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The Food System in the wider Bioeconomy: the BioSAM perspective

An Economic Impact Analysis for EU Member States

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Abstract

The Bioeconomy emerges as an opportunity towards more economic, social and environmental sustainability, becoming a priority for many countries, including the European Union and its Member States. According to the definition in the European Union's strategy, the Bioeconomy includes all sectors of the economy that are based on the use of renewable biological resources to produce value added products such as food, feed, energy, and bio-based products (European Commission, 2012). Due to the importance of promoting the Bioeconomy, it is necessary to analyse the impact of the sectors directly involved. However, the lack of available data is one of the main obstacles for monitoring its progress. As a response to this problem, the Bioeconomy Social Accounting Matrix (BioSAM) database has been developed for the EU Member States (Mainar-Causapé 2021). The purpose of this report is to present an overview of the European Union bio-based products and industries. Our focus is mainly on the analysis of the impacts of final demand variation on value added and employment by sectoral level disaggregation. By using the BioSAM database it is possible to deepen the impact analysis by considering a detailed disaggregation of bio-based products. A country cluster analysis focusing on food system sectors is also introduced. In addition, the results are presented in a dashboard to allow the replication and comparison of different impacts by sector and country.

1 Introduction

The European Green Deal (European Commission 2019) requires a transition to a more sustainable production and consumption in the current economic model to reach climate neutrality by 2050. Different initiatives, including the Bioeconomy Strategy (European Commission 2018) and the Farm to Fork Strategy (European Commision 2020)([1]), are supporting the implementation and transformation of the European agro-food system towards more economic, social and environmental sustainability.

According to the EU definition, the Bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. The five goals of the EU Bioeconomy Strategy aim to i) ensure food and nutrition security, ii) manage natural resources sustainably, iii) reduce dependence on non-renewable, unsustainable resources, iv) limit and adapt to climate change, and, v) strengthen European competitiveness and create jobs. The Bioeconomy is linked to different sectors of the economy such as agriculture, forestry, fishery, chemicals, food and bio-based materials and energy.

The growing interest on the Bioeconomy has been confirmed not only by the promotion of related strategies in many countries, but also by the growing scientific literature focusing on its analysis (Ferreira et al. 2018; Mougenot and Doussoulin 2021). In spite of its importance, it is still a concept that needs to be further analysed in terms of the evaluation of its impacts.

In recent years, different research studies have been published that attempt to measure the importance of the Bioeconomy and quantify the contribution of its sectors using different methodologies and databases (Wesseler and von Braun 2017). Monitoring and impact evaluation tools to measure the progress of the Bioeconomy sectors in terms of their economic, social and environmental impact are being developed (see Robert (2020) for the European monitoring). Methodologies vary from multi-sectoral analysis considering national and regional Input-Output tables and Social Accounting Matrices (Heijman 2016; Mainar-Causapé 2019; Kuosmanen et al. 2020; Cingiz et al. 2021), as well as different ways of estimated each bio-based sector (Vandermeulen et al. 2011; Efken et al. 2016; Ronzon and M'Barek 2018). Indeed, a main problem is faced when estimating those sectors that are partially bio-based, as official statistics do not show them separated (e.g. Ronzon et al. (2017, 2022); Ronzon & M'Barek (2018)). Another important challenge refers to the aggregation of sectors in the Bioeconomy.

In this regard, the Joint Research Centre of the European Commission has developed the BioSAMs for all EU members for 2010 and 2015 ([2]). These are social accounting matrices developed specifically for the Bioeconomy analysis considering a disaggregated breakdown of accounts (in total 49) related to the agricultural and agri-food industries and the sectors that use biomass such as bioenergy, biofuels and bioindustries (Mainar-Causapé et al. 2018c; Mainar-Causapé 2021). The usefulness of the BioSAM database (previously named as AgroSAM) has been demonstrated and widely applied in different research projects on both the European Union and Member States (Fuentes et al. 2017; Mainar-Causapé et al. 2018c, 2020; Philippidis and Sanjuán 2018; Mainar-Causapé 2019; Ferreira et al. 2020, 2021).

The first part of the report offers a comprehensive application of the BioSAMs for the year 2015, considering the European Union and each Member State. The aim of this study is to analyse the Bioeconomy through the calculation of the value-added and employment multipliers. This allows us to identify the main bio-based sectors drivers in terms of value added and employment generation. A dashboard for the simulation of exogenous commodity shocks is also introduced, as to present a visual understanding and an analysis on the potential of bio-based activities in the EU Member States.

A second part of the report is dedicated to the sectors of the Bioeconomy related to food systems. The agriculture and food industry are providing about three quarters of the value added and employment of the Bioeconomy. Therefore, it is important to look at the food system within the wider Bioeconomy, following the concept proposed by von Braun et al. (2021), which embeds the food system in the transformation towards a sustainable circular Bioeconomy. This concept includes food and non-food products from interlinked value

([1]) The EU's Farm to Fork Strategy, being a central pillar of the European Green Deal, aims to make food systems fair, healthy and environmentally-friendly. A fairer food system entails also fairer economic returns and increased competitiveness of the EU supply sector, whose economic performance matters also for upstream and downstream activities (Eurostat, 2021; https://ec.europa.eu/eurostat/documents/3217494/13957877/KS-FK-21-001-EN-N.pdf/dcf8d423-fa1c-5544-0813-b8e5cde92b59?t=1639565437333).

([2]) Published in the Data portal of agro-economics research of the European Commission.
Link: https://datam.jrc.ec.europa.eu/datam/area/BIOECONOMY

chains, which are of particular importance in the food industry/processing industry. A country cluster study is presented as to describe the potential of the countries in each product group.

The report is structured as follows. Section two introduces the SAM and BioSAM framework and the implication of the multiplier methodology employed in the Bioeconomy and in the Food Systems perspective. Section three provides the analysis of the value added and employment multiplier considering an industry overview of the EU27 bio-based industries. Section four presents the case study that considers BioSAMs with a multi-level application on food system. Finally, section five summarises the main results and remarks.

2 Bioeconomy Social Accounting Matrices for EU Member States: Framework and Methodology

A Social Accounting Matrix (SAM) is a comprehensive and economy-wide database capturing all income and expenditure flows made between agents in an economy over a period of time, which is generally one reference year. The origins of this framework are found in the pioneering works by Stone (1962, 1978) and Pyatt and Round (1979), among others.

A SAM extends the information provided by the Input-Output table by incorporating all economic transactions among institutional sectors, using a more disaggregated accounting structure than the Input-Output scheme that allows to close the circular flow of income and expenditure. Thus, a SAM includes the relationships between economic agents in terms of production, trade, income generation, consumption, saving, and investment. In this sense, the SAM is a very useful tool for two main reasons. On the one hand, it presents a complete picture of the economy, considering economic transactions between economic agents and showing a descriptive detail of the economy under study. On the other hand, it is a suitable database for economic modelling to analyse how the economy works and to predict the effects of policy interventions through its use as a database in multisectoral linear models by calculating multipliers, and in the calibration and exploitation of Computable General Equilibrium (CGE) models.

The SAM database is generally represented by a square matrix, showing economic transaction by each agent (along rows) and how it is expended (along columns). Thus, each cell (i, j) shows the transaction between account i and j, in which account i receives income from j. Typically, a Social Accounting Matrix has six basic groups of accounts:

- Activities and Commodities
- Factors of production
- Private Institutions (Households and Corporations/Enterprises)
- Public Institution (Government)
- (Combined) Capital accounts
- Accounts for the Rest of the World.

Table 1 shows the basic structure of a standard SAM ([3]), however, the structure of the matrix will be determined by the disaggregation of the accounts chosen that will depend on the analysis to be carried out.

([3]) For more detail of this general structure see Miller & Blair (2009), Mainar-Causapé, Ferrari, et al. (2018b) or Round (2003a).

Table 1. A Social Accounting Matrix (SAM) standard structure

	Commodities	Activities	Margins	Factors	Households	Enterprises / Corporations	Government	Investment-Savings	Rest of the World	*Total*
Commodities		Intermediate (inputs) consumption	Transaction costs (trade / transport)		Household consumption		Government expenditure	Investment and stock changes	Exports	*Demand*
Activities	Domestic production									*Gross output / Production (activity income)*
Margins	Transaction costs (trade / transport)									*Margins*
Factors		Remuneration of factors / Factor income							Factor income from RoW	*Factor income*
Households				Factor income distribution to households	*(Inter Households transfers)*	Distribution of enterprise income to households	Government transfers to households		Transfers to Households from RoW	*Household income*
Enterprises / Corporations				Factor income distribution to enterprises			Government transfers to enterprises		Transfers to Enterprises from RoW	*Enterprise income*
Government	Net taxes on products	Net taxes on production		Factor income to Government / Factor taxes	Direct Household taxes / Transfers to Government	Direct Enterprise taxes / Transfers to Government			Transfers to Government from RoW	*Government income*
Investment-Savings				*(Depreciation)*	Household savings	Enterprise savings	Government savings	*(Capital accounts transfers)*	Capital transfers from RoW (Balance of Payments)	*Savings*
Rest of the World	Imports			Factor income distribution to RoW	Household transfers to RoW	Enterprise income to Row	Government transfers to RoW			*Payments to RoW*
Total	*Supply*	*Costs of production activities*	*Margins*	*Expenditure on factors*	*Household expenditure*	*Enterprise expenditure*	*Government expenditure*	*Investment*	*Incomes from RoW*	

Source: Round (2003a).

2.1 BioSAM structure and grouping

In this report the BioSAMs are used to analyse the industries of the Bioeconomy in the European Union and its Members States, therefore, the structure of the BioSAM framework is presented in detail, explaining its more important accounts and the disaggregation of the bio-based sectors.

The BioSAM database builds on the AgroSAMs experience (Müller et al. 2009) and Philippidis et al. (2014) considering the agri-food sector detail and incorporating additional accounts in order to include others bio-based applications (Mainar-Causapé 2021) ([4]). The report *'BioSAM 2015: Estimation and basic considerations'* (Mainar-Causapé 2021) explains in detail the construction and estimation of this accounting scheme.

Each matrix has a total of 171 entries. The BioSAMs distinguish between activities (that carry out the production of commodities) and commodities (goods and services), representing 80 sectors each of them. There are 49 accounts that are part of the Bioeconomy, which can be classified by groups considering three levels (as shown in table 2). Indeed, one of the main issues when it comes to dealing with the Bioeconomy is that bio-based activities/ commodities are not sufficiently disaggregated in the official statistics. In view of the fact that for the analysis of the Bioeconomy it is necessary to work with the detailed bio-based sectors, certain disaggregated databases have been constructed. Such sectoral grouping will allow to better understand the potential of each bio-based sector without leaving aside the macroeconomic full picture. This visual understanding is presented in the dashboard hosted by the Data-Modelling platform of resource economics, DataM.

Considering the third level, there are 21 sectors classified under the 'primary arable, vegetables and horticulture production' that can also be divided in 5 groups considering the second level (cereals, horticulture, other annual crops, oilseeds and feedstock). Under the group 'other 'traditional' bio-based' activities there are 3 sectors (specialist non-food energy crops, fishing and forestry). Then, there are 6 sectors for 'animal production' classified within extensive and intensive livestock and intermediate products. The 'food processing' sector includes 2 main groups (livestock products and crop processing) disaggregated in 13 sectors. Lastly, within the Bioeconomy is the 'bio-based energy and industry' group that includes 6 sectors classified by conventional and advanced biofuels, bio-electricity and bio-chemicals. Finally, the remaining 27 sectors cover natural resources, energy, manufacturing and services.

In addition, the BioSAMs contain two production factors (labour and capital), one account for trade and transportation margins and three tax accounts (taxes and subsidies on production and consumption and direct taxes). Finally, there is a single row and column account corresponding to the transactions involving each of the private household, corporate activities, central government, investments-savings and the rest of the world.

These matrices have already been used in research published in prestigious international journals for the analysis of the European Union and some members (Fuentes et al. 2017; Mainar-Causapé et al. 2018c; Philippidis and Sanjuán 2018) such Spain (Mainar-Causapé 2019; Ferreira et al. 2020, 2021).

A general caveat of the work concerns the disaggregated database with the Bioeconomy accounts. According to the authors, the main problem is the availability of coherent, consistent and updated data to perform the split of the non-agricultural/food bio-based sectors from their 'parent' activities, which leads to the use of information from dispersed and even unpublished data sources and expert opinion (Mainar-Causapé et al. 2020).

([4]) The BioSAM database for all EU member states in 2015 (i.e., including the UK), plus a EU28 and a EU27 (less the UK) aggregate is available at https://datam.jrc.ec.europa.eu/datam/mashup/BIOSAMS_EU_2015/.

Table 2. Sectoral categories in the Bioeconomy

Level 1	Level 2	Level 3
Primary arable, vegetables and horticulture production	Cereals	Paddy Rice Wheat Barley Maize Other cereals
	Horticulture	Tomatoes Other vegetables Grapes Fruits and nuts
	Other annual crops	Sugar beet Fibre plants Potatoes Live plants Tobacco
	Oilseeds	Rapeseed Sunflower Soya Olives Other oilseeds
	Feedstock	Fodder crops Other Crops
Animal production	Extensive livestock	Sheep, goats, horses, asses, mules and hinnies
	Intensive livestock	Swine Poultry Bovine cattle Other animal and their products
	Intermediate products	Raw Milk
Other “traditional” bio-based activities	Fishing	Fishing
	Forestry	Forestry
	Specialist non-food energy crops	Specialist non-food energy crops
Livestock and processed livestock products	Meat	Meat of bovine animals Meat of swine Meat of sheep, goats, and equines Meat and edible offal of poultry
	Dairy	Dairy products
Crop processing	Horticulture production	Rice, milled or husked Wine
	Sweeteners	Processed sugar
	Feeding stuff	Prepared animal feeds
	Vegetable oils	Olive oil Vegetable oils and fats
	Other food and beverages	Other food products Other beverages and tobacco
Bio-based energy and industry	Conventional generation liquid biofuels	Bio-gasoline Bio-diesel
	Advanced generation liquid biofuels	2nd generation biofuel – biochemical pathway fuels 2nd generation biofuel – thermal pathway fuels
	Bio-chemical	Bio-chemical
	Bio-electricity	Bio-electricity

Source: own elaboration based on the BioSAM 2015. There are 6 groups of sectors represented by a different colour each.

2.2 Linear multiplier analysis

The richness of the information available in the SAM allows to analyse the linkages between the sectors and all other accounts. Linear multiplier analysis provides a description of the information available in the SAMs on the interdependencies among sectors and on the structure of an economy.
The analysis is carried out considering the Leontief's equilibrium equation $\boldsymbol{y_n} = \boldsymbol{A_n y_n} + \boldsymbol{x}$, applied on a SAM framework, by obtaining the SAM Leontief inverse represented as follows: $M = (I - \mathrm{A})^{-1}$ (Pyatt and Round 1985). The matrix A (named the coefficient matrix) is obtained dividing each element of the SAM by the total of their corresponding column. Then, M is the SAM multiplier matrix in which each element m_{ij} shows the output requirements of account i to increase the final demand of account j by one monetary unit (Mainar-Causapé et al. 2018a).

As a result of the linear process between output and final demand, the multipliers carry on three types of effects: direct effect, on the sector that receives the unitary exogenous change. Indirect effects due to the increased intermediate demands that generate additional output. Induced effects caused by the income generation process when the model is closed with respect to institutional sectors (in this case, with respect to Households) (e.g. labour payments and the associated consumer expenditures on goods produced by the various sectors, (Miller and Blair 2009)). The sum of three effects is called *Total effect* while the indirect and induced effects are also considered as spillover effects.

Through the calculation of multipliers, it is possible to analyse the relationships between the different accounts considering the circular flow of income, which is useful tool for ex-ante policy evaluation (Round 2003b). The results of this exercise should be considered as an indication of which sectors among others have more potential to generate outputs within the economy under study.

2.2.1 Multipliers

Multiplier's analysis is a relevant tool also used to assess the capacity that each economic sector has in generating economic growth and employment in the rest of the economy, and therefore, identifies those sectors that are suitable to be promoted through policies.

This report focuses on the analysis of the economic impacts of new final demand in each commodity within the Bioeconomy, and its distributive effect among the economy, measured by the variation on the value added and the jobs created (by activity).

By using the BioSAM scheme, once the total output multipliers are computed, results can be converted into jobs (physical) or value added (monetary) by using sectoral coefficients. The multipliers are so calculated to represent the value added contribution or the jobs created by a commodity in each region under study. Each element of the value added multiplier shows the new value added created by the additional production due to a unitary exogenous injection into the final demand of a commodity (i.e. an exogenous increase in exports demand). Likewise, the values of the employment multipliers indicate the increment in the number of jobs generated in responses to an exogenous shock in demand.

2.2.1.1 Employment multipliers

The employment multiplier indicates the number of jobs that would be generated by an exogenous shock in final demand. Its calculation requires an employment vector $\boldsymbol{e}$ that represents the ratios between the number of jobs and the output of each activity. The employment multiplier is calculated as:

$$\boldsymbol{M_e} = \boldsymbol{E} \times \boldsymbol{M_a},$$

where the employment matrix $\boldsymbol{E}$ is a diagonal matrix, whose elements are the vector e and $\boldsymbol{M}_a$ is part of the multiplier matrix with rows of activities and columns of commodities. The sum of each column of the employment multiplier matrix $\boldsymbol{M_e}$ indicates the overall employment effect caused by the exogenous increase in demand.

2.2.1.2 Value Added multipliers

The value added multiplier indicates the value added created by each sector because of the additional production resulting from an exogenous demand shock. It is commonly asserted to be a better measure of a sector's contribution to an economy than total output (Miller and Blair 2009). As in the case of the calculation of the employment multiplier, a value added vector $\mathbf{v}$ is used, indicating the ratios of the value added per output of each activity.

