

BIOECONOMY MALAYSIA REPORT



OCTOBER 2014

ECONOMIC FINDINGS REPORT: THE VISION FOR 2020 AND BEYOND

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EXECUTIVE SUMMARY

The Bioeconomy is an important component in creating a sustainable resources based future. It has been emphasised worldwide and recently given priority in Malaysia as well. Principally, Malaysia is looking for Bioeconomy based on sustained biodiversity and natural resource for the country's future economic development.

To achieve this, the Bioeconomy Transformation Programme (BTP) has been initiated by the national government which is second in Asia and first in ASEAN region. Through BTP, Malaysia has planned to provide a favourable platform for the sustained development of Bioeconomy and to pledge effective initiatives for the bio-based industries to improve industry's competitiveness to contribute more to the national development.

Based on national statistics 2010, the Bioeconomy today here is about 13.4 per cent of total Gross Domestic Product (GDP) and its current value is RM106.66 billion. This comprises of all economic activities involving production of bioresources and its conversion into food, feed, chemicals, energy and healthcare & wellness products. BTP's goal is to maximise the economic impact of these activities through the application of innovative and efficient technologies.

This report applies two separate methods of analysis to the Malaysian Bioeconomy to model the condition and multiplier impacts of the sector as well as project possible scenarios of growth in the future: dynamic computable general equilibrium modelling (DCGE) and Input-Output modelling (IO). It also attempts to identify implications for policy-makers to guide the strategic direction for growth of the sector. Data was obtained from the Department of Statistic (DOS), Malaysia.

Through DCGE of 23 sectors, sectoral quantity of Bioeconomy and its share has been identified by three scenario analyses (5 per cent growth rate, 10 per cent growth rate and 15 per cent growth rate). The objective is to explore the effective Bioeconomy related investments in Malaysia from year 2010 to 2030 and potentials to leverage on the existing strength of most robust sectors in the Bioeconomy.

Based on current growth rate, Malaysian Bioeconomy GDP could increase to RM117.60 billion by 2015, RM129.65 billion by 2020 and RM157.60 billion by 2030. Targeted growth rate of 10 per cent could increase GDP to RM129.36 billion by 2015, RM142.62 billion by 2020 and RM173.35 billion by 2030. A stimulated growth rate of 15 per cent could increase the Bioeconomy GDP estimates to RM135.23 billion by 2015, RM149.10 billion by 2020 and RM181.23 billion by 2030.

In each scenario, oil palm, rubber, oil & fat processing, fishing, forestry & logging, food crops, and wood products' sectors were found to have the capability to produce the most significant amounts of Bioeconomy share, with lower results from sectors like bio-based chemicals and biofuels (classified as a component of refined petroleum products). An accurate and efficient strategic direction and sectoral investment targets can increase the growth rate of the Bioeconomy.

Further analysis was completed to identify specific contribution of bio-based technologies or biotechnology to Bioeconomy. Based on ratios projected by the Organisation for Economic Co-operation and Development (OECD), 46.8% of Malaysia's Bioeconomy will utilise bio-based technology in 2030. This means that the remaining 53.2%, (equivalent to between RM83.8 million and RM96.4 million, depending on rate of growth) worth of Bioeconomy activity will still be utilising conventional processes and technologies.

This "non bio-enhanced" portion of Bioeconomy can be targeted for introduction of bio-based technologies to catalyse and improve value and economic contribution beyond initial forecast.

In order to gauge the current contribution and multipliers of Bioeconomy revenue as well as the interdependence of its sectors, an Input-Output (IO) model was employed to estimate multipliers of six sectors (i.e. Agriculture, Fishing, Forestry & Logging, Rest of Sector, Manufacturing, and Services) in terms of output and employment. This method gives a more wide-ranging view of the Bioeconomy by capturing indirect and induced effects, in addition to the direct impacts of sectors.

Overall, the total amount of output impact generated by the six sectors of Malaysian economy from the Bioeconomy revenue is RM1,136,079,332.90. This is coupled with an employment impact of 12,548.78.

Agriculture sector was shown to be one of the highest output generating sectors with the multiplier of 2.132971 impact per RM spent. Of this multiplier, 0.513119 Ringgit created by direct effect, 1.533826 Ringgit by indirect effect and 0.086027 Ringgit by induced effect. Output impact was calculated at RM227,505,963.44 or 23.06% of GDP.

Only the Services sector contributed higher impact with multiplier contribution of direct, indirect and induced effects equal to 0.579539, 1.620282 and 0.146732 Ringgit respectively (total multiplier = 2.346553). Output impact was calculated at RM250,286,913.96 or 25.37% of GDP. However, it is important to mention that in the IO computation, not all sectors considered in the Services sector are linked to the Bioeconomy. If Services was limited to the Health sector (sector no. 117 of the Malaysian IO table), its impact would not be much larger than the Agriculture sector.

Employment multiplier analysis yielded similar results, with high multipliers for Services (0.00003900, or 1 million of output generates 39.00 jobs) and Agriculture (0.00002887).

For analysis purpose, focusing on sectors that were classified 100% as Bioeconomy (e.g. not considering Services sector), Agriculture appeared as the most vital sector for Malaysian Bioeconomy. Furthermore, the secondary (Indirect + Induced) output impact of Bio-revenue is found to be significantly higher than the primary (direct) impact. This means that Bioeconomy revenue contributes more to the Malaysian economy through inter-industrial linkages together with household consumption.

Although Forestry & Logging sector yielded the lowest total output impact, the secondary output impact (124919079.69) generated by this sector is found to be about nine times more than the primary (direct) impact. Thus, this sector retains the higher propensity to generate more impact through secondary impact among the 100% Bioeconomy related sector.

In the case of employment multiplier of 100% Bioeconomy sectors, the Agriculture sector and Fishing sector contributed in generating about 46% of the total employment from Bioeconomy revenue and ranked 2nd and 3rd largest employment generating sector

respectively (after Services sector). Agriculture appeared to be the most important employment generating sector among directly linked Bioeconomy sector for both primary and secondary employment generation. Hence, this sector can be considered to be well-integrated with other sectors of Malaysian economy as appeared from the ratio impact analysis.

The execution of these two studies provides policy makers with useful insights on the state of Malaysia's Bioeconomy today, illustrating impacts and trends of individual sectors. The results are a resource that can be used as bases for key policy decisions like which individual sector to emphasise and invest in to maximise future impact¹.

¹ In drawing conclusions from this report, it is important to note the differing characteristics of the two models conducted. DCGE was computed based on 2010 social matrix whereas IO utilised 2005 Input-Output tables from DOS. Additionally, DCGE involved 23 pre-identified Bioeconomy subsectors; IO involved 6 sectors from the Input-Output tables. Finally, the DCGE only computes direct impacts, whereas IO considers direct, indirect, and induced impacts.

1. INTRODUCTION

The contribution of Bioeconomy is increasing worldwide with on-going momentum. The concern about global climate change has resulted in demand for environmental goods and services and is attracting Bioeconomy and bio-based investors. Biomedical, bioindustry, food, feed, fiber, alternative fuel, chemicals and renewable energy are the key sectors of the global Bioeconomy which is recently a subject of focused attention from decision makers, researchers and public policymakers in the biophysical sciences and social sphere (Wesseler, Spielman, & Demont 2010).

Due to Malaysia's natural abundance of biological resources, Bioeconomy has been identified as a potential key contributor to the national economy. In addition to being a key contributor to economic growth, Bioeconomy benefits the society and nation through breakthroughs in agricultural productivity, discoveries in healthcare and the adoption of sustainable industrial processes, while helping to meet the most pressing global challenges, such as the increasing global population, depletion of fossil fuels and natural resources, and increasing environmental pressures and climate change.

The Malaysian government acknowledged Bioeconomy as one of the key strategic drivers to uplift the nation's development by the adoption of sustainable industrial processes, discoveries in healthcare and agricultural productivity. The National Biotechnology Policy (NBP) has launched in 2005 to oversee this developing sector and to achieve the target contribution to the national GDP.

The NBP consists of three phases including national capacity building in 2005-2010, commercialisation of technology (science) to business in 2011-2015 and global expansion in 2016-2020. Malaysian Biotechnology Corporation (BiotechCorp) is set up as an agency to drive the industry growth and expansion as well as to assist the national three phase's targets.

BiotechCorp is currently stimulating the transition of science to business under the second phase by providing a suitable environment to initiate the nation's Bioeconomy. This transition is encapsulated further by the Bioeconomy Transformation Programme (BTP), launched in October 2012. The BTP has planned to foresee to boost up national Bioeconomy development

in agriculture, healthcare and industrial processes. The BTP is projected to result in an increase Gross National Income (GNI) of RM48 billion in 2020, creation of 170,000 job opportunities and a cumulative attraction of RM50 billion domestic and foreign investments. This estimation is made based on the current condition of the Bioeconomy involvement, sectoral bio-share to the other sectors and on-going projects added with on-going engagement with private sector involvement over the period from 2013 to 2020 and beyond.

These quantified goals were formulated as foundations to nurture Bioeconomy into a pillar of the national economy, supporting the nation's efforts to achieve high-income status by the year 2020. Further to this, within the context of the greater global economy, the Organisation for Economic Cooperation and Development (OECD) estimates that by 2030 Bioeconomy will contribute a global average of 2.7 per cent to GDP. The BTP contributes to this by nurturing the growing impact of the agricultural, industrial and biomedical sectors.

The government has provided healthy pledge and support to bio-based industries through pro-business policies, improvements of human resource development and infrastructure building. Further providing attractive incentives, the government has also invested extensively in logistic support, building infrastructure, and technology to bring the industry to par with advanced economies.

Recently, BiotechCorp has identified four flagship agendas to accelerate Bioeconomy. These are namely Bionexus Go Global, Bio-Entrepreneurship Programme, Technology Development and Innovation, and the Bioeconomy Community Development Programme (BCDP). These accelerator programmes, or "Bio-Accelerators" catalyse growth of the industry through various means including developing SMEs, enhancing market access, improving links between industry stakeholders and optimising the Bioeconomy supply chain. These programmes will support efforts to efficiently leverage on local R&D as well as foreign technology to bridge the gap and to ensure sustained growth.

Today, Malaysia's rank for Bioeconomy is currently 6th among 189 economies that are involved in Bioeconomy and related activities, an improvement from 18th position in 2012 and 12th position in 2013. Malaysia has been placed in the same league as developed nations¹ in

²According to BiotechCorp resource and information

terms of Bioeconomy ranking by World Bank's *Doing Business Report 2014* (Doing Business, 2014). Particularly, gradual improvement is made by BTP initiatives to facilitate business and investments with government support. However, Research & Development (R&D) spending, capital raised and commercialisation of research is still lacking in Malaysia. Recent figures show that the Research & Development spending in United States is USD73.2 billion whereas in Malaysia USD 0.03 billion (Battelle 2012).

To achieve the targets set and maintain the objectives of vision 2020 sustainably in the long-run is not an easy task. The implementation of accelerator programmes and precise allocation of investments in the correct sectors both in the short and long-term are necessary steps to work toward our goals. In addition, to reach the targeted goal, the government must implement a cohesive policy, governance and regulation for the Bioeconomy addressing questions like:

- i) How best to characterise the scope of Bioeconomy within the national structure, as well as linkages with other sectors;
- ii) How Bioeconomy integrates within Malaysia's existing policy thrusts and agenda;
- iii) What is the long-term aggregated impacts of Bioeconomy in the society;
- iv) What is its current and future impact to development processes; and
- v) What model is to be used for capacity findings (including consideration of its limitations)?

