

Editorial

Biorefineries in the bio-based economy: opportunities and challenges for economic research

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Guest editors

1. 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. As a broad technological definition, biorefinery is intended as the conversion of all kinds of biomass (organic residues, energy crops, aquatic biomass etc.) 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 approach the biorefinery concept with an eye to 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 increasingly at the core of the bioeconomy vision at the 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 for 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 challenges that the development of biorefineries will face in Europe, and the world over, from economic, strategic and organisational perspectives. 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 and local sustainability transitions, including considerations of State vs. industrial group strategies, is an open issue. This topic can be approached 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 particular importance for the economy is that of territories and the local/regional anchoring of biorefineries, the role of farmers and farmers organisations

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 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 these topics are emphasised both directly and indirectly in the following articles, with more theoretical and empirical developments on the issue of business models, consumption and impacts of/on the institutional environment.

We will first present the overall content of these articles. Second, we will relate them to the wider scope of the question of biorefinery and to paths for future research.

2. The papers in this issue

The three papers in this issue are very different in scope and method and 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 that of the territorial biorefinery, in opposition with the port biorefinery. They highlight that the concept of territorial biorefinery does not reach a consensus among scholars. Their article provides the key findings of several theoretical approaches, from the socioeconomics of proximity to governance of territorial assets, industrial and territorial ecology and sociotechnical transition. They suggest that a clarification of what constitutes the territorial biorefinery from a business model point of view and an identification of its 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) as a result of a new biomass power plant fed by locally cultivated cardoon. The cardoon in question also allows for the production of biopolymers. In their article, the impact is assessed at an economy-wide scale using two multi-regional closed Input-Output models that make it possible 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. The results also suggest that there are specific territorial areas that are more sensitive to negative effects induced by substitution.

The article by Sivashankar (2016) assesses 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 the 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.

3. Outlook and perspectives for future research on biorefinery

The articles in this special section, though limited in number, underscore the diversity of effort needed for the economic analysis of biorefinery; in particular, they hint at a need for contribution on the part of the economic literature in at least three directions. The first is a conceptual one, focusing on understanding 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 concerns the need for rigorous assessments of the potential market and non-market role of emerging biorefinery solutions.

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

First, although the biorefinery is one of the building blocks of the bio-based economy of the future, it is undoubtedly 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 directly 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 toward sustainability assessment brings into question the methodologies being used in the various research communities. Indeed, as we have seen in this issue, the veritable 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 whereby natural and industrial processes are intertwined: the complementarities in terms of material, energy and information flows highlight the need for an even more expanded 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 could emerge from biorefineries range from mass products to intermediary and even niche products, in the various categories of food and feed, bioenergy, biomaterials and biochemical products. Besides the traditional dichotomy dilemma, between market size (large or small)/market price (low or high), the opportunities of the biorefinery model in terms of future developments and impacts for local producers (and thus rural development) are extremely diverse. Future research should investigate how to reach optimal solutions in the trade-offs between relevant dimensions.

The biorefinery also brings into question the topic of customer needs and customer behaviour, 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 in the first generation biofuels with respect to the food versus non-food uses of land. On the contrary, innovative bio-based products open up possibilities of wider consumer and industrial acceptance. Yet, what remains unclear is the pathway for 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 concern for citizens (e.g. use of wastes).

From a technological perspective, the economic efficiency of different conversion technologies is one of the questions to be addressed. Researchers in the social sciences could provide valuable insights into developing results not exclusively from a static economics efficiency and optimisation angle, but more from dynamic process perspectives. Indeed, the ability of players to develop innovative triple helix models of collaboration between research organisations, 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 research in organisational and institutional economics in parallel with the more traditional approaches of economic optimisation of alternative conversion technologies both within the biomass sector and between other resources (solar, oil etc.).

A final issue that researchers must take into consideration is the question of territory. The development of biorefineries has deeply redefined the link between the processing unit and the space in which this economic activity is embedded. Once again, in line with the systemic reasoning that is at the base of the biorefinery concept, the way farmers belong to and participate (or not) in the design of the bio-based sectors is crucial. Research into participatory approaches, design thinking and the conception of innovative biorefinery models that integrate multi-scale analysis provide promising opportunities for the research community.

A few references

- Cherubini, F. (2010). The biorefinery concept: using biomass instead of oil for producing energy and chemicals. *Energy Conversion and Management*, 51(7), 1412-1421.
- Colonna, P., Tayeb, J., & Valceschini, E. (2015) Les nouveaux usages de la biomasse. Le Déméter, Paris.
- Chertow, M., & Ehrenfeld, J. (2012). Organizing Self-Organizing Systems. *Journal of Industrial Ecology*, 16(1), 13-27.
- Demirbas A. (2010). Biorefineries. For biomass upgrading facilities. Springer-Verlag, London.
- German Bioeconomy Council (2015a). Bioeconomy policy (Part I). Synopsys and analysis of strategies in the G7. Office of the Bioeconomy Council, Berlin.
- German Bioeconomy Council (2015b). Bioeconomy policy (Part II). Synopsis of National Strategies around the World. Office of the Bioeconomy Council, Berlin.
- German Bioeconomy Council (2015c). Global Visions for the Bioeconomy – an International Delphi-Study. Office of the Bioeconomy Council, Berlin.
- Kokossis, A. C., & Yang, A. (2010). On the use of systems technologies and a systematic approach for the synthesis and the design of future biorefineries. *Computers & chemical engineering*, 34(9), 1397-1405.
- Langeveld, J. W. A., Dixon, J., & Jaworski, J. F. (2010). Development perspectives of the biobased economy: a review. *Crop Science*, 50(Supplement_1), S-142.