2.2.1.3 Limitations

Regarding the multipliers, the value added and the employment multiplier interpretation should be taken with caution due to the limitations of the methodology. These limitations are mainly related to the excess capacity in all sectors and unemployed factors of production (no supply constraints) and fixed prices (not taking substitutions effects into account) (Miller and Blair 2009). Thus, the impact analysis is limited to the short term and the values of the multipliers should be considered, with great caution, almost as qualitative indicators.

Furthermore, the results of the employment multiplier do not take into account social variables, such as the quality of employment and should not be interpreted as an accurate forecast of job creation resulting from exogenous shocks (Philippidis et al. 2014).

Despite the above-mentioned limitations, the analysis of multipliers is a useful tool for ex-ante policy evaluation and the results of the employment multiplier can be useful as an indicator of the commodities in the economy with the greatest potential for jobs generation.

3 EU27 Bio-based industry impact analysis

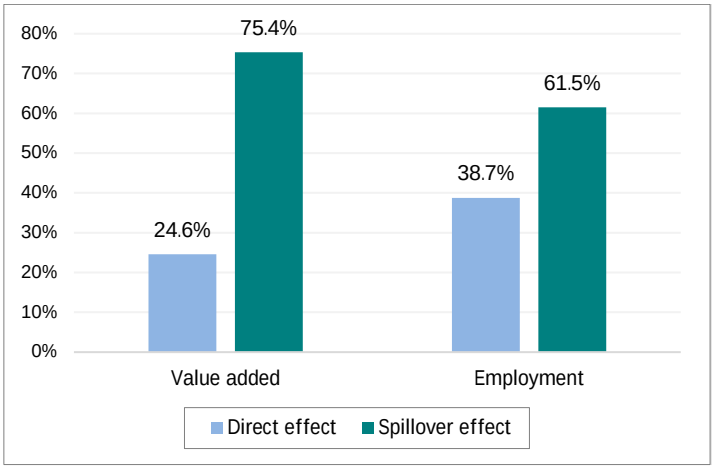
In this section, the analysis focuses on the results of a unitary shock in exogenous final demand for bio-based products mentioned in Table 2 (1M€) for the EU27 aggregate. To this end, the section is divided into two main parts. Firstly, an overview with the analysis of the value added and employment multiplier considering the EU27 bio-based industry as a whole. The second part examines in detail each of the aggregated sectors of the bio-based products industry for the EU27 (considering different 'levels' of sectorial aggregations as described in Table 2).

Note that the content presented in this report is fully available in the DataM portal, and is complementary with the ones released by the JRC at https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html. The latter follows a different approach and definition as to provide a sectoral coverage attributed to the Bioeconomy. Methodological aspects and scope are detailed in Ronzon et al. (2022).

3.1 General overview

As an overview of the bio-based industry in the EU, the direct and spillover multiplier effects are detailed in Figure 1. Thus, Figure 2 shows that 38.7% of the total employment created by the bio-based sectors is a direct effect on those activities that receive the exogenous final demand shock. In the case of the value added generated the direct effect is relatively lower (24.6%) compared to the corresponding result for employment, with spillover effects playing a greater role. The fact that there are significant spillover effects in the results further reinforces the benefit of having an economy-wide framework to capture the true sphere of influence of bio-based activities.

Figure 1. Bio-based Industries value added and employment Direct and Spillover multipliers effects (EU27)



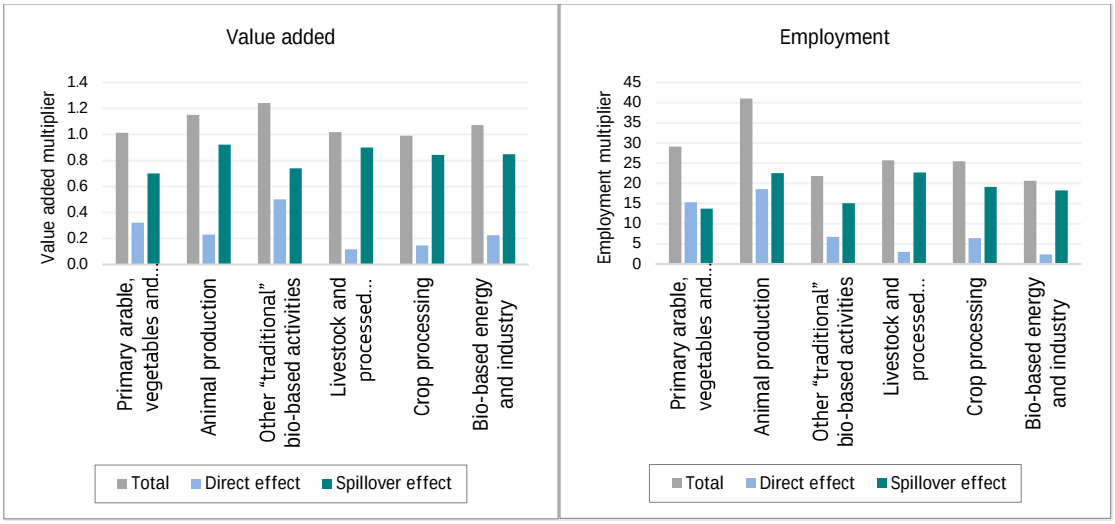
Source: own elaboration with BioSAM 2015.

Figure 2 presents for the EU27 aggregate region across level 1 sectoral categorisations, the heterogeneity of value added and employment multiplier impacts. Subsequently, Figure 3 further analyses each case by providing a relative weighting share between the direct and spillover effects of each multiplier value.

For value added, the highest total multiplier effect is 1.24 in the sector 'other traditional bio-based activities', largely driven by its relatively large direct effect (40%); followed by 'animal production' and 'bio-based energy and industry'. Examining the spillover effect, which is typically higher across all the sectors examined, the both 'livestock' sectors return the highest multiplier outcomes, although for 'other traditional bio-based activities' and 'primary arable, vegetables and horticulture production' the direct effect represent more than 30% of the total multiplier.

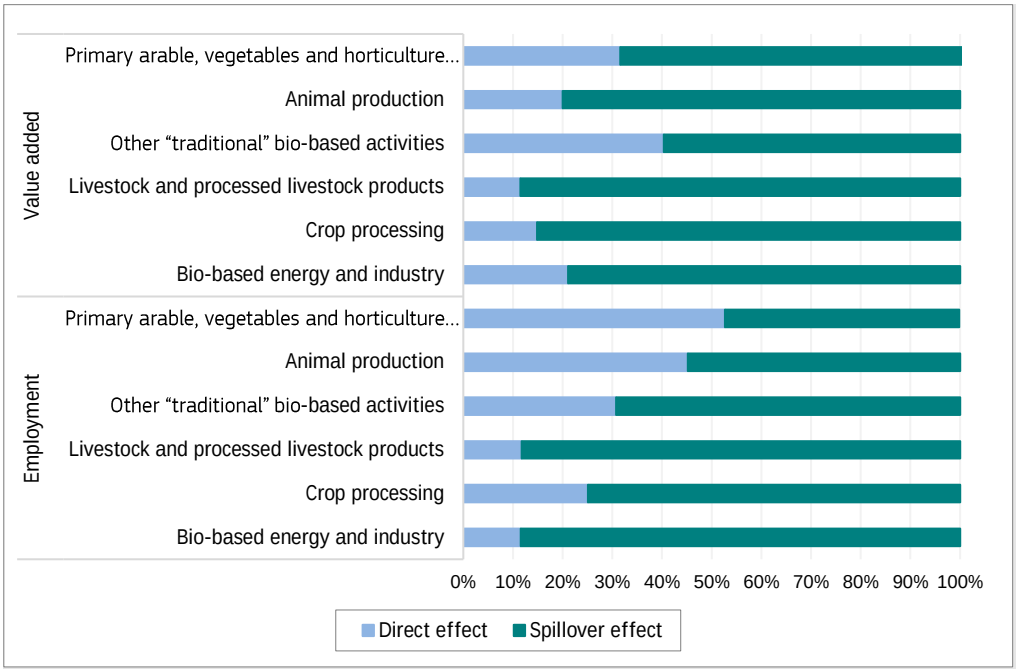
When looking at the absolute values of the employment results, 'animal production' has the highest multiplier total effect, followed by 'primary arable, vegetables and horticulture production'. Likewise, in the relative numbers, the direct effect in both sectors amounts to 45% and 53% of the total multiplier, respectively. The employment multiplier is lower for the sector related to bio-based energy and industry, with low influence on the own sector demonstrated by its spillover effect of about 88%.

Figure 2. Total, Direct and Spillover value added and employment effects of EU27 by bio-based industries



Source: own elaboration with BioSAM 2015.

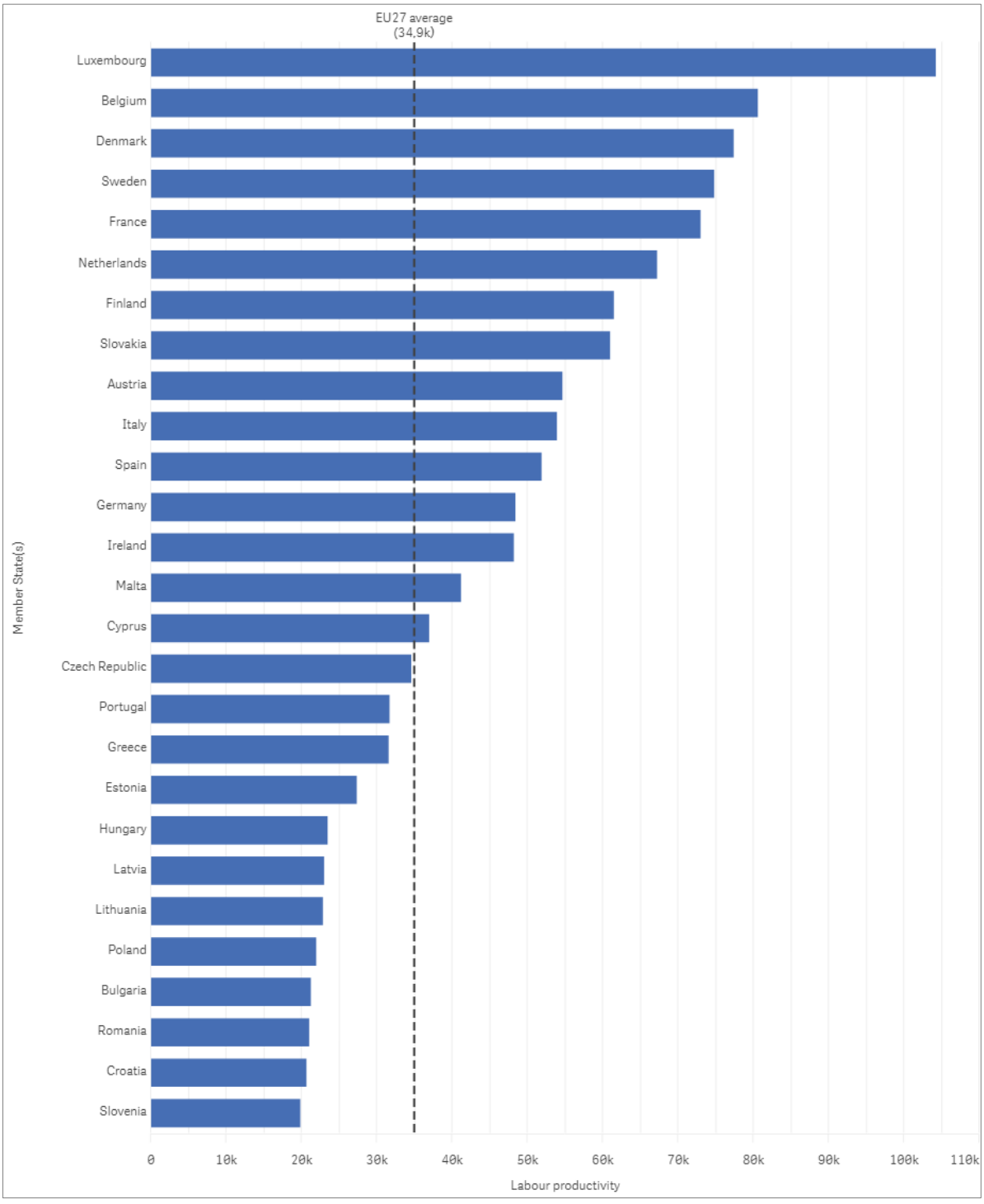
Figure 3. Direct and Spillover value added and employment effects of EU27 by bio-based industries



Source: own elaboration with BioSAM 2015.

This exercise also allows to combine the results of the two indicators in terms of labour productivity, considering the 49 bio-based sectors. Figure 4 presents a measure of the wealth generation and competitiveness within the EU27 Member States, derived by a unitary shock to final demand. Under the same sectoral perspective, the outcome of value added generated per job created is aligned with the statistics on Labour productivity presented by the main data warehouses (for example ESTAT and ILOSTAT), highlighting the best performers in terms of efficiency and quality of human capital in the production process.

Figure 4. Bioeconomy labour productivity by EU Member State. Value added generated per job created by a unitary shock.

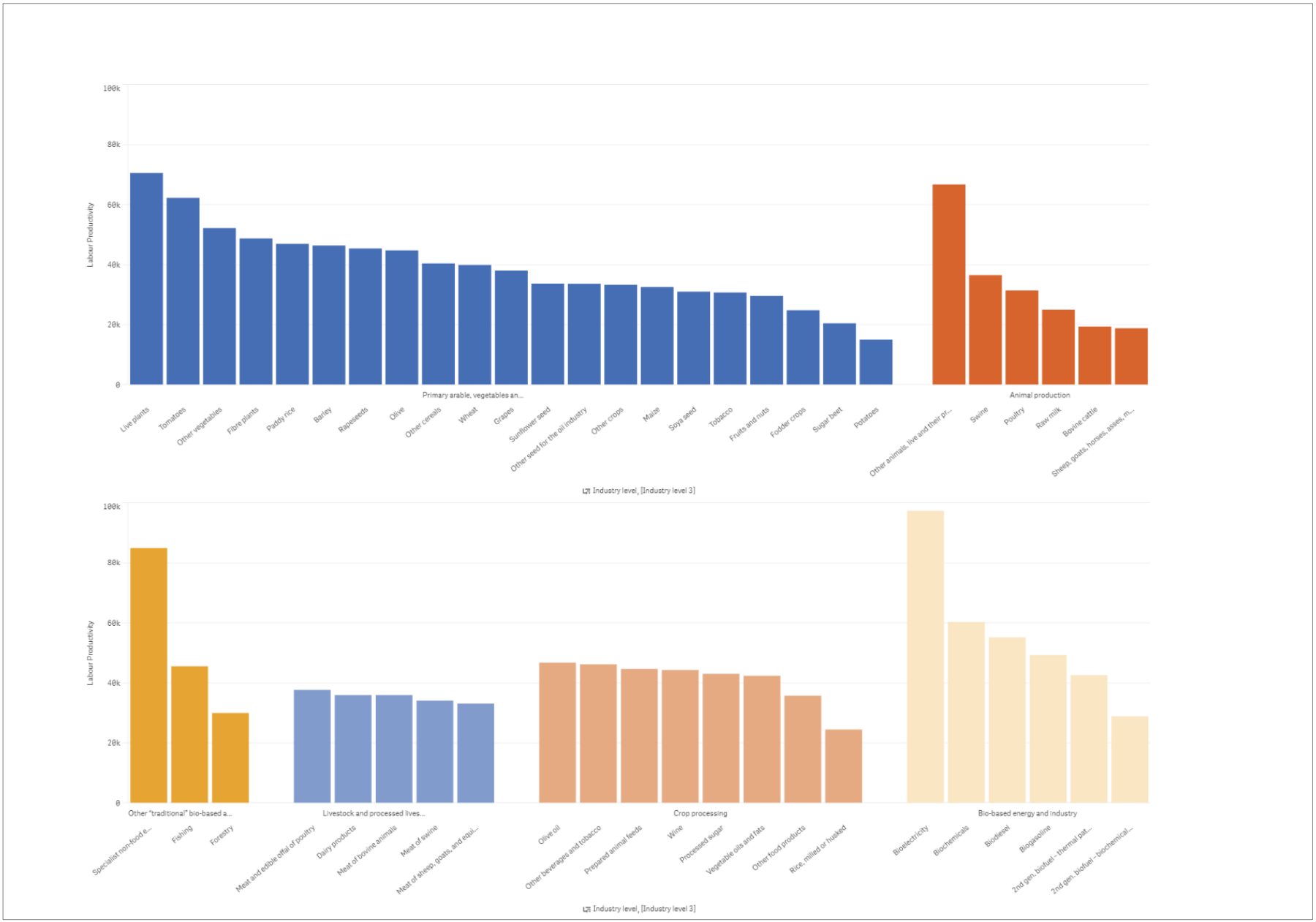


Source: own elaboration with BioSAM 2015.

Luxembourg leads the ranking as main promoter of wealth generation, followed by other western and northern European countries as Belgium, Denmark and Sweden (please see the country grouping from the case study in section 4). Among other regions, Italy and Spain confirm their importance among the southern EU regions, standing above the EU27 average (34.9 thousand of euro) with 53.9 and 51.3 thousand of euro, respectively.

A detailed composition of the main figures for the EU27 aggregate is proposed in Figure 5, where the 'bio-based energy and industry' are the activities that show high labour productivity per unit of labour input in the reference year. 'Bioelectricity' records the highest value across all the categories (97.4), followed by 'specialist non-food energy crops' (84.9). Those are capital intensive activities that can be categorized as specialized or niche sectors.

Figure 5. EU27 Bioeconomy labour productivity by activities. Value added generated per job created by a unitary shock.



Source: own elaboration with BioSAM 2015.

3.2 Granularity of the Bio-based Products Industries

This section examines in detail the multiplier values of the bio-based products industries in the EU27. In this exercise, a key role is played by the visualization tool, presented in Figures 6 and 7, proposed for the visual understanding and customization of the main Bioeconomy sectors. This tool allows to drill down to different sectoral levels, from level 1 down to level 3 (see Table 1) and, moreover, to zoom into the structural composition of each multiplier.