By answering these questions, Malaysia can provide a platform to initiate effective initiatives for the bio-based industries to improve industry's competitiveness to contribute toward sustained development. Today, transition to Bioeconomy needs an integrated response to several drivers such as environment, fuels, population and life expectancy, emerging environmental sustainability, and expansion of biobased food stock (JRC, 2013).

Accurate and up-to-date assessments of Bioeconomy's contribution to the national economy can serve to guide us in answering these questions. Simultaneously, the results help to ensure that initial goals and targets are still relevant, and to provide insight as to possible issues that may arise in the programme implementation. In this respect, regular monitoring provides an ample timeframe for any remediative actions that may be necessary from the perspective of

policymaking. The following report is produced with that objective in mind: a snapshot of Malaysia's Bioeconomy today, in order for us to plan for Malaysia's Bioeconomy tomorrow.

2. BENCHMARKING THE BIOECONOMY

In its handbook *The Bioeconomy to 2030: Designing a Policy Agenda*, OECD has estimated that by 2030, biotechnology applications would contribute to 35% of output of chemicals and other industrial intermediates, up to 80% of pharmaceuticals and diagnostic products, as well as up to 50% of agricultural produce in OECD regions.

In anticipation of the growing importance of the Bioeconomy sector, economies like the United States, the European Union, Canada, and South Africa have announced comprehensive roadmaps to develop bio-based industries as engines of economic growth.

It should be mentioned that Malaysia's introduction of a framework for Bioeconomy is in line with similar initiatives. In this regard, the Bioeconomy Transformation Programme is envisioned as a platform to contribute towards shaping Malaysia as a high income nation by 2020. As such it would be of value to benchmark our status with "*highly developed*", "*developed*", and "*developing*" nations as classified in the following:

2.1 Highly Developed: United States of America

The development of Bioeconomy in the United States is predicated on robust, well-funded biotechnology research and development. This is demonstrated through numerous metrics including total R&D spending, biotechnology capital raised, and patents filed.

Table 1: Comparison of Bioeconomies: USA vs Malaysia

Metric	USA (2011)	Malaysia (2013)
Research & Development Spending	USD 73.2 billion	USD 0.03 billion
Capital Raised (Biotechnology)	USD 29.8 billion	USD 0.8 billion
Number of Biotechnology Companies (entire value chain)	4,343	229
Number of Biotechnology-related Jobs Created	7.2 million	3,006
Patents Issued	121,247	54

(Sources: Battelle 2012, E&Y Beyond Borders 2011, BiotechCorp, FPA analysis)

In this respect, comparing Malaysia's nascent biotech industry with a highly developed one like the United States' yields key insights into global best practices that can be adopted by our nation. The metrics assessed in the table above suggest that research and development is the basis of revenue generation in the biotech sector, of which the United States recorded USD 146 billion in 2011 (*Marketline 2012*). Malaysia, by comparison, recorded approximately USD 0.4 billion in 2013 (*BioNexus data, BiotechCorp*).

Further, the impacts of the biotech sector ripple through the rest of the Bioeconomy due to its deeply integrated and cross-cutting nature. The technologies developed in the biotechnology space can be applied to enhance sectors like crop production, manufacture of chemicals, healthcare and diagnostics.

Significantly contributing to the prosperity of Bioeconomy in the United States is the policy framework recently introduced which lays out trends and objectives for development of the sector and serves as a platform for greater cross-industry cooperation: The National Bioeconomy Blueprint 2012.

This initiative was designed to establish Bioeconomy as a priority of the US administration, with strategies for:

- Supporting coordinated and integrated R&D investments;

- Facilitating the transition of inventions from research lab to market;
- Developing and reforming regulations to reduce barriers to commercialisation;
- Addressing national workforce needs through training programmes and academic institution incentives; and
- Developing and supporting public-private partnerships.

These strategies focus on key areas like Health, Energy, Agriculture and Environment, with the ultimate goal of improving quality of life for the average citizen. This includes displacement of fossil fuel usage, improving nutrition and well-being of the population, and creating high value revenue streams for economic producers.

2.2. Developed: Netherlands

The European Union has established an action plan for its Bioeconomy: *“Innovating for sustainable growth: A Bioeconomy Strategy for Europe”*. Within the framework of this roadmap, the Netherlands is a major component of European Bioeconomy.

The Dutch biotechnology sector is expected to continue expanding – with approximately 400 firms involved and a revenue growth rate of 3.3% CAGR over 2007-2011, it is a cornerstone of the estimated USD 2.7 trillion EU biosciences industry (*Marketline 2012*).

Similar to the US, the emphasis on research & development and scientific knowledge creation contribute to growth of commercial biotechnology and subsequently the Bioeconomy as a whole. From 2004-2010, R&D expenditure and number of patents rose through focused efforts at public-private partnerships (PPP) at rates in excess of 2% and 9% respectively (*Frontier Private Advisors analysis*).

Through cooperation between private companies, academic institutions and the public sector, a system has been developed in which commitments from each stakeholder are made on a project-by-project basis. In such PPPs, investments will eventually be driven by the private sector. The Government mainly plays a coordinating role through launch of initiatives like Netherlands Genomics Initiative and Netherlands Federation for Innovative Drug Research.

2.3. Developing: Thailand

Thailand has yet to launch a strategy roadmap for Bioeconomy. Instead it implements a top-down policy framework for biotechnology: the National Biotechnology Policy Framework (NBPF). It quantifies goals and details key objectives for the sector but despite clear targets and resource allocation, achievements have been underwhelming. Revenues fell short of 2011 targets – only 22% of the targeted USD 972 million. Only an estimated USD 36 million has been invested in biotech R&D in 2010, with 60% allocated by the public sector. Furthermore, only 17% of the committed public spending has been spent (*National Center for Genetic Engineering and Biotechnology (BIOTEC)*).

Compared to the more developed economies described in previous sections, progress of the biotechnology sector is limited by R&D funding. As a result, the potential for enhancing value of Bioeconomy through application of technology is also hindered. Existing activities like shrimp, rice, and cassava cultivation are candidates for application of agriculture biotechnologies but suffer from the lagging investment.

Additionally, NBPF is a policy that singles out biotechnology from the overall economy. A more holistic roadmap, like the initiatives launched by the US and the EU, pushes for greater synergy, collaboration and cooperation between industries and agencies. This is particularly crucial in light of the cross-cutting nature of Bioeconomy.

In examining the three bioeconomies above, several trends can be identified, especially the importance of a strong, guiding mandate for inter-agency coordination. This is due to the fact that Bioeconomy, or the application of biotechnologies to improve economic activity, is applicable across numerous sectors.

Biotech applications can involve primary production in agriculture, health, energy, environment, and industrial activities. These sectors are governed by authorities with differing perspectives, objectives, and domains of expertise. A comprehensive policy instrument can improve synergy between multiple stakeholders within the public sector. In addition, this will create a foundation for the establishment of public-private partnerships to greater increase the role of private investment in Bioeconomy.

A Bioeconomy increasingly driven by the private sector encourages the sustainable growth of the industry. Based on the comparison in the previous sections, there is a strong correlation between biotechnology R&D investment and maturity of an economy. More mature markets like the US and the Netherlands derive up to 70% of investment from private sources. In comparison, newer entrants like Thailand and Malaysia obtain the majority of their R&D funding from public sources. The table below indicates the contribution of Bioeconomy to the national GDP of several selected economies:

Table 2: Comparison of Bioeconomy contribution as a percentage of total country GDP

Economy	Bioeconomy GDP Contribution		Year	Source
	USD billion	%		
Thailand	95	24.6	2012	Calculated from United Nations data (www.data.un.org)
Indonesia	152	17.3	2012	Calculated from United Nations data (www.data.un.org)
Malaysia	34	13.4	2010	BiotechCorp internal (See Appendix A)
South Africa	48	12.0	2012	Dept of Science and Technology, South Africa (2013). <i>The Bioeconomy Strategy</i> .
Canada	70	6.4	2007	Pellerin W. and Wayne Taylor D. (2008). <i>Measuring the bio-based economy: A Canadian Perspective</i> .
US	1125	8.5	2007	Pellerin W. and Wayne Taylor D. (2008). <i>Measuring the bio-based economy: A Canadian Perspective</i> .
EU	431	2.5	2008	Ecorys (2009). <i>Study on the competitiveness of the EU eco-industry, commissioned by the European Commission</i>
Netherlands	28	3.6	2008	Ecorys (2009). <i>Study on the competitiveness of the EU eco-industry, commissioned by the European Commission</i>

Germany	130	4.3	2007	Pellerin W. and Wayne Taylor D. (2008). <i>Measuring the bio-based economy: A Canadian Perspective.</i>
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(Sources: FPA analysis)

It is noteworthy that developing countries like Thailand, Indonesia, Malaysia and South Africa have Bioeconomy sectors that contribute a significant percentage of the national GDP. Specifically in comparison with economies in Europe, this is largely due to the greater impact of the agriculture sector in emerging economies.

This particular detail suggests a latent potential for the enhancement of value within the Bioeconomy in Malaysia. Agriculture's critical position in the supply chain for bio-based industries can form the basis for development of the other key areas in Bioeconomy: enhanced agriculture Bioeconomy can provide a secure, high-quality supply of raw materials for the BioIndustrial and BioMedical sectors.

These findings suggest that, like Thailand, Malaysia is still a developing Bioeconomy. A policy like the BTP that cuts across the many sectors involved can serve as a framework to facilitate the maximisation of our underlying potential. A coordinated vision and synced implementation can then drive public-private partnerships and ensure the transition toward a mature, sustainable, private-sector driven Bioeconomy.

3. ECONOMIC ANALYSES

This section demonstrates the empirical findings of Bioeconomy contribution to Malaysia economy based on Dynamic Computable General Equilibrium (DCGE) Modeling and Input Output Modeling for the Malaysian Bioeconomy sector based on the Bioeconomy data obtained from the Department of Statistics, Malaysia.

3.1 Findings: Dynamic Computable General Equilibrium (DCGE) Modeling

According to the national statistics 2010, the Bioeconomy as a whole in Malaysia is estimated to be about 13.4 per cent of total Gross Domestic Product (GDP) and is valued at RM106.663 billion (see Table 3).

Table 3: Malaysian Bioeconomy scenario as of GDP share (RM Billion)

Year	Scenario 1	Scenario 2	Scenario 3
2010	106.663*	--	--
2015	117.596	129.356	135.236
2020	129.650	142.615	149.098
2025	142.939	157.233	164.380
2030	157.591	173.350	181.229

* Scenario 1: growth rate (5%), Scenario 2: growth rate (10%) and Scenario 3: growth rate (15%)

The growth of Malaysian Bioeconomy has been forecasted at “Current rate” (Scenario 1, i.e. 5 per cent growth rate), “Targeted rate” (Scenario-2, i.e. 10 per cent growth rate) and “Stimulated rate” (Scenario-3, i.e. 15 per cent growth rate). According to the current growth rate as per Scenario 1 in Table 3, Malaysian Bioeconomy as of GDP share would increase to RM117.60 billion by 2015; RM129.65 billion by 2020 and RM157.59 billion by 2030. Scenarios 2 and 3 are more promising but require a more aggressive growth rate to be able to be achieved.

It is thus urgent that a proper and efficient strategic direction and sectoral investment plan within the Bioeconomy sector itself be designed based on the contribution of the Bioeconomy's constituent sectors along with operational assistance in converting biological resources into high value products. Linkages between public and private sector and favourable infrastructure development are also key enablers.

