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From Agricultural to Bio-based Economics? Context, State of the Art and Challenges

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The world economy is experiencing dramatic changes. The key issues for the future appear to be increasing human demands (food, energy, environmental public goods) that will put greater pressure on natural resources, exacerbating old scarcities and leading to new ones (water, biomasses, environmental quality). Agriculture has gone through an innovation process attaining long-term productivity growth, but has also become less central to the production of bio-based products, though remaining a key sector.

Disciplines related to bio-based industries and rural issues are searching for a better understanding of their potential role in future research and policy-making, and, finally, in contributing to society's ability to face the major challenges ahead. While major changes have already occurred in these disciplines in recent decades, the on-going trends and perspective scenarios seem to involve further challenges, as witnessed by the changing aim and scope of scientific research and publications, as well as university curricula. The variety of academic literature in the field is increasing remarkably and, for some issues, such as bioenergy and biotechnology, the number of contributions has been growing exponentially.

In this context, the concept of bioeconomy (or bio-economy, or bio-based economy) has emerged as a key strategy to match human needs while facing resource efficiency requirements, based on the sustainable exploitation of biological resources. Actually the definition of the term 'bioeconomy' is still a matter of discussion (see Schmidt et al., 2012). On the policy side, after having proposed several different definitions in recent years, the EU Communication on the Bioeconomy (European Commission, 2012a) does not provide a clear-cut definition. The accompanying working document (European Commission 2012b) states that "the bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Its sectors have a strong

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innovation potential due to their use of a wide range of sciences (life sciences, agronomy, ecology, food science and social sciences), enabling and industrial technologies (biotechnology, nanotechnology, information and communication technologies (ICT), and engineering), and local and tacit knowledge."

Based on this delimitation, the EU bioeconomy accounts for an annual turnover of 2.046 billion euro (of which 965 come from the food sector and 381 from the agricultural sector) and 21,5 million employees (of which 4,4 million are employed in the food industry and 12 million are employed in the agriculture sector) (Clever Consult BVBA, 2010).

Besides its economic weight and potential, the bioeconomy represents a major challenge for policy and research. The recent BECOTEPS (2011) white paper emphasizes that a "successful bioeconomy needs coherent and integrated policy direction", with key areas of action including: investment in research, encouraging innovation, strengthening entrepreneurship in the bioeconomy, providing a skilled workforce, guaranteeing an innovation-friendly regulatory framework which balances both risks and benefits, and a good two-way communication with the public embedded in R&D projects to ensure societal appreciation of research and innovation. Several of these challenges are already taken up in the draft documents on the Horizon 2020 research and innovation program of the EU (European Commission, 2011).

In this context, the Italian Association of Agriculture and Applied Economics (AIEAA) is launching a new journal, "*Bio-based and applied economics*" (BAE). The main questions behind this initiative are: why a Journal on bio-based economics? And, why is it launched by a scientific society of agricultural economists? We will try to answer these questions by briefly reviewing current trends in the evolution of academic responses to past, recent and emerging research needs in the field of agriculture economics and its interaction with the closest fields of economics, building on this examination to single out relevant challenges for future research. As expected, a systematic review of all issues related to the evolution of agricultural economics and the potential emerging field of the "bio-based economics" is too wide to be addressed in a single article. We rather focus on some key trends and exemplary cases, mainly in order to kick-off the debate and set the stage for a research forum in this broad field, which is what this Journal aims to be.

1. Evolution of agricultural economics

Both in the US and Europe, agricultural economics arose from the fields of Agronomy and Economics, as the first scholars mainly focused on farm management (Nou, 1967; Olsen, 1991). The agronomic ascendant is linked to the peculiarities of agricultural production, that is usually conceived as a process, namely "a set of tasks with a certain length in time that unfold along the time dimension, at given dates, with characteristics defined by agronomic techniques" (Romagnoli, 1990). The firm and the organisation of production were the economic themes at the core of the discipline as is illustrated by the corresponding entry in the New Palgrave Dictionary of Economics: "Agricultural economics arose in the late 19th century, combined the theory of the firm with marketing and organization theory, and developed throughout the 20th century largely as an empirical branch of general economics" (Runge, 2008).

