

The Future of Governance in the Global Bioeconomy: Policy, Regulation, and Investment Challenges for the Biotechnology and Bioenergy Sectors

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Today more than ever, the global bioeconomy is the subject of focused attention from public policymakers, corporate decision makers, researchers in the social and biophysical sciences, and the general public. With both short- and long-term shifts in the world's demand and supply of agricultural and industrial production, there is growing concern over the economics of improving productive efficiency through science conducted at the genetic and molecular levels. Parallel to this, there is growing concern about global climate change, and the demand for environmental services from agriculture continues to increase. Food, fiber, feed, and fuel are all key elements of this global bioeconomy, and all are treated in this issue of *AgBioForum*.

The increasing demand of the bioeconomy's key elements can be met through two pathways: by increasing the land area cultivated with crops for food and biofuel production or by increasing the per-unit production on existing land under cultivation. Both an increase in productivity and an increase in land area under cultivation can have important environmental costs. Biotechnology used to increase the productivity of food, fiber, feed, and fuel production is a key technological opportunity in this effort. However, biotechnology brings with it a host of policy, regulation, and governance issues to the bioeconomy.

These issues were the focus of discussions at two events held in 2010: The 14th International Consortium on Applied Bioeconomy Research (ICABR) Annual Conference entitled "Bioeconomy Governance: Policy, Environmental and Health Regulation, and Public Investments in Research," and the 3rd Berkeley Bioeconomy Conference entitled "The Current Situation of Biofuel: Economics, Policy, Technology, and Research." This special issue includes a selection of 13 articles presented at the two conferences, and provides

an overview about the important governance issues at stake, from both theoretical and empirical perspectives.

The Political Economy of Governance in the Biotechnology Sector

There are differences in how countries regulate biotechnology, and a number of theories have been developed to explain these different regulatory regimes. Of particular interest is the difference between the United States and the European Union. While the United States leads in the approval of genetically modified (GM) plants developed by using modern biotechnology, the European Union has only approved two GM plants for cultivation. Johan F.M. Swinnen and Thijs Vandemoortele (Article 1) explain the divergence in approval by small differences in consumer preferences in the past that have resulted in differences in the regulatory systems and, as a consequence, in substantially large differences in the approval process. The authors discuss the EU's current authorization procedure for GMOs and illustrate how this has resulted in regulatory gridlock. They further describe some institutional reforms that are being proposed and undertaken at the EU level to overcome this gridlock. In the end, the authors remain skeptical about the impacts of the proposed EU institutional reforms on the approval of GMOs for cultivation.

But the approval process is only one among several governance issues facing the biotechnology sector. Carl E. Pray and Latha Nagarajan (Article 2) examine state-imposed price controls and their impact on innovation in India's bioeconomy. They find that although both farmers and seed companies benefited substantially from the first generation of Bt cotton introduced in India, the Indian government's introduction of price controls on Bt cotton in 2006 has had mixed outcomes. The controls increase the share of the benefits received by farmers, but reduce the technology's profit level for its technol-

ogy providers. The authors express concerns about the negative impact the price control will have on innovation and suggest that—while the time frame is too short to draw major conclusions—experiences from China and first observations within India strongly suggest a negative impact on innovation that may cause substantially more long-term harm to farm households than the short-term gains of price controls.

This observation is supported by the study of Maros Ivanic and Will Martin, ‘Poverty Impacts of Improved Agricultural Productivity: Opportunities for Genetically Modified Crops’ (Article 3). The authors show that increasing total-factor productivity in developing countries can substantially reduce poverty. The authors develop a number of scenarios investigating the potential effects of the technology on poverty reduction. These effects could be substantial if farmers have access to the technology. This returns us to the issue of governance in the bioeconomy, raising the question of whether or not the bioeconomy’s contribution to technological changes needed to reduce poverty will ever become available.

The Technology Pipeline and Evidence from the Field

Jennifer A. Thomson, Dionne N. Shepherd, and Hodeba D. Mignouna (Article 4) examine these very contributions of the bioeconomy to Sub-Saharan Africa’s agriculture. They draw our attention to a number of drought-tolerant and insect-resistant crops in the pipeline and illustrate how, in South Africa, government regulations are delaying access to many of these technologies.

Jeffrey D. Vitale, Gaspard Vognan, Marc Ouattarra, and Ouola Traore (Article 5) also examine the bioeconomy’s contribution to Sub-Saharan Africa with a study on Bt cotton adoption in Burkina Faso. Their study finds that Bt cotton cultivation contributed significantly to increasing cotton yields by an average of 18.2% over conventional cotton, while also increasing farmers’ profits by \$61.88 per hectare relative to conventional cotton.

Intellectual Property, Public-Private Partnerships, Public Policies, and the Bioeconomy

Public-private partnerships in biotechnology product development continues to garner attention, as does the management and protection of intellectual property (IP) used in product development. Dario G. Frisio, Giovanni Ferrazzi, Vera Ventura, and Mauro Vigani (Article 6)

provide an in-depth analysis of biotechnology patents filed in the European Patent Office (EPO) and US Patent and Trademark Office (USPTO). Results show a larger number of patents filed with the USPTO than the EPO, and a greater degree of market-oriented patenting behavior in the private sector when compared to public-sector patenting that is mainly focused on innovations useful in specific agricultural landscapes. Interestingly, European research centers are more focused on obtaining IP protection in the United States than in Europe. This provides a basis for addressing broader questions such as science policy in agriculture, public-sector IP policies, and the design of more effective IP management strategies to maximize the exploitation of patented technologies in the industry.

