DOI: 10.2478/vjbsd-2018-0013

MEASURING THE SIZE OF THE DUTCH BIO-ECONOMY

Wim Heijman*, **Thijs Schepman**

Wageningen University & Research, Department of Social Sciences, Agricultural Economics and Policy Group, Nederlanden

This paper estimates the size of the Dutch Bio-Economy, based on its value added. Using consolidated input-output tables, the size of the Dutch Bio-Economy is estimated for the period 2008–2015 and future predictions are made for the period 2016–2020. During the period 2008–2015, the Dutch Bio-Economy has grown from 5.5% of the total Dutch value added in 2008 up to 6.6% in 2015. For future prediction, five scenarios are analysed, with projected growth of the Bio-Economy ranging from 6.87% of total value added on the low end to 8.48% on the high end in 2020.

Keywords: bio-economy; input output table; scenario's

Introduction

The Bio-Economy has been getting more attention from governments and policy makers. Policy makers look to the Bio-Economy to help solve the fossil fuel problem (Golembiewski et al., 2015; De Besi and McCormick, 2015). The general idea is that the use of biomass can ease the transition from fossil fuels to a sustainable alternative (EIA, 2016). Food and non-food applications of biotechnology, especially where GMOs are concerned, are drawing a lot of attention as well. Also for pharmaceutical companies, the growth of the Bio-Economy is relevant for innovation in the sector (Wield, 2013). For policy makers, it is useful to measure the size of the Bio-Economy at the macroeconomic level, to make informed policy decisions (Dries et al., 2016).

One place these policy decisions are being made is at the EU, which in 2012 has adopted a strategy "Innovating for sustainable growth: A Bio-Economy for Europe" (EU, 2012). The EU states in this strategy: "The Commission estimates that the EU's Bio-Economy sectors are worth 2 trillion Euros in annual turnover and account for more than 22 million jobs and approximately 9% of the workforce. The Commission is convinced that to solve the problems connected with the scarcity of non-renewable resources, global warming, and environmental pollution the development of the Bio-Economy is crucial".

Concepts

The Bio-Economy is a multi-faceted concept with different definitions depending on what discipline is studying the Bio-Economy. The difference in definitions used to describe the Bio-Economy or the lack of coherent definition, can make it harder to compare the Bio-Economy on an international scale (Staffas et al., 2013). Bugge et al. (2016) review three different points of view looking at the Bio-Economy. Firstly, there is the biotechnology view of the Bio-Economy, that emphasises the importance of research into biotechnology and the commercialization of biotechnology. Secondly, there is the bio-resource view of the Bio-Economy. This vision focusses on the role of research and development related to raw resources in the primary sector as well as establishing new value chains. Lastly, there is the bio-ecology vision that focusses on the importance of ecological processes that optimize the use of energy and nutrients and to promote biodiversity. The first two visions are largely focussed on R & D in global systems, whilst the bio-ecological vision emphasizes the potential in regional systems.

In the past, there have been various attempts to measure the Bio-Economy. Vandermeulen et al. (2011) have tried to compute the size of the Flemish Bio-Economy by gross margins and employment measures. They arrived at rather low figures of 1.8% in terms of gross margin and 0.4% in terms of employment. The United States Department of Agriculture (USDA, 2011) have also tried to measure the size of the Bio-Economy by using specific bioindicators to estimate the size of the Bio-Economy. It does, however, prove to be difficult to choose and define the indicators needed. Both these methods have the disadvantage that they are very difficult to compare between different countries.

Pellerin and Taylor (2008) estimated the size of the Canadian Bio-Economy to be 6.4% of total Canadian GDP. They calculated this figure using an econometric model, using the bio-based North American Industry Classification System (NAICS). In their paper, they have also noted the possibility of using Input-Output tables for measuring the Bio-Economy. In this paper, we propose a method which allows for easy international comparison and aggregation of the results based on UN standardised Input-Output tables (CBS, 2016a).

For this paper, we define the Bio-Economy as the primary sector, as this is the sector of primary bio-based production. This sector consists of production in the fields of agriculture, fisheries, aquaculture, forestry and veterinary services. We will call this aggregate of the Sector 1. All sectors not included in Sector 1 are grouped in thirteen other sectors, based on industry type. All the other industries are divided into the different sectors mainly based on common sense and logical pairs. Together, 14 sectors are distinguished.