Later, the interests of the discipline widened to the economics of the agricultural sector and the related policies as witnessed by the renaming of the Journal of Farm Economics, which became the American Journal of Agricultural Economics in 1968. Driven by the contraction of the agricultural sector in developed countries and the quest for a wider field of investigation, the discipline has never ceased to enlarge its scope outside the boundary of agriculture.

Runge (2008) identifies seven broad areas in which agricultural economists have made "distinctive contributions" since the 1970s. The list substantially mirrors the structure of US-based reference texts such as the Handbook of Agricultural Economics (Gardner and Rausser, 2001):

- technical change and returns to human capital investments;
- environmental and resource issues;
- trade and economic development;
- risk and uncertainty;
- price determination and income stabilization;
- market structure and the organization of agricultural businesses;
- consumption and food supply chains.

As the issue of trade and economic development gained momentum in the 1970s, the focus shifted to overall regional development of rural areas worldwide, highlighting topics such as the linkages between agriculture and non-agricultural sectors in rural development, the competition for the use of land and environmental externalities of agriculture. By the late 1980s further areas were added, notably food industry and policy, biotechnology, agricultural research, farming systems and environmental issues (Bellamy, 1991).

Overall, the changing scope of the discipline may be traced back to three main characteristics of the agricultural (and forestry) production processes: their biological nature, the presence of land as a basic (and scarce) resource and the horizontal division of labour that increasingly affected agriculture in the 20th century.

Land provides the link between agricultural and rural economics. In the countryside a large portion of the soil is used by agriculture but agriculture is not the sole economic activity that takes place in rural areas. Integrated development of rural areas is often based on a coherent network of primary, secondary and tertiary activities that exploits the specific potentiality of places and communities. In agriculture, the heterogeneity of land is the source of "location specific factors" (Nerlove, 1996) that affect human capital through the role of contextual knowledge of soil and environmental conditions that is shared by farming communities (Ray, 1998). Thus, social and technological factors contribute to extend the scope of agricultural economics towards rural economics. Rural economics, however, has gained wider and more complex dimensions over time, including relations with other sectors.

The process of the horizontal division of labour and the increased importance of processes located downstream of agriculture is the source of the growing interest of many agricultural economists in food economics. The division of labour and the related productivity gains and the increasing size of markets explain how most of the activities and functions that were once performed at the farm level have been increasingly carried out in other sectors of the economic system. This is also at the roots of the Agribusiness (Davis and Goldberg, 1957) and Agri-Food System approaches (Malassis, 1973).

2. Tracing connections between agricultural economics and the bioeconomy: selected examples

Several examples may be used to qualify the new bioeconomy challenges and to trace their connections to agricultural economics.

If one considers the demand side of markets for bio-based products, especially food, the main challenge for the future is clearly that of securing safe food for an increasing population in a profoundly changing world. According to FAO estimates, in 2030 the average daily per-capita consumption will reach 2850 kcal while the additional annual food energy production required to meet global needs will be about 2,000,000 billion kcalories. Of course, the steady and unpredictable growth of emerging economies, *in primis* China and India, will likely put an even stronger pressure on food demand, especially if associated with a transition of diets towards animal products. At the same time, the steadily growing demand for bioenergy, although motivated by the need to control for greenhouse gas emissions, will compete for the use of renewable resources (mainly land).

Traditional economic determinants (prices and income), although still important, have been losing relevance in explaining food consumption in advanced economies; other factors have been gaining more and more relevance. Even the traditional framework of a fully rational utility-maximizing food consumer has been challenged, since choices often appear to be attributable to irrational or purely instinctive behaviour as witnessed by the growing relevance of unhealthy diets, obesity or overreaction to food scares. In this context, the role of information is, of course, crucial: information provision becomes a key element in consumer reactions, and the lack of information is an explanation for behaviour. The existence of 'uncertainty' related to food choices (uncertainty regarding product attributes and quality, food safety, health consequences, etc.) will worsen the problem and boost the attention given to relatively new fields of investigation, such as behavioural economics. The ramification of the interest of economists in underexplored areas is even more apparent when one looks at the growing number of multidisciplinary works involving scientists from the biological sciences, which fit very well with the title and aims of this journal. It is not necessary to go as far as neuroeconomists (or even neuromarketing experts) do and look at the interaction between brain functions and consumer choices (Mirja, 2010). This is especially the case when looking at the relationship between food consumption and health; recognising that it is bi-directional (hence extremely difficult to model!) leads to very interesting pathways even in 'standard' economic research (Strauss, 1998; Shogren, 2005).