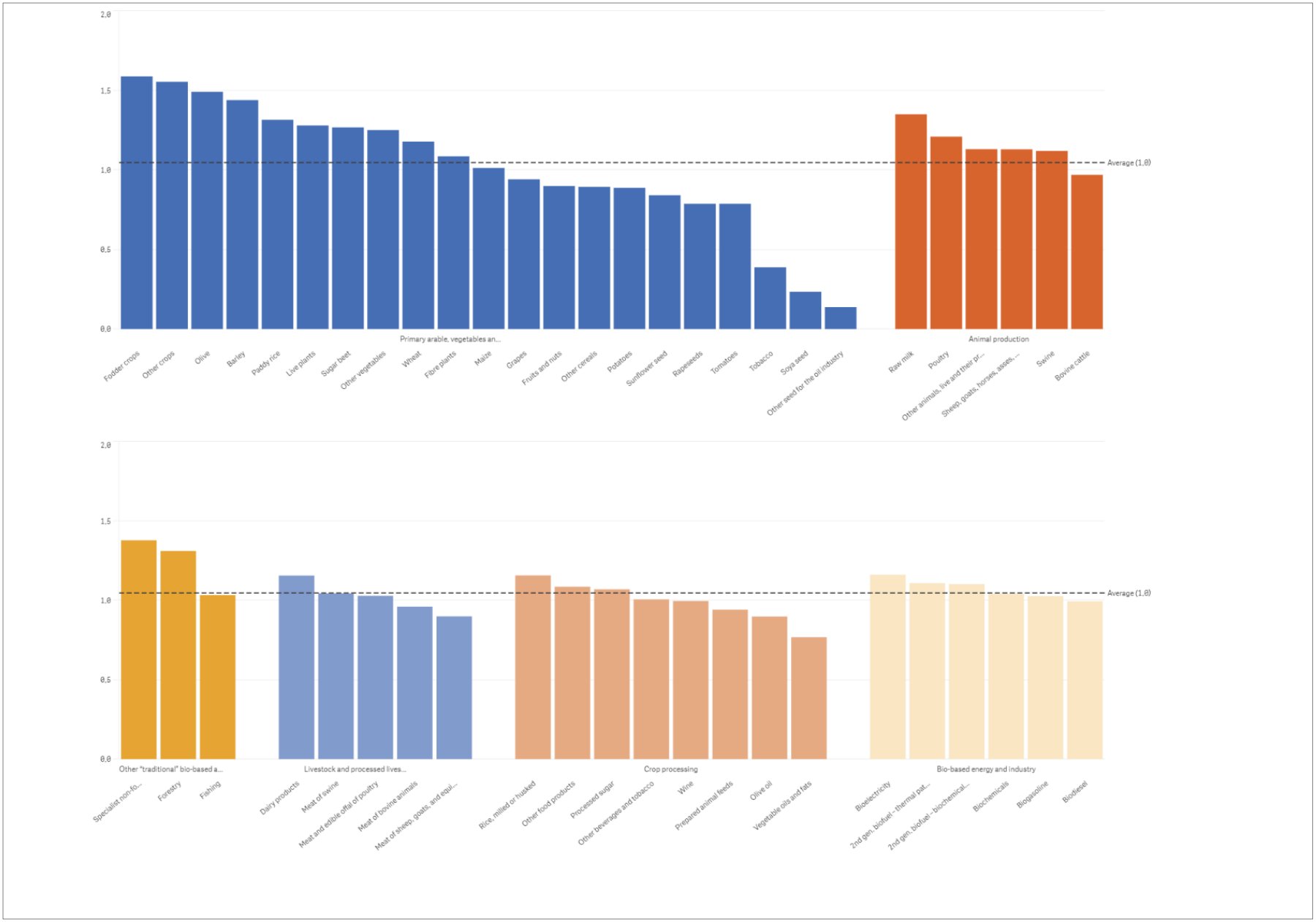
Figure 6 clearly highlights that 'fodder crops' and 'other crops' within the 'primary arable, vegetables and horticulture production' group are the ones with higher value added multipliers. The 'animal production' group is mainly characterised by the importance of 'raw milk' and 'poultry', among others. Another important group is 'other traditional bio-based activities', where 'specialist non-food energy crops' and 'forestry' as a relevant multiplier value.

Figure 7 presents the employment multipliers, showing the potential of each sector in terms of job creation in the EU27. In a group ranking, the 'primary arable, vegetables and horticulture' and 'animal production' aggregate sectors are clearly the most integrated labour-intensive sectors. Within the former, the sectors of 'sugar beet', 'fodder crops', 'potatoes', and 'other crops' stand out over the average value (28 job created). In the latter, the highest values can be observed in 'sheep, goats, horses, asses, mules, and hinnies', followed by 'bovine cattle', 'raw milk' and 'poultry' rank over the dashed reference line. In this group, 'swine' and 'other animals, live and their products' are the ones with values below the 'bio-based average'. Within crop processing, the commodity 'rice, milled or husked' stands out considerably, and within the 'bio-based energy and industry' the most important one is '2nd generation biofuels – biochemical pathway fuels'.

Across the bio-based products in line with the EU27 average it can be observed: 'forestry' in 'other traditional bio-based activities'; 'meat of sheep, goats and equines' and 'dairy products' in 'livestock and processed livestock products'; 'processed sugar' in the 'crop processing'. Among the products with a lower employment impact it can be noted the 'other seed for the oil industry' and 'soya seed'.

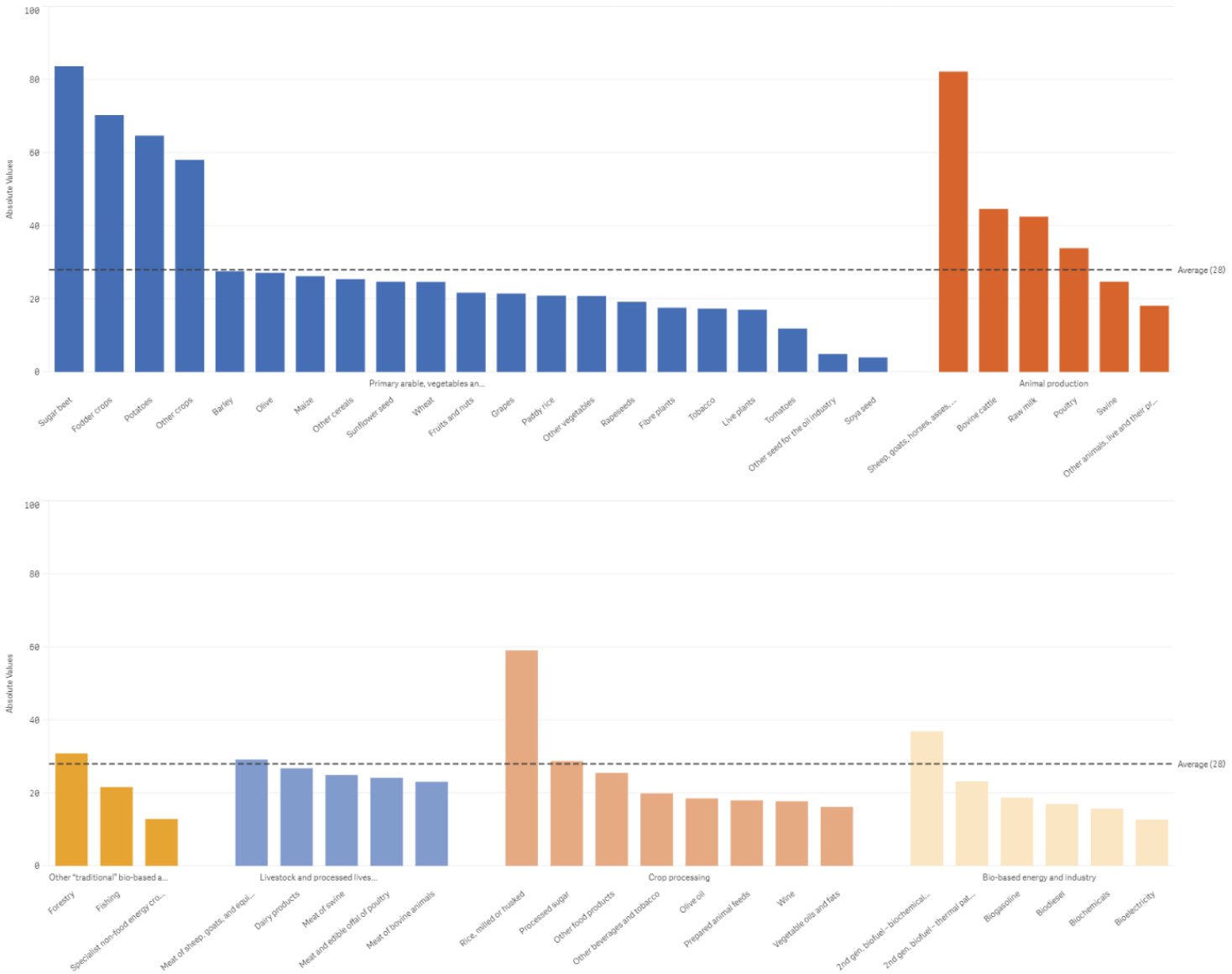
Focusing on each sector (level 1), the following sections analyse the direct and spillover multiplier effects at product disaggregation level 3 and the distribution of the effects among other subsectors. This means that for each products group, a figure will show the detail of the value added and employment multiplier decomposed into its effects (total, direct and spillover), in order to know the potential of each product and the influence of each effect. In addition, for each case, it shows how the value added or employment generated is distributed across the different sectors of the economy.

Figure 6. EU27 value added multipliers by sector groups (2015)



Source: own elaboration with BioSAM 2015.

Figure 7. EU27 employment multipliers (jobs per million euros of demand) by sector groups (2015)



Source: own elaboration with BioSAM 2015.

3.2.1 Primary arable, vegetables and horticulture production

This group includes 21 products of which five are classified in the domain of 'cereals', four in 'fruits and vegetables', five in 'oilseeds', two in 'feedstock crops' and five in 'other annual crops' (Table 3).

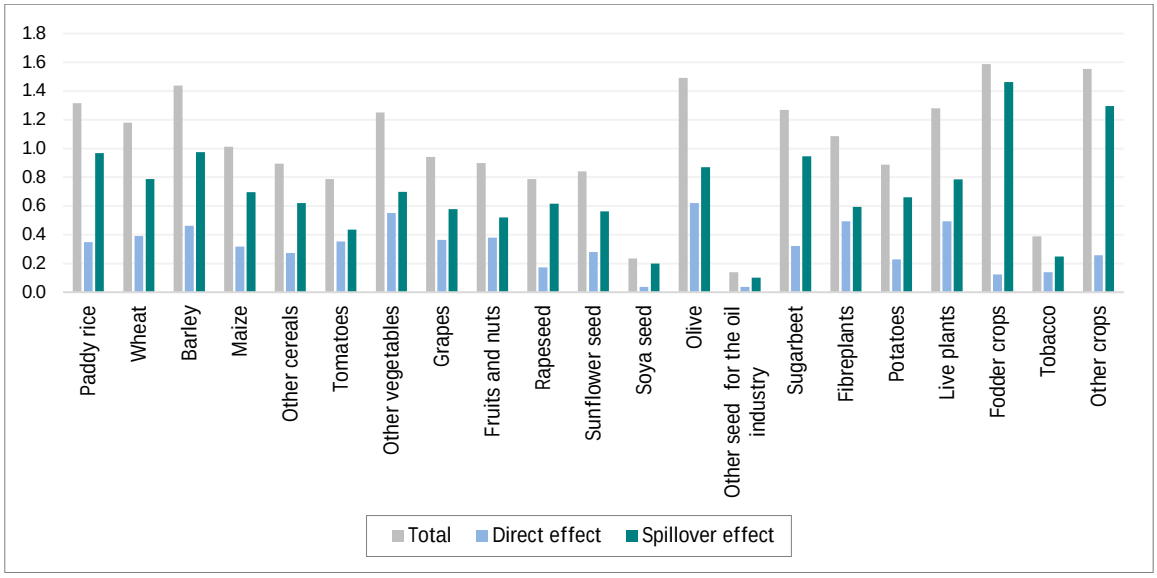
Table 3. Sectoral categories in 'Primary arable, vegetables and horticulture production'

Level 2	Level 3
Cereals	Paddy Rice Wheat Barley Maize Other cereals
Horticulture	Tomatoes Other vegetables Grapes Fruits and nuts
Other annual crops	Sugarbeet Fibreplants Potatoes Live plants Tobacco
Oilseeds	Rapeseed Sunflower Soya Olives Other oilseeds
Feedstock	Fodder crops Other Crops

3.2.1.1 Value Added Effects

As mentioned in the general overview, the value added multiplier generated in the 'primary arable, vegetables and horticulture' group is slightly above one. A detailed composition of this group is presented in Figure 8, where 'fodder crops' and 'other crops' in the 'feedstock' category show the highest total effect values, along with the 'olives' and 'barley'. To be noted the different composition of the effects: the feedstock products generate value added across other sectors (spillover effect) while in the case of the 'olives', for example, the direct effect generated is higher within the sector that receives the exogenous shock. In this group, other products which have a high direct effect are 'tomatoes' and 'other vegetables' in the 'horticulture' category, 'fibre plants' and 'live plants' grouped under 'other annual crops'.

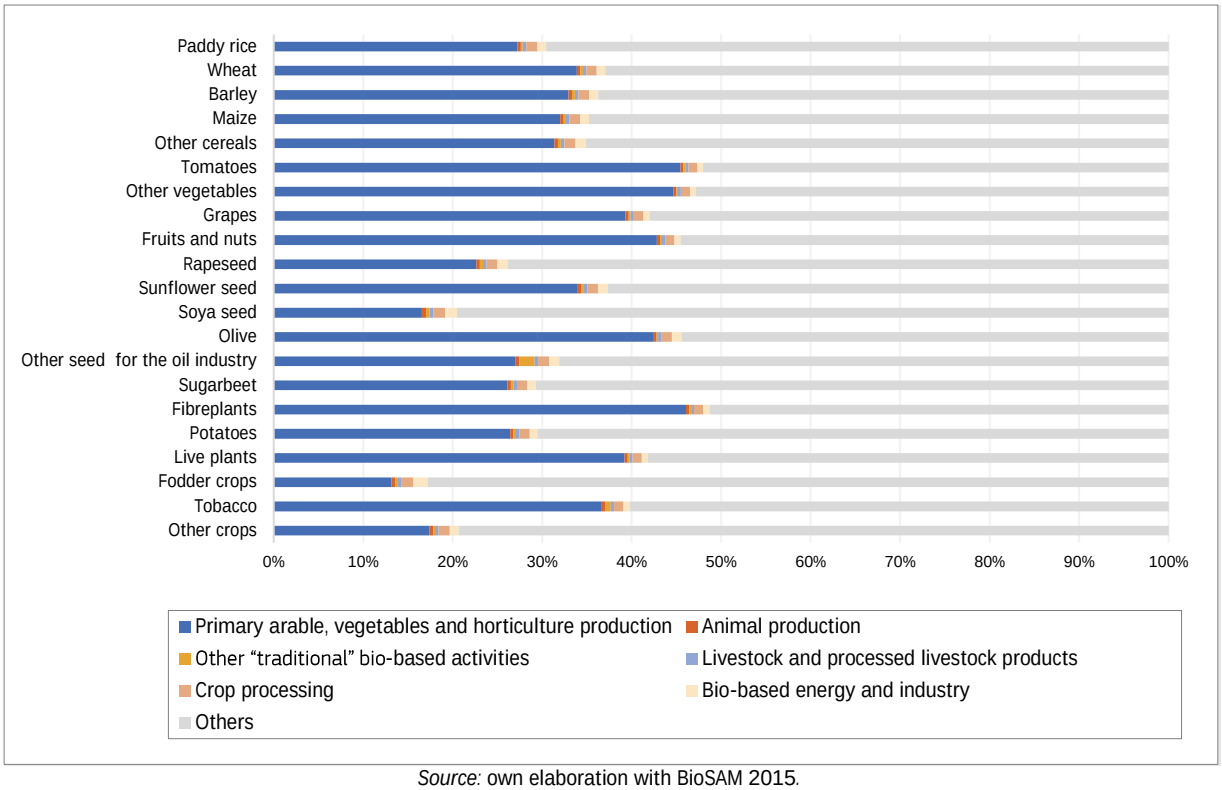
Figure 8. Total, Direct and Spillover value added effects (million €) by primary arable, vegetables and horticulture production



Source: own elaboration with BioSAM 2015.

Considering the total value of the value added multiplier for each product, Figure 9 represents how this value is distributed across each activity in the economy. For most of the products that receive the shock, about 20-40% of the value added generated goes to the 'primary arable, vegetables and horticulture production' sector. For those products with high value added multiplier under the feedstock group, more than 80% of the multiplier effect is concentrated in other sectors.

Figure 9. Distribution across each activity of the value added generated due to an exogenous impact on primary arable, vegetables and horticulture production demand.