Such planning is important to develop and enable selection of promising higher value added technologies and the identification and selection of such investments based on its contribution to the whole Bioeconomy sector as a whole. The selection of investment based on necessity and highest value-add to the Bioeconomy as a whole is crucial to policy makers as it will lead to the highest economic impact for the same amount of effort and investments expended.

Further analysis identifies the amount of economic impact that involves application of bio-based technologies or biotechnology in the Bioeconomy sectors. This involves the utilisation of ratios determined by the Organisation for Economic Co-operation and Development (OECD) specifically forecasting the use of bio-based technology in 2030, i.e. 50% of primary production sectors, 35% of industrial applications, and 80% of healthcare.

By applying these ratios, it is determined that the impact of technology in the Bioeconomy of 2030 ranges from RM73.8 billion to RM84.9 billion under differing scenarios. This means the remainder of between RM83.8 billion and RM96.3 billion of Bioeconomy activity in 2030 is "non bio-enhanced". This portion can be targeted for development through policy direction and facilitation to increase uptake of technology.

Application of technology improves quality, yields and productivity of upstream activities and develops high-margin, high-value markets through downstream activities. This subsequently can improve total Bioeconomy contribution beyond initial forecasts of between RM 157.6 billion and RM181.2 billion.

**Table 4: Malaysian Bioeconomy by utilisation of bio-based technology or biotechnology
(RM Billion)**

	Scenario 1	Scenario 2	Scenario 3
Enhanced through technology	73.8	81.2	84.9
Conventional processes (potential for enhancement)	83.8	92.2	96.3
Total	157.6	173.4	181.2

* Scenario 1: growth rate (5%), Scenario 2: growth rate (10%) and Scenario 3: growth rate (15%)

3.1.1 Sectoral Quantity (Current, Targeted and Stimulated Growth)

Through scenario analyses, the DCGE modeling exercise on the Bioeconomy has identified areas within the Bioeconomy to guide effective investment and resource allocation over a 20 year period (from year 2010 to 2030) as per Tables 4, 5 and 6. This can enable policy makers to leverage on the existing strengths of Malaysia's most robust Bioeconomy sectors or focus on lower-contributing sectors.

For instance policy maker will have to choose between investing into the on palm oil sector now which suggest the highest potential for returns in the year 2015 (Table 4: RM41.194 billion) or into biofuels (classified as refined petroleum products) which shows the lowest potential sector in year in 2015 (Table 4: RM 0.035 billion). A correct identification of investment areas within the Bioeconomy sector as a whole stimulates effective Bioeconomy growth and channels resources to areas that are important in intensifying national efforts to harness Malaysia's huge Bioeconomy potential.

Table 5: Scenario-1 (Current): Sectoral quantity of Bioeconomy in Malaysia**(RM Billion)**

Sectors	2010	2015	2020	2025	2030
Paddy	1.528	1.685	1.858	2.048	2.258
Food Crops	2.557	2.820	3.109	3.427	3.779
Vegetables	4.197	4.627	5.102	5.625	6.201
Fruits	2.444	2.695	2.971	3.276	3.612
Rubber	9.741	10.739	11.84	13.053	14.391
Oil Palm	37.365	41.194	45.417	50.072	55.204
Livestock	6.810	7.508	8.277	9.126	10.061
Forestry & logging	8.521	9.395	10.358	11.419	12.590
Fishing	8.871	9.780	10.783	11.888	13.106
Other Agriculture	0.582	0.642	0.708	0.780	0.860
Oil & Fat Processing	9.156	10.095	11.13	12.27	13.528
Food Processing	8.215	9.058	9.986	11.009	12.138
Beverage Processing	3.816	4.208	4.639	5.114	5.639
Wood Products	2.348	2.589	2.854	3.147	3.469
Refined Petroleum products	0.035	0.038	0.042	0.047	0.051
Chemicals & Chemical products	0.475	0.524	0.578	0.637	0.702

*Scenario 1: Current growth rate (5%)

Table 6: Scenario-2 (Targeted): Sectoral quantity of Bioeconomy in Malaysia**(RM Billion)**

Sectors	2010	2015	2020	2025	2030
Paddy	1.528	1.854	2.044	2.253	2.484
Food Crops	2.557	3.102	3.419	3.770	4.156
Vegetables	4.197	5.090	5.612	6.187	6.821
Fruits	2.444	2.964	3.268	3.603	3.973
Rubber	9.741	11.813	13.024	14.359	15.83
Oil Palm	37.365	45.314	49.959	55.079	60.725
Livestock	6.810	8.259	9.105	10.038	11.067

Forestry & logging	8.521	10.334	11.393	12.561	13.849
Fishing	8.871	10.758	11.861	13.077	14.417
Other Agriculture	0.582	0.706	0.778	0.858	0.946
Oil & Fat Processing	9.156	11.104	12.243	13.497	14.881
Food Processing	8.215	9.963	10.985	12.110	13.352
Beverage Processing	3.816	4.628	5.103	5.626	6.202
Wood Products	2.348	2.848	3.140	3.462	3.816
Refined Petroleum products	0.035	0.042	0.047	0.051	0.057
Chemicals & Chemical products	0.475	0.576	0.635	0.701	0.772

*Scenario 2: Targeted growth rate (10%)

Table 7: Scenario-3 (Stimulated): Sectoral quantity of Bioeconomy in Malaysia

(RM Billion)

Sectors	2010	2015	2020	2025	2030
Paddy	1.528	1.938	2.136	2.355	2.597
Food Crops	2.557	3.243	3.575	3.941	4.345
Vegetables	4.197	5.321	5.867	6.468	7.131
Fruits	2.444	3.099	3.417	3.767	4.153
Rubber	9.741	12.350	13.616	15.011	16.55
Oil Palm	37.365	47.374	52.229	57.583	63.485
Livestock	6.810	8.634	9.519	10.495	11.57
Forestry & logging	8.521	10.804	11.911	13.132	14.478
Fishing	8.871	11.247	12.400	13.671	15.072
Other Agriculture	0.582	0.738	0.814	0.897	0.989
Oil & Fat Processing	9.156	11.609	12.799	14.111	15.557
Food Processing	8.215	10.416	11.484	12.661	13.959
Beverage Processing	3.816	4.839	5.335	5.881	6.484
Wood Products	2.348	2.977	3.282	3.619	3.990
Refined Petroleum products	0.035	0.044	0.049	0.054	0.059
Chemicals & Chemical products	0.475	0.603	0.664	0.732	0.808

*Scenario 3: Stimulated growth rate (15%)

3.1.2 Policy Implications of DCGE Modeling Output

The scenario forecasts from the DCGE model will allow for effective investment selection choice to boost the Bioeconomy's contribution and to strengthen in Malaysia's bio-based industries. The areas/sectoral association share of Bioeconomy has been analysed for a long run i.e, over 20 years to identify the correct areas of investment focus. The forecasts and sectoral shares would help in developing regulatory frameworks, strategic thrust, public commitment, support and assistance between technology developers, business organisations and policy makers to reach the national target for the sustainable Bioeconomy.

Under the BTP, Malaysia is looking for appropriate and effective niche areas that would have the best opportunities for growth and development from the short run to long run. Thus, it is important to know whether the government should emphasise or invest in Oil Palm (RM37.37 billion), Oil & Fat Processing (RM9.16 billion), rubber (RM 9.74 billion), Forestry & logging (RM8.52 billion), or Food Processing (RM8.22 billion) related sectors which are highly potentials, or would invest on refined petroleum products (RM 0.04 billion) lowest potential sector in year 2010 and beyond.

It is also important to recognise, whether BTP or public & private partnership should transfer technology from highly potential sectors to lower potential sectors to get maximum gains (e.g. by utilising lower potential sectors as well). However, that depends on the spending R&D and new innovation and technology. Principally, a correct identification of investment stimulates effectively and channels resources to other related sectors that are important in intensifying national efforts to harness Bioeconomy's potentials. That means that appropriate and effective R&D investments, commercialisation support and facilities influence new technologies utilising biological resources.

According to the DCGE model forecasts it was determined that the ranking for policy makers' focus in policy design and investment to drive the Malaysian Bioeconomy, ranked in order of importance with no. 1 being the most important are:-

- 1) Oil Palm

- 2) Rubber
- 3) Oil & fat processing
- 4) Fishing
- 5) Forestry & logging
- 6) Food processing
- 7) Livestock
- 8) Vegetables
- 9) Beverage processing
- 10) Food crops
- 11) Fruits
- 12) Wood products
- 13) Paddy
- 14) Other Agriculture
- 15) Chemicals & chemical products
- 16) Biofuels (Refined petroleum products)

For policy makers in the Bioeconomy the big five for focused targeting will be oil palm, rubber, oil & fat processing, fishing and forestry & logging sectors that have the capability to produce significant amounts of Bioeconomy impact.

This creates value for the future as these industries can play a vital role in Malaysia moving up the value chain. Actions can be taken to stimulate improvement in yield, quality and efficiency of outputs. Particularly, the application of innovative and advanced technologies can strengthening these upstream portions of the Bioeconomy industry supply chain, providing a steady supply of high-grade raw materials and a foundation for the development of higher value, higher technology downstream applications.

Development of these downstream technologies can form another component of the strategic direction of Bioeconomy. Value added economic processes can extract the maximum benefits for the national economy through technologies enabling converting waste to wealth, producing high value chemicals from low value sustainable inputs, like non-food based renewable feedstock and cultivating biological resources into higher value products.

This can capture the significant potential of the currently (predicted) low-impact sectors like bio-based chemical products.

To meet the targeted goals, operational assistance, strategic direction and specialised infrastructure is required, with an initial focus on oil palm, rubber, oil & fat processing, fishing and forestry & logging sectors. This will serve to create immediate impact to the Bioeconomy share of GDP to achieve a “Targeted” to “Stimulated” rate as shown in Scenarios 2 and 3 (Table 1).

As part of a holistic approach to develop the entire industry value chain, developing upstream sectors like oil palm and rubber can then form a foundation for exploration and commercialisation of higher value downstream processing sectors. This must be driven by an emphasis on investment in research & development and will enable the fulfilment of the Bioeconomy goals set by Malaysia for 2020 and beyond.

3.2 Findings: Input-Output Modeling

The Bioeconomy contribution to Malaysia’s economy based on Output Multipliers and Output Impact was determined using Input-Output modeling (IO). This allows for policy makers to gauge precisely the impact of investments into a particular constituent sector of the Bioeconomy from a multiplier and financial impact dimension.

3.2.1 Output Multipliers

The output multipliers of Malaysia Bioeconomy contribution to the Malaysian economy through the classified Bioeconomy sectors are shown in Table 8 below including normal and ratio multipliers.

Table 8: Output Multipliers for the Malaysian Bioeconomy

SECTOR	Normal Multipliers				Rank	Ratio Multipliers		
	Direct	Indirect	Induced	Total		Type I	Type II	Rank
	1	2	3	(1+2+3)		(1+2)/1	(1+2+3)/1	
Output:								

Agriculture	0.513119	1.533826	0.086027	2.132971	2	3.989221	4.156875	5
Forestry & Logging	0.128112	1.120858	0.050315	1.299285	6	9.749033	10.141772	1
Fishing	0.344275	1.261164	0.067226	1.672665	4	4.663242	4.858510	3
ROS*	0.163218	1.171958	0.024300	1.359475	5	8.180320	8.329197	2
Manufacturing	0.421292	1.368116	0.050900	1.840308	3	4.247432	4.368251	4
Services	0.579539	1.620282	0.146732	2.346553	1	3.795813	4.049000	6
Average Multipliers	0.358259	1.346034	0.070916	1.775210		5.770844	5.983934	

*ROS = Rest of the Sectors (ROS is defined as Crude Oil and Natural Gas sector, Metal Ore Mining sector, Stone Clay and Sand Quarrying sector, and Other Mining and Quarrying sector.)