An example on the supply side is the issue of innovation. Agriculture and the bioeconomy are presently dominated by projections concerning production needs of food, fibres, bioenergy and biomaterials (biodegradable plastics, bio-based polymer, biopharming), and related trade-offs. Agriculture will have to face the challenge of securing enough supply without impoverishing natural resources. One route to meet these competing goals is either to increase arable land beyond current levels or to increase yields. Increasing yields can be reached through technological progress, the rate of which has been slowing down in recent years; one possible solution may be the growing research effort in agricultural biotechnology, mainly devoted to contrasting abiotic and environmental stresses, also allowing to reintroducing crops to marginal areas without resorting to sowing previously uncultivated land. Food energy supply will also greatly benefit from more attention towards 'waste': this

will imply a greater efficiency in food processing and marketing, reducing losses along the supply chain, as well as in the purchase, preparation, consumption and disposal of food. Once again, biotechnologies at both the agricultural and the processing level may help in reaching such objectives. A guiding issue in the study of innovation is the discrepancy between the speed of development of new technologies and the factors hampering innovation potential in the agricultural and food sectors (Brander, 2009). While one could affirm that "there is little doubt that technological innovation is the most important economic force underlying improvement in the human condition and that more inputs are being provided to the innovation process than ever before" (Brander, 2009), the study of innovation adoption has always emphasized the complexity of the process. This is made even more relevant by the recent emphasis on the interaction between consumer concerns and the production of innovation itself, as witnessed by the GMO debate in the EU.

More generally, a bioeconomy is characterised by forms of technical progress that may loosen up the constraints of relative resource scarcity (Quadrio Curzio et al., 2011) as agricultural innovations did in the 1970s. However, biotechnology can also compete with other more traditional agricultural activities for the use of scarce resources as in the case of first generation biofuels that reallocate land towards non-food production with potential impacts on food prices (Mitchell, 2008).

On the policy side, recent contributions on the most appropriate policy to build a bioeconomy (see the EuropaBio, 2011) outline the need to move from a number of sectoral and separated policies and funding mechanisms to a more integrated and holistic approach. This implies coordination among policies in different areas such as climate change, energy security, renewable feedstock supplies, research and innovation, agriculture, environment and trade. This quite ambitious approach is fully embedded in the EUROPA 2020 strategy and the on-going debate on the 2014-2020 financial perspectives. The CAP is mentioned as a central component of the bioeconomy strategy (European Commission, 2012a), paving the way for new potential areas of reform for the CAP and related research challenges. Nowadays, one key research area is the role of the CAP in promoting the sustainable management of natural resources and in the provision of environmental public goods. In this regard, the manner in which policy instruments are designed and targeted is crucial in understanding policy efficiency and effectiveness.

This comes on the heels of at least two decades in which a number of societal concerns have dominated the agriculture policy agenda (Swinnen, 2008) leading to a long lasting reform process, which began at the end of the 1980s and the early 1990s under several pressures, including market surpluses and international trade liberalization agreements. This is also confirmed by the current debate on the CAP reform for the 2014-2020 period.

A major point of connection between agriculture and the bioeconomy is in the field of public policy and institutional arrangements that regulate innovation, production processes and the allocation of intellectual property rights. In the case of gene technology, for example, it is the very nature of living things that makes the allocation of property rights problematic (CIPR, 2002). Plant genetic resources are often available because generations of farmers contributed to their conservation and development. How this contribution should be rewarded or protected is a debated issue (CIPR, 2002). To some extent this debate echoes property rights issues in environmental and food economics. Most environmental goods provided by nature are considered in legal systems to be based on Roman

law, *res nullius* or *res communis,* that is things common to all and usable by all citizens (Brans, 2001, p. 36-37). Similarly, geographical indications in the food system are considered to be the property of communities rather than of single individuals (Moran, 1993).

A major cross-cutting issue is that of societal coordination and decision-making, bringing together the different roles of human beings as consumers, agents of the production process and "citizens". The debate about some of the key components of the bioeconomy, (i.e. biotechnology), has drawn attention to the issue of wider societal coordination. While this is often simplistically narrowed down to a mere problem of communication, it actually calls for a stronger focus on the interface between economics, psychology, sociology and political science in studying how institutions evolve in responding to external drivers. In this context, a growing area of attention for research is social innovation, in the wider sense of studying innovation in social structures and institutions.

