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THE AGRICULTURAL KNOWLEDGE SYSTEM: APPROPRIATE ROLES AND INTERACTIONS FOR THE PUBLIC AND PRIVATE SECTORS

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For over one hundred years, Land Grant Universities (LGUs) have pushed the frontiers of knowledge; have translated new knowledge into practice for the benefit of farmers, agribusiness and consumers; and have prepared the next generation of agricultural scientists and entrepreneurs. Historically, there have been strong arguments for public investment in such knowledge generation and transfer activities. The basic argument is that knowledge is by nature a "public good" and, therefore, the private sector would be unwilling to invest in fundamental research. The public sector should do so instead. In this way, new concepts, processes, techniques and materials could be developed and flow in the economy with positive social welfare effects.

There is substantial evidence that such investments have served the public well. The estimated average annual return on public investment for agricultural research and technology transfer in the U.S. is over 30%, which is high by any standard of investment efficiency. Benefits for consumers have come in various forms including low-priced, high quality, and safe food. There is little argument about the size and relevance of consumer benefits from agricultural innovation. The benefits to U.S. farmers, however, have been questioned in some cases.

Over the years, agricultural innovation has contributed to increased food supplies. Since agricultural products are mostly commodities with inelastic demand, prices have gradually slipped proportionally more than supplies have grown, often resulting in net income losses for farmers. At the same time, fewer, larger and more sophisticated farms have supplied the food chain in the U.S. and beyond. Smaller or less technically sophisticated farms have become less competitive over time. Within such a technologically evolving farming sector, early adopters of new technologies have been the beneficiaries of economic gains while laggards have lost out.

The New Agricultural Knowledge System

In recent years, the traditional agricultural knowledge system has been undergoing significant change. The leadership role of LGUs in agricultural knowledge generation and transfer has been challenged by the private sector's increased involvement in such activities. Extension services have been privatized in many parts of the world or have become parts of technology packages offered by input suppliers, integrators, independent consultants, and other entrepreneurs. Similarly, private investments in research have continued to rise. Even basic research, an area

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long-viewed as the exclusive domain of the public sector, has attracted private funding in recent years. In agricultural genomics research, for example, private investments dwarf public spending.

Private investment in knowledge generation and transfer has increased because knowledge assets are gradually becoming less "public" in nature. Institutional changes, consistent with the ongoing transformation from a material- to knowledge-based economy, have been largely responsible for this transformation. Intellectual property rights for innovation in biological systems have expanded and efforts to homogenize and secure the enforcement of such rights around the globe have intensified over the last three decades. The intent has been to provide incentives for investment by increasing the ability of innovators to capture value from knowledge assets through market transactions. The motivation has been the realization that innovation is the main source of economic growth.

In the current agricultural knowledge system the private and public sectors both collaborate and compete. A portion of the private investment in knowledge generation and transfer has been regularly outsourced to universities and other public institutes and laboratories through research contracts, collaborative research and development agreements (CRADAs), material exchanges, intellectual property licenses, and use of university researchers in scientific boards and think tanks. Such funding has covered shortfalls from shrinking public investment and has accelerated the development and transfer of knowledge from the laboratory to the market place.

But private financing of public sector research has not been without controversy. It has been argued that the private sector may be unduly influencing the public research agenda, directing it towards socially sub-optimal targets. Moreover, it may be doing so by paying only at the margin after the public has paid for the significant infrastructure of LGUs and other public research organizations.

As private investments in the generation and transfer of agricultural knowledge have grown, questions about an appropriate division of labor between the public and private sector have surfaced. Will private sector involvement continue to grow? If so, will it crowd-out public sector investment? How will the emerging agricultural knowledge system be structured? What will the future role of LGUs be? In this issue, leading experts provide arguments about relevant divisions of labor between the private and public sectors as well as about appropriate levels of public-private interactions in agricultural knowledge generation and transfer.

Some key arguments are:

- Synergies between practical knowledge and basic science substantially increase the efficiency of agricultural knowledge generation and transfer. Private-public interactions create a fertile ground for such synergies to materialize. Public-private interactions must then be nurtured in the emerging agricultural knowledge system (Buller & Taylor; Holt & Bullock; Rausser).