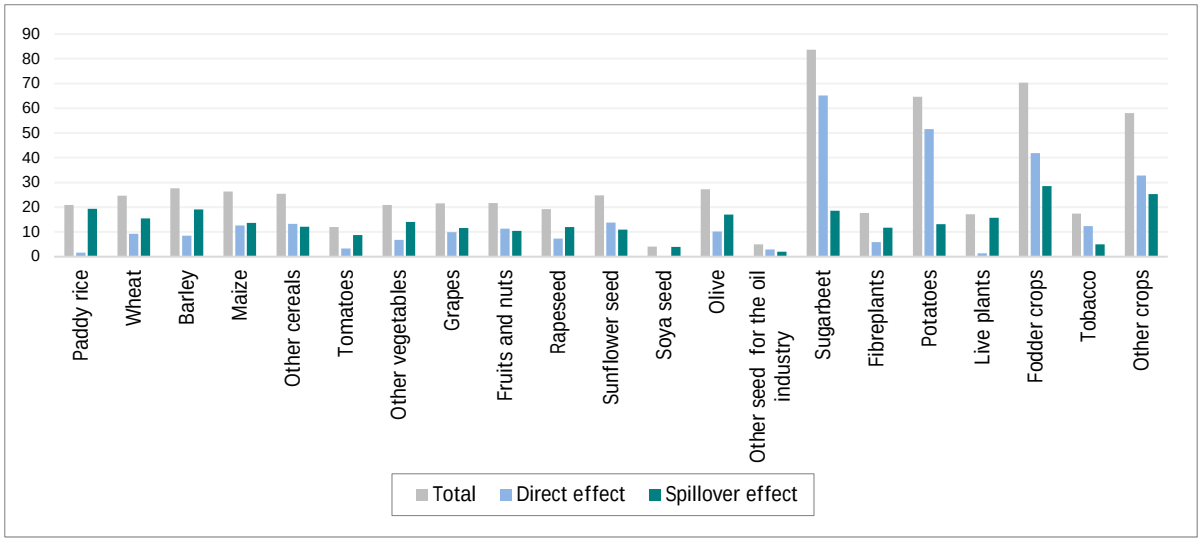


Source: own elaboration with BioSAM 2015.

3.2.1.2 Employment Effects

Considering the employment results derived by the final demand change by products, the more labour intensive sectors lead the way, within this category, such as only 'sugar beet', 'potatoes' and 'feedstock' products (fodder crops and other crops) which clearly stand out. This is also confirmed by the value of the direct effect for these commodities in terms of job creation (Figure 10).

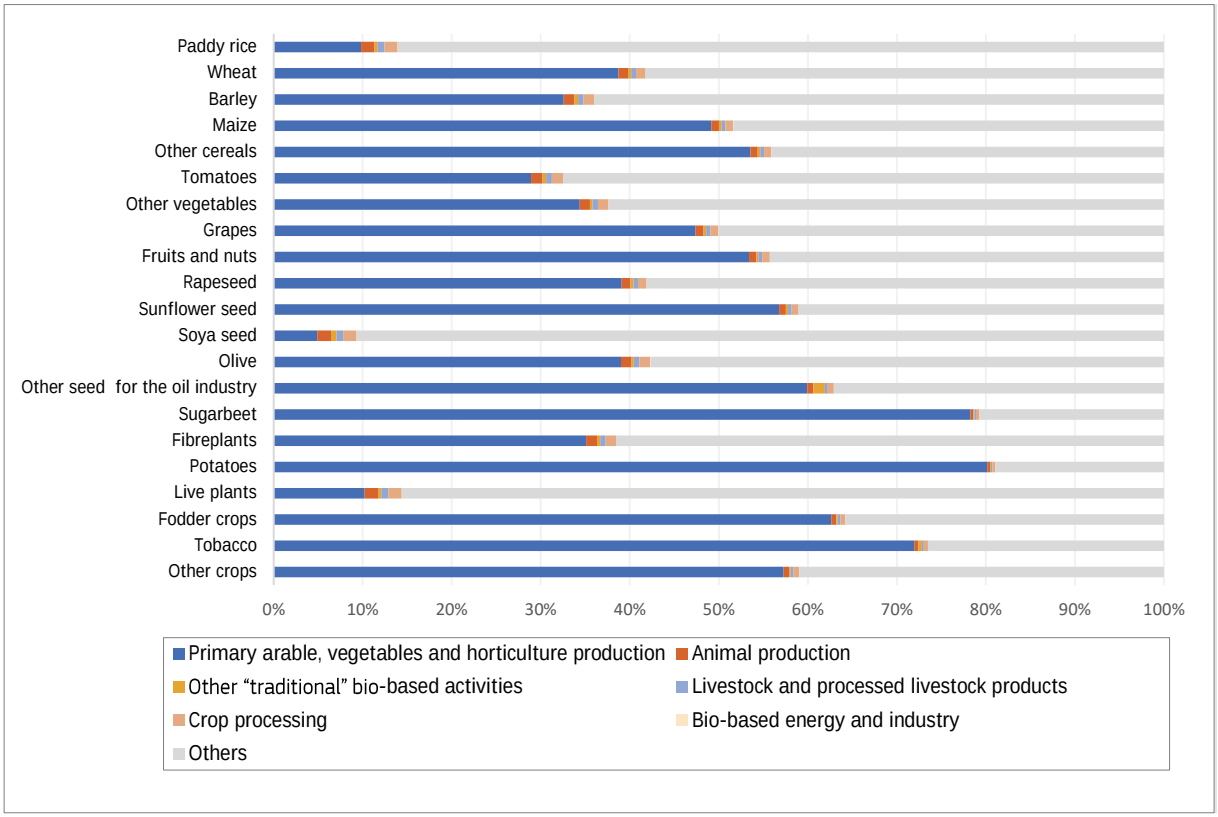
Figure 10. Total, Direct and Spillover employment effects (persons) by primary arable, vegetables and horticulture production



Source: own elaboration with BioSAM 2015.

For most of the products analysed in this group, the distribution of the employment multiplier impact is highly concentrated within the 'primary arable, vegetables and horticulture' and other sectors (Figure 11). 'Sugarbeet' and 'potatoes' stand out, with almost 80% of the employment impact that remains in the 'primary arable, vegetables and horticulture' macro-group.

Figure 11. Distribution across each activity of the employment generated due to an exogenous impact on primary arable, vegetables and horticulture production demand.



Source: own elaboration with BioSAM 2015.

3.2.2 Animal production

This group includes 6 products of which 4 are classified as 'intensive livestock', one as 'extensive livestock' and another one as 'intermediate products' (Table 4).

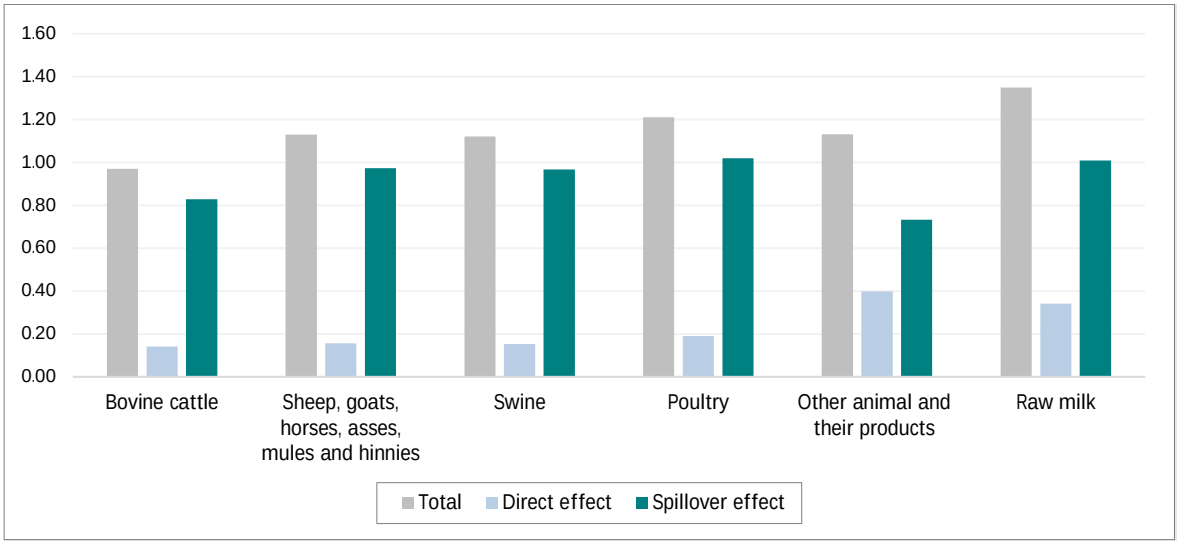
Table 4. Sectoral categories in 'Animal production'

Level 2	Level 3
Extensive livestock	Sheep, goats, horses, asses, mules and hinnies
Intensive livestock	Swine Poultry Bovine cattle Other animal and their products
Intermediate products	Raw Milk

3.2.2.1 Value Added Effects

Almost all the products classified under animal production have a value added multiplier above one, with spillover effects accounting for more than 70% of the total effect (see Figure 12). This can also be read as the capacity of this macro category to generate value added across other sectors and so being able to distribute value across the value chain.

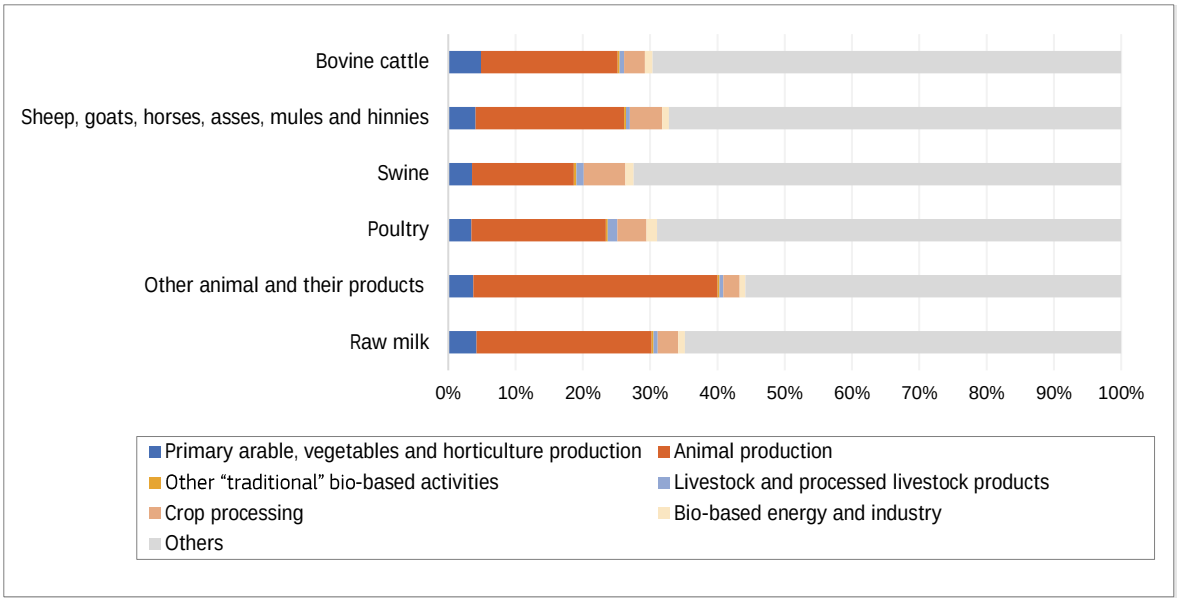
Figure 12. Total, Direct and Spillover value added effects (million €) by animal production



Source: own elaboration with BioSAM 2015.

As can be seen in Figure 13, the value added generated by an exogenous increase in demand in the animal production sector is mainly distributed among itself and 'others', also having a relevant influence on the primary arable and crop processing sectors, mainly on 'cereals', 'fodder crops' and 'prepared animal feed products'.

Figure 13. Distribution across each activity of the value added generated due to an exogenous impact on animal production demand.

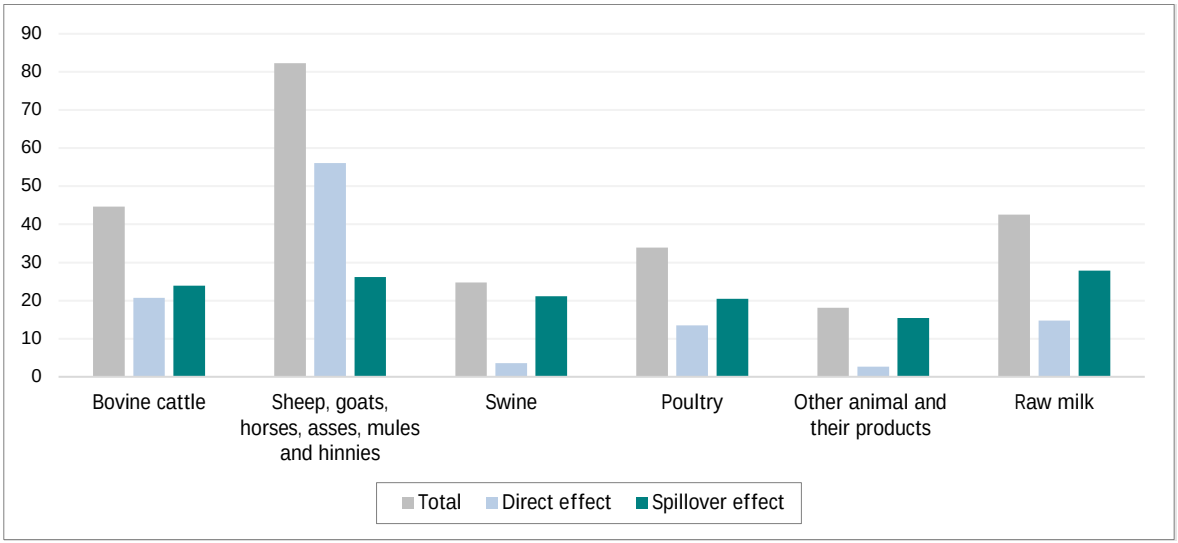


Source: own elaboration with BioSAM 2015.

3.2.2.2 Employment Effects

The employment multiplier has the highest value in the 'extensive livestock' sector, where about 68% of its value counts as a direct impact. In the 'intensive livestock' sector, the most important products are 'bovine cattle' and 'poultry', and 'raw milk' as intermediate product (Figure 14).

Figure 14. Total, Direct and Spillover employment effects (persons) by animal production

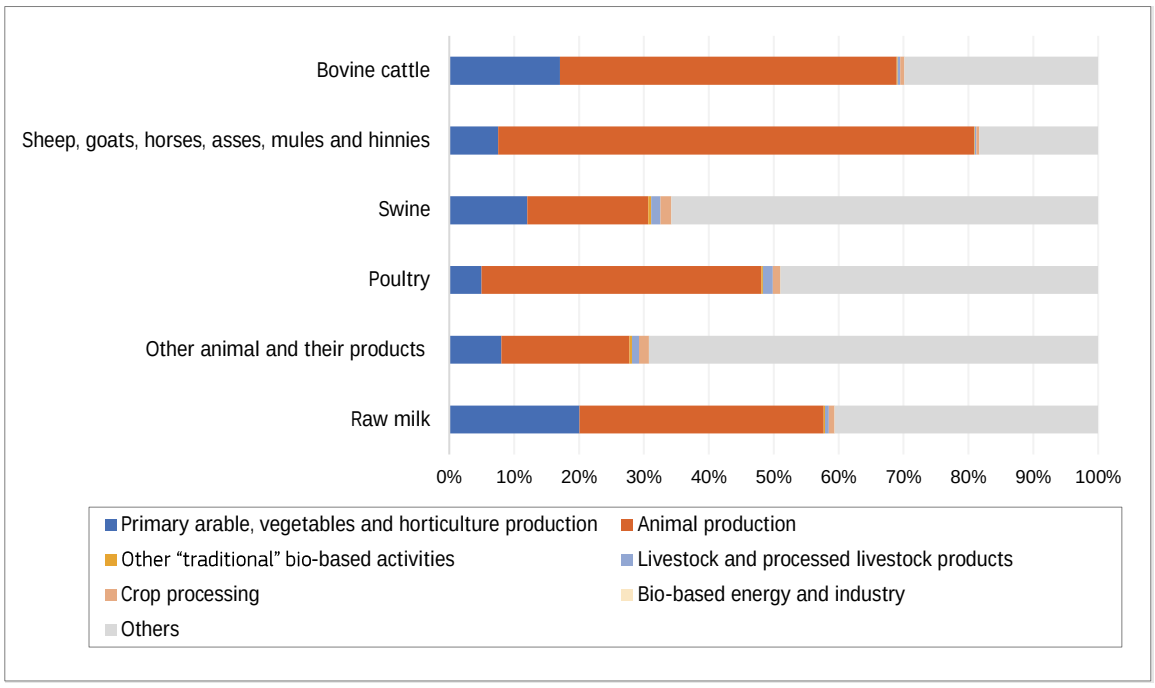


Source: own elaboration with BioSAM 2015.

As can be seen in Figure 15, the employment impact of the 'extensive livestock' sector (sheep, goats, horses, asses, mules and hinnies) is concentrated in the animal production group (almost 73.3%) and, to a lesser extent, in the primary arable mainly consisting of 'fodder crops', 'wheat' and 'maize' (7.6%). For 'bovine cattle' and 'raw milk', more than 50% of the multiplier impact is distributed across 'animal production and the primary arable' groups.

In the case of 'poultry', 'swine' and 'other animal and their products', although the multiplier value is not high, the value chain composition shows that the impact is distributed mainly in other sectors, but also highlighting the impact towards the 'animal production', the 'primary sector', the 'livestock and processed livestock products' and 'crop processing' group (see Figure 15).

Figure 15. Distribution across each activity of the employment generated due to an exogenous impact on animal production demand.



Source: own elaboration with BioSAM 2015.

3.2.3 **Other "traditional" bio**-based activities

This "heterogeneous" group includes the traditional primary sector with food purposes (such as 'fishing') and the non-food purposes, distinguishing between 'forestry' and 'specialist non-food energy crops' (Table 5).