A further stimulating area of interaction lies between this broad field and that of rural governance. The concept of "rural governance" itself has only recently been thoroughly examined and developed in the literature. Goodwin (1998) highlights the existence of an incomprehensible lack of interest in rural studies regarding the modalities with which rural areas are governed. This appears in sharp contrast with what has instead taken place in other fields of the social sciences, where issues relating to governance have long since assumed a certain theoretical importance. This is also in contrast with policy concerns. The recent Barca Report (2009), for example, puts governance at the centre of the reform for the new Cohesion Policy 2014-2020.

Altogether, we can argue that technological factors are still at the core of the recent trends towards the expansion of agricultural economics research, namely the path towards bio-based economics, with a common distinguishing focus on technologies based on biological processes. Production processes based on the biological means of production without (extensive) use of land are widespread in the field of fisheries and aquaculture, or in microbiological production of algae, yeasts or drug substances. Compared to the previous broadening of the subject, e.g. towards studying fisheries or forestry, the bioeconomy is much wider in scope, as shown by the definitions mentioned in the introduction. Besides being broader in the range of sectors involved, it encompasses both primary, secondary and tertiary activities (such as the agri-business sector), but it draws particular attention to innovation and dynamic aspects of such activities and broadens the concept of the consumer to better account for a variety of human needs and their interaction.

On the other hand, being so broad in scope, the bioeconomy does not share all the technological peculiarities of agriculture that, in turn, determine the patterns of production organization in the sector (such as the role of family vs. capitalistic farms). Indeed, certain biotechnological processes, such as those involved in bioplastic production, are akin to the production processes in the chemical industry and have similar economies of scale.

3 Discussion and future challenges

The opening question was: Why does an agricultural economics association launch a Journal on Bio-based economics? The answer to this question can be largely found in the analysis of the contents of the evolving field of agricultural economics and the emerging area of the bioeconomy, which has allowed to emphasize several connections and simi-

larities, particularly in relation to the distinguishing character of dealing with biological resources. At the same time, several emerging areas of research in agricultural economics already address issues that are included in the definition of the bioeconomy. This is, on the other hand, not exclusive of agricultural economics, as areas such as biotechnologies, bioenergy and innovation are already largely addressed by environmental and applied economics, as well as by industrial and organization studies.

Projecting this consideration into the future would require a further discussion – based on the above – that could be structured around three main questions: a) Are we really witnessing a move towards bio-based economics? b) Are we able to define this field of research with some precision? c) What are the key directions for further research in this field?

The answer to the first question is a (partial) yes. Though it may be too early to identify a new field of research and education, there appears to be scope for this area to emerge and it is also up to the academics to develop and shape such disciplinary area, as it is already the case in the policy sphere. This is emphasized by the growing number of initiatives targeting the bioeconomy as a research subject (e.g. conferences such as: ICABR, IAAE 2012, AIEAA 2012) and the policy attention given to the concept of the bioeconomy.

The answer to the second question could be either a (qualified) yes or a (even more qualified) no. The impression from the literature is that while a reductionist vision of the bioeconomy (i.e. based on a list of sectors) seems to be the most straightforward, a definition based on key technological or institutional characteristics remains a problematic issue. It is interesting to note that, in this field, academic research and policy development have initiated a debate. How this debate is likely to lead to the foundation of a separate branch of economic analysis is still unclear. This is a challenge for a newly founded Journal, but at the same time provides ground for scientific discussion and is hence a stimulating context to start with.

This leads to the third question – maybe the most difficult one – about future research directions. It would be too easy to conclude that this question is too broad and that answering it is beyond the scope of this paper. As a first step it could be argued that there are at least two directions for attention. The first is the large bulk of specific research fields related to individual issues. Consumer sciences, markets, property rights, and innovation, are but a few examples. Attention to individual sectors appears to be even more telling in this respect if we consider the economic and social aspects of bioenergy, biotechnologies and biomaterials. The second challenges the real meaning of the broad concept of bioeconomy for research and for policy making. What is the added value of the concept of bioeconomy as a whole and how could this comprehensive approach help economic analysis and policy design, besides the common issue of biological resources and the importance of strengthening links between different sectors? This is likely the most difficult but also the most interesting question, and likely the one to which researchers should pay particular attention in the years to come.

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