EDUCATION FOR BIOECONOMY IN ROMANIA – AN EMPIRICAL INVESTIGATION OF HIGHER EDUCATION PROGRAMMES

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Abstract
The aim of the paper is to explore the place and importance of bio-economy and its related topics in the academic curriculum of higher education institutions (HEI), I addition the paper debates their stake in the current society and economy & expected challenges and opportunities. From a methodological point of view we apply an empirical content-based analysis of the academic curriculum from several Romanian universities. This helps us to map bio-economy topics and to present main conclusions regarding the question of how well the Romanian education system is prepared to train specialists in bio-economy. Furthermore, we provide recommendations and suggestions that might be adopted by HEI such as to be prepared to play an important role in achieving *the Europe 2020 goals* with respect to *a long-term smart, sustainable and inclusive development* through *bio-economy*.

Keywords
Bio-economy, academic curriculum, higher education institutions, training

JEL Classification
Q01, Q57, I23

Introduction

Bio-economy has recently become one of the most important European Union concerns within the broader objectives of achieving a smart, sustainable and inclusive development. To this purpose, in 2012 the European Commission developed *the Bio-economy Strategy*. The key issues included within this strategy refer to the development of new technologies and processes dedicated to bio-economy, but also to the development of markets and competitiveness within the bio-economy sector, by supporting a better co-operation between policymakers and stakeholders (European Commission, 2012). The term bio-economy was coined by the Romanian origin economist Nicholas Georgescu-Roegen (Iancu, 2006). European Commission uses term *Knowledge-Based Bio-economy* referring mainly to the process of transforming life-science knowledge into new, sustainable, eco-efficient and competitive products (Aguilar, et al., 2009). Bio-economy refers also to the transfer of biological sciences knowledge such as to contribute to the production of environmentally friendly and competitive outputs (Sasson and Malpica, 2018). According to the Organisation

for Economic Co-operation and Development (OECD), bio-economy encompasses numerous economic activities that benefit from new discoveries and related products and services generated by the biosciences (OECD, 2006).
Some of the areas that can mostly benefit from the development of bio-economy are: agriculture, food industry and nutrition, health, environmental protection industries, energy, security, etc. The OECD states that bio-economy refers to refer to *the aggregate set of economic operations in a society that use the latent value incumbent in biological products and processes such as to capture new growth and welfare benefits for citizens and nations*.

1. Brief review of the scientific literature

D'Amato, et al.(2017) argue that Bio-economy is related to *the Circular Economy* and *Green Economy* in that all three concepts are meant to reconcile the economic, environmental and social dimensions of development. However, bio-economy seems to stand out through its focus on resources, biosecurity and rural policies. These authors base their research highlighting that bio-economy has to take into account the requirements according to which *industrial inputs should be derived mostly from renewable biological resources*. Thus many of the research studies and innovation are enabling and facilitating such *a complex, dynamic* and *transformational process*. The authors further identify the main research topics related to bio-economy such as: biomass and renewables in energy production, rural policies, bio-technologies applications in health science and, correspondingly, in the materials sciences, bio-mass supply/demand and bio-security. While the *environmental concerns* regard bio-security, crops, species, risks, yield and invasive, the *social concerns* include: rural policies, research & applications in health science.
Bugge et al. (2016) argue that there are three visions of Bio-economy:

- *the bio-technology vision*, which stresses the role of bio-technology research and application and, correspondingly, the commercialisation of bio-technology;
- *the bio-resource vision*, that refers to the processing and upgrading of biological raw materials and to the establishment of new value chains;
- *the bio-ecology vision*, that implies the optimisation of energy and nutrients use, but also the promotion of biodiversity and avoidance of monocultures and soil degradation.

