Ecological Economics 149 (2018) 120–128

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Competitive Bioeconomy? Comparing Bio-based and Non-bio-based Primary Sectors of the World

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A R T I C L E I N F O

Keywords:
Bioeconomy
Primary sector
Raw material
Total output at basic prices
Competitiveness
Constant market share analysis (CMS)

A B S T R A C T

Bioeconomy as a political-economic concept proposes the replacement of fossil resources by bio-based resources in order to address climate change mitigation and counteract resource depletion. The aim of this paper is to figure out how competitiveness across primary sectors, i.e. sector A, bio-based *agriculture*, *forestry and fishing*, and sector B, non-bio-based *mining and quarrying*, is distributed across geographical regions and how it changes over time.

A *constant market share* analysis based upon sectoral output data (2000–2014) shows that competition for market share was significantly lower in sector A than in sector B across 43 countries and one rest of the world country group (ROW), consisting mainly of smaller non-European economies. As a long-term trend, ROW gained market share in both sectors but with a much higher magnitude in sector B, from Europe, the USA, China and other countries. At times when *world growth* was negative or near zero (2009 and around 2013), ROW substantially lost market share in sector B with respect to the other regions mentioned.

1. Introduction

The terms *bioeconomy* and *bio-based economy* refer to one of the recently most prominent political-economic concepts in Europe, and designate the substitution of bio-based resources for fossil resources (e.g. Staffas et al., 2013; Aguilar et al., 2017). The concept addresses ecological objectives, e.g. climate change mitigation and reduction of environmental impacts (European Commission, 2012). Studies confirm — at least conditionally — that an intensified use of biomass can lead to greenhouse gas emission savings (see for example Börjesson Hagberg et al., 2016; Braun et al., 2016; Kalt et al., 2016; Mihai and Ingrao, 2016; Jasinevičius et al., 2017). Apart from its ecological impact, bioeconomy is also intended to have socioeconomic benefits such as fostering economic competitiveness, meeting rising demand, and counteracting resource depletion (European Commission, 2012).

According to the OECD (2006) the concept of a bioeconomy can be defined as "transforming life science knowledge into new, sustainable, eco-efficient and competitive products". Innovation thus plays a crucial role when realizing the vision of a bioeconomy. Bioeconomic innovations aim at replacing fossil resources for energy, chemicals and materials with renewable and bio-based feedstocks. Looking at related innovation systems, recent studies have identified (e.g. Wield, 2013; Giurca and Späth, 2017) a number of internal and external system weaknesses (e.g., fragmented policies, underdeveloped market formation). There is thus a clear need for policy integration and coordination in order to increase the competitiveness of future bioeconomies. The respective economic competitiveness of fossil and bio-based resources is a decisive factor in ascertaining how far and quickly a transition to a bioeconomy is possible. "Growing demand for feedstocks based on agricultural, silvicultural, and marine sources will increasingly shift global value chains from fossil-rich to biomass-rich countries, but how quickly this will happen depends very much on the cost-competitiveness of the various biomass-based versus fossil-based raw materials" (Kircher, 2014, p. 11; see also Meester et al., 2011 and Purkus et al., 2017).

Although this study focuses on the driving and limiting factors behind a bioeconomic transition, it is vital to realise that a bioeconomic transition will undoubtedly lead to a reallocation of ecological, economic, and social benefits and burdens. This has led some authors to criticize bioeconomic concepts for promulgating a relatively narrow view of sustainability, i.e. one which usually excludes the social dimension (Pülzl et al., 2014, Schmidt et al., 2012, or for an overview, see Priefer et al., 2017). Thus, the possible consequences of large-scale process implementations need to be closely monitored, e.g. the impact on indigenous small farms and forest landowners (Müller and Knierim, 2012). There are, however, concepts such as community forestry and agro-forestry, which attempt to widen the perspective by actively integrating local smallholders and thus contribute to a more inclusive

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https://doi.org/10.1016/j.ecolecon.2018.03.014
Received 25 October 2017; Received in revised form 2 February 2018; Accepted 15 March 2018
0921-8009/

bioeconomy (Pfau et al., 2014, Siegner et al., 2017). As a further outcome of bioeconomic transition, the associated redirection of money flows will also affect the economic welfare of those countries that rely heavily on exports of fossil-based commodities. As far as we know, this topic has not been tackled in current bioeconomy-related literature.

In order to gain a comprehensive picture of the global status of bioeconomies in recent years, the aim of this paper is to figure out how economic competitiveness for both bio-based and non-bio-based primary sectors has been distributed across geographical regions and how the pattern has changed over time. The primary sectors mark the very first stages of each global value chain involving primary raw material transformation and therefore mark the boundaries between socioeconomic systems and the environment. Each piece of material that passes through the economic lifecycle (except water and air [Eurostat, 2013]), has at some time been an output of such a sector. Consequently, material-related changes in the entire socioeconomic system are reflected in primary sector outputs and may thus influence their competitiveness. Although several studies dealing with international competition between different commodities already exist (see Materials and Methods), little attention has yet been paid to the issue in terms of raw material type as a main differentiation criterion. To address this research gap we conducted *constant market share* analyses (CMS) in order to derive some insight concerning possible future transitions towards a bioeconomy.