Note: Rank 1 and rank 2, in terms of normal and ratio multipliers, signify the relative significance of each of the six Bioeconomy sectors, where 1 is the most important and 6 is the least important correspondingly. Oil Palm is included in Agriculture sector and Healthcare is included in Services sector.

Based on IO modeling, amongst the Bioeconomy sectors, the Services sector yields the largest output multiplier of with multiplier of 2.346553. That is, an injection of RM1 generated RM2.346553 amount of output by the Services sector. It should be mentioned that out of the total output multiplier generated by Services sector, the corresponding contribution of direct, indirect and induced effects are 0.579539, 1.620282 and 0.146732 Ringgit respectively. This outcome also indicates that the secondary (indirect + induced multiplier) multiplier effect generates more output than the primary (direct) multiplier effect.

Meanwhile, the components of the Bioeconomy in the Agriculture sector contribution considered to be the second most important output generating sector with the multiplier of 2.132971. Of this multiplier, 0.513119 Ringgit created by direct effect, 1.533826 Ringgit by indirect effect and 0.086027 Ringgit by induced effect. Moreover, the Bioeconomy economy components of the Manufacturing sector is considered to be the third most important sector generated the multiplier of 1.840308. It should be recalled, that the other remaining

Bioeconomy sectors, such as Fishing (1.672665), Rest of the Sectors (ROS) (1.359475), and Forestry & Logging (1.299285) on a comparative basis retained low output multipliers with less than the economy's average multiplier of 1.775210.

On the other hand, although the Forestry & Logging sector yielded the lowest output multiplier, this sector generated the largest Type I (9.749033) and Type II (10.141772) multipliers, in fact, which are greater than the industry average of 5.770844 and 5.983934 respectively, reflecting the high degree of interdependence of this sector with all sectors of the economy.

Finally, among the obtained multipliers, it is noticeable that the sectors that generate high normal multipliers yield low ratio multipliers which are even lower than industry average. Notwithstanding of high normal output multipliers, the services sector yields low ratio multipliers of Type I (3.795813) and Type II (4.049000) that implies that this sector has relatively weak linkages with other sectors of the economy. The sector of Agriculture yields the second lowest ratio multiplier of Type I (3.989221) and Type II (4.156875) whereas manufacturing sector generates the third lowest ratio multiplier of 4.247432 and 4.368251 for Type I and Type II respectively.

3.2.2 Output Impact

The output impact illustrates the amount of output generated by six economic sectors (see table 8) from the revenue earned by Bioeconomy of Malaysia which is RM106, 661, 520 or 13.4% of GDP (RM797,327,000).

Table 9: Output Impact for the Malaysian Bioeconomy (RM million)

SECTOR	General Impact					Ratio Impact		
	Direct	Indirect	Induced	Total	Rank	Type I	Type II	Rank
	1	2	3	(1+2+3)		(1+2)/1	(1+2+3)/1	
Output:								
Agriculture	54.73004	163.60020	9.17572	227.50596	2	425.4964047	443.3786565	5

Forestry & Logging	13.66465	119.55244	5.36664	138.58373	6	1039.846679	1081.736794	1
Fishing	36.72092	134.51765	7.17041	178.40898	4	497.3885307	518.2160794	3
ROS*	17.40908	125.00279	2.59182	145.00370	5	872.525316	888.4048282	2
Manufacturing	44.93562	145.92538	5.42905	196.29005	3	453.037572	465.9242464	4
Services	61.81450	172.82177	15.65064	250.28691	1	404.8671573	431.8724908	6
Total Impact	229.27482	861.42023	45.38428	1136.07933		3693.16166	3829.533095	

*ROS = Rest of the Sectors (ROS is defined as Crude Oil and Natural Gas sector, Metal Ore Mining sector, Stone Clay and Sand Quarrying sector, and Other Mining and Quarrying sector.)

Note: Rank 1 and rank 2, in terms of normal and ratio multipliers, signify the relative significance of each of the six Bioeconomy sectors, where 1 is the most important and 6 is the least important correspondingly. Oil Palm is included in Agriculture sector and Healthcare is included in Services sector.

The total amount of output impact generated by the six sectors of Malaysian economy from the Bioeconomy revenue of RM106, 661, 520 is RM1, 136,079,332.90. The components of Malaysian Services sector had obtained the greatest output impact of RM250,286,913.96 from the Bioeconomy revenue of RM106,661,520. In fact, this sector contributed about 22.03% of total output impact and 25.37 % of Malaysian Domestic Product (GDP). Of the total output impact generated by Services sector, the amount of secondary (indirect + induced impact) impact (188472412.58) is found to be about three times higher than primary (direct) impact (61814501.39). The Agriculture sector components maintained the second largest contributor (RM227,505,963.44 or 28.53% of GDP), representing about 20.03% of total output impact generated by Bioeconomy revenue. Meanwhile, the third and fourth vital sectors in terms of business turnover were constituted by the Manufacturing sector (RM196, 290,048.82) and Fishing sector (RM178,408,981.67) respectively. The contributions of these two sectors were 17.28% and 15.70% of output impact generated by Bioeconomy revenue contributions which were 24.62% and 22.38% of GDP respectively. Finally, the least output impact generating sectors were Rest of the Sectors (ROS) (RM145,003,698.82 or 18.19% of GDP) and Forestry & Logging sector (RM138,583,726.18 or 17.38% of GDP), both contributed a total Bioeconomy output impact of 12.76% and 12.20% respectively.

It is important to mention here that the secondary (indirect + induced) output impact of RM106,661,520 of Bioeconomy revenue is found to be significantly higher than primary (direct) impact. Most important to mention here that although Forestry & Logging sector yielded the lowest total output impact, the secondary output impact (124919079.69) generated by this sector is found to be about nine times more than the primary (direct) impact. Similarly, The ROS (a sector that yielded the second lowest output impact in terms of normal impact) also yielded about seven times higher secondary (127594614.10) output impact than the primary (direct) output impact.

3.2.3 Employment Multipliers

The number of employment generated for a given unit of output produced can be estimated by employment multiplier. The indirect employment effect represents the additional employment resulted from production effect and the induced employment effect describes the induced number of employment created resulting from household consumption. According to our findings in (Table 9), the highest employment multiplier of 0.00003900 has been retained by the Services sector. This is meaning that per unit of output produced generates 0.00003900 amount of employment or 1 million of output generates 39.00 jobs.

The second highest important sector in generating employment is the Agriculture sector with a multiplier of 0.00002887, i.e. Agriculture sector generates 28.87 unit of employment per 1 million of output produced followed by the Fishing sector with employment multiplier of 0.00002542. The Manufacturing sector, Forestry & Logging sector, and ROS (a sector) ranked fourth, fifth and sixth in terms of employment multiplier.

The employment multipliers of Services sector, Agriculture Sector, and Fishing sector were found to be higher than the economy's average employment multiplier of 0.00001961. Thus, it can be concluded that the propensity to generate employment is higher for these sectors compared to other economic sectors. This also explains that these three sectors are more labour-intensive than any other sector of the economy. When ratio multipliers are taken into consideration, the ROS with lower normal multiplier has relatively strong linkages with the rest of the sectors of the economy. While Services sector retains the highest normal multiplier, it has relatively low ratio multipliers as it ranked 4th in terms of ratio multipliers. It is also evident that the Agriculture and Fishing sector with second and third ranked normal

multiplier has relatively weaker linkages with other sectors as they ranked third and sixth in terms of ratio multipliers. Similar to the results found for the output and income multiplier, the contrary results between normal and ratio multipliers are also apparent in employment multiplier analysis.

Table 10: The direct, indirect, induced normal multipliers and Type I and Type II ratio employment multipliers of Malaysian economy

SECTOR	Normal Multipliers				Ratio Multipliers			
	Direct	Indirect	Induced	Total	Rank	Type I	Type II	Rank
	1	2	3	(1+2+3)		(1+2)/1	(1+2+3)/1	
Agriculture	0.00001370	0.00001411	0.00000107	0.00002887	2	2.02961219	2.10737594	3
Forestry & Logging	0.00000466	0.00000260	0.00000062	0.00000788	5	1.55747970	1.69119275	5
Fishing	0.00001684	0.00000775	0.00000083	0.00002542	3	1.46002282	1.50946065	6
ROS*	0.00000091	0.00000452	0.00000030	0.00000573	6	5.96634561	6.29703592	1
Manufacturing	0.00000239	0.00000773	0.00000063	0.00001075	4	4.23411455	4.49785908	2
Services	0.00002036	0.00001682	0.00000182	0.00003900	1	1.82621862	1.91546938	4
Average	0.00000981	0.00000892	0.00000088	0.00001961		1.90929402	1.99881870	

*ROS = Rest of the Sectors (ROS is defined as Crude Oil and Natural Gas sector, Metal Ore Mining sector, Stone Clay and Sand Quarrying sector, and Other Mining and Quarrying sector.)

Note: Rank 1 and rank 2, in terms of normal and ratio multipliers, signify the relative significance of each of the six Bioeconomy sectors, where 1 is the most important and 6 is the least important correspondingly. Palm Oil is included in Agriculture sector and Healthcare is included in Services sector

3.2.4 Employment Impact

The ability to create full time equivalent employment by RM106, 661, 520 of Bioeconomy revenue in 2013 is represented in table 6. The number of employment in the labour force was 13.21 million (DOS, 2013). The total number of employment generated by RM106, 661, 520 of Bioeconomy revenue is found to be 12, 548.78. Of the total employment, the most

important contributing sector in terms of employment generation was supported by Services sector. This sector supported approximately 3978.47 jobs through primary and secondary impact of Bioeconomy revenue. The amount of employment generated by this sector through the Bioeconomy revenue of RM106, 661, 520 was about 0.031% of total employment of Malaysian economy. The direct employment created by this sector was found to be 2171.63 while indirect and induced employment impacts generated by this sector were about 1794.24 and 193.82 jobs respectively.

The second largest contributor in generating employment was Agriculture sector which supported 3079.43 employments from the Bioeconomy revenue of RM106, 661, 520. This sector contributed 0.0233% of employment into the total employment of 13.21 million for the Malaysian economy through RM106, 661, 520 amount of Bioeconomy revenue. The Fishing sector and Manufacturing sector accounted for the third (2711.26) and fourth largest (1146.60) employment generating sectors respectively. These sectors contributed 0.0205% and 0.0087% of total employment of Malaysian economy in 2013 from the Bioeconomy revenue of RM106, 661, 520.

The Services sector (33.15%), Agriculture sector (24.54%) and Fishing sector (21.61%) supported 79.29% of the total employment generated by RM106, 661, 520 of Bioeconomy revenue. This indicates that these three sectors together were seemed to be highly effective in employment generation from Bioeconomy revenue. The ROS (a sector) with 4.87% of total employment and Forestry & Logging sector with 6.70% of total employment were conceded the least two important employment generating sectors, both contributed less than 12% of total employment impact contributed by the Bioeconomy revenue of RM106, 661, 520. The examination of the table 6 also reveals that the sectors with lower direct employment impact do have the ability to generate more employment through secondary (indirect + induced) impact. For example, although direct employment generated by ROS (a sector) is found to be 97.06 jobs, this sector generated more employment (482.04 + 32.10) through secondary (indirect + induced) impact of Bioeconomy revenue (RM106, 661, 520). The similar results were also evident for the sector of Manufacturing and Agriculture. The potential ability to generate more employment through secondary employment impact outlines the importance of inter-industrial linkages of Bioeconomy sectors with these sectors.