One of the broader issues affected by IP policies is the development of pest-resistance management. Often, pest-resistance management strategies are required to limit the regional adoption rate of the technology, thus reducing private-sector profits in the short run to potentially sustain profits in the longer run. Successful pest-resistance management often requires government intervention to organize private behavior as discussed by George Frisvold and Jeanne M. Reeves (Article 7). They argue that public and private plant breeding plays a critical role in developing stacked varieties that reduce the overreliance on single chemical compounds that cause herbicide resistance problems.

But government intervention—whether through regulation or through partnerships with the private sector—is often difficult to manage. Viktoriya Galushko, Richard Gray, and Stuart Smyth (Article 8) demonstrate this for the case of canola research in Canada, where over the past decade firms moved away from mergers-and-acquisition strategies to cross-licensing of IP. This affects the freedom to operate (FTO) within the industry and slows down the innovation process.

The Political Economy of Bioenergy Production

The governance issues faced by the biotechnology sector are also found in the bioenergy sector, another key element of the global bioeconomy. GianCarlo Moschini, Harvey Lapan, Jingbo Cui, and Joseph Cooper (Article 9) present results of different scenarios that assess the main welfare implications of US policies to support biofuels, with an emphasis on corn-based ethanol. The results of their open economy, multimarket equilibrium model that links world and domestic energy and agricultural markets, and explicitly accounts for the externalities

ties of carbon emissions, provides as a first-best solution a carbon tax, an import tariff on oil, and an export tax on corn. Although political considerations might render this policy unfeasible according to the authors, they propose a second-best policy with a fuel tax and an ethanol subsidy that can approximate fairly closely the welfare gains associated with the first-best policy. A clear lesson is that fuel taxes are a more powerful instrument for reducing carbon dioxide emissions and increasing welfare than are ethanol support policies per se.

These tax incomes or other sources can be used to support R&D for renewable energy. In case of a positive response by the private sector, investors nevertheless will be exposed to risk and start to lobby for protection. Gordon Rausser, Reid Stevens, and Kiran Torani (Article 10) address the question that arises of optimal R&D policy under such circumstances that avoid the pitfalls discussed by Moschini et al. They present an ex-ante portfolio analysis framework under risk and uncertainty based on expert elicitation, which can be developed further to better guide public-sector investments.

A related issue in the bioenergy sector is the effect of biofuel production on indirect land use. A major concern raised by some analysts is that biofuel production can induce indirect land-use changes that generate negative impacts on the environment, that in turn exceed the favorable impacts of biofuel production. David Zilberman, Gal Hochman, and Deepak Rajagopal (Article 11) investigate this issue in more detail. The authors argue that indirect land-use effects are a double-edged sword: once introduced, other indirect effects of biofuels may need to be considered that will increase the cost of biofuel regulations. The authors recommend a greater concentration on direct regulation of biofuels and direct efforts to reduce deforestation. This might be a more effective strategy to address environmental problems than policies aimed at addressing indirect land-use change.

Roger A. Sedjo (Article 12) investigates this topic in more detail. The interest in GM trees is the transfer of

traits that confer faster growth rates. However, the regulatory process in the United States tends to be slow and costly, to the extent that traditional breeding may achieve comparable results within the same amount of time and effort. This means that the innovator must assess which is more efficient and less costly—pursuing a traditional approach or through deregulation of a GM product. This is a situation being observed in the EU par excellence, where the regulation on GM plants (as discussed in Article 1) in combination with the regulations on biofuels make the release of GM technologies for biofuels almost impossible within the European Union.

Jadwiga Ziolkowska, William H. Meyers, Seth Meyer, and Julian Binfield discuss in ‘Targets and Mandates: Lessons Learned from EU and US Biofuels Policy Mechanisms’ (Article 13) the EU regulations on biofuels and compare them with the regulations found in the United States. It is evident for the authors that, despite many differences in the starting points, the US and EU policies are both converging toward more reliance on mandates (obligations) as the principal means to achieve policy objectives. Both regions also rely to varying degrees on subsidies, tax credits, and tariffs. Again, in building an industry so reliant on policy interventions, both regions have risked creating a situation where the removal of those policies would have significant impacts on parts of the rural economy and would therefore constrain the policy options for the future. A conclusion already provided for the regulation of biotechnology in the European Union. As Ziolkowska et al. argue, the regulation of biofuels resembles the results of the regulation on biotechnology, but not only in the European Union but also in the United States and governance issues seem to increase in importance in reaping the benefits of new technologies.

As the contributions in this special issue illustrate, we are just at the beginning of understanding the complexity of the subject. As substantial welfare benefits are at stake, governance of the bioeconomy warrants further investigation.