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Agricultural Biotechnology, Academic Capitalism, and the Two Cultures of Science

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Abstract

In recent years partnerships between U.S. universities and industries have become generally more varied, wider in scope, more aggressive and experimental and higher in public visibility. In addition, public and private interests have advocated for government policies and laws to globally promote the commercialization of university science. This paper examines the persistence or convergence of the two cultures of science and the implications of this commercialization for university-industry relationships in agriculture biotechnology. The perceptions and values of over 200 U.S. University and industry scientists, managers and administrators who participate in or oversee research collaborations in agricultural biotechnology were analyzed. The findings revealed that the participants in these research relationships continue to perceive very distinct cultures of science and identify a wide range of concerns and disadvantages of these partnerships. Several actions are discussed to ensure that the two cultures serve complementary roles and that they maximize the public benefits from these increasing collaborations

Keywords

Agricultural biotechnology; Academic capitalism; Two cultures of science; University-industry relationships

Introduction

Previously several papers and presentations by the authors examined the university and industry collaborative research relationships focused on agriculture biotechnology. Our particular interest was on the nature of those university-industry relationships (URI), the goals and values of each community of scientists, perceived advantages and disadvantages, impacts of those collaborations, and the existence and the persistence or convergence of the two cultures of science. These questions were explored primarily through in-depth interviews (N=214) with university scientists and research administrators engaged in agricultural biotechnology research at six U.S. public universities, as well as with their industry partners

Agricultural Biotechnology

Focusing on agricultural biotechnology scientists had a number of advantages. Traditionally, agriculture has been the recipient of substantial public investment to support and attract private sector investment. Further, university research plays a more integral role in the field of biotechnology than for many other areas. More than two decades ago, writers were referring to university-industry as the lifeblood of biotechnology (Welsh et al. 2008) [20]. In addition, agricultural biotechnology was an early target of efforts to commercialize university research because so much of the research for the emerging agricultural biotechnology sector was conducted in the large public U.S. universities and their colleges of agriculture and life sciences. Statements from university leaders and industry 20 years ago indicated that agricultural biotechnology would revolutionize farming in the future with tremendous impact on the crops and animals grown for food and affecting agriculture in ways never before dreamed possible (Busch et al. 1991).

Biotechnology crops have been the fastest adopted crop technology in recent years. The first commercial biotech crops (maize, cotton, soybean, and canola) were introduced in 1996. The hectares for these crops have increased every year from 1996 to 2018 in both developing and industrial countries, increasing from 1.7 million hectares in 1996 to over 190 million hectares in 2018 with the US at 75 million. The average adoption rate in the top five biotech crop-growing countries has increased to reach close to saturation (ISAAA 2020) [7]. Public and private research cultures and their relationships to each other will continue to play a key role in the future of agriculture biotechnology shaping the priorities and directions of these

developments, from measuring and improving efficacy to determining health and environmental impacts.

Academic Capitalism

Partnerships between U.S. universities and industries have existed for several decades particularly in the fields of agriculture and natural resources but in recent those relationships have become generally more varied, wider in scope, more aggressive, commercial, and experimental and higher in public visibility as universities pursued what has been referred to as academic entrepreneurship and academic capitalism (Slaughter & Rhoades 2004, Busch&Lacy 1983, Lacy 2000) [3,9]. Since the turn of the last century, universities have patented and licensed their findings. Over much of the 20th century, university patenting and licensing activity continued to grow slowly until the passage of a series of legislation beginning with the Bayh-Dole Act of 1980, executive orders and court decisions. These actions placed a new emphasis on harnessing university research to foster the emergence of the knowledge economy and promote university-industry collaborations (Welsh et al. 2008, Glenna et al. 2011) [6]. The Bayh-Dole Act, in particular, created a uniform patent policy among the many federal agencies that fund research, enabling non-profit organizations, including a provision enabling universities to retain title to inventions made under federal funded research programs. Universities were encouraged to collaborate with commercial organizations to promote the utilization of inventions arising from federal funding (Mowery et al. 2004, Kenney & Patton 2009) [8,13].

These policy and court decisions led to the widespread establishment of new university technology transfer offices which promoted patenting of federally funded research and drove increases in the number of universities actively engaged in patenting and licensing technologies and discoveries. The AUTM, a global nonprofit that represents 3,000 technology managers at 800 research institutions, about 80 percent of which are universities, reported in their 2017 yearly survey a record 1,080 start-ups were formed and 6,050 start-ups reported in previous surveys were still operational. The survey also revealed that 7,459 patents were issued, 7,849 licenses and options (the agreements that give companies the right to manufacture a product) were signed and 755 new products were created (AUTM 2020) [1].

The federal policy changes and actions have been coupled with a decrease in state and federal support for all basic research including agricultural research relative to private sector investments. In 2017, the federal government funded about 42% of all basic research performed which was a drop from 53% in 2010. The business sector was also a substantial performer of basic science at 27% (up from 22% in 2010) and funded 29% of basic research (up from 23% in 2010). However, higher education institutions have historically been the largest generator of basic research and continued to be the largest performer in 2017 at 48%. At the same time the business sector was both the largest performer (57%) and largest funder (54%) of applied research in 2017 while higher education conducted 18%. (NSF, 2020) [14].