Table 11: The direct, indirect, induced normal impact and Type I and Type II ratio employment impact of RM106, 661, 520 Bioeconomy revenue

SECTOR	Normal Impact					Ratio Impact		
	Direct	Indirect	Induced	Total	Rank	Type I	Type II	Rank
	1	2	3	(1+2+3)		(1+2)/1	(1+2+3)/1	
Agriculture	1461.26	1504.53	113.63	3079.43	2	216481521.27	224775920.80	3
Forestry & Logging	497.04	277.09	66.46	840.59	5	166123152.60	180385189.73	6
Fishing	1796.18	826.28	88.80	2711.26	3	155728253.14	161001367.80	5
ROS*	97.06	482.04	32.10	611.20	6	636379491.16	671651422.21	1
Manufacturing	254.92	824.44	67.23	1146.60	4	451617093.65	479748486.25	2
Services	2171.63	1794.24	193.82	4159.69	1	194787254.22	204306875.57	4
Total	6278.10	5708.64	562.04	12548.78		1821116766.05	1921869262.37	

*ROS = Rest of the Sectors (ROS is defined as Crude Oil and Natural Gas sector, Metal Ore Mining sector, Stone Clay and Sand Quarrying sector, and Other Mining and Quarrying sector.)

Note: Rank 1 and rank 2, in terms of normal and ratio multipliers, signify the relative significance of each of the six Bioeconomy sectors, where 1 is the most important and 6 is the least important correspondingly. Palm Oil is included in Agriculture sector and Healthcare is included in Services sector

3.2.5 Policy Implications of IO Modeling Output

This section is reserved for policy implication of the Bioeconomy input-output modeling. The input-output model is used to estimate the multipliers of economic sectors in order to determine the key sectors of an economy as well as to examine the quantitative interdependence of economic sectors. This is because the framework of input-output model explains the transaction of sales and purchases of goods and services from manufacturing to consumer (Leontief, 1966). The framework of input-output model gains much acceptability in the literature as the model has the applicability in numerous research fields. Input-output

methods have been proposed and extensively used, since its debut, for measuring key sector determination analysis, structural analysis, and impact analysis (Miller & Blair, 1985; Miernyk, 1965). Analysts and policy-makers have been utilising the model in knowing the total economic impact upon the generation of output and employment generated from a particular change in final demand or investment (Miller & Blair, 1985). Input-output is the predominant model in assessing the impact of any change in final demand (in this report, the revenue of Bioeconomy is considered as final demand) in a particular period of time which help the policy makers to trace how multiplier effects are worked out within the economy. The size of the multiplier does have important implication for the policy purposes as they determine the relative contribution of each sector in the economy.

The results of input-output modeling reveal that the Services sector produced the highest economic impact generated from the Bioeconomy revenue. Based on this, Services sector should be given the highest priority when formulating Bioeconomy production related policy while Agriculture and Manufacturing being the second and third highest output generating sector respectively. However, it is important to mention that in the IO computation, not all sectors considered in the Services sector are linked to the Bioeconomy. If Services was limited to the Health sector (sector no. 117 of the Malaysian IO table), its impact would not be much larger than the Agriculture sector.

The Bioeconomy revenue generated more direct output impact into the above mentioned sectors while the Forestry & Logging, ROS (a sector), and Fishing sector has the ability to generate more output impact through secondary (indirect + induced) impact. The policy implication from the above analysis is that if the aim of the government or policy makers to generate more output impact through direct impact of Bioeconomy revenue, it is important to formulate appropriate policies in order to increase the amount of output of the Services, Agriculture, and Manufacturing sector. On the other hand, if policy makers prefer to generate more output impact through secondary impact, appropriate policies has to be designed to increase the output of the Forestry & Logging, ROS, and Fishing sector.

However, according to the ratio multipliers and ratio impact, the importance of Forestry and Logging sector should not be ignored as it produces the largest ratio multipliers and impact; meaning that the sector has a very strong relationship with other sectors although it produces

the lowest normal multiplier and impact. The nature of strong inter-relationship of the Forestry & Logging, ROS, and Fishing sector is also evident from the analysis of secondary impact generating ability of these sectors. This is meaning that these sectors are well-integrated with other sectors of the Malaysian economy, although yielded comparatively lower output impact, than the Services, Agriculture, and Manufacturing sector. In order to increase the output impact, it is important to look at the leakages that are occurring due to import, household savings and taxes. For example, if there is a more tax rebate policy adopted to increase the output of Forestry & Logging sector, this will definitely increase the output impact of this sector. Or, if the government allocates more incentives to import substitute Manufacturing sector, this will essentially extend the output impact of Manufacturing sector. To a large extent the consideration of giving more or less importance to a particular sector is depending the direction of respective policy-makers or governments intention or the objective of the corresponding stakeholders discretion.

Since Services sector, Agriculture sector, and Manufacturing sector yielded higher employment impact than the economy's average from the Bioeconomy revenue, it gives an indication to implement favorable policies in order to increase the output of these sectors. However, since Agriculture & Manufacturing sectors contribution to Malaysian economy is 100% and 12.3%, therefore, favorable policies should be directed towards these sectors in order to generate more output.

Nonetheless, when looking at the employment impact generated by, it reveals that the manufacturing sector which yielded the third highest output impact retained the second lowest employment impact while Services and Agriculture sector maintaining the similar ranking as output impact. The ranking of Fishing sector in terms of employment generation has been improved to the third most important sector, although it ranked fourth with respect to output impact, and Forestry & Logging sector's rank surpassed the ROS (a sector) in generating employment. Therefore, it can be concluded that the sectors that generated higher output impact does not necessarily produce the highest employment impact except Services and Agriculture sector. Therefore, policy makers need to be cautious when formulating policies as the sectors that generate more output may not be efficient enough to generate employment. The above analysis indicates that Fishing and Forestry & Logging sectors have higher propensity to generate more employment than Manufacturing and ROS

(a sector) regardless of the contribution of sectors like Services and Agriculture. As a result, it can be concluded that if the government's objective is to generate more employment from the Bioeconomy revenue, it would be practical to increase the output of Fishing and Forestry & Logging sector besides Services and Agriculture sector as these sectors generate more employment than other sectors.

The secondary employment impact (indirect + induced impact) generated by ROS (a sector), Manufacturing, and Agriculture sector is found to be higher than primary (direct) impact from the Bioeconomy revenue of RM106, 661, 520. This is meaning that these sectors retain the higher propensity to generate more employment through inter-industrial linkages and household consumption than the other sectors. This is implying that an increase in output of other sectors will eventually increase the employment generating ability of these sectors as these sectors are well integrated with the Malaysian economy while Services sector, Forestry & Logging sector, and Fisheries sector are yet to build stronger linkages with the other sectors of Malaysian economy. The results of ratio impact analysis also revealing the similar outcome.

As Services sector, Agriculture sector, and Fishing sector generates higher employment impact than the economy's average from the Bioeconomy revenue, when formulating policies, it is vital to adopt favorable policies in order to increase the output of these sectors. However, since Agriculture & Fisheries sector contribution to Malaysian economy is 100%, therefore, favorable policies should be directed towards these sectors in order to generate more employment.

4. SUMMARY

Based on the DCGE and IO analysis conducted, key information is obtained about the current status of the Bioeconomy as well as the potential for its growth in the future. Table 12 shows a summary of the focus sectors which policy makers may emphasise for the Malaysian Bioeconomy.

Table 12: Summary of Bioeconomy Focus Areas/Sectors for Policy Makers
(in order of importance with 1 being the most important)

Dynamic Computable General Equilibrium (DCGE) Modeling	Input Output (IO) Modeling
1) Oil Palm 2) Rubber 3) Oil & fat processing 4) Fishing 5) Forestry & logging 6) Food processing 7) Vegetables 8) Beverage processing 9) Food crops 10) Wood products 11) Paddy 12) Chemicals & chemical products 13) Refined petroleum products	OUTPUT 1) Services* 2) Agriculture 3) Manufacturing Highest linkage interrelationship sector: Forestry & Logging sector EMPLOYMENT 1) Services* 2) Agriculture 3) Fishing Highest Linkage interrelationship sector: ROS (Rest of Sectors) *Not all sectors in Services involve Bioeconomy

It can be determined that within the Agriculture sector, oil palm, rubber, fishing and forestry & logging appears to be the key levers to grow Malaysia's Bioeconomy. This is reflected in the results of both DCGE and IO modelling. Taking into account the fact that IO Services sector is

not entirely Bioeconomy, Agriculture is the largest impact contributor for sectors considered 100% Bioeconomy.

It is important for further deliberations to be made by Malaysia's policy-makers to decide if they should focus on sectors like oil palm (which was found to be the highest potential sector), or to improve further the biodiesel/biofuels sector (presently lowest potential sector, classified under "refined petroleum products"). For example, improving yields and longevity of oil palm cultivation would build on existing strengths, but commercialising innovative and efficient technologies in sectors like biofuels creates more value-add and allows a greater ceiling for growth. An appropriate balance must be struck between the low value-add production and high value-add production to ensure sustainable growth.

It should be noted at this point that the DCGE model yields more specificity for the current and future contributions whereas the IO model which shows an overall account of current contribution only. Furthermore, IO captures indirect and induced effects of economic activities, whereas DCGE computes direct impacts only. The two models also utilised differing baselines for computations: DCGE (Social Accounting Matrix 2010) vs. IO (National Input-Output tables 2005). Regardless, both models generally agree that policy makers' and investment should be directed to Agriculture with certain key areas such as palm oil, rubber, fishing including aquaculture and Manufacturing with a big focus on oil & fats processing.

Forestry & Logging must not be de-emphasised to prevent side effects to other focus areas as it has high linkages to other sectors although low in economic contribution in the current scenario to the Bioeconomy. The Services sector today seems to be a key contributor to today's Malaysian Bioeconomy according to the IO model but based on the DCGE model going forward it will have little contribution to Malaysia's Bioeconomy in the long run as its contribution will be de-emphasised. Additionally, with regards to the Manufacturing sector, the oil & fats processing area is key to grow Malaysia's Bioeconomy sector.

Policy makers and related agencies should pay attention to the potential scope to create sustainable resources based future by utilising business people, potential industry and society for the country's economic development. This can be achieved by paying special attention to the effective initiatives for the bio-based industries to improve competitiveness to contribute more to the development.

Other enablers include operational assistance in converting biological resources into high value products, improved linkages between public and private sector and favourable infrastructure which should be focused further in developing and enabling access to technologies and investment selection.