A variety of “international competitiveness” indicators can be found in the literature. Some of them concentrate on location-based issues, such as institutions, infrastructure, education, market efficiency, innovation (Schwab, 2016), fiscal policy, societal frameworks, attitudes and values, science and environment (IMD, 2016), or productivity, spatial issues, qualification of employees and leadership (Porter, 1999). The above indicator class has been described as *determinant-oriented*. A second class of indicators also exists, which is referred to as *result-oriented* (Gries and Hentschel, 1994). This latter class focuses on issues such as country export opportunities, e.g. *revealed comparative advantage*, *terms of trade* or *constant market share* (Milana, 1988; Kemfert, 2002; Ahmadi-Esfahani, 2006; Tilton, 2013; Sujová and Hlaváčková, 2015; French, 2017; Norton, 2017). Determinant-oriented indicators are believed to represent variables causally affecting international competitiveness and, accordingly, to possess forecasting capability. However, a recent study (114 countries, 2006–2014) on the interrelations between determinant-oriented competitiveness and (result-oriented) GDP growth found a strong unidirectional *Granger causality* of GDP growth on competitiveness (Kordalska and Olczyk, 2015). In other words, the determinant-oriented indicator — to which forecasting capability is attributed — is found to be unable to predict economic growth, whereas the latter predicted the former quite well. One could thus conclude that determinant-oriented indicators are not necessarily better per se. Furthermore, as determinant-oriented indicators are usually of a macroeconomic nature they may not be able to differentiate between economic sectors.

As they are intended to measure “international trade competitiveness”, conventional applications of CMS only consider export trade flows and completely ignore domestic final consumption and domestic intra- and inter-industry trade. The world trade share — on which CMS analysis is usually based — is thus found to be characterized as a *non-comprehensive* indicator in the literature (Gries and Hentschel, 1994). Irrespective of whether such non-comprehensiveness is regarded merely as a specific feature of the method or as a real disadvantage, it does conflict with the purpose of the present study since the focus here is on primary sectors, and these sometimes show very low export ratios. *Forestry and logging* in Finland (2014), for example, directed only 2% of its output (in monetary terms) towards foreign markets, whereas the remaining 98% went to processing in domestic industries, final consumption and stocks (own calculations based on Timmer et al., 2015). As the figure is also below the 10% level for many other European countries as well (Austria, Cyprus, Denmark, France, UK, Greece, Italy, Portugal, Romania and Sweden), it seems only logical to suggest that domestic flows also be taken into account. If this is not done, the estimation of sectoral competitiveness is based on a relatively small share of exported products, which may lead to wrong conclusions. To overcome this problem, the present study uses data from input-output tables, and thus includes information on both international and intranational trade.

2. Materials and Methods

2.1. Data

In order to employ a more comprehensive world market share indicator this study uses data from input-output tables provided by the *World Input-Output Database* (WIOD) (Timmer et al., 2015). WIOD data has already been used for decomposition analyses in conjunction with other research questions and methods (e.g. Pothen and Schymura, 2015; Pothen, 2017). The 2016 release is structured according to the *International Standard Industrial Classification of All Economic Activities* (ISIC) Rev. 4 and covers the period from 2000 to 2014. The dataset represents trade flows between 56 sectors and five final-use categories for each of 43 countries, and for one rest of the world country group (ROW). For a detailed description of the WIOD data, construction procedures, and underlying assumptions, see also Timmer et al. (2015) and Dietzenbacher et al. (2013). Regarding specific remarks on the 2016 release see Timmer et al. (2016).

For the purposes of the present study, one of the most important statistics is *total output at basic prices* (henceforth simply *output*). This represents the sector-specific sum of all foreign and domestic supplies of that sector. The output of *mining and quarrying*, for example, encompasses export flows as well as deliveries to itself, to the other domestic sectors, to domestic final consumption and to domestic stocks in monetary units. *Basic prices* exclude taxes and transport charges but include subsidies (see OECD Statistics, n.d). The present study focuses on material extraction, i.e. the primary sectors, which are represented by ISIC sections A and B. Section A is related to bio-based industries (see Ronzon et al., 2017) exploiting bio-based resources and covers activities such as *crop and animal production*, *hunting and related service activities* (A01), *forestry and logging* (A02), and *fishing and aquaculture* (A03). Section B denotes non-bio-based industries, which extract fossil resources, and includes *mining of coal and lignite* (B05), *extraction of crude petroleum and natural gas* (B06), *mining of metal ores* (B07), *other mining and quarrying* (B08) and *mining support services activities* (A09) (see United Nations Statistics Division, n.d). Divisions A01, A02 and A03 were first analyzed individually but then aggregated for presentation purposes. Since WIOD does not distinguish between the different divisions of section B, this section was analyzed as a whole. Table 1 shows the framework used in the present CMS analysis and provides sectoral outputs for 2014 on a global level. It is important to note that this analysis follows a production-based approach, assigning the use of natural resources to the country where extraction took place. In contrast, a consumption-based approach would allocate the use to the country where final consumption came about (on this difference see

Table 1
Sectoral framework used for CMS analysis. Global total output at basic prices for 2014 in 10^9 nominal USD based on data taken from the WIOD database (Timmer et al., 2015).

ISIC Rev. 4 primary sectors		Raw material type	Global total output
A	Agriculture, forestry and fishing	Bio-based	5708
A01	Crop and animal production, hunting and related service activities	Bio-based	4911
A02	Forestry and logging	Bio-based	370
A03	Fishing and aquaculture	Bio-based	427
B	Mining and quarrying	Non-bio-based	5963