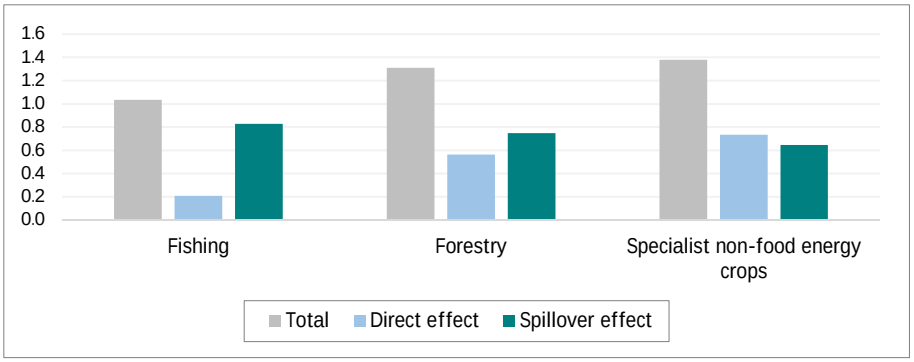
Table 5. Sectoral categories in 'Other "traditional" bio-based activities'

Level 2	Level 3
Fishing	Fishing
Forestry	Forestry
Specialist non-food energy crops	Specialist non-food energy crops

3.2.3.1 Value Added Effects

Figure 16 results clearly show a different effects composition between 'fishing' sector and, 'forestry' and 'Specialist non-food energy crops' as a result of the heterogeneity of this macro-category. In the former case, the spillover effect has a higher value when compared to the direct one, while in the latter, the structure of the impacts show similar direct-spillover ratio and, in the case of 'specialist non-food crops', the direct effect overcome the spillover one.

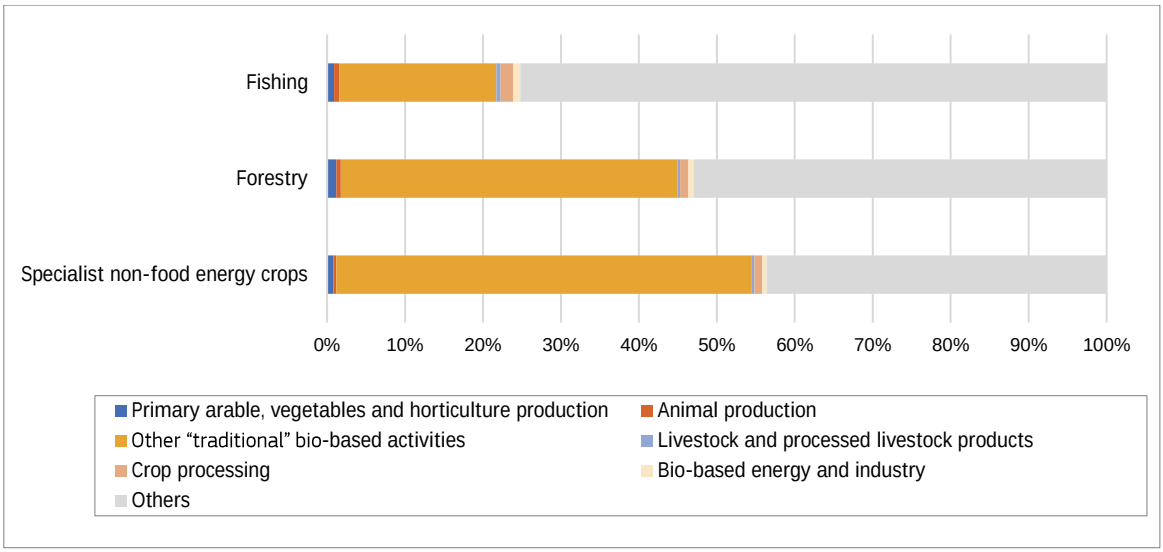
Figure 16. Total, Direct and Spillover value added effects (million €) by other "traditional" bio-based activities



Source: own elaboration with BioSAM 2015.

According to Figure 17, the value added impact of the products within this sector is concentrated towards the products that receive the shock and 'others'. Small percentage values are also noted in the 'primary arable' and 'crop processing' groups.

Figure 17. Distribution across each activity of the value added generated due to an exogenous impact on other "traditional" bio-based activities demand.

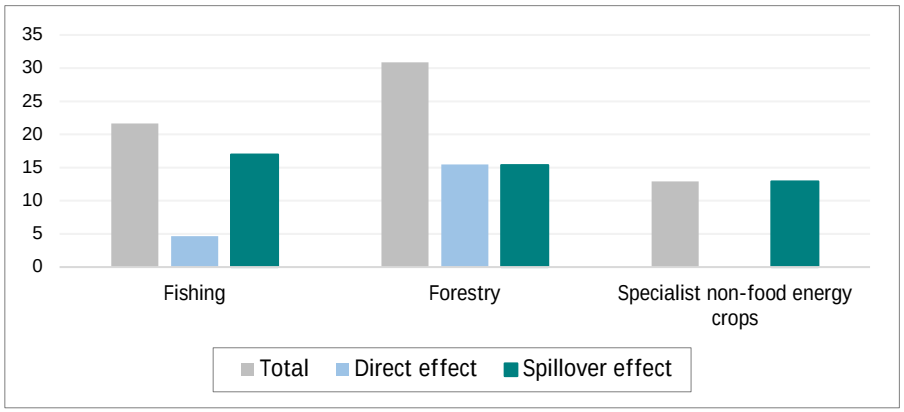


Source: own elaboration with BioSAM 2015.

3.2.3.2 Employment Effects

Despite being able to generate value added when a demand change is computed, 'specialist non-food energy crops' not creates a direct employment. On the contrary, 'forestry' has the highest value added multiplier and can also generate an employment direct and spillover impacts in the same extent (Figure 18).

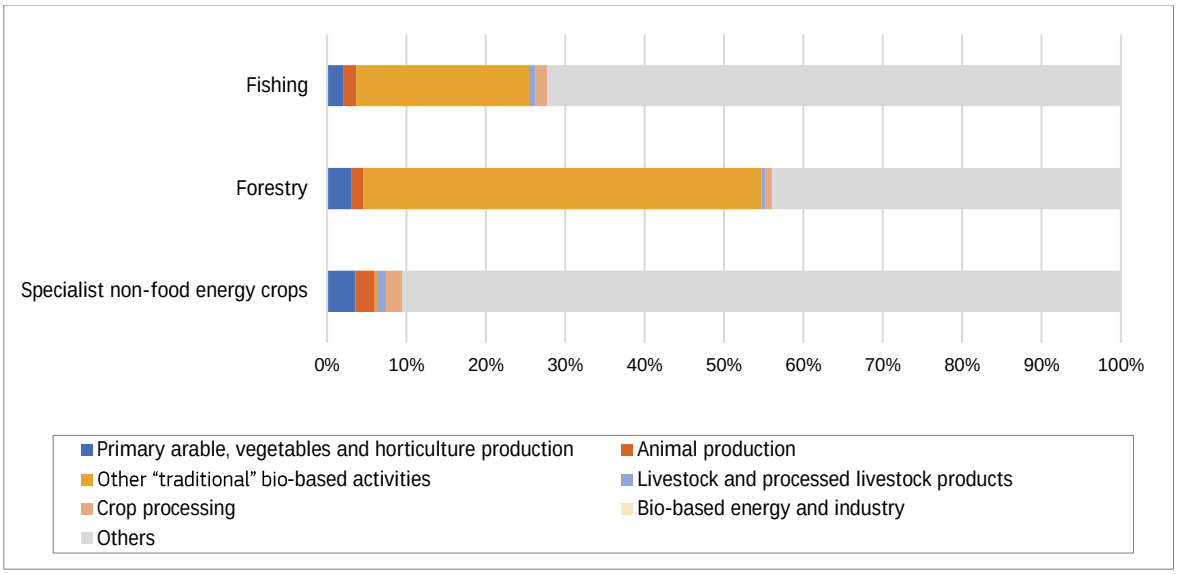
Figure 18. Total, Direct and Spillover employment effects (persons) by other "traditional" bio-based activities



Source: own elaboration with BioSAM 2015.

The effect composition is also displayed in Figure 19, where in both 'forestry' and 'fishing' the 94% of the total effect is distributed between the same group and 'others'. The rest of the multiplier effect is mainly distributed between 'primary arable', 'animal production' and 'crop processing'.

Figure 19. Distribution across each activity of the employment generated due to an exogenous impact on other "traditional" bio-based activities demand.



Source: own elaboration with BioSAM 2015.

3.2.4 Livestock and processed livestock products

This group belongs to the food products identified in the CPA classification. It distinguishes between 'dairy' and 'meat products', differentiating within 4 types of meat products (Table 6).

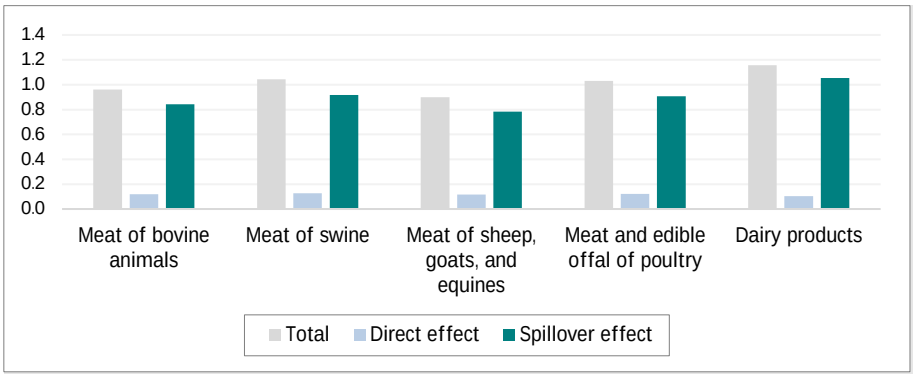
Table 6. Sectoral categories in 'Livestock and processed livestock products'

Level 2	Level 3
Meat	Meat of bovine animals
	Meat of swine
	Meat of sheep, goats, and equines
	Meat and edible offal of poultry
Dairy	Dairy products

3.2.4.1 *Value Added Effects*

Dairy products have the highest value added multiplier within this group, followed by 'meat of swine' and 'meat and edible offal of poultry'. However, the values are slightly higher than one and are mainly concentrated on the spillover effects (Figure 20).

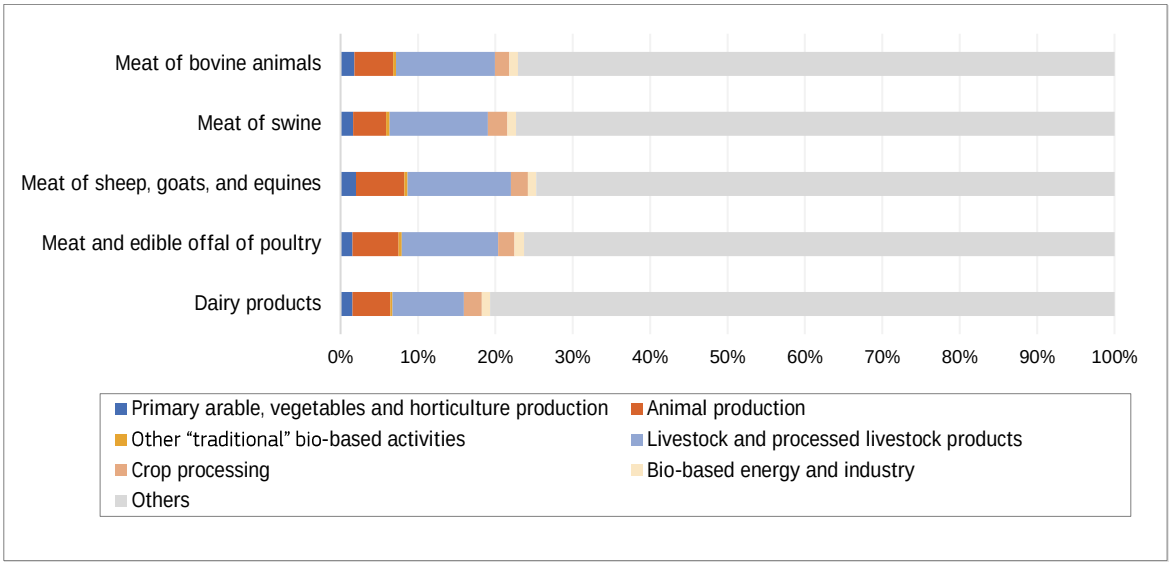
Figure 20. Total, Direct and Spillover value added effects (million €) by livestock and processed livestock products



Source: own elaboration with BioSAM 2015.

Almost more than 70% of the value added generated by the products of these groups is concentrated in 'other sectors' (with an impact mainly on trade and business services) and about 12% in 'livestock and livestock processing products'. To a lesser extent, it has also an impact on products classified in 'animal production', 'crop processing' and 'primary arable, vegetables and horticulture' (see Figure 21).

Figure 21. Distribution across each activity of the value added generated due to an exogenous impact on livestock and processed livestock products demand.

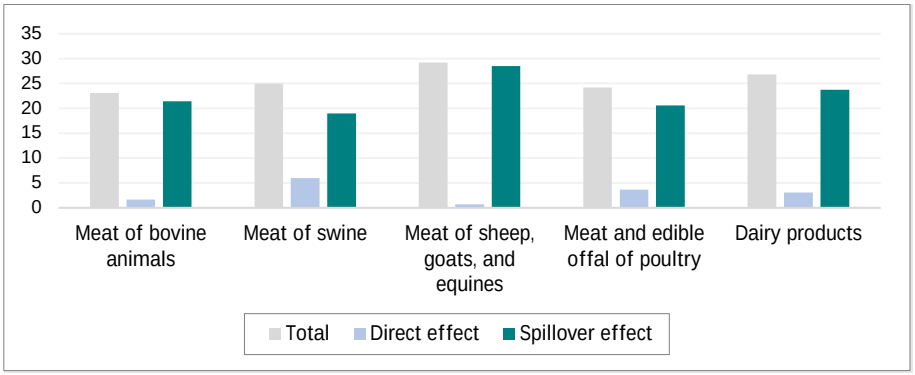


Source: own elaboration with BioSAM 2015.

3.2.4.2 *Employment Effects*

Similar results can also be found for the employment generation, with multiplier values observed in a range between 23 ('meat of bovine animals') and 29 ('sheep, goat and equine meat') job created per one million euro of final demand variation (Figure 22).

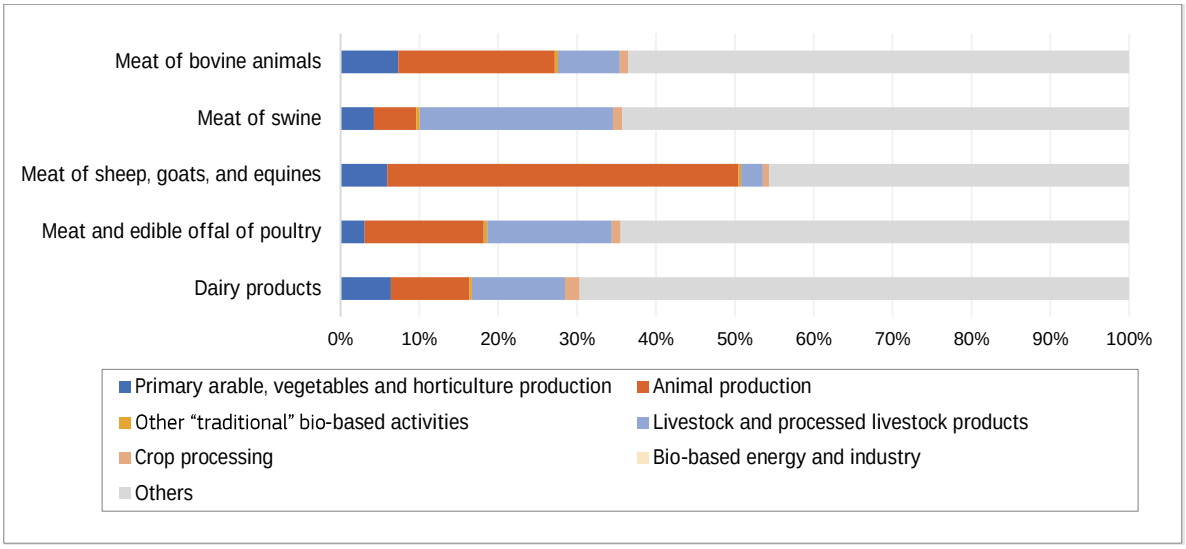
Figure 22. Total, Direct and Spillover employment effects (persons) by livestock and processed livestock products



Source: own elaboration with BioSAM 2015.

Figure 23 also highlights the value chain composition of the sectors included in this group. For example, analysing the distribution of the employment impact in the case of 'meat of sheep, goat and equines', the 44.5% of the multiplier towards 'animal production' group stands out considerably, followed by 6% across the 'primary arable, vegetables and horticulture'.

Figure 23. Distribution across each activity of the employment generated due to an exogenous impact on livestock and processed livestock products demand.



Source: own elaboration with BioSAM 2015.

3.2.5 Crop processing

A second part of the food products is represented by the 'crop processing'. This group includes 8 commodities, covering 'vegetable oils', 'processed sugar', 'animal feed', 'horticultural production' and 'food, tobacco and beverages' (Table 7).