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6. APPENDICES

A. Quantitative Model Estimate of Bioeconomy Contribution to GDP for Malaysia

Malaysian Biotechnology Corporation

Bioeconomy Development Division (BEDD)

Quantitative model to estimate Bioeconomy contribution to GDP of Malaysia

Work in Progress v0.22 (19.7.2014)

Summary Sheet

Total GDP of Malaysia: 797,327.00 [RM million]

Total GDP of sectors related to Bioeconomy: 106,661.52 [RM million]

Bioeconomy as % of Total GDP: 13.4%

Malaysian Economic Sectors	Bioeconomy?	% of respective sector	Bioeconomy GDP RM million
Agriculture	Yes	100.0%	65,224.00
Forestry & Logging	Yes	100.0%	8,521.00
Fishing	Yes	100.0%	8,871.00
Mining & Quarrying	No	0.0%	-
Manufacturing	Yes	12.3%	24,045.52
Utilities	No	0.0%	-
Services	No	0.0%	-
Construction	No	0.0%	-
			106,661.52

Malaysian Biotechnology Corporation
 Bioeconomy Development Division (BDD)
 Bioeconomy contribution to GDP of Malaysia
 Work in Progress, V0.22 (13/7/2024)

Sources: Accounts 2013, GDP at Current prices
 Malaysian Standard Industrial Classifications 2008

GDP analysis

Year	2010		Year 2010	GDP of sectors related to Bioeconomy (RM mil)	% of sector related to Bioeconomy	Remarks
	Historical GDP (RM million)	%				
2010	797,327	100%		65,224	100.0%	*Agriculture sector assumed 100% related to Bioeconomy
Table 1.0						
Historical and current total GDP of Malaysia, 2005-2013:						
Table 1.1						
Breakdown of total national GDP by sector and activity, 2005-2013						
ASIC Section A (Items 0111 - 0329)						
Agriculture						
TOTAL	65,224	8.2%	100.0%	65,224	100.0%	
Oil Palm	37,365	4.7%	100.0%	37,365	100.0%	
Livestock	6,810	0.9%	100.0%	6,810	100.0%	
Paddy	1,338	0.2%	100.0%	1,338	100.0%	
Others	2,444	0.3%	100.0%	2,444	100.0%	
Food crops	2,557	0.3%	100.0%	2,557	100.0%	
Others	587	0.1%	100.0%	587	100.0%	
Forestry & Logging						
TOTAL	8,521	1.1%	100.0%	8,521	100.0%	*Forestry & Logging sector assumed 100% related to Bioeconomy
Fishing						
TOTAL	8,871	1.1%	100.0%	8,871	100.0%	*Fishing sector assumed 100% related to Bioeconomy
ASIC Section B (Items 0510 - 0900)						
Mining & Quarrying						
TOTAL	86,628	10.9%	0.0%	-	0.0%	*Assumed not bioeconomy related
ASIC Section C (Items 1010 - 3200)						
Manufacturing						
Oil & Fats processing	195,534	24.5%	100.0%	24,046	12.3%	*Manufacturing sector "% related to Bioeconomy" linked from Sheet: Breakdown (Manufacturing)
Food processing	9,156	1.1%	100.0%	9,156	100.0%	
Textile processing	8,241	1.0%	100.0%	8,241	100.0%	
Tobacco	3,389	0.4%	0.0%	-	0.0%	
Textiles and apparel	2,804	0.4%	0.0%	-	0.0%	
Leather & footwear	4,690	0.6%	0.0%	-	0.0%	
Wood products	2,597	0.4%	50.0%	2,348	90.8%	
Paper products	2,243	0.3%	0.0%	-	0.0%	
Recorded Materials	2,243	0.3%	0.0%	-	0.0%	
Chemicals and allied products	21,177	2.7%	2.8%	471	2.2%	
Rubber products	5,724	0.7%	0.0%	-	0.0%	
Plastics products	5,720	0.7%	0.0%	-	0.0%	
Non-metallic mineral products	6,918	0.9%	0.0%	-	0.0%	
Basic metal	9,499	1.2%	0.0%	-	0.0%	
Fabricated metal products	5,386	0.7%	0.0%	-	0.0%	
Machinery and equipment	3,880	0.5%	0.0%	-	0.0%	
Electrical machinery and appliances	32,195	4.0%	0.0%	-	0.0%	
Radio, television, and communication equipment	3,720	0.5%	0.0%	-	0.0%	
Medical, precision and optical instruments	2,515	0.3%	0.0%	-	0.0%	
Transport equipment	1,489	0.2%	0.0%	-	0.0%	
Other manufacture	-	-	0.0%	-	0.0%	
TOTAL	19,115	2.4%	0.0%	-	0.0%	*Includes electricity generation, production of gaseous fuels (scope covers biological sources e.g. biogas) as well as waste treatment using microbes, minimal/negligible %
ASIC Section D,E (Items 3510 - 3900)						
Utilities						
Services	178,626	22.4%	0.0%	-	0.0%	
Wholesale and retail trade	106,634	13.4%	0.0%	-	0.0%	
Restaurants and Accommodations	21,438	2.7%	0.0%	-	0.0%	
Transport and storage	26,537	3.3%	0.0%	-	0.0%	
Information and communications	47,973	6.0%	0.0%	-	0.0%	
Finance	13,751	1.7%	0.0%	-	0.0%	
Insurance	11,465	1.4%	0.0%	-	0.0%	
Real estate	16,340	2.0%	0.0%	-	0.0%	
Owner occupied dwellings	5,918	0.7%	0.0%	-	0.0%	
Private health services	5,897	0.7%	0.0%	-	0.0%	
Private education services	60,119	7.5%	0.0%	-	0.0%	
Government services (community, social & personal)	97	0.0%	0.0%	-	0.0%	
Nonprofit serving households	1,388	0.1%	0.0%	-	0.0%	
Domestic services of households	-	-	0.0%	-	0.0%	
ASIC Section F (Items 4210 - 4300)						
Construction						
Construction	27,112	3.4%	0.0%	-	0.0%	
plus Import Duties	7,072	0.9%	0.0%	-	0.0%	
TOTAL	797,331	100.0%	0.0%	-	0.0%	
Table 1.2						
Total GDP of sectors related to Bioeconomy: 105,662						
Bioeconomy % of National GDP: 13.4%						

Sector	Actual			Calculated			Calculated based on growth rate					
	GDP 2005 (RM Million)	GDP 2010 (RM Million)	Bioeconomy GDP 2010 (RM Million)	Bioeconomy Share of GDP (%)	Growth per year (%)	Growth per year (RM million)	GDP 2006 (RM Million)	GDP 2007 (RM Million)	GDP 2008 (RM Million)	GDP 2009 (RM Million)	GDP 2010 (RM Million)	
SEC1-A	1043	1528	1528.0	0.2%	9%	97.00	1140.00	1237.0	1334.0	1431.0	1528.0	
SEC2-A	1504	2557	2557.0	0.3%	14%	210.60	1714.60	1925.2	2135.8	2346.4	2557.0	
SEC3-A	2179	4197	4197.0	0.5%	19%	403.60	2582.60	2986.2	3389.8	3793.4	4197.0	
SEC4-A	1372	2444	2444.0	0.3%	16%	214.40	1586.40	1800.8	2015.2	2229.6	2444.0	
SEC5-A	5445	9741	9741.0	1.2%	16%	859.20	6304.20	7163.4	8022.6	8881.8	9741.0	
SEC6-A	15836	37365	37365.0	4.7%	27%	4305.80	20141.80	24447.6	28753.4	33059.2	37365.0	
SEC7-A	3679	6810	6810.0	0.9%	17%	626.20	4305.20	4931.4	5557.6	6183.8	6810.0	
SEC8-A	7947	8521	8521.0	1.1%	1%	114.80	8061.80	8176.6	8291.4	8406.2	8521.0	
SEC9-A	5472	8871	8871.0	1.1%	12%	679.80	6151.80	6831.6	7511.4	8191.2	8871.0	
SEC10-A	435	582	582.0	0.1%	7%	29.40	464.40	493.8	523.2	552.6	582.0	
SEC11-A	86187	105743	0.0	0.0%	5%	3911.20	90098.20	94009.4	97920.6	101831.8	105743.0	
SEC12-A	4794	9156	9156.0	1.1%	18%	872.40	5666.40	6538.8	7411.2	8283.6	9156.0	
SEC13-A	4629	8215	8215.0	1.0%	15%	717.20	5346.20	6063.4	6780.6	7497.8	8215.0	
SEC14-A	2627	3816	3816.0	0.5%	9%	237.80	2864.80	3102.6	3340.4	3578.2	3816.0	
SEC15-A	3288	2984	0.0	0.0%	-2%	-60.80	3227.20	3166.4	3105.6	3044.8	2984.0	
SEC16-A	4344	4696	2348.0	0.3%	2%	70.40	4414.40	4484.8	4555.2	4625.6	4696.0	
SEC17-A	1703	2947	0.0	0.0%	15%	248.80	1951.80	2200.6	2449.4	2698.2	2947.0	
SEC18-A	16391	27939	35.4	0.0%	14%	2309.60	18700.60	21010.2	23319.8	25629.4	27939.0	
SEC19-A	15148	21177	475.1	0.1%	8%	1205.80	16353.80	17559.6	18765.4	19971.2	21177.0	
SEC20-A	96832	114604	0.0	0.0%	4%	3554.40	100386.40	103940.8	107495.2	111049.6	114604.0	
SEC21-A	36434	51357	0.0	0.0%	8%	2984.60	39418.60	42403.2	45387.8	48372.4	51357.0	
SEC22-A	30141	47973	0.0	0.0%	12%	3566.40	33707.40	37273.8	40840.2	44406.6	47973.0	
SEC23-A	173673	279326	0.0	0.0%	12%	21130.60	194803.60	215934.2	237064.8	258195.4	279326.0	
Total:			106,661.52	0.0%	13.4%							

Bioeconomy % of National GDP:

13.4%

Imports	432900	528800				19180.00	452080.00	471260.0	490440.0	509620.0	528800.0
Exports	536200	638800				20520.00	556720.00	577240.0	597760.0	618280.0	638800.0

**Malaysian Biotechnology Corporation
Bioeconomy Development Division (BEDD)**
Quantitative model to estimate Bioeconomy contribution to GDP of Malaysia
Work in Progress v0.22 (19.7.2014)

Sources:
Economic Census (Manufacturing) 2011, at Current prices
Malaysian Standard Industrial Classifications 2008

Table 2.6
Breakdown of economic impact by sub-activity (2010).
Manufacturing Sector

Sub-activity	Breakdown of subsectors by %		Conversion/production into: (choose one)										Bioeconomy related?	Bioeconomy Application (INPUT VALUE)		% related to Bioeconomy	
	Value added (RM Mil)	%	Involves biosources	Conversion/Production	Food	Feed	Chemicals	Energy	Healthcare/wellness products	Others	Check	%		Subactivity	Activity		
Manufacturing	9,650	100%	Yes	Yes	Yes	No	No	No	No	No	OK	100.0%		100.0%			
Food processing	8,223	100%	Yes	Yes	Yes	No	No	No	No	No	OK	100.0%		100.0%			
Beverage processing	1,562	100%	Yes	Yes	Yes	No	No	No	No	No	OK	100.0%		100.0%			
Tobacco	988	100%	Yes	Yes	Yes	No	No	No	No	No	OK	100.0%		100.0%			
Textiles and apparel	1,033	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Leather & footwear	501	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Wood processing	1,404	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Paper products	310	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Recorded media	302	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Refined petroleum products	63	21%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Chemicals	239	79%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Rubber products	4,636	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Plastics products	5,853	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Non-metallic mineral products	6,900	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Basic metals	4,554	63%	No	No	No	No	No	No	No	No	OK	0.0%	0.0%	0.0%			
Fabricated products	5,931	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Machinery and equipment	4,929	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Office, accounting and computing machinery	5,567	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Electrical machinery and apparatus	3,843	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Radio, television, and communication equipment and apparatus	18,003	71%	No	No	No	No	No	No	No	No	OK	0.0%	0.0%	0.0%			
Medical, precision and optical instruments, watches, and clocks	588	32%	No	No	No	No	No	No	No	No	OK	0.0%	0.0%	0.0%			
Motor vehicles and transport equipment	9,300	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			
Furniture	1,060	11%	No	No	No	No	No	No	No	No	OK	0.0%	0.0%	0.0%			
Other manufacturing	2,947	100%	Yes	Yes	No	No	No	No	No	Yes	OK	0.0%	0.0%	0.0%			