Due to the relatively high profitability of agricultural research and development and to the rapid population growth compared to the rate of increase in food resources, as well as to environmental concerns, Beachy (2014) argues that a reconfiguration of the research funding and technology transfer mechanisms is needed in order to better, faster and more efficient and effective use of modern discoveries in this field. Among the required changes, *the education and research pillars* have to be reconsidered.
The author incriminates and often points out to the inappropriate and insufficient practical training of the graduates of the HEI in biosciences. This vision seems to be opposed to the appropriate cooperation between engineering higher education institutions and the private sector, whence the proper training of engineers. Conversely, there are authors criticising the increasing attention paid to the bio-economy and bio-concepts, arguing that this phenomenon is just new political discourse rather than a new genuine analytical work. However, it is acknowledged the role of the education science for the bio-economy (Birch, 2017). Irrespective of the definition or understanding of bio-economy, it is obvious that it has recently become an extremely important stake within the objective of achieving smart sustainable and inclusive development. Thus we consider bio-economy can be one of the answers to the current issues of the global economy (food and energy security, healthcare, environmental protection, etc.). Moreover, there are researchers who suggest that, besides the economic, environment and social benefits of the bio-economy, the latter can be reach as far as becoming a yardstick of a new type of political power and technological supremacy.

Due to the global interest in the stakes and benefits of bio-economy, it is high time that the higher education institutions (HEI) have to be prepared to meet the current economic, environment and social requirements. It can be done like this by adapting the academic curriculum to the latest developments of bio-sciences by fostering a tight and close relation with the industry, on the one hand, and by preparing the future specialists in the life sciences and engineering to be equipped with knowledge and skills in the field of bio-economy.

2. Research methodology

We conducted a study of the academic curricula of twelve public universities in Romania, which fall under the following four categories: universities of agronomic sciences and veterinary medicine (*University of Agronomic Sciences and Veterinary Medicine of Bucharest – UASVMB, University of Agronomic Sciences and Veterinary Medicine of Cluj-Napoca – UASVMCN*), universities or faculties of medicine and pharmacy (*Carol Davila University of Medicine and Pharmacy of Bucharest – CDUMPB, Iuliu Haţieganu University of Medicine and Pharmacy of Cluj-Napoca – IHUMPCN, Victor Babeş University of Medicine and Pharmacy of Timişoara – VBUMPT, Gr. T. Popa University of Medicine and Pharmacy of Iaşi – GTPUPMI, University of Oradea - Faculty of Medicine and Pharmacy of Oradea* – UO, *Ovidius* University of Constanţa - Faculty of Medicine, Faculty of Pharmacy – OUC); technical universities (*Politehnica University of Bucharest – PUB, the Technical University of Cluj-Napoca – TUCN*); general universities (*University of Bucharest – UB, Dunărea de Jos University of Galaţi – DJUG (non-medical faculties*)).

The main selection criteria for the universities included in our study were: all selected universities are public universities; all selected universities are accredited universities; selected universities are raking *top positions* in their field on national level; selected universities provide life sciences or engineering academic programmes or are general universities teaching bio-economy subjects. All the academic curricula programmes in force at the time of writing this paper (*the academic year 2017/2018*) were explored, both those *for undergraduate studies* and those for *master studies*.

The main objective of our paper was to screen them and to identify to what extent bio-economy-related subjects are being taught in higher education programmes, to explore the nature of such subjects, to find similarities between the curricula of different universities having the same profile, and to draw conclusions as to how life sciences are included in engineering studies and as to how engineering subjects are included in life sciences studies. The information was found on the official websites of the universities mentioned above.

3. Main results and discussion

There is a wide array of subjects related to the bio-economy, but for the scope of our paper we have sought to identify the existence of the following subjects: *Biotechnology, Bioengineering, Biomaterials*, as well as their derivatives, within the academic curricula of the selected universities. These *three main generic subjects* will be further analysed separately. We further present *Biotechnology-related subjects* for the first type of university investigated, that of *agronomic sciences and veterinary medicine.*

The two universities under scrutiny, the one in Bucharest (*UASVMB*) and the one in Cluj-Napoca (*UASVMCN*) provide numerous specialised subjects in the field of Biotechnology.

The distinction between undergraduate and graduate subjects is of lesser importance in this analysis, reason for which they are listed altogether, without any discussion about the programme to which they belong. *UASVMB* teaches the following subjects at *the Faculty of Biotechnologies*: General Biotechnology, Food Biotechnologies, Biotechnology and Food Security, Fermentation Biotechnologies, Biotechnology and Food Security, Medical Biotechnologies, Biotechnological Therapy Products, Biotechnologies in the Pharmaceutical Industry, Residual Products Recycling Biotechnologies, Biotechnologies in Environmental