Methods

The method for the measurement of the Dutch Bio-Economy is a more elaborate version of the method described in Heijman (2016). The assumption made is that there is a fixed relation between total inputs and total outputs within a sector. Value added V_i of sector i equals the output O_i minus inputs I_i of sector i:

$$V_i = O_i - I_i$$

The total inputs I_i for sector i equals the sum of all inputs j into sector i:

$$I_i = \sum_{j=1}^{n} I_i^j$$

$$V_i = O_i - \sum_{j=1}^{n} I_i^j$$

For all sectors k, which includes all sectors apart from Sector 1, the following simple production function with perfectly substitutable inputs is assumed:

$$O_k = \alpha_k I_k = \alpha_k \sum_{j=1}^{n} I_k^j$$

so:

$$\alpha_k = \frac{O_k}{\sum_{j=1}^{n} I_k^j}$$

If α_k is known, it is possible to calculate O_{kb}, the part of O_k that can be attributed to the Bio-Economy, and therefore also the value added V_{kb} of the Bio-Business:

$$I_{kb} = I_k^1 + BIOIMP_k$$

$$O_{kb} = \alpha_k \sum_{j=1}^{n} I_{kb}^j$$

$$V_{kb} = O_{kb} - \sum_{j=1}^{n} I_{kb}^j$$

Total value added V_{bb} of the bio-business equals:

$$V_{bb} = \sum_{k=1}^{n} V_{kb}$$

Total value added V_{be} of the bio-economy equals:

$$V_{be} = V_1 + V_{bb}$$

The shares S_1 and S_{kb} of each sector k in total value added V equal:

$$S_1 = \frac{V_1}{V}$$

$$S_{kb} = \frac{V_{kb}}{V}$$

The combined shares S_{bb} and the share S_{be} of the Bio-Economy in the total value added then equals:

$$S_{bb} = \sum_{k=1}^{n} S_{kb}$$

$$S_{be} = S_1 + S_{bb}$$

Finally, the total value added V_{be} of the Bio-Economy, equals:

$$V_{be} = S_{be} V$$

Results and discussion

The size of the Dutch Bio-Economy in the period 2008–2015

For the calculation of the model, the Input-Output tables provided by CBS (2016a) are used. First, the Input-Output tables are consolidated into smaller tables, with the input-output relation given for each of the fourteen sectors. Consolidating the tables is done by adding up all rows and columns that are relevant for the specific input-output relation. Using the consolidated tables, the values for V_1, S_1, $\bar{\alpha}$, V_{bb}, S_{bb}, S_{be} and V_{be} are calculated. All calculations are in real amounts with base year 2008, inflation figures are gathered from CBS (2016b). Agricultural imports are calculated as a percentage total imports based on figures from LEI (2015) for total agricultural import and CBS (2016c) for total import figures. The results of V_1, S_1, $\bar{\alpha}$, V_{bb}, S_{bb}, S_{be} and Vbe are presented in Table 1 and Figure 1.

In the period from 2008 until 2015 the size of the Bio-Economy grew from 5.8% of total value added to 6.6% of total value added. The impact of the financial crisis of 2008 clearly

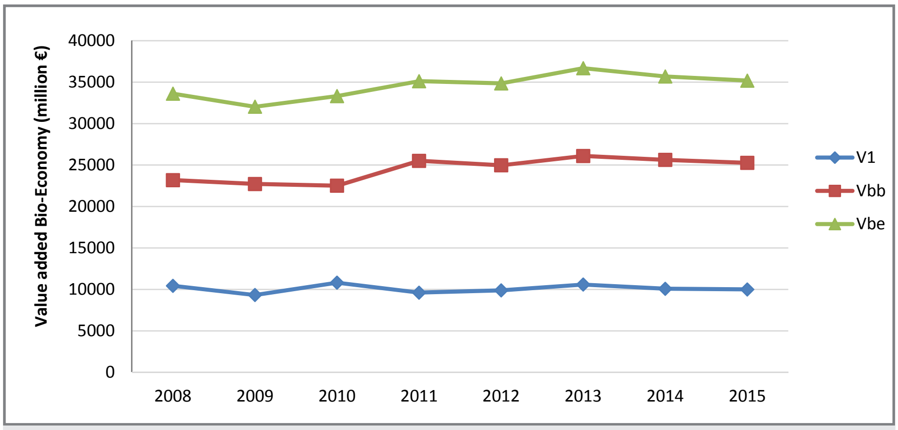

Figure 1 Graph showing the value added (in millions of euros) of Sector 1 V_1, Bio-Business V_{bb} and the total Bio-Economy V_{be}, 2008–2015