Malaysian Biotechnology Corporation
Bioeconomy Development Division (BEDD)
 Quantitative model to estimate Bioeconomy contribution to GDP of Malaysia
 Work in Progress (v.22 (19.7.2014))

Sources:
 Economic Census (Services) 2011, at Current prices
 Malaysian Standard Industrial Classifications 2008

Table 3.0
 Breakdown of economic impact by sub-activity (2010),
 Services Sector

Services	Breakdown of subsectors by %		Conversion/production into: (choose one)								Bioeconomy related?	Bioeconomy Application (INPUT VALUE)	% related to Bioeconomy	
	Value add (RM/Mt)	%	Involves bioresources	Conversion/Production	Food	Feed	Chemicals	Energy	Healthcare wellness products	Others			Check	Subactivity
Business services	17,325.51	100%												
-Legal	2,495.78	14%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Accounting	1,367.45	8%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Architectural	1,004.83	6%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Engineering	2,520.45	15%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Surveying	533.01	3%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Advertising	1,064.87	6%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-veterinary	31.13	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Mgmt consultancy & Market research	938.62	5%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Scientific R&D	217.47	1%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Design	306.62	2%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Technical testing & analysis	329.92	2%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Photography	133.14	1%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Other business services	866.36	5%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Admin and Support	5,515.87	32%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
Private health services	4,773.88	100%												
-Hospital Services	2,457.18	51%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Maternity Home Services	8.58	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-General Medical	1,063.98	22%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Specialised Medical	447.63	9%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Dental Services	264.73	6%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Dialysis	127.39	3%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Medical Labs	91.62	2%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Acupuncture	8.33	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Herbal & Homeopathy	10.66	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Other healthcare	125.10	3%	Yes	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Residential care services	19.63	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Social work	12.00	0%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%
-Child daycare	137.07	3%	No	No	No	No	No	No	No	Yes	Ok		0.0%	0.0%

B. Notes on Economic Analysis: Dynamic Computable General Equilibrium (DCGE) Modeling

The DCGE modeling was undertaken to study Malaysia's Bioeconomy, and its macroeconomic impacts which must capture national future thrust, agenda, structure of production in the overall economy, industry demand and preferences, consumer demand and preferences, exports, investment, and other related effect.

The DCGE technique was determined to be able to develop and show these kinds of interactions in a snapshot and thus was determined to be a suitable option to see the impact of Bioeconomy.

DCGE modeling attempts to evaluate Malaysia's Bioeconomy with scenario forecasts that would allow for effective investment selection choices by policy makers to boost the Bioeconomy's contribution and to strengthen Malaysia's bio-based industries. The benchmark DCGE model representing the baseline economy constructed using a Social Accounting Matrix (SAM) 2010 with Malaysian national accounts' datasets.

The SAM reflects a snapshot of economic interactions with complex economic dimensions to evaluate the future outcomes. The DCGE technique is a dynamic quantitative approach that develops complex interdependent relationship between Bioeconomy and other related actors in the Malaysian economy by considering a "general equilibrium" followed with further optimisation.

To fulfil the general equilibrium outcome several parameters has utilised such as:-

- a) nested constant elasticity of substitution (CES),
- b) constant elasticity of transformation (CET) function,
- c) function of government, industry and consumers, and
- d) factor incomes based on fixed shares (derived from SAM based data).

The sectoral investment and Bioeconomy's shares and contributions are allocated in proportions among various sectors and exogenously determined with national outcomes and expenditure. In terms of closure, factors are assumed to be mobile across activities, available in fixed supplies, and demanded by producers at market-clearing prices.

METHODOLOGY

In order to achieve the target of bio-economy: vision 2020 and beyond, this study use dynamic computable general equilibrium (DCGE) model which is based on applied general equilibrium framework (Robinson, S., Yunez-Naude, A., Hinojosa-Ojeda, R., Lewis, D. J. & Devarjan, S. 1999; Relnert, K. A. & Roland-Holst, D. W., 1997; Robinson, S. 1990; Robinson, S. 1989 and Sadoulet & Janvry. 1995). The general equilibrium framework has been chosen for this study because it has the capability to represent in a comprehensive way to see the bio-economy: vision 2020 and beyond by sectoral scope of policy changes and responses. It considers non-linear quantitative analysis that based on secondary data collected from different institutions of Malaysia, mainly from BiotechCorp, Department of Statistics (DOS), Economic Planning Unit (EPU), Household Income and Expenditure Survey (HIES) and Labor Force Survey (LFS). These all data are utilised to prepare Social Accounting Matrix (SAM) for Malaysian economy to make a baseline study of year 2010. The originality of approaching dynamic CGE model is that it captures the economy wide-impacts with each policy changes, targets and economic effects simultaneously. Specifically, it captures the sectoral changes in bioshare output, domestic production, net consumption, government revenue and other macroeconomic variables resulting from each policy changes.

Detailed Data sources

This study uses cross-section data for all Bioeconomy sectors from the national economy which gathered from recent Input Output (I-O) table and industrial classification prepared by DOS Malaysia. Among the data that used are Bioeconomy Shares (BS) to the national economy, Intermediate Inputs (II), Final Goods and Services (FGS), Domestic Production (DP), Total National Demand (TND), Total Supply (TS), Export and Import (E&I), labor and capital and indirect taxes. In order to construct a SAM for year 2010, a time series data for the year 2010 has been used as well (DOS, 2010; DOS, 2013a & b; MDP, 2006 & 2010). SAM requires additional data following on the Bioeconomy target 2020 namely Bioeconomy vision of 2020, government expenditure and investment for Bioeconomy, Bioeconomy sectoral shares, total factor payments, total household income (by income category), total government receipts (including intergovernmental transactions), institutional income distribution, and transfer payments both to households and to production sectors. It is also combined with the national accounts and Malaysian Household Income and Expenditure Survey (HIES) data within a consistent framework for expenditures and savings patterns. Specifically, the secondary time series data used to construct the SAM for year 2010 such as by Malaysian Household Income and Expenditure Survey (HIES) for the year 2010 and National Account Statistics data for the year 2010 published by the Department of Statistics, Malaysia (DOS), Malaysian Government Expenditures and Revenues data for 1990 - 2010 published by Malaysia (DOS, 2010; DOS, 2013a & b).

Instrument for Data Analysis

This study utilises several instrumental techniques for the data analysis. In order to develop a benchmark database with Input Output (I-O) table with SAM framework, this study usage the cross-entropy method to update and balance SAM of year 2005 to year 2010 prepared by DOS and Economic Planning Unit (EPU) Malaysia. The main instrument for analysis to achieve the target is the General Algebraic Modelling System (GAMS) and Syntax Programming (SP). The GAMS and SP is used to solve non-nonlinear and mixed-integer problems and make Malaysian economy-wide mathematical models to construct. The instrument for data analysis proceeds for 8 steps as by:

1. The first step is to delineate agents (producers, consumers, state) and markets,
2. The second step is to organise the data for a computer program,
3. The third step is the market form development,
4. The fourth step is set an arbitrary benchmark price,
5. The fifth step is the functional forms of supply and demand to set up,
6. The sixth step is the calibration of the model,
7. The seventh step is the procedure with the analysis of dynamic effects, and
8. The eighth step is to compute the policy effects.

This study considers the circular flow map of Malaysia shows in Figure 1 which captures all Bioeconomy transfers and transactions between sectors and institutions. Productive activities including Bioeconomy involvement and capital inputs from the factor markets, and intermediate inputs from commodity markets, and use these to produce goods and services. These are supplemented by imports and commodity markets to households, the government, investors, and foreigners. The household and government purchases of commodities provide the incomes producers need to continue the production process. Additional inter-institutional transfers, such as taxes and savings, ensure that the circular flow of incomes is considered closed. Importantly, all income and expenditure flows are accounted for, and there are no leakages from the system for SAM 2010. This study has chosen 23 types of different sectors, and activities and commodities following on Bioeconomy target set by national government and BiotechCorp.

In the study modelling, government receives transfer payments from the rest of the world (e.g. foreign grants and development assistance). This is added to all of the different tax incomes to determine total government revenues. The government uses revenues to pay for recurrent consumption spending and transfers to households. The difference between total revenues and expenditures to the national economic with Bioeconomy is the fiscal surplus. Information on the government accounts is drawn from public-sector budgets published by EPU. According to the ex-post accounting identity, investment or gross capital

formation considered changes in stocks or inventories. The difference between total domestic savings and total investment demand is total capital inflows from abroad in the current account balance. Information on the current account (or rest of world) is drawn from the balance of payments, which is published by DOS (2010). Finally, all Bioeconomy related information has taken from BiotechCorp.

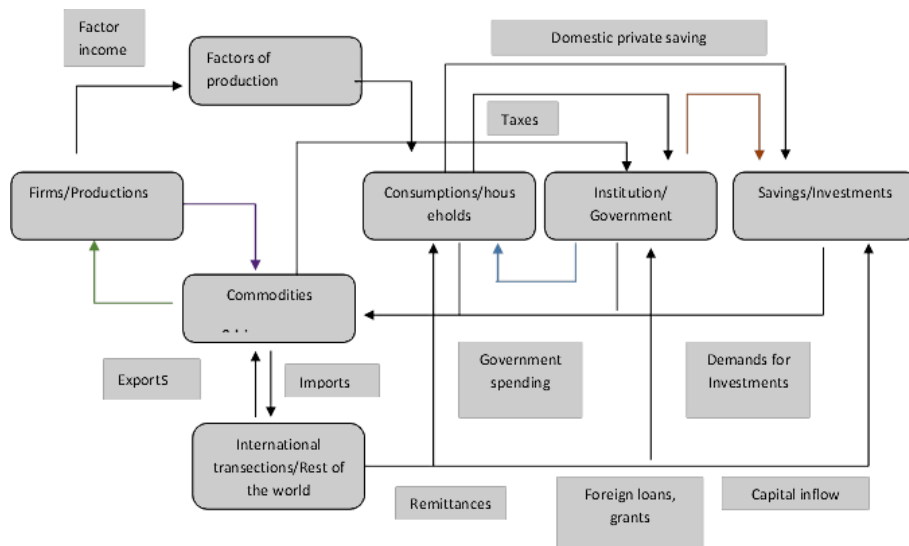


Figure 1. Circular flow map of Malaysian economy

Market Clearance Condition

The market clearance conditions involve commodity market balance and factor market balance in CGE modelling namely as:

- a) Commodity market balance
- b) Factor market balance

Basic structure of the model

This study assumed that as a (relatively) small open economy Malaysia would be a price taker country. Thus import price is considered as exogenously taken in the model. Bioeconomy is contributing to the national development with a certain share. The countries export demand function is downward sloping. The domestic prices of imports and exports are determined by world prices, exchange rate and import tariff or export subsidy. The price system of the model is ironic, primarily because of the assumed quality differences among commodities of different origins and destinations (exports, imports, and domestic outputs used domestically). The original I-O tables consist of 120x120 sectors. However, to meet the Bioeconomy objectives, all economics sectors were regrouped into 23 groups of

sectors. This study consists of four institutional agents, two primary factor productions, and the rest of the world (ROW). The 23 sectors were aggregated from the 2005 Malaysian Input-Output Table (and later updated to 2010) with details of Bioeconomy contributions.