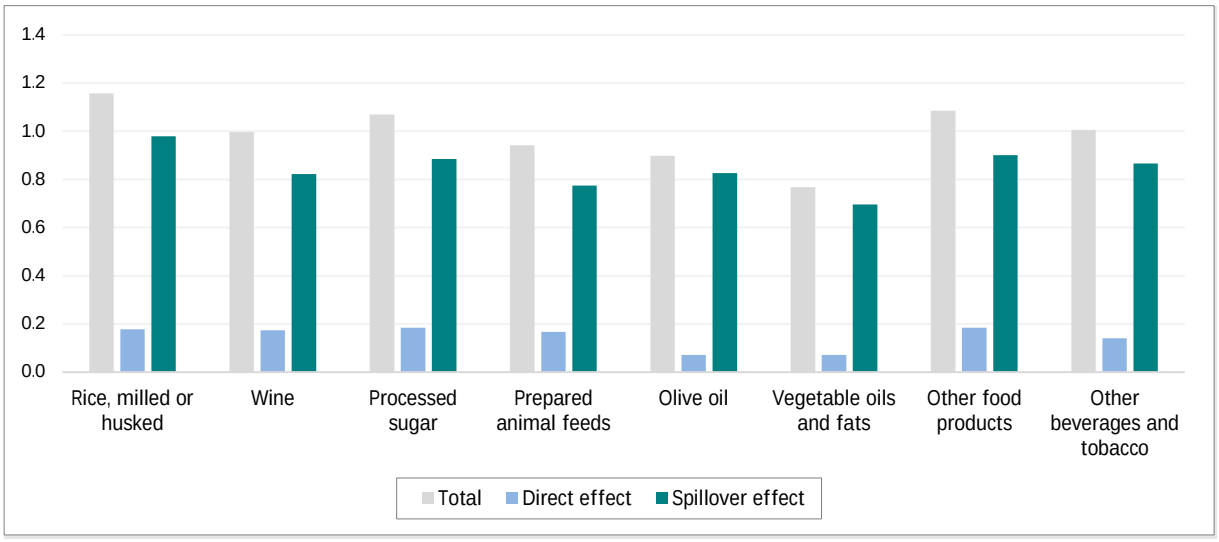
Table 7. Sectoral categories in 'Crop processing'

Level 2	Level 3
Horticulture production	Rice, milled or husked Wine
Sweeteners	Processed sugar
Feeding stuff	Prepared animal feeds
Vegetable oils	Olive oil Vegetable oils and fats
Other food and beverages	Other food products Other beverages and tobacco

3.2.5.1 *Value Added Effects*

Within this group there are four products with value added multipliers slightly above one: 'rice, milled or husked' 'other food products', 'processed sugar' and 'other beverages and tobacco'. The composition of the multiplier effects for these products is similar, with around 84% of the spillover effects standing out (Figure 24).

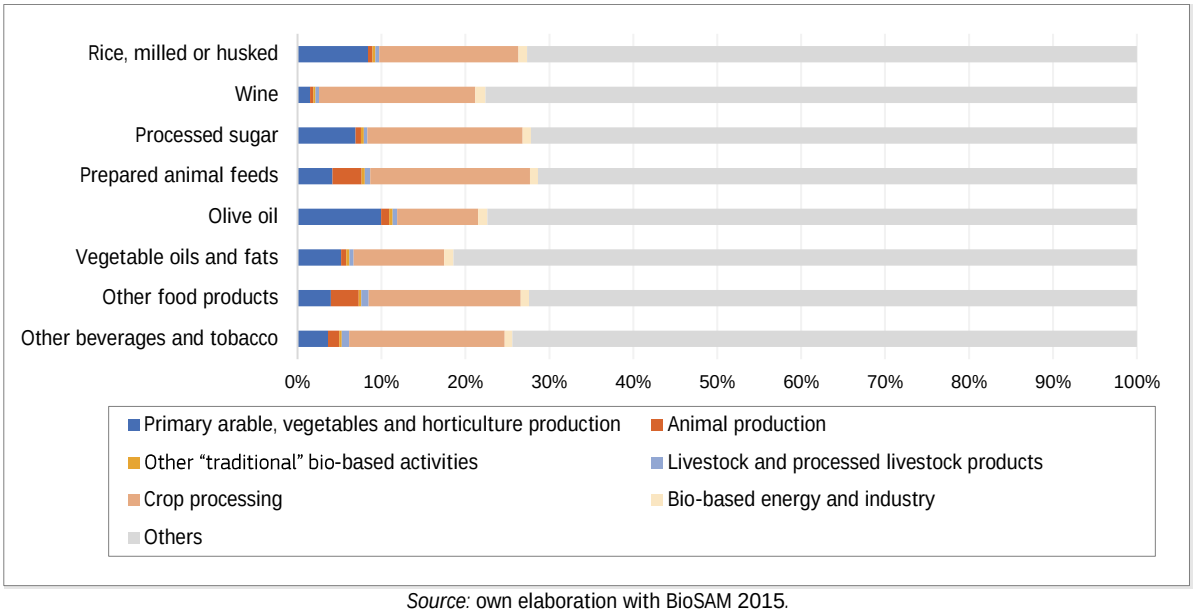
Figure 24. Total, Direct and Spillover value added effects (million €) by crop processing



Source: own elaboration with BioSAM 2015.

In addition to the effect on the group of other sectors (due to mainly the impact on trade, transport and business services), the value added generated by 'crop processing' products is mostly distributed within the sector itself, into the 'primary arable, vegetable and horticulture' sector and with lower impact through 'animal production' (Figure 25).

Figure 25. Distribution across each activity of the value added generated due to an exogenous impact on crop processing demand.

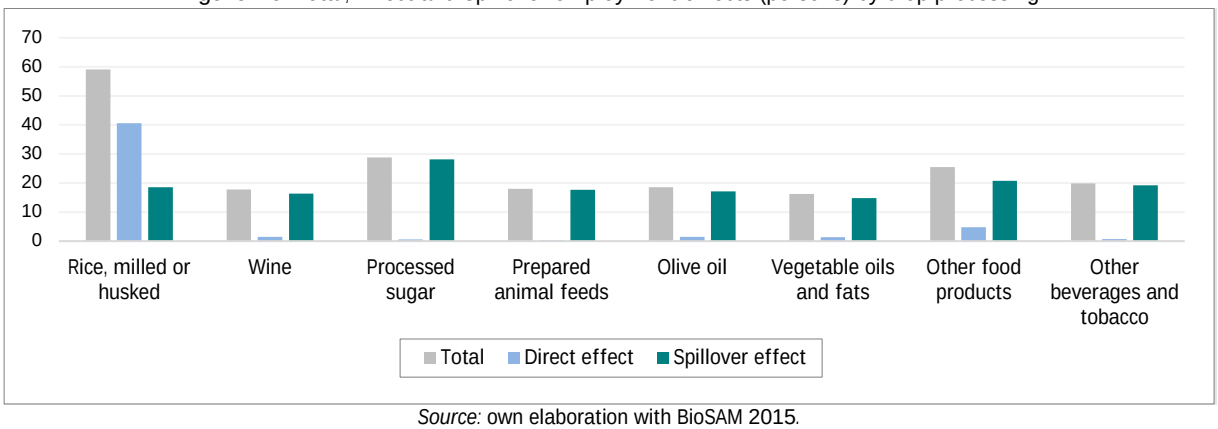


Source: own elaboration with BioSAM 2015.

3.2.5.2 *Employment Effects*

Considering the employment multiplier, the 'rice, milled or husked' product has the highest value, generating approximately 59 jobs per million euro of additional external input. The composition of the multiplier (Figure 26) shows that the jobs created have a high direct impact of around 70% of the total effect. 'Processed sugar' and 'other food products' follow with lower employment multiplier values of 28.8 and 25.5 respectively. For the other products in this group, the multiplier values are less than 20.

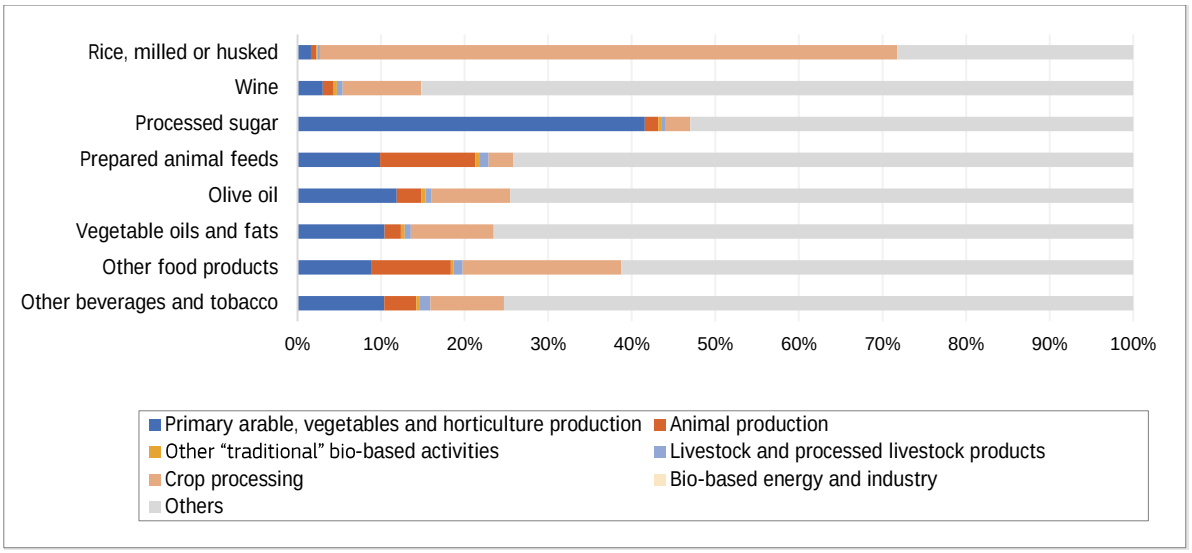
Figure 26. Total, Direct and Spillover employment effects (persons) by crop processing



Source: own elaboration with BioSAM 2015.

The products that generates a higher employment multiplier values present a different composition of the spillover effect derived by the 'others' group. In the case of 'rice, milled or husked' employment is concentrated in the crop processing sector, however, in the case of 'processed sugar' 41.5% of the impact is attributable to the 'primary arable, vegetable and horticulture' group. In the case of 'other food products', the employment multiplier is mostly distributed across 'others' and the 'crop processing' group, but also has an impact on 'primary arable, vegetables and horticulture' sector and 'animal production' (Figure 27).

Figure 27. Distribution across each activity of the employment generated due to an exogenous impact on crop processing demand.



Source: own elaboration with BioSAM 2015.

3.2.6 Bio-based energy and industry

Bio-based energy and industry group includes partially 'manufacture of chemicals and chemical products' and 'electricity and gas, steam and air conditioning supply'. Within this macro category there are four accounts for liquid biofuel divided into conventional and advanced generation, one account for the 'bio-chemical' and one for the 'bio-electricity' (Table 8).

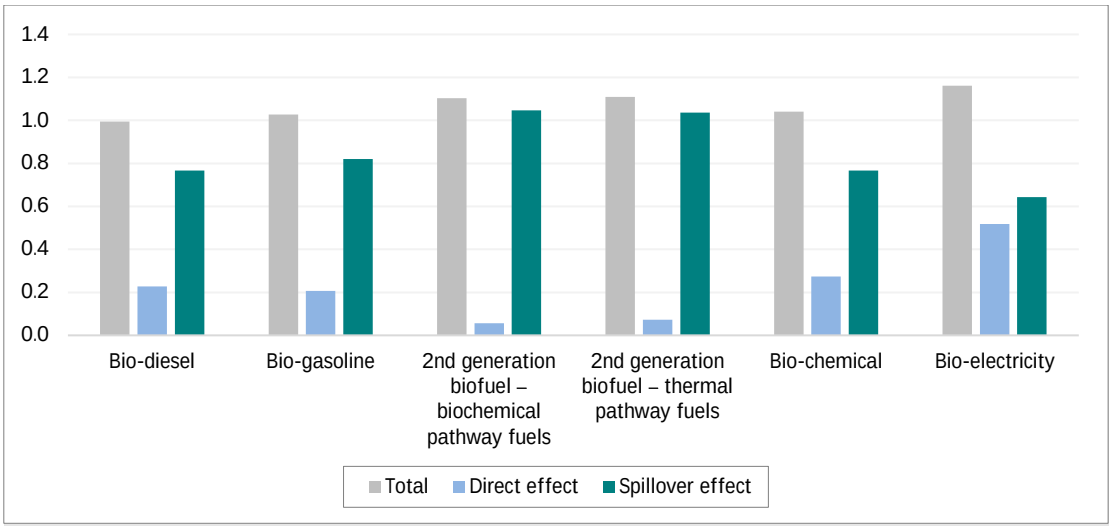
Table 8. Sectoral categories in 'Bio-based energy and industry'

Level 2	Level 3
Conventional generation liquid biofuels	Bio-gasoline Bio-diesel
Advanced generation liquid biofuels	2nd generation biofuel – biochemical pathway fuels 2nd generation biofuel – thermal pathway fuels
Bio-chemical	Bio-chemical
Bio-electricity	Bio-electricity

3.2.6.1 *Value Added Effects*

Bio-energy and bio-industry related products show value added multiplier values that are slightly higher than one, with 'bio-electricity' and '2nd generation biofuels' with the highest value. The spillover effect is also notable for all products, except for 'bio-electricity', whose multiplier is distributed almost proportionally between the direct effect and the rest (Figure 28).

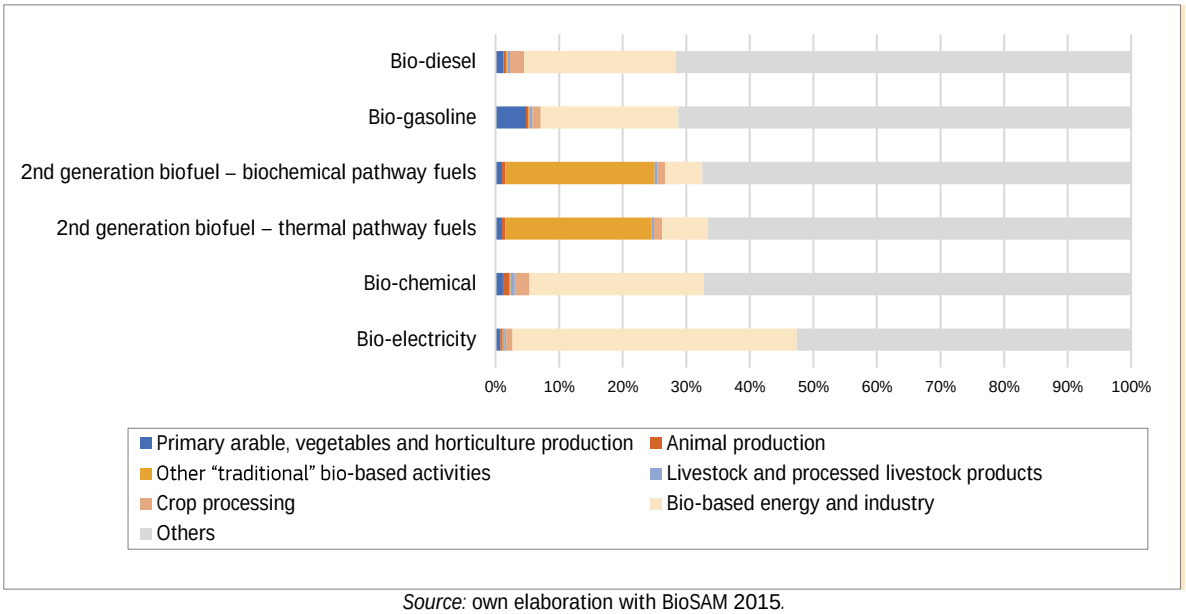
Figure 28. Direct and Spillover value added effects (million €) of by bio-based energy and industry



Source: own elaboration with BioSAM 2015.

As shown in Figure 29, the value added generated for the '2nd biofuels' has a high impact on 'other "traditional" bio-based activities', especially 'forestry'. Most of the value added impact is concentrated in the group 'others' and in the sector itself, however, in the case of 'bio-gasoline', 'bio-diesel' and 'bio-chemicals', the 'primary arable' and 'crop processing' sector also stand out.

Figure 29. Distribution across each activity of the value added generated due to an exogenous impact on bio-based energy and industry demand.

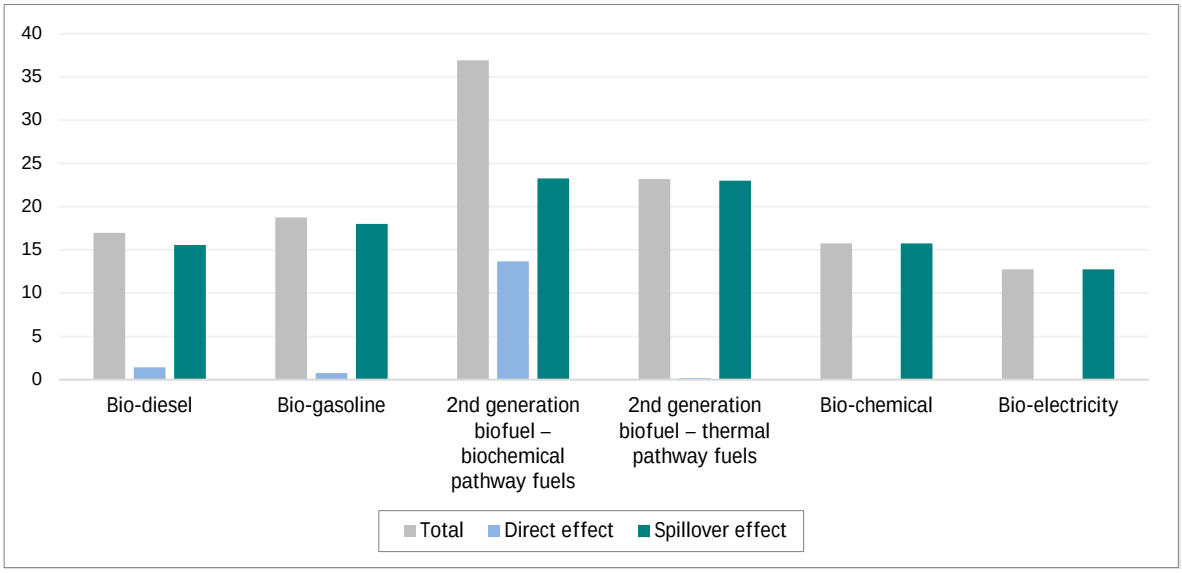


Source: own elaboration with BioSAM 2015.

3.2.6.2 *Employment Effects*

In terms of employment, the 'advanced generation liquid biofuels' sectors stand out among others, especially the product related to biochemical pathway fuels. The latter being also the one able to generate the highest direct effect value. On the other hand, thermal pathway fuels, 'bio-chemical' and 'bioelectricity' only generate spillover effect (Figure 30).