Table 1 Results of the model calculations for The Netherlands (million €, 2008, basic prices)

	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2008	10,433	0.0182	1.9474	23,178	0.0405	0.0587	33,611
2009	9,323	0.0171	1.9275	22,714	0.0417	0.0589	32,037
2010	10,809	0.0197	1.9213	22,508	0.0411	0.0608	33,317
2011	9,609	0.0174	1.8996	25,506	0.0461	0.0635	35,115
2012	9,881	0.0181	1.8827	24,967	0.0459	0.0640	34,848
2013	10,589	0.0198	1.8961	26,095	0.0489	0.0687	36,684
2014	10,070	0.0190	1.9112	25,619	0.0483	0.0673	35,690
2015	9,993	0.0187	1.9067	25,265	0.0476	0.0663	35,183

shows in the results. Then in 2010, the value added of the Sector 1 V_1 and share S_1 of Sector 1 grew back to the amount it was in 2008 and stayed relatively constant up and until 2015. The Bio-Business lagged behind Sector 1 in recovering from the 2008 crisis. Then in 2011, the Bio-Business seemed to recover quickly, mainly due to an increase in the amount of Bio-Imports whilst the total amount of imports did not increase as quickly. This will lead to a larger portion of imports being attributed to Bio-Imports and therefore an increase in the share of the Bio-Economy. In 2012 and 2013, the growth of the Bio-Business and therefore the Bio-Economy continued. 2014 and 2015 show a small decline in the size of the Bio-Economy after a period of growth.

Future predictions for the size of the Bio-Economy

Using the model used to measure the current size of the Bio-Economy for the data available, we can also estimate the future size of the Bio-Economy in The Netherlands. To make this future prediction, five scenarios are proposed. Each scenario has two variables that are changed to predict the future size, economic growth and substitution. All scenarios are based on real growth with 2008 as the base year.

The five scenarios are:

Scenario 1:

- Economic growth: Annual average growth over the period 2008–2015 for each sector.
- Substitution: None.

Scenario 2:

- Economic growth: None.
- Substitution: Bio-inputs increasing annually by 5% without total inputs rising.

Scenario 3:

- Economic Growth: Annual average growth over the period 2008–2015 for each sector.
- Substitution: Bio-inputs increasing annually by 2% without total inputs rising.

Scenario 4:

- Economic Growth: Annual average growth over the period 2008–2015 for each sector.
- Substitution: Bio-inputs increasing annually by 5% without total inputs rising.

Scenario 5:

- Economic growth: 1% annual growth for each sector.
- Substitution: Bio-inputs increasing annually by 5% without total inputs rising.

In Scenario 1 the economy is projected to grow with the average growth over the period 2008–2015. Average growth is calculated separately for each of the fourteen different sectors, therefore each sector might grow or shrink at different rates. The second scenario shows growth under substitution of non-bio-inputs by bio-inputs, with bio-inputs increasing by 5% without total inputs rising, for every € 1 million extra bio-inputs, there is € 1 million less in non-bio-inputs. In the third and fourth scenario, economic growth and the substitution effect are combined in two scenarios. In the third scenario, a low rate of substitution is assumed, a 2% increase in Bio-inputs while total inputs remain constant. In the fourth scenario, a high rate of substitution is assumed, a 5% increase in Bio-inputs while total inputs remain constant. In the fifth and final scenario, we assume an economic growth of 1% for the total economy combined with a 5% substitution of Bio-Inputs. In the average growth in the period 2008–2015, the value added of the total economy shrank by 1%, which is rather pessimistic for the period 2016–2020. Therefore the final scenario shows what might happen if economic growth is more in line with predictions for economic growth, although still being conservative. Table 2 and Figure 2 present the results for Scenario 1.

Under Scenario 1, the size of the Bio-Economy is projected to grow from 6.63% in 2015 to 6.87% in 2020, with total value added of the Bio-Economy decreasing from € 35,183 million in 2014 to € 34,683 million in 2020. The average growth of the total economy was negative on average over the 2008–2015 period, but relatively Bio-input intensive sectors grew at a faster rate than the total economy. That is why, whilst the total value added of the Bio-Economy will decrease in this scenario, the share of the Bio-Economy will increase slightly. The results for the second scenario are presented in Table 3 and figure 3.