In addition to stimulating the great expansion of university technology transfer offices these changes have significantly contributed to new and expanded university-industry relations offices, university research parks, innovation campuses, and new organizations to promote and strengthen university-industry collaborations. Cornell Tech, a $2-billion campus on New York City's Roosevelt Island, was created in 2012 and The University of Pennsylvania, in 2016, opened its Pennovation Center, a blend of offices, labs, and production space aimed at advancing knowledge and generating economic development (Wisnioski&Vinsel, 2019) [21]. Other new models for university-industry collaborations are emerging.

Two Cultures of Science

With the rapidly growing number of diverse university-industry relationships, the dynamic expansion of university technology transfer offices and a range of university academic capitalism activities, several scholars have raised fundamental questions regarding the complementary roles of university and industry research and the impact of these relationships for those roles. Keys to defining and implementing the university roles, particularly for public universities, were the Land-Grant College Act of 1862 which focused applied research that addressed social problems and the public good, and the 1950 formation of the National Science Foundation which designated the universities as the primary basic research infrastructure for the nation (Slaughter and Rhoades 2004; Glenna et al. 2007, Busch et al. 1991) [4].

These and other related policies assumed that both public goods and private goods are needed to enhance the general public goodand created a division of labor between the private and public research sectors (Lacy 2001) [10]. Universities received public funding to do basic and other research without direct applications for commercial products. The private sector, on the other land, conducted more applied and proprietary research (Slaughter and Rhoades 2004) [17].

Consequently, the values of these two communities vary significantly. The primary goal of industry research is to generate trade secrets, patents and exclusive licensing for commercial gain. Research agendas are set through a multidisciplinary, hierarchical structure with an emphasis on team research, secrecy, short-term agendas, intellectual property and proprietary products. In contrast, university research primarily conducted within a more individualistic, disciplinary, long-tern, organizational structure is generally expected to advance knowledge and address broad social problems. Research priority setting and review processes are more transparent, and knowledge is made available to the public through professional journals and university and government publications (Glenna et al. 2007) [5].

The rationale behind these policy reforms and partnerships was that the knowledge economy provided new opportunities for the private sector to utilize research universities' technologies to foster economic growth. The assumption was that the UIRs would foster the flow of knowledge and technology from the university to the private sector, while also generating increased basic research funding without changing

the activities of working scientists, the university at a structural level, or the process and outcomes of research and educational activities.

However, a number of research analysts have countered that commercialization of university science threatens the distinct cultures and their important complementary functions (Lacy 2001; Glenna et al. 2011). They claim that the university is losing its distinctive incentive system, which is structured to promote a focus on publicly accessible outputs for which the private sector cannot capture sufficient rewards. Some claim that the two research cultures. Moreover, these analysts maintain that the two research cultures are converging (Vallas&Kleinman 2008) and that convergence favors the private sector [18]. Studies have found a rise in data withholding, secrecy, and impaired communication among university scientists (Powers and Campbell 2011) [15]. Studies have also explored how academic-industry interactions lead university and industry collaborators to take on characteristics of their counterparts and foster institutional conflicts of interest (Rudy et al. 2007) [16]; how university research topics over time come to parallel private sector research topics (Welsh and Glenna 2006) [19]; and how scientific fraud is associated with commercial ties (Martinson et al. 2009) [12]. Industry funding has also been correlated with outcomes favorable to the funder, perhaps due to researcher bias, whether conscious or unconscious, associated with conflicts of interests.

Perceptions of the Two Cultures

To examine the persistence or convergence of the two cultures of science, and the possible implications for agricultural biotechnology, 214 in-depth qualitative interviews were conducted with university scientists and research administrators engaged in agricultural biotechnology research at six U.S. public universities, as well as with their industry partners. Details of the research design and procedures can be found in other articles published by Glenna (2007, 2011), Welsh (2008) and Lacy (2014) [11].

Six prominent public research universities across the U.S. were chosen for their emphasis on agricultural biotechnology research, significant and steadily growing annual research expenditures and private sector funding, and academic capital activities (Cornell University, North Carolina State University, Oregon State University, Texas A & M University, University of California, Davis, and University of Wisconsin). Industry partners included Monsanto, Pioneer (a Dupont Company), Syngenta, Bayer Crop Science,Sagres Discovery,Seminis, Bioworks, Paradigm Genetics, Cropsolution, and AgraQuest.

To explore the potentially different research cultures each respondent was asked to assess the characteristics of their institution's research environment along 12 dimensions, as well as their counterpart's institution's research environment. Respondents indicated that university research environments place a high emphasis on advancing knowledge, basic and disciplinary science, open communication, long-term research, an individual orientation, and problem solving. Universities scored low on applied science, team-orientation, short-term emphasis, and proprietary emphasis. In stark contrast, respondents characterized the industry research environment high on proprietary emphasis, short-term focus, applied science, multidisciplinary emphasis, and problem solving. They gave lower scores on individual orientation of scientists, long-term emphasis, disciplinary emphasis, open communication, basic science, and advancement of knowledge.