Protection, Biotechnological Installations, Quality Control of Biotechnological Products. Besides, the Faculty of Horticultures teaches Applications of Biotechnologies in Fruit Farming, the Faculty of Animal Productions, Engineering and Management teaches Food Biotechnologies in Animal Nutrition, Reproduction Biotechnologies and Biotechnologies, Residual Products Recycling Biotechnologies, while the Faculty of Veterinary Medicine teaches Food Biotechnologies and Reproduction Biotechnologies. *The second university, UASVMCN* has the following educational offer: Biotechnologies, Agricultural Biotechnologies (at the Faculty of Agriculture), General Biotechnologies, Food Biotechnologies, Residual Products Recycling Biotechnologies (at the Faculty of Food Science and Technology), while the Faculty of Animal Science and Biotechnologies teaches: General Biotechnologies, Biotechnologies in the Food Industry, Biotechnology of Fermentation Processes, Biotechnological Methods for Plant Improvement, Biotechnologies for Processing and Quality Control of Plant and Animal Products, Biotechnology for Embryo Transfer and In-Vitro Fertilisation, Embryo-Related Biotechnologies, Pharmacology and Pharmaceutical Biotechnologies, Residual Products Recycling Biotechnologies, Biotechnologies Applied in Preproduction, Biotechnological Installations.

One important conclusion is that in both universities Biotechnologies faculties operate - either as *a stand-alone specialisation (in Bucharest*) or as part of *the Animal Science* faculty (*Cluj-Napoca*).

It is worth mentioning that *the subjects taught in both universities* cover fields such as: *general biotechnologies and biotechnologies applied in agriculture and the food industry*, *animal industry* (reproduction IVF and embryo-related), *medicine and pharmacy* (healthcare), *environmental issues, quality contro*l and *installations*.

Moreover, faculties *specialised in one branch*, for instance in animal science, include in their curricula *subjects from related fields as well*, i.e. *agriculture*. There is an obvious intertwining of such subjects, which is an asset of these study programmes because they ensure training in the specific areas of study, but also extend the knowledge and skills in adjacent fields. Graduates of *the Faculty of Animal Science* and *Biotechnologies* will be equipped with skills in *Animal Science*, but also in *Vegetal, Medical, Pharmaceutical* or *Environmental Biotechnologies*.

The analysis of *the universities/faculties of medicine and pharmacy* reveals *a common point in the academic curricula* - all the six faculties of pharmacy included in the study provide education in the field of biotechnologies within the common subject titled *Drug Industry and Pharmaceutical Biotechnologies*, which is salutary with regard to equipping the future pharmacists with skills in this field. Only two out of six universities extend their studies of biotechnologies to their other faculties, and in only one university there operates *a dedicated faculty of biotechnologies*. Thus, the academic offer of *IHUMPCN* also includes subjects like: Medical Biotechnologies (at the *Faculty of Medicine*) and *Food Biotechnologies* (at the *Faculty of Pharmacy*). Similarly, *GTPUMPI* teaches Biotechnologies and Nanotechnology at its *Faculty of Medicine*, as well as Medical Biotechnologies at *the Faculty of Medical Bioengineering.*

The educational offer of technical universities is a lot similar in terms of variety and scope to that of universities agronomic sciences and veterinary medicine. To illustrate this, we further present *the biotechnology subjects taught at PUB*. *The Faculty of Biotechnical Systems Engineering* teaches the following subjects: Biotechnologies Automation of Technological Processes and Biotechnologies, Theory of Biotechnical Systems, Analysis of Biotechnical Systems, Biotechnical and Ecological Systems, the Faculty of Medical Engineering teaches Biotechnology, the Faculty of Applied Chemistry and Materials Science teaches General Biotechnologies, Food Biotechnologies, Fermentation and Biotransformation Processing Biotechnology, Bionanotechnologies, Pharmaceutical Biotechnologies, Biotechnologies for Environmental Protection, Residual Products

Recycling Biotechnologies, Biotechnological Installations Design, Quality Control of Biotechnological Products, Risks in Biotechnology Membrane Separation and Biotechnologies, Applications of Low Temperatures in Biotechnologies, Oxidic Materials Used in Biotechnologies, Enzyme and Protein Biotechnology, the Faculty of Materials Science and Engineering teaches Biotechnology Elements and *the Faculty of Entrepreneurship, Business Engineering and Management* teaches Biotechnologies.

