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Biorefineries in the biobased economy: opportunities and challenges for economic research

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Background and objectives

This special issue of Bio-based and Applied Economics (BAE) is devoted to the topic of biorefinery, with a focus on third generation biorefinery. In a broad technological definition, biorefinery is intended as the conversion of all kinds of biomass (all organic residues, energy crops, aquatic biomass) into a wide range of bio-based products, such as fuels, chemicals, power and heat, materials, food and feed (Demirbas, 2010). In this special issue we attempt to approach the biorefinery concept as defining a new business model involving the complete valorisation of biomass in energy, food, feed, biomaterials and bio based chemicals. The development of this industry opens important opportunities for many countries in a context of sustainability and competitiveness. Industrial initiatives are growing rapidly in Brazil, the USA, Italy, France, and Sweden. Biorefineries are more and more at the core of the bioeconomy visions at EU level and worldwide, as highlighted by the documents of the recent World Bioeconomy Summit (German Bioeconomy Council, 2015a; 2015b; 2015c). Their future development is connected to key developments, including sustainability concerns and the need of a decoupling from food production.

The evolution and the increasing relevance of biorefineries underscore the need for new economic and organisational knowledge about the concept of biorefinery and its practical applications. This also challenges researchers to provide new theoretical approaches, as well as empirical studies, including cross country

comparisons, scenario building, business model assessment, and analyses of impacts on economic growth and employment.

The objective of this BAE special issue is to address some of the main questions that the development of biorefineries will face in Europe, and the world over, from economic, strategic and organisational perspectives. The biorefineries are challenging economic research from several perspectives, some of which are explicitly in the background and form the motivation of this special issue. Firstly, the role that biorefineries will play in global/national/local sustainability transitions, including considerations of State vs. industrial group strategies, is an open issue. A perspective of this topic can be taken through international comparisons of the business models used by biorefineries: levels of horizontal/vertical integration, the role of cooperatives, processors and distributors, and the role of public-private partnerships (PPP) and public procurement. A second topic concerns instruments that are used for chain coordination related to biorefinery, in particular contracts and chain management approaches. A third issue that is of tremendous importance for the economy is the importance of territories and the local/regional anchoring of biorefineries, the role of farmers and farmer groups in the development of territorial biorefineries, and the role of cooperatives and professional bodies. Finally, when developing research on biorefineries, it is also of paramount importance to take into account the topic of the institutional environment, legal framework, international negotiations and public perceptions of the development of biorefineries. As a complementary view, an analysis and design of dedicated biorefinery policies and interactions with related existing policies (e.g. agricultural policy, waste policy, etc.) is also to be considered. We will see that, both directly and indirectly, these topics are emphasized in the following articles, with more theoretical and empirical developments on the question of business models, consumption and impacts of institutional environment.

We will present firstly the overall content of these articles. Secondly we will relate them to the wider scope on the question of biorefinery and to some directions for future research.

The papers in this issue

The three papers in this issue, being very different in scope and method, provide examples of different and complementary issues in addressing the topic of biorefinery.

Ceapraz, Kotbi and Sauvée (2016), in their article, put forward the underlying business models of the new generations of biorefineries, and more specifically the territorial biorefinery type, in opposition with the port biorefinery. They show that the concept of territorial biorefinery does not reach a consensus among scholars. Their article provides the key findings of several theoretical approaches, from socioeconomics of proximity to governance of territorial assets, industrial and territorial ecology and sociotechnical transition. They suggest that a clarification of what is the territorial biorefinery from a business model point of view and an

identification of their main characteristics should be made explicit in order to facilitate the manner in which practitioners study, develop and set up businesses of this kind.

Bonfiglio and Esposti (2016) investigate the impact on the economy of Sardinia (Italy) generated by a new biomass power plant fed by locally cultivated cardoon. The cardoon also serves the production of biopolymers. In their article the impact is assessed at an economy-wide level using two multiregional closed Input-Output models, which allow to take into account the entire supply chain activated and the supra-local effects generated by trade across local industries. The effects are computed under alternative scenarios simulating different levels of substitution of existing agricultural activities with the new activity (cardoon). Their results show positive and locally significant impacts in terms of value added and employment. However, these impacts are substantially influenced by the degree of substitution. Results also suggest that there are specific territorial areas that are more sensitive to negative effects induced by substitution.