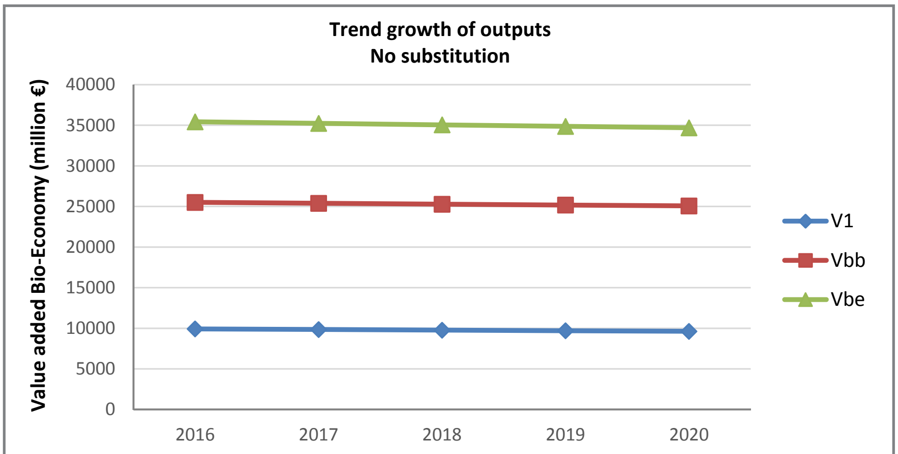

Figure 2 Graph showing the amount of value added (in million €) of: Sector 1 (V_1), Bio-Business (V_{bb}) and the total Bio-Economy (V_{be}) for Scenario 1

Table 2 Scenario 1: Average growth of the period 2008–2015 (million €)

Trend growth of outputs, No substitution	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2016	9,917	0.0189	1.9112	25,500	0.0486	0.0674	35,418
2017	9,842	0.0189	1.9112	25,385	0.0488	0.0677	35,227
2018	9,767	0.0190	1.9112	25,274	0.0491	0.0680	35,042
2019	9,693	0.0190	1.9112	25,167	0.0493	0.0683	34,860
2020	9,619	0.0190	1.9112	25,064	0.0496	0.0687	34,683

Table 3 Results for growth under 5% substitution (Scenario 2, million €)

No growth, Substitution 5%	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2016	10,493	0.0198	1.9112	26,900	0.0507	0.0705	37,393
2017	11,018	0.0208	1.9112	28,245	0.0533	0.0740	39,263
2018	11,568	0.0218	1.9112	29,658	0.0559	0.0777	41,226
2019	12,147	0.0229	1.9112	31,141	0.0587	0.0816	43,287
2020	12,754	0.0240	1.9112	32,698	0.0617	0.0857	45,452

Table 4 Scenario 3: Average economic growth with 2% substitution (million €)

Trend growth of outputs, 2% Substitution	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2016	10,116	0.0193	1.9112	26,010	0.0495	0.0688	36126
2017	10,240	0.0197	1.9112	26,411	0.0508	0.0705	36651
2018	10,365	0.0201	1.9112	26,821	0.0521	0.0722	37186
2019	10,492	0.0206	1.9112	27,242	0.0534	0.0740	37734
2020	10,621	0.0210	1.9112	27,672	0.0548	0.0758	38293

