and Economics, USDA, Testimony Before the House Agriculture Committee, Resource Conservation, Research and Forestry Subcommittee, May 14, 1996.
2. *Achievements in Agricultural Utilization Research*, ARS Committee on Research Achievements, ARS, Washington, DC, November 1966.

The same 25-yr period, 1941–1966 was examined in a PhD thesis at the University of Georgia by Harold B. Jones, Jr., of the USDA's Economic Research Service. He found that by 1966, 9% of the projects undertaken by the regional laboratories had produced an economic return. That figure compared favorably with returns on food industry research. The cost-benefit ratio was 20 to 1 or better (cited in *Always Something New: A Cavalcade of Scientific Discovery*, USDA, Agricultural Research Service, Miscellaneous Publication 1507. November 1993).

3. Fred C. White, B. R. Eddleman, Joseph Purcell, et al, "Nature and Flow of Benefits from Ag-Food Research," in *An Assessment of the United States Food and Agricultural Research System*. Volume 2. Commissioned Papers, IR-6 Information Report No. 5. Office of Technology Assessment, Washington, DC, December 1980, pp. vii–x.
4. Speech by Senator John F. Kennedy at the National Plowing Contest, Sioux Falls, SD, September 22, 1960.
5. David M. Russo and Edward McLaughlin, *Farmers Can Get Bigger Share of Food Dollar*. New York State College of Agriculture and Life Sciences, Cornell University, April 1991, estimates the retail price of corn flakes at $1.56 per 18-oz box. Corn represents about 10¢ of the cost. The Economic Research Service, in *Food Marketing and Price Spreads: Farm-to-Retail Price Spreads for Individual Food Items* (2003) Washington, DC, estimated the year 2000 cost of an 18-oz box of corn flakes to be $2.14, with corn flakes representing 8¢ of that cost.
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