The article by Sivashankar (2016) attempts assessing diesel vehicle owners' willingness to pay (WTP) for *Jatropha* biodiesel in Sri Lanka, and the factors affecting their decisions. The study was carried out in Kandy region among diesel vehicle users. The WTP was assessed using a Contingent valuation method (CVM). The factors affecting WTP were estimated using probit regressions. The mean WTP for biodiesel by the diesel vehicle users was 0.74 euro/litre for lower bound levels. The median WTP was 0.85 euro/litre. Elderly respondents with higher education are less likely to pay for biodiesel. Married respondents with higher income are more likely to pay higher prices for biodiesel.

Outlook and perspectives for future research on biorefineries

The articles in this special section, though small in number, show the diversity of effort needed for the economic analysis of biorefinery; in particular they hint at a need for contribution by economic literature in at least three directions. The first is a conceptual one, focusing on understanding of the logic of biorefinery and its connection with theoretical views and business models. The second concerns the modelling of the economics of biorefinery and its effects. The third concern evaluation issue related to the potential market and non-market role of emerging biorefinery solutions.

A common feature of the state of the art concerns the fact that that the biorefinery concept is largely addressed using ideas taken from other fields, and the level of specificity and adaption of the tools used is still rather low. However, as this special issue also shows, the development of the biorefinery in the biobased economy opens up some opportunities and needs for future research in trying to meet the specificities of concerned processes. In this section we identify a few of them.

First of all, if the biorefinery seems to be one of the building blocks of the biobased economy of the future, it is surely not the only one. The potential of the biorefinery to expand, especially in rural areas, and to become a significant part of the bio based economy is related to its ability to articulate economic aspects with environmental and social dimensions, as well as to match the needs of related sectors. The importance of integrated approaches of sustainability assessment questions heavily the research communities in their methodologies. Indeed, as we have seen in this issue, the real novelty of the biorefinery concept is the new representation that it provides of the functioning of the economy. The so called ecological economics approach already introduced a vision where natural and industrial processes are intertwined: the complementarities in terms of material, energy and information flows put strongly forward the need for an even extended system approach.

Systemic in spirit, the biorefinery is notwithstanding a business model that should be economically efficient. Researchers have shown that the categories of products that would emerge from the biorefineries would range from mass products to intermediary and even niche products, in the different categories of food and feed, bioenergy, biomaterials and biochemical products. Besides the traditional dichotomy dilemma, between market size (high or low)/market price (low or high), the opportunities of the biorefinery model in terms of future developments, of impacts for local producers (and thus rural development) are extremely contrasted. Future research should investigate how to reach optimal solutions in the trade-offs between relevant dimensions.

The biorefinery also question the topic of customer needs and customer behaviours, either at the industrial market level or at the consumer market level. We have seen in the past that the controversy faced by GMO products on the market found some resonance with the first generation biofuels in the food vs non-food uses of land. On the contrary, innovative biobased products open up possibilities of wider consumer and industrial acceptance. However, what it is still unclear is the pathway of change in these behaviours towards products that are sourced through renewable resources. In addition, technologies avoiding trade-offs with food production may yield other sources of preoccupation for citizens (e.g. when wastes are used).

From the technological side, the economic efficiency of different conversion technologies is one of the questions to be addressed. Researchers in social sciences could provide valuable insights in developing results not exclusively from static economics efficiency and optimization angle, but more from the dynamic process perspectives. Indeed, the ability of players to set up innovative triple helix models of collaboration between research organizations, institutions and private companies is a key enabling factor in the process. The diversity of open innovation models to back up third generation biorefineries will necessitate researches in organizational and institutional economics in parallel with more traditional approaches of economic optimization of alternative conversion technologies both within biomass sector and between other resources (solar, oil etc.).

A last issue that researchers should face is the question of territory. The development of biorefineries deeply redefined the link between the processing unit and the space where this economic activity is embedded. Again, in line with the systemic reasoning which is at the basis of the biorefinery concept, the way farmers belong and participate (or not) in the design of the biobased system is crucial. Researches on participatory approaches, on design thinking and on conception of innovative biorefinery models that integrates multiscale analysis will be a promising field of development for the research community.

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