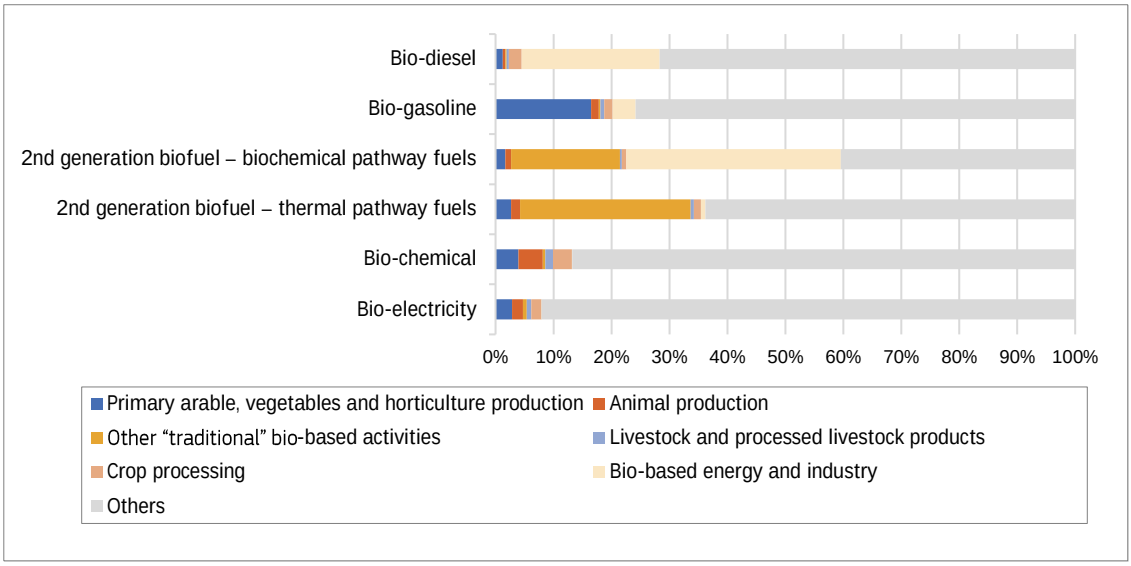
Figure 30. Direct and Spillover employment effects (persons) of by bio-based energy and industry



Source: own elaboration with BioSAM 2015.

As mentioned in the case of the value added results, the employment impact for 'advanced generation liquid biofuels' is also distributed across the 'other "traditional" and bio-based activities' impacting on 'forestry'. For the other products, for example the 'conventional generation liquid biofuels' or 'bio-chemical', even if they have a low employment multiplier, the impact is distributed, with different shares, in the primary sector, e.g., cereals, sugar beet, oilseeds and vegetable oils (Figure 31).

Figure 31. Distribution across each activity of the employment generated due to an exogenous impact on bio-based energy and industry demand.



Source: own elaboration with BioSAM 2015.

4 Case study: BioSAMs in the food system perspective

This section presents a focus related to the food system perspective, analysing the potential of each product group in the EU Member States.

Thus, the following groups are considered:

- Primary arable, vegetables and horticulture production
- Animal production
- Other "traditional" bio-based activities (only fishing)
- Livestock and processed livestock products
- Crop processing

The next Figure (32) shows the value added and employment multipliers for the EU27 aggregate considering the commodities grouped under the classification proposed in the previous section. However, by using the dashboard it is possible to zoom into the content of each sector and drill down into the different commodities.

Note that the estimates of value added and employment presented in this section are not fully comparable with those released by the JRC at https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html. The latter compiles data from Eurostat - National accounts for the sectors of Agriculture, Forestry and Fisheries, and from Eurostat – Structural business statistics for processing industries.

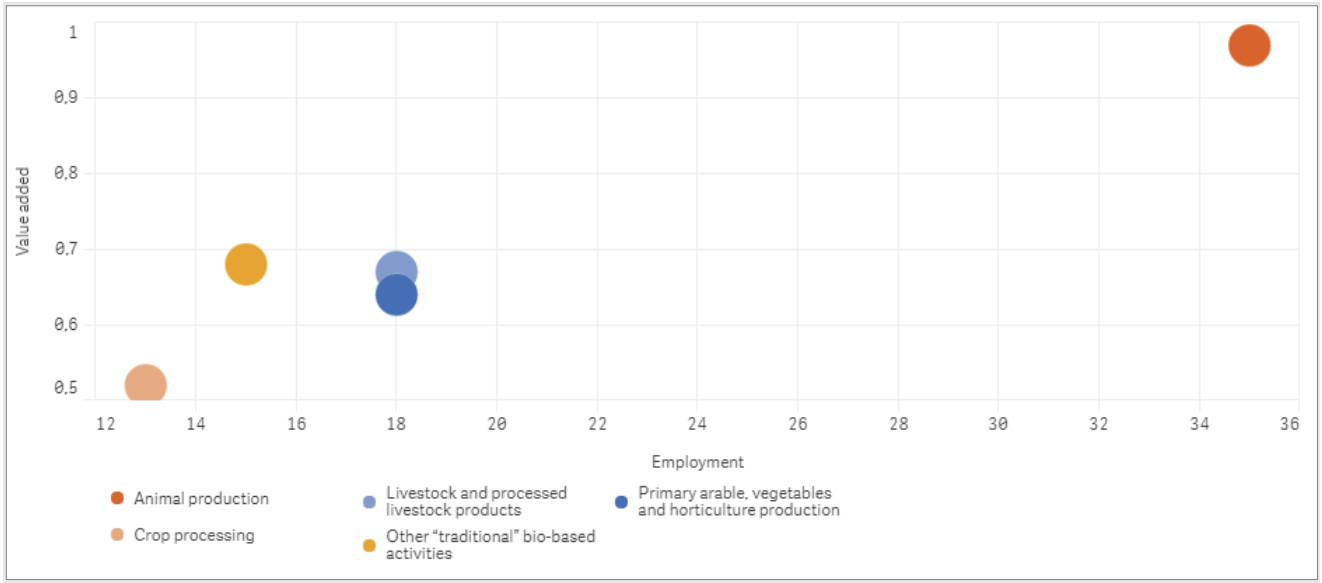
With the aim to analyse the potential impact of the sectors related to the food chain across EU countries, the following country clustering was considered:

- Northern: Denmark, Finland, Sweden, Latvia, Estonia and Lithuania.
- Southern: Greece, Italy, Portugal, Spain, Malta and Cyprus.
- Eastern: Bulgaria, Croatia, Hungary, Czech Republic, Poland, Romania and Slovakia.
- Western: France, Austria, Belgium, Germany, Ireland, Netherlands, Luxembourg and Slovenia.

Figure 33 shows the value added and the employment generated by the total of commodities related to agriculture and food industry analysed (aggregated results) for each cluster. Thus, it displays a visual detail of those European areas with more labour-intensive food system related industries (such as Eastern) or capital-intensive (such as Southern). It also shows the EU27 average for comparison. In this case the dashboard also allows to select a cluster and to analyse the position of its countries. At the same time, the results of each cluster or country selected are automatically reflected in the dashboard (considering the example of Figure 32) and showing the analysis by sectors.

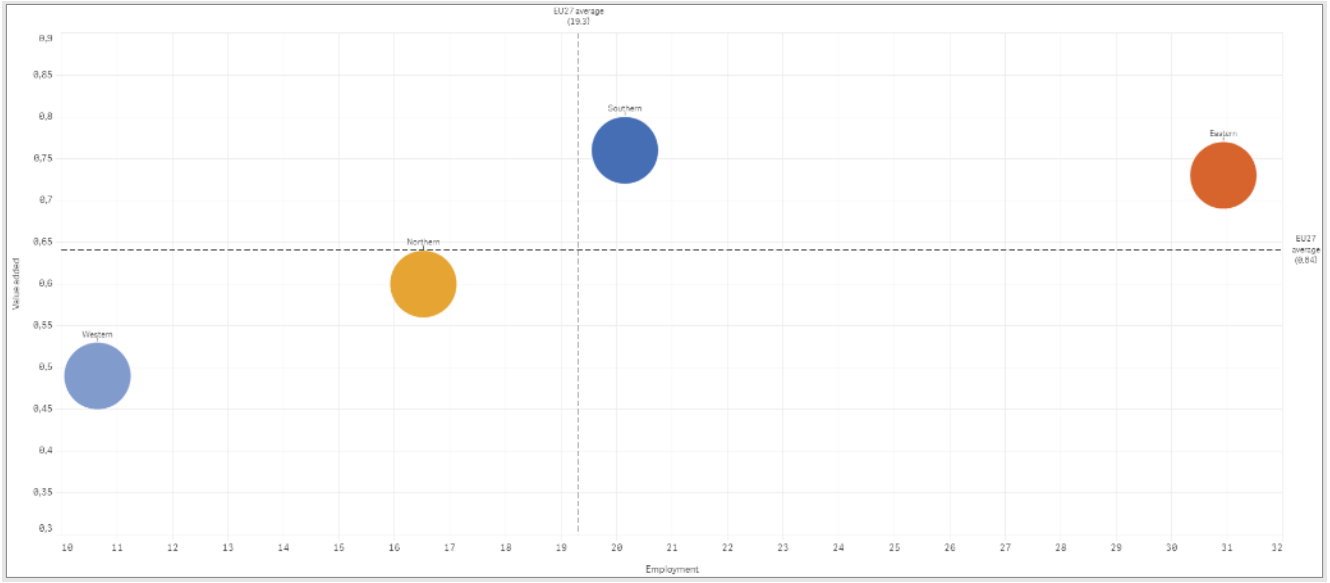
This chart gives a picture of the potential impact of the food system sector across European Union. Considering both the employment and value added impacts, Eastern and Southern regions have higher values than the EU27 average. For the country detail, the following sub-section considers results divided by area and country while for a deeper level of disaggregation we recommend visiting the dedicated dashboard in the DataM portal.

Figure 32. Value added (million €) and employment (persons) multipliers effects for EU27 aggregated sector classifications.



Source: own elaboration based on the BioSAM 2015.

Figure 33. Value added (million €) and Employment (person) multipliers effects by European Union clusters of countries, aggregated results.



Source: own elaboration based on the BioSAM 2015.

4.1 Value added results and cluster analysis

Figure 34 portrays the map for the four above mentioned geographical clusters, representing the average value added multipliers arising from the exogenous demand shock in the food system related industries. With a darkest shade of green the highest impacts are highlighted. According to the map, the resulting value added generated within our classification of the food sector stands out for the Southern and Eastern countries. In a nutshell, EUR 1 million invested in the food system products would result in the creation of EUR 0.76 million of value added in the Southern region, EUR 0.73 million in the Eastern region, EUR 0.60 million in the Northern region and 0.49 in the Western region.

The results can be further analysed by considering the impact of the value added multiplier by the countries in each cluster (as in Figure 35) and by sector for each cluster (in absolutes values, as in Figure 36).

The share contribution calculation based on each sector's value added generated (measured in millions of euros) for each cluster can be observed in Figure 36. In addition, by using the dashboard it is possible to dig into the composition of each Food system category per Member State within the clusters. Thus, the analysis can be carried out considering the aggregate level of products (level 1), as well as the more disaggregated levels (level 3). The results can be analysed in relative values so as to understand the shares of the impact (as shown in the dashboard) or in absolute values to compare the results of each sector between countries (as in Figure 36).

For Southern regions, the best performers in terms of value added generation are Greece, Spain, Italy and to a lesser extent Portugal. Considering the value added impacts within sectors, 'animal production' stands out in most of the southern countries, especially in Greece, Spain and Italy. The key sectors within this cluster are represented by 'fishing' and 'animal production', with similar values in all the countries of the group (see Figure 36).

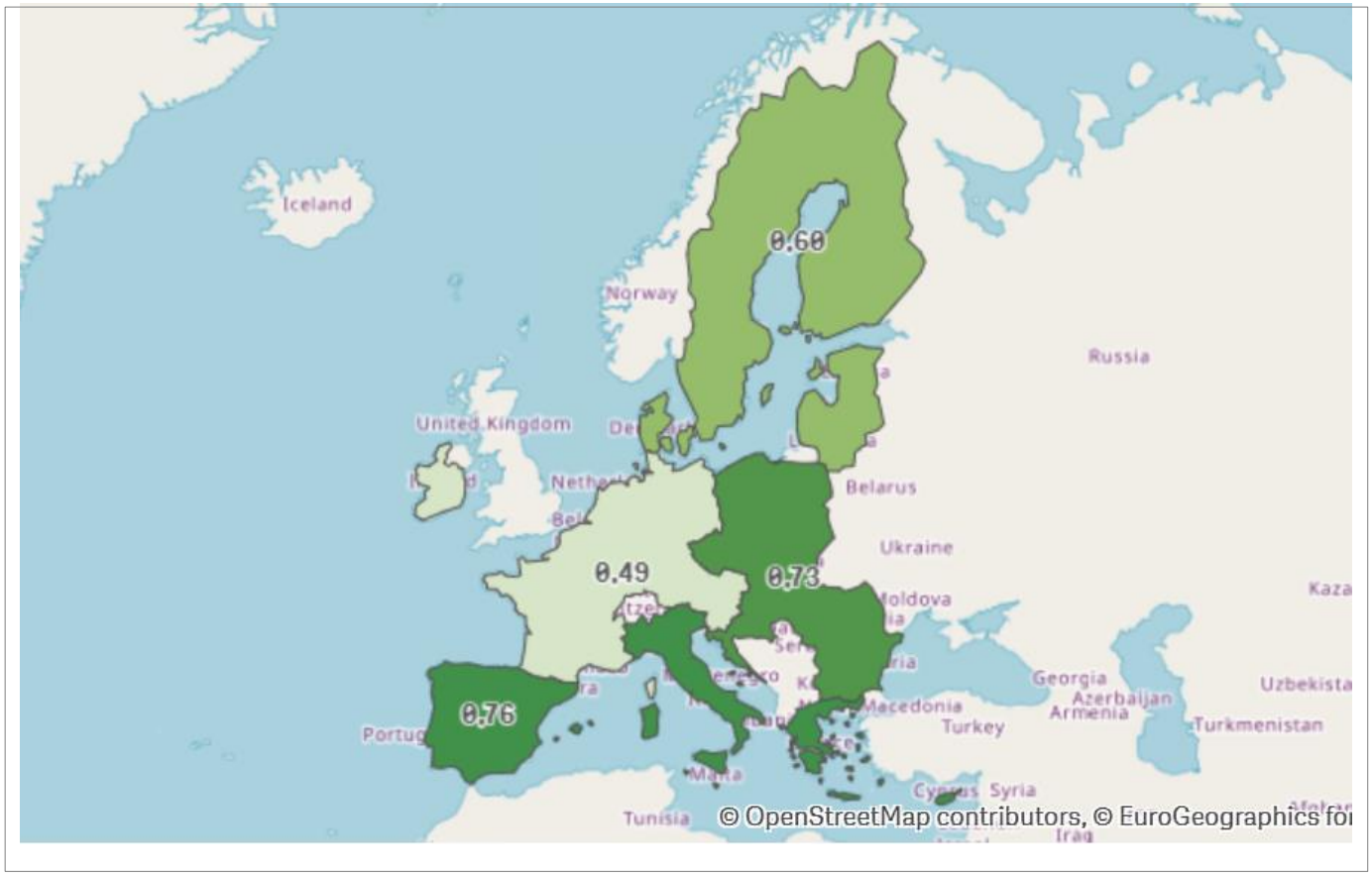
Within the primary sector, 'cereals', 'feedstock' and 'horticulture production' stand out mainly for Greece, Italy and Spain. Considering the 'animal production' sectors, the 'intermediate products' and 'livestock extensive' sectors are the most important for all the southern countries in terms of value added.

For Eastern countries, Romania and Poland have the highest value added multiplier value, with most of the value added impact coming from the 'animal production' and the 'livestock processing' sectors.

By focusing on the Northern countries, Denmark and Finland have the highest value added multiplier for food system, with a high impact from agriculture and animal production. In the case of Denmark, agriculture is mainly focused on the generation of added value from 'rapeseed'. For Finland, 'feedstocks' and 'other annual crops' such as 'fibre plants' stand out. Within 'animal production', 'extensive livestock' and 'intermediate products' stands out for both countries.