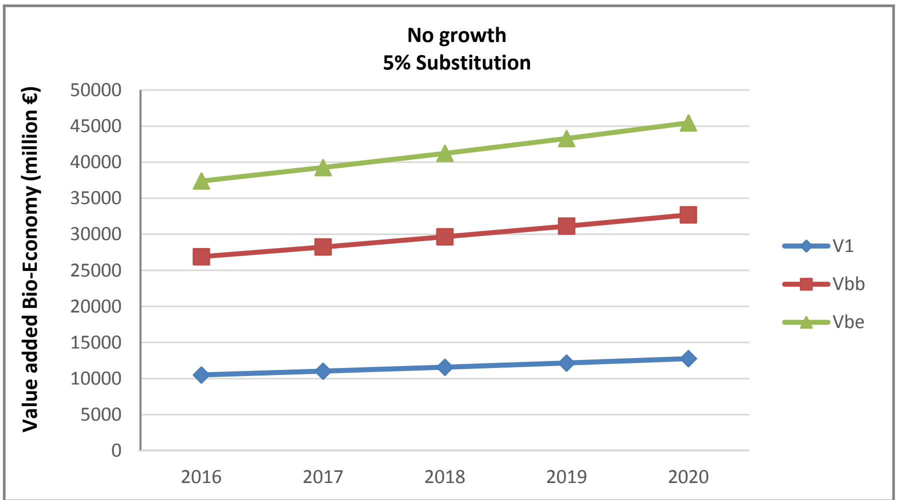

Figure 3 Graph showing the amount of value added (in million €) of: Sector 1 (V_1), Bio-Business (V_{bb}) and the total Bio-Economy (V_{be}) for Scenario 2

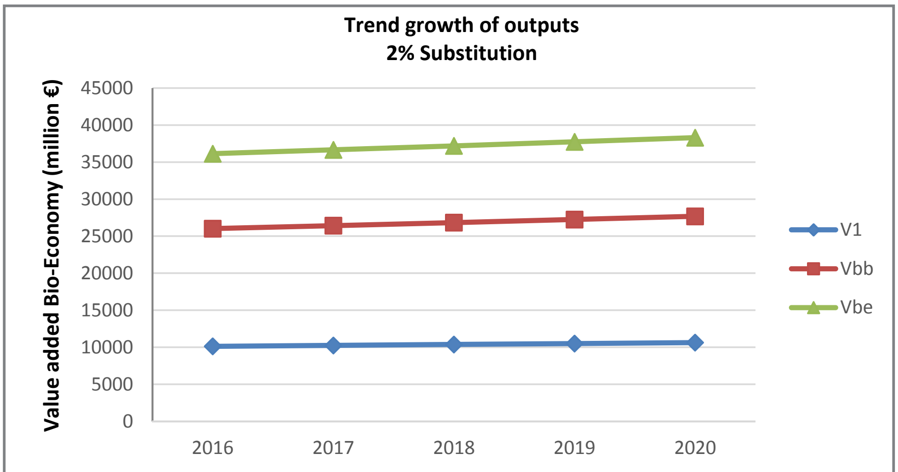

Figure 4 Graph showing the amount of value added (in million €) of: Sector 1 (V_1), Bio-Business (V_{bb}) and the total Bio-Economy (V_{be}) for Scenario 3

In the second scenario, the size of the Bio-Economy is projected to grow from 6.63% in 2015 to 8.57% in 2020, with total value added of the Bio-Economy growing from € 35,183 million in 2015 to € 45,452 million in 2020. The growth in this scenario is in both the primary sector and the Bio-business. Both effects add up in the final result. Growth of the Bio-Economy in this scenario is at a linear rate of 5% compared to the previous year. The results for the third scenario are presented in Table 4 and Figure 4:

In the third scenario, the size of the Bio-Economy is predicted to grow from 6.63% in 2015 to 7.58% in 2020, with total value added growing from €35183 million in 2015 to €38293 million in 2020. With low substitution, both value added and share of the Bio-Economy increase slightly. A nearly one percentage point increase in share over a period of five years is slightly higher than the growth observed in the period 2008–2015. The results for the fourth scenario are presented in Table 5 and Figure 5:

In the fourth scenario, the size of the Bio-Economy is projected to grow from 6.63% in 2015 to 8.69% in 2020, with total value added growing from € 35,183 million in 2015 to € 43,915 in 2020. At the high substitution level, the share of the Bio-Economy is projected to grow by just over 2 percentage point, which is over twice the growth observed in the period 2008–2015.