According to our main results it seems that, in our country, the best educational offer in terms of biotechnology knowledge and skills is provided by *the Faculty of Applied Chemistry and Materials Science.*

The types of subjects are *very similar* to those taught in the faculties of biotechnologies of universities of agronomic sciences and veterinary medicine (general biotechnologies, food and food-related biotechnologies, pharmacy, environmental biotechnologies), in addition to which *very specific and technical subjects* are included. Biotechnologies are included in the academic curriculum of *the Faculty of Biotechnical Systems Engineering*, with a focus on the specific field of study. In our opinion, a single subject of *Biotechnologies* could be deemed as insufficient for the academic curriculum of *the Faculty of Medical Engineering.*

Last but not least, the inclusion of biotechnologies in the academic curriculum of the *Faculty of Entrepreneurship, Business Engineering and Management*, an engineering and economics faculty, is salutary and an example to follow.

The se*cond technical university analysed, TUCN,* provides studies of Industrial Biotechnologies at *the Faculty of Civil Engineering*, as well as Current Biotechnologies through *the Department of Chemistry and Biology*. Eventually, two general universities have been included in the study in order to identify to what extent biotechnologies have penetrated their academic curriculum. *UB* teaches Biotechnology, Applied Genetics and Biotechnology and Microbian Biotechnology and Genetics at *the Faculty of Biology*, while *DJUG* teaches Biotechnologies at *the Cross-Border Faculty of Humanities, Economics and Engineering*. The conclusion is that *general universities* do not include Biotechnologies in their academic curriculum unless they provide life sciences or engineering studies.

Bioengineering studies are taught by *technical universities* or by *medicine and pharmacy universities*. Thus, *PUB* teaches *Information Bioengineering*, *Information Bioengineering, Bio-Devices* and *Cell Nanotechnology* at *the Faculty of Electronics, Telecommunications and Information Technology, Bioengineering Quality Management* and *Regulations* at the *Faculty of Medical Engineering, Bioengineering* at *the Faculty of Automatic Control and Computer Science, Modelling and Simulation Applied in Bioengineering* at *the Faculty of Materials Science and Engineering and Carbon-Based Polymeric Nanomaterial for Bioengineering Applications at the Faculty of Applied Che*mistry and *Materials Science*. *TUCN* teaches Introduction to Biomedical Engineering and Special Issues in Biomedical Engineering at *the Faculty of Electrical Engineering*, while *GTPUMPI* teaches *Medical Bioengineering, Recovery Bioengineering* at *the Faculty of Medical Bioengineering*.

It seems that *technical universities* are more involved in *bioengineering* than life sciences universities are. This fact may be explained by *the technical skills* needed for completing such subjects, which are mainly offered by technical universities. Conversely, *medicine and pharmacy universities* do not teach technical knowledge and skills that could allow the completion of bioengineering subjects. We have screened all the selected universities for Biomaterials subject, and obtained results in four of the cases: two technical universities (*PUB, TUCN*) and two medicine and pharmacy universities *(CDUMPB, GTPUMPI*).

PUB educational offer includes the following subjects: Biomaterials, Advanced Biomaterials, Trial and Expertise of Implant Biomaterials, Micro and Nanostructured Advanced Biomaterials, Carbon-Based Polymeric Nanomaterial for Bioengineering Applications (at *the Faculty of Applied Chemistry and Materials Science*), Biomaterials, Ceramic Biomaterials, Polymeric Biomaterials, Biomaterials and the Nano-Dimension