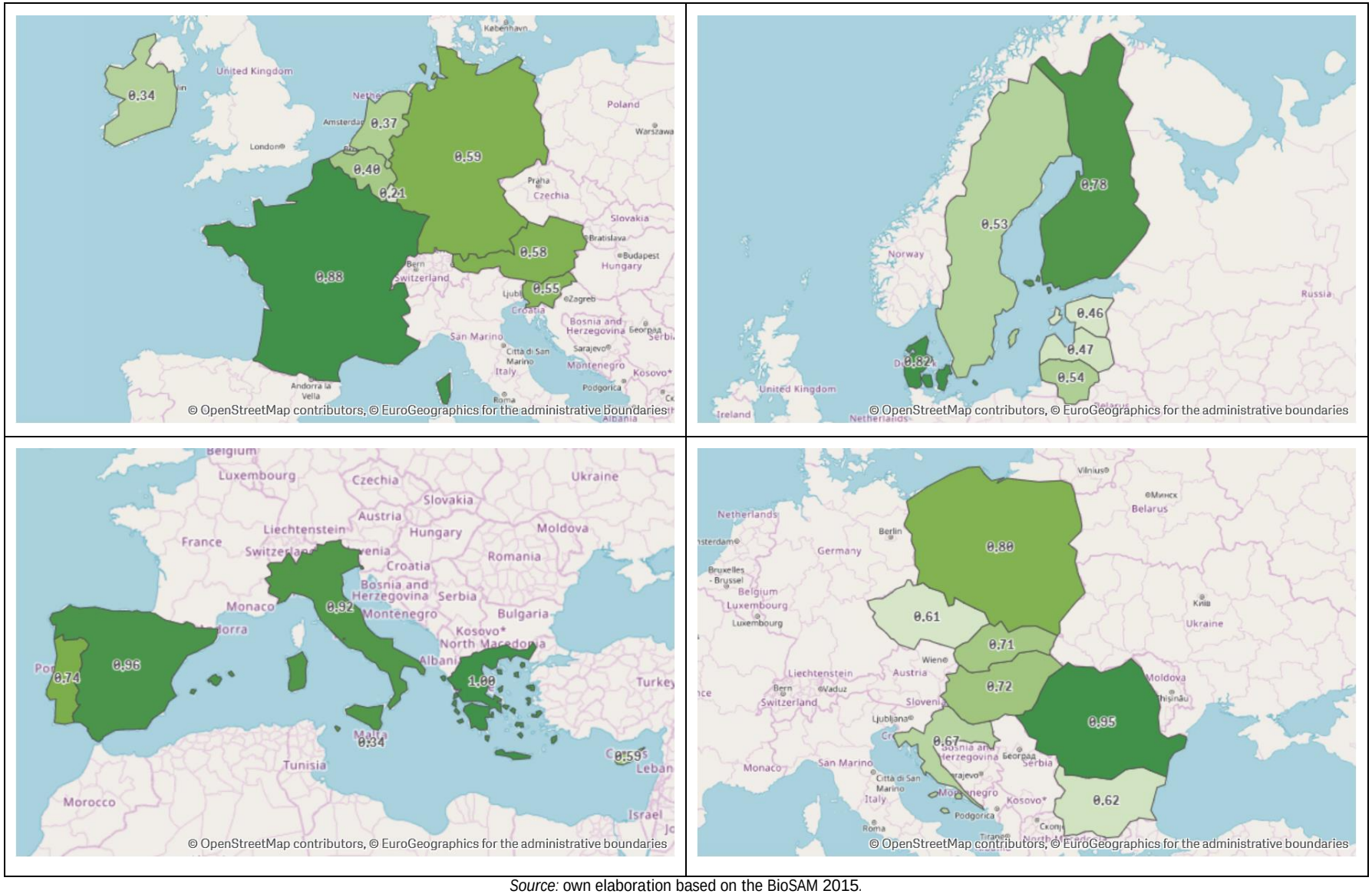
Western countries as a whole generate the lowest value added impacts across the four clusters. Among these countries the case of France stands out, mainly due to the primary and animal production sectors.

Figure 34. Map of value added multiplier effects by EU clusters (million €), average value of all food system related sectors.



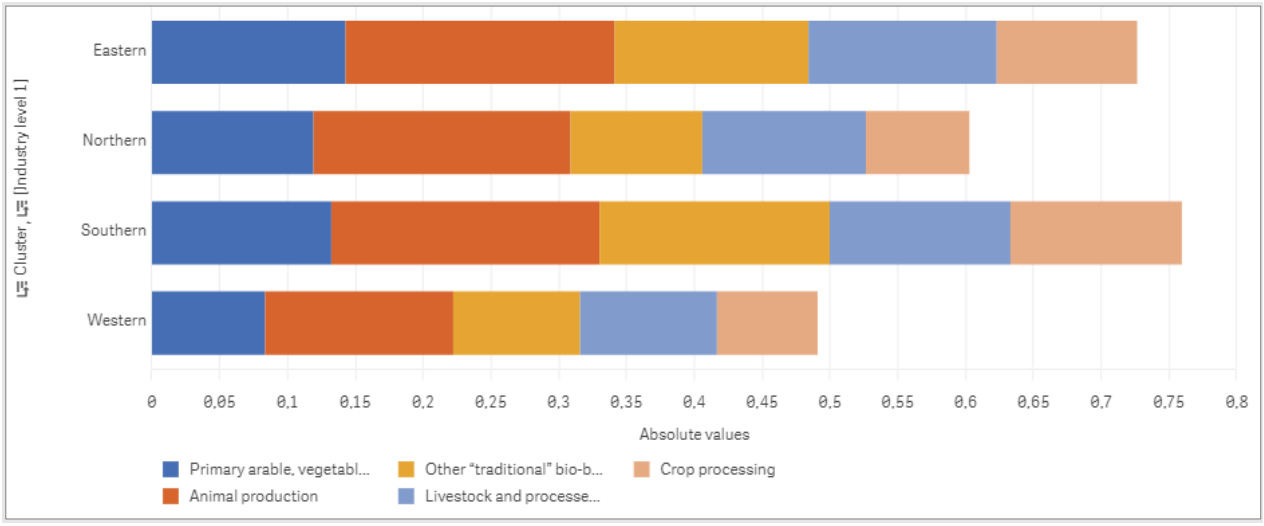
Source: own elaboration based on the BioSAM 2015.

Figure 35. Map of value added multiplier effects by EU countries within each cluster (million €), average value of all food system related sectors



Source: own elaboration based on the BioSAM 2015.

Figure 36. Value added shares by clusters and sector level (absolute values)



Source: own elaboration based on the BioSAM 2015.

4.2 Employment Results and cluster analysis

Under the same experimental conditions, Figure 37 shows the European map by cluster, representing the employment impacts due to the exogenous demand shock for food system related products. Measured in terms of the average number of jobs created by cluster, the map indicates that the Eastern countries perform best, followed by the Southern region. Thus, EUR 1 million invested in the food system products would result in 31 new jobs in the Eastern region, 20 in the Southern region, 17 in the Northern region and 11 in the Western region.

The results can be further analysed by considering the impact of the employment multiplier by the countries in each cluster (as in Figure 38) and by sector for each cluster (in absolutes values, as in Figure 39).

As aforementioned, the employment related to food-system intensive sectors stand outs for Eastern countries, mainly due to the 'primary arable, vegetable and horticulture' and 'animal production' activities. Within this group, Romania and Poland are the most important countries. For 'animal production' activities, 'extensive livestock' and 'intermediate products' stand out for both countries. In the primary sector, 'feedstock' is the most important activity, followed by 'potatoes' for both countries and also by 'sugar beet' in the case of Poland (see Figure 39).

Greece is the southern country with a higher employment multiplier, followed by Portugal. Similar to what was considered with the value added, the employment impact is greater in those sectors related to 'primary arable, vegetable and horticulture' and 'animal production'. Within the primary sector, 'feedstock' and 'other annual crops' stand out for Greece. Considering the 'livestock and processed livestock' activities, the 'extensive livestock' sector is the main driver in all the southern countries, as well as the 'dairy products' sector, as in the case of Greece and Portugal.

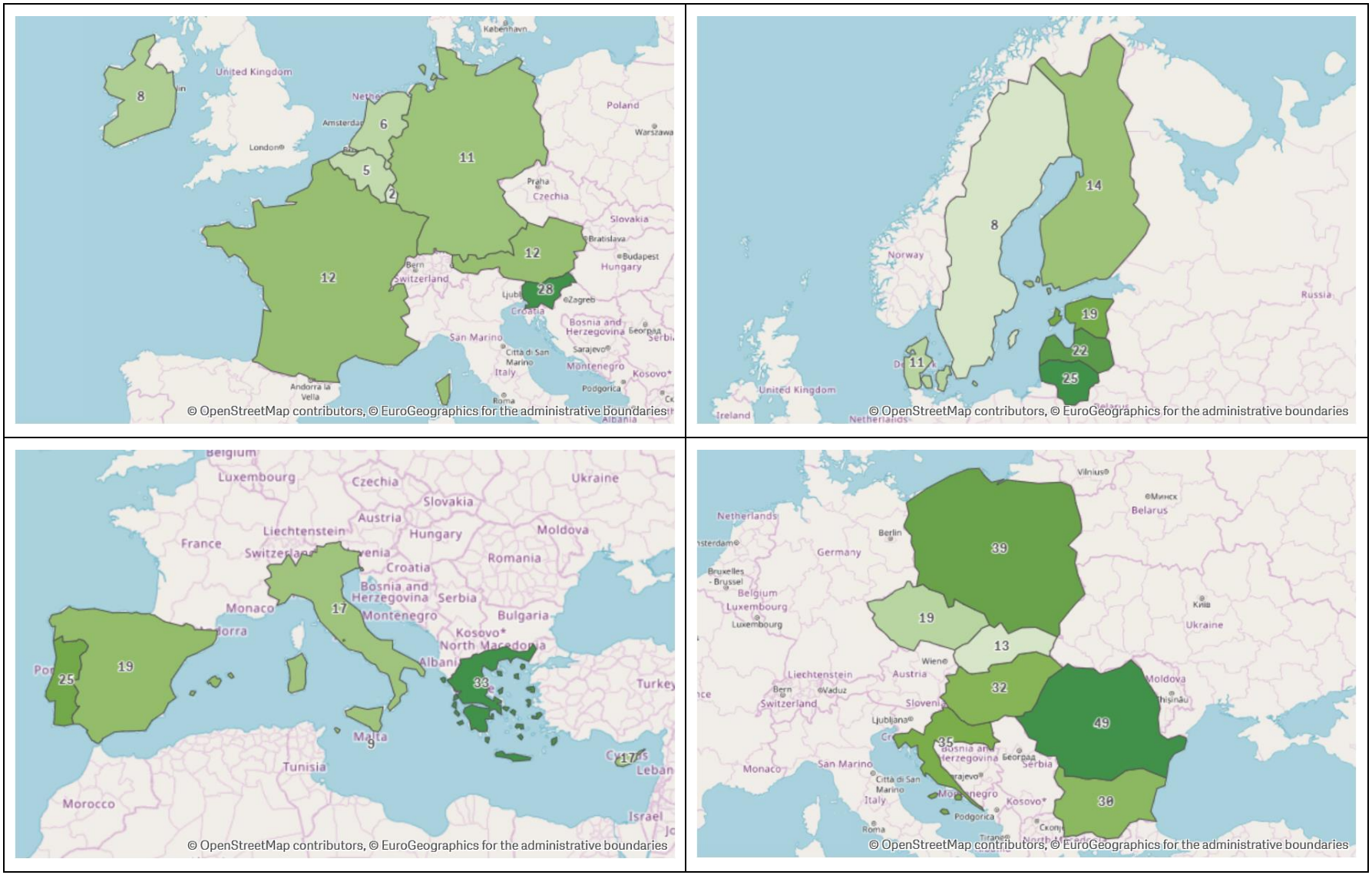
Amongst the Northern countries, in contrast to what was observed for value added impacts, the countries of the Baltic region stand out in terms of employment, especially Lithuania and Latvia, where the key sectors are represented by 'extensive livestock' for Latvia and 'intermediate products' for Lithuania.

For the Western countries, only Slovenia is the one with higher employment multiplier value due to 'animal production' and 'livestock processing' sectors, where 'extensive livestock' and 'dairy products' are the main drivers.

Figure 37. Map of Employment multiplier effects (person) by EU clusters of countries, average value of all food system related industries.

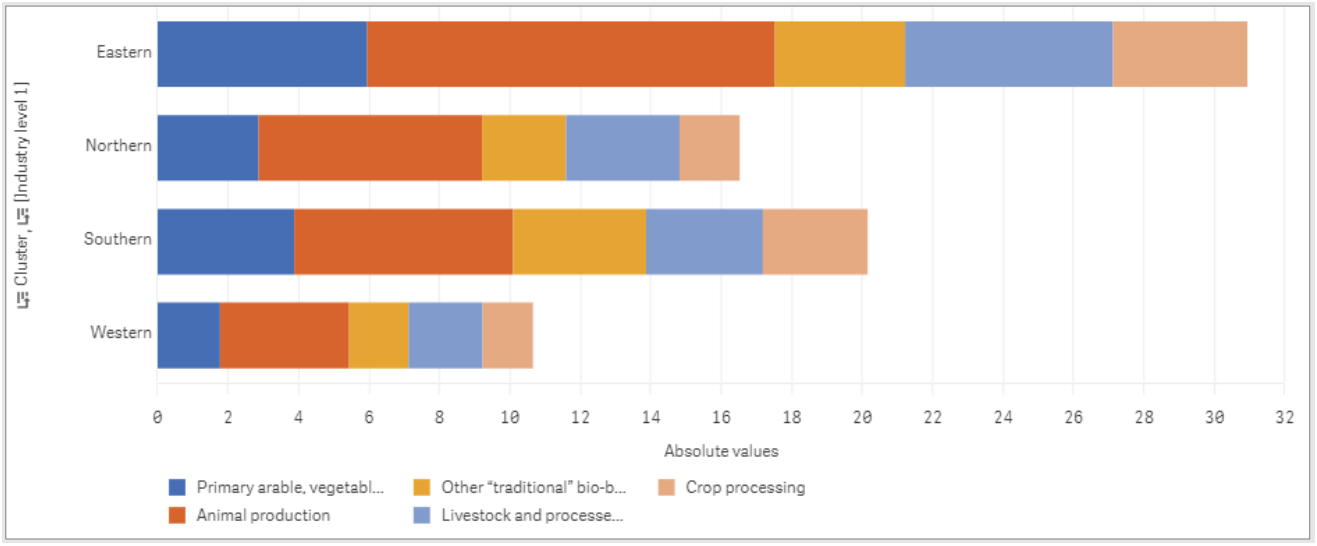
Source: own elaboration based on the BioSAM 2015.

Figure 38. Map of Employment multiplier effects (person) by EU countries within each cluster, average value of all food system related sectors



Source: own elaboration based on the BioSAM 2015.

Figure 39. Employment shares by clusters and sector level (absolute values)



Source: own elaboration based on the BioSAM 2015.

5 Conclusions

The European Bioeconomy, which covers the food system, the non-food supply and usage of biomass and related services, is a key component of the transformation of the European economy towards more economic, social and environmental sustainability.

Despite the increasing importance demonstrated by the promotion of related strategies in the European Green Deal, as well as a growing scientific literature, the lack of available data is one of the main obstacles to assessing its potential.

The Bioeconomy Social Accounting Matrix (BioSAM) database has been developed for the EU and its Member States to improve this data gap (Mainar-Causapé et al., 2021). The BioSAMs are tables with highly disaggregated sectoral breakdown of the agricultural and agro-food industries, and also providing explicit representation of the bio-based energy, bio-based industry and other "traditional" bio-based activities. The level of disaggregation and the features of the BioSAM make it a novel database suitable for research work with a focus on Bioeconomy, including the agriculture and therefore, the food system.

In this report, the recently published BioSAMs (for the year 2015) are employed to analyse the value added and employment multipliers in order to understand the impacts of an exogenous final demand variation for the products in the different sectors. As a valuable contribution, this report introduces a dashboard that allows replication, comparison and visualisation of the results of the different impacts by sector and country.

The direct and spillover effects presented in the section 3 show that 38.7% of the total employment created by the bio-based sectors is a direct effect on those activities that receive the exogenous final demand shock. When looking at the value added generated, the direct effect is relatively lower (24.6%) compared to the corresponding result for the employment, with spillover effects playing a greater role. The fact that there are significant spillover effects in the results further reinforces the benefit of having an economy-wide framework to capture the true sphere of influence of bio-based activities.

An overall analysis of the Bioeconomy for the EU27 shows that the impact of the value added multiplier stands out for several products within the group of 'primary arable, vegetable and horticulture', 'animal production' and 'other traditional bio-based activities'.

A further observation when focusing exclusively on the food system sectors relates to the value added results which present the Southern regions as best performers of wealth generation (0.73 million €) per million of euro of final demand variation, where the main driver is represented by the animal production followed by fisheries and livestock processing, and for cereals, feedstocks and horticulture production, in both Southern and Eastern countries.

For the employment results, the overall analysis of the Bioeconomy shows that the primary sector and animal production exhibit very high values, as well as for '2nd generation biofuel'. When focusing on sectors related to the food system, eastern European regions are the one that create more jobs (31) per million of euro of final demand variation, mainly in the animal production which covers around 30% of the overall impact.

This report accompanied by interactive dashboards presents from a spatial and sectors point of view, the best performers in terms of wealth generation and job creation in the Bioeconomy related topic, and more specifically in the food system where a country cluster analysis is presented. This allows to deepen the understanding of the economic contribution also with the visual support of dashboard as to zoom in and out across broad and diverse collective of economic activities.

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List of abbreviations and definitions

BioSAM	Bioeconomy Social Accounting Matrix
CGE	Computable General Equilibrium
DataM	Data-modelling platform of agro-economics research
ESTAT	Eurostat
ILOSTAT	International Labour Organization Statistics
JRC	Joint Research Centre
SAM	Social Accounting Matrix
ROW	Rest of the World

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Annexes

Annex 1.

Table A1. Products and activities of the BioSAM 2015 for EU27 Member States

Paddy rice	Processed sugar
Wheat	Prepared animal feeds
Barley	Other food products
Maize	Wine
Other cereals	Other beverages and tobacco
Tomatoes	Textiles, wearing, leather apparel
Other vegetables	Wood products
Grapes	Pellets
Fruits and nuts	Paper products, publishing
Rapeseed	Petroleum, coal
Sunflower seed	Chemical, rubber, plastic products
Soya seed	Bio-gasoline
Olive	Bio-diesel
Other seed for the oil industry	2nd generation biofuel – biochemical pathway fuels
Sugarbeet	2nd generation biofuel – thermal pathway fuels
Fibreplants	Fertilizers
Potatoes	Bio-chemical
Live plants	Mineral products nec
Fodder crops	Metals
Tobacco	Metal products
Other crops	Motor vehicles and parts
Bovine cattle	Transport equipment nec
Sheep, goats, horses, asses, mules and hinnies	Electronic equipment
Swine	Machinery and equipment nec
Poultry	Manufactures nec
Other animal and their products	Electricity and gas
Raw milk	Bio-electricity
Forestry	Water
Specialist non-food energy crops	Construction
Fishing	Trade
Mining	Transport nec
Meat of bovine animals	Water transport
Meat of swine	Air transport
Meat of sheep, goats, and equines	Communication
Meat and edible offal of poultry	Financial services nec
Vegetable oils and fats	Insurance
Olive oil	Business services nec
Oil-cakes	Recreational and other services
Dairy products	Public administration, defense, education, health
Rice, milled or husked	Dwellings

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