In Scenario 5, the size of the Bio-Economy is projected to grow from 6.63% in 2015 to 8.48% in 2020, with total value added growing from € 35,183 million in 2015 to € 47,295 in 2020. With a growth of 1% over the entire economy, the 5% linear growth effect of the substitution is amplified by 1%, which together with the 1%

Table 5 Results for average economic growth with 5% substitution (Scenario 4, million €)

Trend growth of outputs, 5% Substitution	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2016	10,413	0.0198	1.9112	26,775	0.0510	0.0708	37,189
2017	10,541	0.0203	1.9112	27,987	0.0538	0.0741	38,528
2018	10,984	0.0213	1.9112	29,258	0.0568	0.0781	40,242
2019	11,445	0.0224	1.9112	30,591	0.0600	0.0824	42,036
2020	11,926	0.0236	1.9112	31,988	0.0633	0.0869	43,915

Table 6 Results of 5% substitution and 1% economic growth (Scenario 5, million €)

Growth 1%, Substitution 5%	V_1	S_1	$\bar{\alpha}$	V_{bb}	S_{bb}	S_{be}	V_{be}
2016	10,598	0.0198	1.9067	26,793	0.0500	0.0698	37,391
2017	11,239	0.0208	1.9067	28,414	0.0525	0.0733	39,653
2018	11,919	0.0218	1.9067	30,133	0.0551	0.0770	42,052
2019	12,640	0.0229	1.9067	31,956	0.0579	0.0808	44,596
2020	13,405	0.0240	1.9067	33,890	0.0608	0.0848	47,295

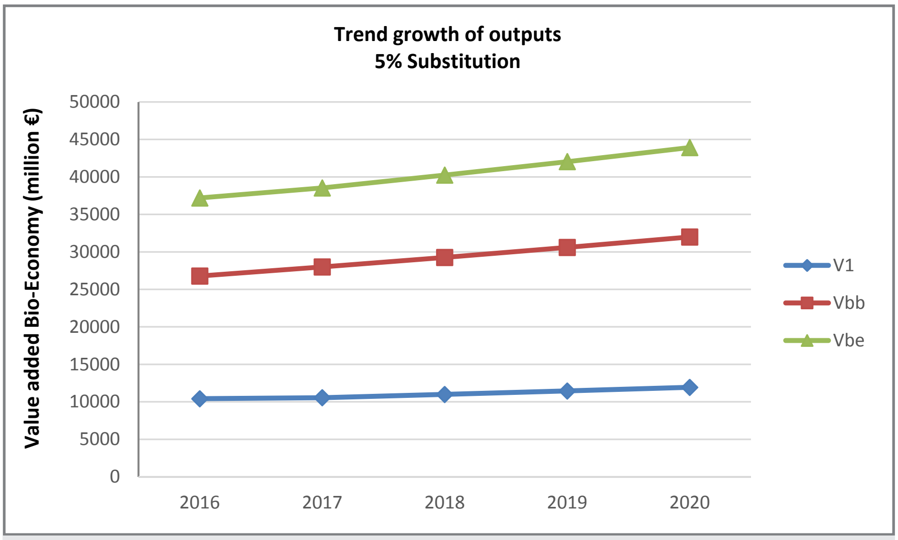

Figure 5 Graph showing the amount of value added (in million €) of: Sector 1 (V_1), Bio-Business (V_{bb}) and the total Bio-Economy (V_{be}) for Scenario 4

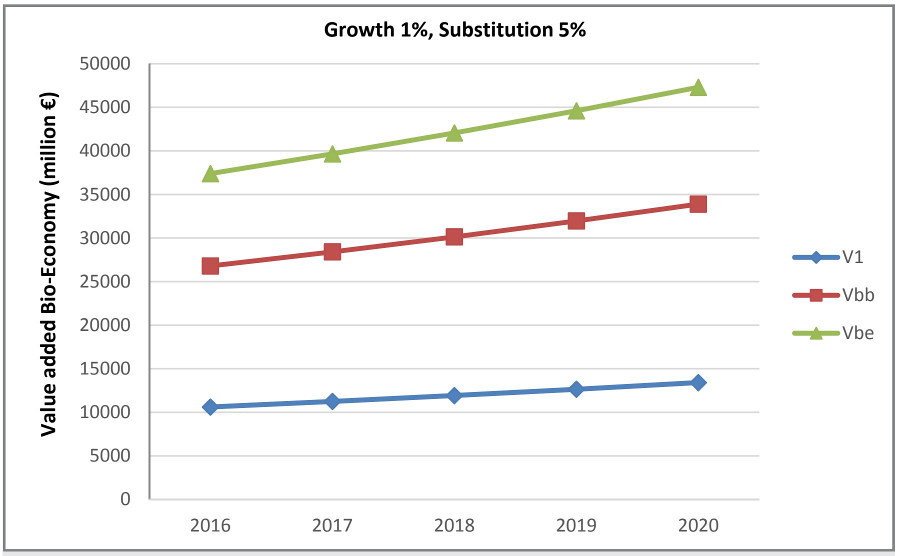

Figure 6 Graph showing the amount of value added (in million €) of: Sector 1 (V_1), Bio-Business (V_{bb}) and the total Bio-Economy (V_{be}) for Scenario 5

economic will lead to a growth of the total value added by the Bio-Economy of 6,05%.