Effect (at *the Faculty of Medical Engineering*), Smart Biomaterials and Applications (taught by *the Department of Bioengineering and Biotechnology*), Introduction to Biomaterials, Structural Theory of Biomaterials Properties, Biomaterials Degradation, Biomaterials Testing Methods, Biomaterials Analysis and Control Techniques, Specific Plastic Deformation Processes of Biomaterials, Specific Moulding Processes of Biomaterials, Engineering of Metallic Biomaterials, Engineering of Non-Metallic Biomaterials, Thermal Processes of Biomaterials, Equipment and Installations Used for the Processing of Biomaterials (at the Faculty of Materials Science and Engineering), Metallic Biomaterials, Nanobiomaterials for Tissue Engineering, Biomaterials Characterisation by Advanced Techniques (taught at *the Faculty of Engineering in Foreign Languages*).
TUCN educational offer includes the following subjects: Biomaterials and Manufacturing Methods (at the Faculty of Materials and Environmental Engineering), Biomaterials (at the Faculty of Electrical Engineering), Biomaterials, Biodegradable Materials, Lubricants and Ecological Fuel for Motor Vehicles (at the Faculty of Mechanics). *CDUMPB* teaches Biomaterials and Nanomaterials - Modern Alternative to Biomaterials at *the Faculty of Dentistry* and *GTPUMPI* teaches Biomaterials at *the Faculty of Medical Bioengineering*.
Medical universities provide very general subjects related to biomaterials, while technical universities have adopted specialised biomaterials subjects. An explanation of the large number of subjects in technical as compared to life sciences universities is the same as for bioengineering - students from *technical universities* are better (and suitably) equipped to study this subject, while *medical students* only study biomaterials and nanomaterials for very specific purposes, within the scope of their specialisation and training.

Conclusions

The analysis of the current state of bio-economy studies at higher education level and their mapping is, from our point of view, an extremely valuable step in assessing to what degree the Romanian higher education institutions are prepared to embrace new technologies and to keep abreast with the latest innovations in the field. Also, fostering a tight relation between universities and the industry is a must in such a high-tech field, because the industry also carries out research and development activities, the results of which universities should be able to disseminate and further develop. As far as we know, this is the first attempt for mapping the bio-economy higher education subject represents a starting point for further research in the area of knowledge creation and management in bio-economy. The results of the study clearly indicate that technical and agronomic sciences and veterinary medicine universities are those mostly involved in teaching bio-economy-related subjects, while their place in other types of universities (medical, pharmaceutical, general universities) is a marginal one. These conclusions should allow for a rethinking of the technical knowledge and skills that other universities should equip their students with in order to be able to include bio-economy studies in their curricula.

References

Aguilar, A., Bochereau, L. and Matthiessen, L., 2009. Biotechnology as the engine for the knowledge-based bio-economy. *Biotechnology and Genetic Engineering Reviews,* [e-journal] 26(1). Available through: Taylor and Francis Online website <http://www.tandfonline.com/doi/pdf/10.5661/bger-26-371> [Accessed 19 February 2018]

Beachy, R. N., 2014. Building political and financial support for science and technology for agriculture. *Philosophical Transactions of the Royal Society B-Biological Sciences,* [e-journal] 369(1639). Available through: The National Center for Biotechnology

Information website <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3928883/> [Accessed 19 February 2018]

Birch, K., 2017. The problem of bio-concepts: bio politics, bio-economy and the political economy of nothing. *Cultural Studies of Science Education,* [e-journal] 12(4). Abstract only. Available through: Springer Link website <https://link.springer.com/article/10.1007/s11422-017-9842-0> [Accessed 18 February 2018]

Bugge, M. M., Hansen, T., Klitkou, A., 2016. What is the Bioeconomy? A Review of the Literature. *Sustainability,* [e-journal] 8(7). Available through: Lunds Universitet website: <https://lucris.lub.lu.se/ws/files/10408102/sustainability_08_00691.pdf> [Accessed 20 February 2018]

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lahtinen, K., Korhonen, J., Leskinen, P., Matthies, B. D. and Toppinen, A., 2017. Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production,* [e-journal] 168. Available through: ScienceDirect website <https://www.sciencedirect.com/science/article/pii/S0959652617320425> [Accessed 18 February 2018]

European Commission, 2012. *Innovating for Sustainable Growth. A Bioeconomy for Europe.* Luxembourg: Publications Office of the European Union

Iancu, A., 2006. Opera lui Nicholas Georgescu-Roegen. *Revista OEconomica,* [e-journal] 01. Available through: EconPapers website: <https://econpapers.repec.org/article/oeneconom/y_3a2006_3ai_3a01_3aid_3a73.htm> [Accessed 18 April 2018]

OECD, 2006. *The Bioeconomy to 2030: Designing a Policy Agenda.* Paris: OECD Publications.

Sasson, A. and Malpica, C, 2018. Bioeconomy in Latin America. *New Biotechnology,* [e-journal] 40(A). Available through: ScienceDirect website <https://www.sciencedirect.com/science/article/pii/S1871678417300080> [Accessed 19 February 2018]