- The structure of private-public interactions, and the relevant institutional environment in which such interactions occur, have meaningful effects on their efficiency and effectiveness (Buller & Taylor; Holt & Bullock; Rausser; Pray).

- The public sector must continue to lead the research efforts in areas where weak incentives for private investment exist, like in basic research, socioeconomic and environmental issues and food safety (Klotz-Ingram & Day-Rubenstein; Ruttan; Traxler; Wolf & Zilberman).

- Publicly funded research, especially in the area of agrobiotechnology, must create a decentralized system of innovation to fuel competition and countervail market power of technically dominant firms (Sonka & Pueppke; Wolf & Zilberman).

Towards A Socially Optimal Agricultural Knowledge System

Alternative roles and interactions of the private and public sectors lead to different efficiency and equity outcomes. The issue of efficiency relates to society's efforts to get more out of its investments by improving the input-output relationships in the agricultural knowledge system. Hence, efficiency improves when more new knowledge results from a given set of scarce resources, when such knowledge is transferred faster from concept to use, and when better solutions emerge to satisfy our food and fiber needs while sustaining our resource endowment for future generations. The issue of equity, on the other hand, deals explicitly with how the resulting benefits and costs are distributed among different social groups, and among current and future generations.

The key realization, of course, is that efficiency and equity are inextricably connected and, in most cases, move in opposite directions. Hence, highly efficient outcomes may not be equitable. The standard approach in such cases is to compensate those bearing most of the costs by redistributing part of the efficiency gains in pursuit of more equitable solutions. This option is always available but not without shortcomings. Influence activities tend to affect redistribution in non-optimal ways. Furthermore, redistribution is often a source of alternative economic inefficiencies.

Should we then structure the knowledge system in ways that specific equity targets are satisfied under any circumstances? This option is not without shortcomings either. The process of new knowledge generation is inherently uncertain both in terms of technical outcomes and social impacts. Uncertainty derives from the evolutionary nature of new knowledge discovery and use. Individuals and organizations build on previous knowledge in complex, interactive and novel ways, typically unanticipated by previous innovators. Elimination of a single contribution can often drastically change the path of discovery. It is therefore problematic to predicate equity goals that are too specific on the agricultural knowledge system, as relevant efficiency/equity tradeoffs can not be up-front anticipated.

Clearly, the burden of social responsibility should not be placed on the knowledge system alone. Relevant supporting institutions must also play their intended roles in filtering new knowledge to achieve desirable social, economic and environmental outcomes. If existing antitrust and environmental regulation, agricultural policies and common law are not up to the task within the new economic and scientific realities, they should be appropriately adjusted. Social engineering of new knowledge is probably a poor substitute for an appropriate institutional framework.

The new agricultural knowledge system must also adapt to the emerging economic and scientific realities. The distance from the laboratory bench to the consumer table has been shortened. The process of knowledge transfer has become more transparent. The motto that "good science will take care of itself" is obsolete. In the knowledge economy, science and technology are as much social and economic activities as they are technical. Openly communicating with the broad public on an ongoing basis about the flows of new knowledge, their utility and potential socioeconomic implications is essential. Given that future outcomes of new knowledge cannot be fully anticipated in advance, the agricultural knowledge system must be transparent and responsive and must foster trust.

This is a time of extraordinary structural adjustment for the whole agricultural knowledge system. It is essential that we not only maintain its integrity, capacity and efficiency, but that we expand it. We have chosen to close this issue of *AgBioForum* with Professor Ruttan's paper as he reminds us that finding innovative solutions to our emerging sustenance problem will be critical within our lifetime. Current projections suggest that the Earth will have some 8 billion inhabitants by 2025. While its probably true that Malthusian-type predictions have been overused, and ring hallow to satiated citizens in developed countries, there is little doubt that the human race is already having and will continue to have an unprecedented impact on the planet. This fact should not escape anyone.

In this issue, fourteen academic experts offer different viewpoints on the appropriate roles of the public and private sectors in the agricultural knowledge system. We would like to know your point of view.