The results for the fifth and final scenario are presented in Table 6 and Figure 6:

One of the large advantages of this model, as also noted by Heijman (2016), is that it is easily compared internationally. This is mostly useful in the EU-context, where the European Commission can easily compare individual countries for policy monitoring purposes. The trade-off in this model, compared to methods used in USDA (2011) and Vandermeulen (2011), is that at the expense of very detailed and specific indicators for the Bio-Economy for a specific country or area, this model makes international comparison much easier.

A disadvantage of this model is, as noted by Pellering and Taylor (2008), that Input-Output tables are generally published in the third quarter of the next year, which can be considered quite late to make model calculation relevant for current policy decisions.

In this paper, the different subsectors are chosen arbitrarily, based on common sense and logical pairs. This was more easily applied to some sectors than others. Choosing different combinations of industries into the different subsectors can have an influence on the model, as well as on what the different measures for the subsectors can tell us about their contribution to the Bio-Economy. Not making these subsectors and instead using all different industry types as stated in the Input-Output table, might, on the other hand, lead to the over complication of the calculations, which leads to a less clear outcome.

This model relies heavily on the assumption that there is a fixed relation between inputs and outputs in a certain sector denoted by α. Support for this assumption is provided by the relatively constant value of α for all different sectors over the years, the weighted average of alpha stays between 1.88 and 1.95 between 2008 and 2015.

Another assumption that is made in this model is that the proportion of imports that are Bio-based compared to the total imports are equal for all different sectors. The model, therefore, overestimates the size of the Bio-Economy for sectors with relatively large imports compared to the sectors with relatively low imports. This could be an opportunity to further improve upon the model.

Under the assumptions made in the model, there are two mechanisms that can influence the share of the Bio-Economy. The substitution of Bio-inputs for non-Bio-inputs increases the share of the Bio-Economy linearly, a 1% substitution gives a 1% increase in the share of the Bio-Economy. Another effect is a growth difference between the different sectors. If a sector has a relatively large effect share of Bio-Economy is growing faster, the total share of the Bio-Economy rises. This growth seems to be exponential, but with sectors growth being very small, this exponential effect is rather small as well. This effect of different relative growth between the different sectors can be refined in further attempts to improve this model, mainly by improving the effect of Bio-imports as mentioned before, as well as creating a method to compute economic growth for each different sector for future predictions.

The size of the Bio-Economy at this moment seems rather small, growing from 2009 up until 2013, but after 2013 growth stagnates. One would expect, with a large emphasis placed on growing the Bio-Economy, growth would not stagnate but keep increasing.

Conclusions

The size of the Bio-Economy in The Netherlands has increased from 5.5% in 2008 to 6.6% in 2015. The Bio-Economy recovered more smoothly from the financial crisis than the non-Bio-Economy, shown by increasing shares of the Bio-Economy in the period from 2008 to 2012, whilst the total value added did not reach 2008 levels. This makes sense because the areas of the economy that were hit hard by the crisis have little value added for the Bio-Economy.

For future predictions, with economic growth for each sector equalling average growth over the period 2008–2015, the share of the Bio-Economy is projected to grow to 6.95% in 2020, whilst the value added of the Bio-Economy is projected to decrease. With a 5% substitution of Bio-inputs instead of non-Bio-inputs, the share of the Bio-Economy is projected to grow to 8.57% in 2020. In the third and fourth scenario, the share and value added of the Bio-Economy increases. At the low substitution level, projected growth is slightly higher than the growth observed in the period 2008–2015. At the high substitution level, the growth of the Bio-Economy is projected to be twice the amount observed in the period 2008–2015. Therefore, to obtain an increasing growth of the Bio-Economy, the combination of substitution and economic growth of Bio-Input intensive sectors needs to outperform Scenario 3.

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Contact address:

Wim Heijman, Wageningen University & Research, Department of Social Sciences, Agricultural Economics and Policy Group, Netherlands, e-mail: wim.heijman@wur.nl