The results suggest that the university and industry respondents characterize each other's research environments similar to the theoretical characterization of the two research environments reported above. Although there were some significant differences, university and industry agreed on the general characterizations of the distinct research cultures on every item. University and industry partners recognize clear distinctions in research cultures.

A second analysis examined the advantages of university-industry collaborations, as well as the disadvantages. Generally, both communities share similar views of the major advantages of university-industry research collaborations. Both groups see the collaborations providing new research funds and tools, support for students and post-doctoral fellows, expanding their network of scientists and enhancing product development. Both groups also agreed, albeit less strongly, that access to industry intellectual property was an advantage of the collaborations. There were significant differences between the two groups were on the issues of access to new knowledge and whether these collaborations elevated university prestige (both seen as lower by university scientists.

There is a much greater disparity when examining the two communities perceived disadvantages of university-industry research collaborations. Ingeneral,both groups perceived substantial advantages. However, the research partners held significantly different perspectives on 8 of 10 of the disadvantages. Scores for all the items were low when compared to scores on the advantage items, but the disparity between the groups is substantial. The greatest perceived disadvantage is the potential for conflicts of interest, followed by restriction of communication, inhibiting material transfer, and a de-emphasis of non-proprietary research. Other disadvantages such as potential lawsuits over intellectual property, limiting of student and faculty publishing, a de-emphasis of basic science and undermining of university scientists' credibility were seen as only moderately characteristic of UIRs.

While the perceived advantages are viewed as more strongly characteristic of UIRs than the disadvantages, particularly among the industry respondents, many industry scientists also expressed concern that the complementary roles of the two cultures may be eroding and contributing to negative consequences of the UIRs. Some of the most insightful observations of the appropriate division of labor between the two cultures surfaced in the debate about the effect of the Bayle-Dole Act. One industry respondent recognized the mixed results with the insightful comment, "there's generally now more emphasis placed on protecting intellectual property as opposed to publication, where it has caused issues is in conflicts with the mission of the university, especially land-grant (public) universities. Their goal is to ensure that these technologies are protected but commercialized for the public good. Nowhere in

the mission does it say for as much revenue as we can possibly generate. But they're focused now on revenue." These comments from industry participants indicate that even though they generally see research collaborations to have many advantages, they also recognize shortcomings.

CONCLUSION

This study of university scientists, university administrators, and industry scientists and managers who collaborate on agricultural biotechnology research supports the continued though modified thesis of the two cultures of science. Since these two groups of scientists are increasingly working together and collaborating on research, one might expect a great deal of convergence among them on the perceived characteristic of their research environment, and their views of the advantages and disadvantages of this collaboration. The findings, however, revealed that the participants in these university-industry research relationships continue to perceive very distinct cultures of science. The two cultures hold very different values and goals, characterize their research environments in distinctively different ways. While both communities view similar advantages to engaging in university-industry collaborations, they identify a wide range of concerns and disadvantages of these partnerships. There is a recognition that these disadvantages could negatively derail the advantages of the collaborations between the two cultures and undermine the complementary roles the two groups serve in commercializing knowledge.

These findings are paradoxical in terms of the long-term sustainability of the two cultures. The perceived disadvantages indirectly confirm the persistence of the two cultures, but they also indicate that there are shared concerns. After all, industry scientists indicate substantial concern regarding conflicts of interests, restricted communication, inhibited material transfer, a de-emphasis on non-proprietary research, lawsuits over intellectual property, the de-emphasis of basic science, and the undermining of the university's credibility.

Many researchers have noted that university science is only valuable as a generator of economic development if it maintains a degree of autonomy from industrial interests. Consequently, the increasing number and intensity of university-industry collaborations and the potential blurring of the distinct differences between the two cultures of science result in both real opportunities and challenges. Maximizing the public benefits from these increasing collaborations will require several actions:

- Monitoring the nature, goals, and outcomes of these relationships will be important. As Derek Bok (2003) [2], former president of Harvard University noted, "It will take very strong leadership to keep the profit motive from gradually eroding the values on which the welfare and reputation of universities ultimately depend"
- Second, it will require strong intelligent, creative and appropriate policies, practices and organizational arrangements to enhance university interactions with the private sector while protecting the autonomy and freedom of operation of university scientists. These policies should be both transparent and be directed at realizing the goals of both cultures of science. Several industry respondents acknowledged that the very independence and publicness of universities are what make university expertise valuable and publications legitimate. At the same time, it is the rise of UIRs that can erode the very thing that makes them valuable and turns university scientists into subcontractors;
- There needs to be adequate public agricultural research funding and support to ensure that public research institutions and the culture of science they promote are strong and complementary partners with industry. Only then can there be an appropriate balance between the goals and mission of the broad, long-term public interest emphases of the university and its scientific culture, and the narrower, short term, proprietary and profit interests of the private sector and the industry scientists culture.

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