Calibrating the DCGE Model

Calibration technique is performed to estimate the related coefficient parameters in order to find the desired bio-outcomes. The parameter and elasticity values (i.e. CES, CET) that are employed in the study model are vital to assess the impact of various policy effects. Malaysian updated Social Accounting Matrix (SAM) for year 2010 has been used as a data for calibration. The model and equation is written in General Algebraic Modeling System (GAMS) language to estimate the solving parameters with a non-linear programming.

MATHEMATICAL STATEMENT OF THE MODEL

Notation

$a \in A$	A is activities.
$c \in C$	C is commodities.
$c \in CM$	CM is imported commodities and is subset of C .
$c \in CNM$	CNM is non-imported commodities and is subset of C .
$C \in CE$	CE is exported commodities and is subset of C .
$c \in CNE$	CNE is nonexported commodities and is subset of C .
$f \in F$	F is factors with f being labor or capital.
$h \in H$	non-government domestic institutions with h .
$i \in I$	institutions with i being household, enterprise, government, or rest of world.
ad_a	production function efficiency parameter.
aq_c	shift parameter for composite supply (Armington) function.
at_c	shift parameter for output transformation (CET) function.
cpi	consumer price index.
$cwts_c$	commodity weight in CPI.
$icac_a$	quantity of c as intermediate input per unit of activity a .
mps_h	share of disposable income to savings.

pwe_c	export price (foreign currency).
pwm_c	import price (foreign currency).
qg_c	government commodity demand.
$qinv_c$	base-year investment demand.
$shry_{hf}$	share of the income from factor f in h .
te_c	export tax rate.
tm_c	import tariff rate.
tq_c	sales tax rate.
$tr_{i'}$	transfer from institution i' to institution i .
ty_h	rate of income tax for h .
α_{fa}	value-added share for factor f in activity a .
β_{ch}	share of commodity c in the consumption of h
δ_c^g	share parameter for composite supply (Armington) function.
δ_c^t	share parameter for output transformation (CET) function.
θ_{ac}	yield of commodity c per unit of activity a .
ρ_c^g	exponent for composite supply (Armington) function, $(-1 < \rho_c^g < \infty)$.
ρ_c^t	exponent for output transformation (CET) function, $(-1 < \rho_c^t < \infty)$.
σ_c^g	elasticity of substitution for composite supply (Armington) function.
σ_c^t	elasticity of transformation for output transformation (CET) function.
ygi	government investment income
$irepat$	investment surplus to ROW
$yfrep_{atf}$	factor income to ROW
bs_c	Bioeconomy shares
$PBIO_{ct}$	price condition of Bioeconomy for commodity c
$BIOE_{ct}$	Bioeconomy absorption for commodity c
PB_{ct}	price of Bioeconomy
BIO_c	Bioeconomy sectors
$sumbios$	sum of share for Bioeconomy

$bios_c$	Bioeconomy share in the sectoral level from sectoral GDP		
$biostot_c$	Bioeconomy sectoral contribution from sectoral GDP		
$sumbiostot$	Bioeconomy total contribution in base year		
QB_c	quantity of Bioeconomy		
t	time periods for dynamic option		
EG	government expenditure	EXR	foreign exchange rate
$FSAV$	foreign savings	$IADJ$	investment adjustment factor
PA_a	activity price	PD_c	domestic price of domestic output
PE_c	export price (domestic currency)	PM_c	import price (domestic currency)
PQ_c	composite commodity price	PVA_c	value-added price
PX_c	producer price	QA_a	activity level
QD_c	qty of domestic output sold domestically	QE_c	quantity of exports
QF_{fa}	quantity demanded of factor f by activity a	QFS_f	supply of factor f
QH_{ch}	qty of consumption of commodity c by h	$QINT_c$	quantity of cused in activity a
$QINV_c$	quantity of investment demand	QM_c	quantity of imports
QQ_c	qty supplied to domesticmarket	QX_c	quantity of domestic output
$WALRAS$	dummy variable (zero at equilibrium)	WF_f	average wage of factor f
$WFDIST_{fa}$	wage distortion factor for f in a	YF_{hf}	transfer of income to h from f
YG	government revenue	YH_h	income of h

A. The price block

Import and export price

$$PM_c = pwm_c(1 + tm_c) \cdot EXR \quad (1)$$

$$PE_c = pwe_c(1 - te_c) \cdot EXR \quad (2)$$

Absorption

$$PQ_c \cdot QQ_c = [PD_c QD_c + (PM_c QM_c)](1 + tq_c) \quad (3)$$

Domestic output value

$$PX_c \cdot QX_c = PD_c QD_c + PE_c QE_c \quad (4)$$

Activity price

$$PA_a = \sum_{c \in C} PX_c \theta_{ac} \quad (5)$$

Value added price

$$PVA_a = PA_a - \sum_{c \in C} PQ_c ica_{ca} \quad (6)$$

B. Production and commodity block

Activity production function

$$QA_a = ad_a \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \quad (7)$$

Factor demand

$$WF_f WFDIST_{fa} = \frac{a_{fa} PVA_a QA_a}{QF_{fa}} \quad (8)$$

Intermediate demand

$$QINT_{ca} = ica_a QA_a \quad (9)$$

Output function

$$Qx_c = \sum_{a \in A} \theta_{ac} QA_a \quad (10)$$

Composite supply (Armington) functions

$$QQ_c = aq_c \left(\delta_c^q QM_c^{-\rho_c^q} + (1 - \delta_c^q) QD_c^{-\rho_c^q} \right)^{\frac{-1}{\rho_c^q}} \quad (11)$$

Import-domestic demand ratio

$$\frac{QM_c}{QD_c} = \left(\frac{PD_c}{PM_c} \frac{\delta_c^q}{(1 - \delta_c^q)} \right)^{\frac{1}{1 + \rho_c^q}} \quad (12)$$

Composite supply for non-imported commodities

$$QQ_c = QD_c \quad (13)$$

Output transformation function

$$QX_c = at_c \left(\delta_c^t QE_c^{\rho_c^t} + (1 - \delta_c^t) QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad (14)$$

Export-domestic demand ratio

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PD_c} \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad (15)$$

Output transformation for non-exported commodities

$$QX_c = QD_c \quad (16)$$

C. Institution block

Factor income

$$YF_{hf} = shry_{hf} \sum_{a \in A} WF_f WFDIST_{fa} QF_{fa} \quad (17)$$

Non-government domestic institution

$$YH_h = \sum_{f \in F} YF_{hf} + tr_{h,gov} + EXR \cdot tr_{h,row} \quad (18)$$

Household consumption demand

$$QH_{ch} = \frac{\beta_{ch} (1 - mps_h) (1 - ty_h) YH_h}{PQ_c} \quad (19)$$

Investment demand

$$QINV_c = qinv_c \cdot IADJ \quad (20)$$

Government Revenue

$$YG = \sum_{h \in H} ty_h \cdot YH_h + EXR \cdot tr_{gov,row} + \sum_{c \in C} tq_c (PD_c QD_c + PM_c QM_c) \\ + \sum_{c \in CM} tm_c EXR \cdot pwm_c \cdot QM_c + \sum_{c \in CE} te_c EXR \cdot pwe_c \cdot QE_c + ygi \quad (21)$$

Government Expenditures

$$EG = \sum_{h \in H} tr_{h,gov} + \sum_{c \in C} PQ_c \cdot qg_c \quad (22)$$

D. System constraint block

Factor Markets

$$\sum_{a \in A} QF_{fa} = QFS_f \quad (23)$$

Composite Commodity Markets

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + qg_c + QINV_c \quad (24)$$

Current Account Balance for ROW

$$\sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in I} tr_{i,row} + FSAV = \sum_{c \in CM} pwm_c \cdot QM_c + irepat + yfrepat_f \quad (25)$$

Savings-Investment Balance

$$\sum_{h \in H} mps_h \cdot (1 - ty_h) YH_h + (YG - EG) + EXR \cdot FSAV = ygi + EXR \cdot irepat + \sum_{c \in C} PQ_c \cdot QINV_c + WALRAS \quad (26)$$

Price Normalisation

$$\sum_{c \in C} PQ_c \cdot cwts_c = cpi \quad (27)$$

E. Bioeconomy block

Price of Bioeconomy

$$PB_{ct} = sbios_{ct} \cdot PQ_{ct} \quad (28)$$

Value added price for Bioeconomy

$$PBVA_a = PB_a - \sum_{c \in C} PQB_c \cdot ica_{ca} \quad (29)$$

Intermediate demand of Bioeconomy

$$QBINT_{ca} = ica_a QB_a \quad (30)$$

Quantity of Bioeconomy

$$QB_{ct} = sbiostot_{ct} . PB(1 + tq_c) \quad (31)$$

C. Notes on Economic Analysis: Input Output Modeling

In order to determine the economic impact of Bioeconomy of Malaysia, the multipliers should be derived. There are a number of methodologies developed to determine the multipliers. The most widely used approach is the input-output techniques. The major strength of input-output analysis is that it provides detailed information on direct, indirect and induced effects of any event on all economic measures for different industries in the local economy (Loomis and Walsh, 1997). Therefore, in order to satisfy the aforementioned objectives, the methodology employed is based on Leontief input-output techniques where structure of an economy is analysed in terms of inter-relationships between economic sectors (e.g. Miller and Blair, 1985)). The input-output techniques of a particular economy represent the flow of goods and services among its different industries for a particular time period. In the framework of input-output technique, the relationships between economic sectors can be described in a system of linear equations where total output produced by each sector is either consumed as an intermediate input by other sector, or, sometimes internally by the producing sector itself, or, by the final demand sector, or both. The presentation of the flow of goods and services could be expressed either by physical units or in money terms. To define, let there be an economy with n-producing sectors and a final demand sector. Total output of sector i will be:

$$X_i = \sum_{j=1}^n x_{ij} + F_i \quad (1)$$

where, X_i = gross output of sector i; X_{ij} = the sales of sector i to sector j; F = the final demand vector; $i= 1, \dots, n$

Let a_{ij} be the technical (input) coefficient which represents the amount (value) of sector i's output needed to produce one unit (one Ringgit) of sector j's output; thus, using the assumption of constant production coefficient, we get:

$$a_{ij} = x_{ij}/X_j \quad \text{or} \quad x_{ij} = a_{ij} X_j$$

Which means that the total value of purchases of goods and services by sector j from sector i is equal to $a_{ij} X_j$.

Consequently, for a given target of final demand on goods and services, F , this relation defines how much each producing sector must produce in order to satisfy a particular bundle of final demand on goods and services, i.e., Equation (1) in reduced matrix form can be written as:

$$X = AX + F \quad (2)$$

Solving the equation (2) can be found as:

$$X = [I - A]^{-1} F \quad (3)$$

In Equation (3), X is the output vector; I is an identity matrix and $[I - A]^{-1}$ is the total requirement matrix or mostly known as the Leontief inverse matrix.

The general solution of Equation (3) determines how much each sector of the economy must produce in order to satisfy a given level of final demand. It is mandatory that $[I - A]$ should be a non-singular matrix meaning that the determinant of $[I - A]$ does not equal to zero to have a unique solution in the form of $[I - A]^{-1}$. When the Leontief inverse matrix is assumed to be $[I - A]^{-1} = Z$, then z_{ij} 's stand for the elements of the Leontief inverse matrix. Each element of the $[I - A]^{-1}$ shows the direct and indirect requirements of output of sector i per unit of final demand which is the total revenue of the Bioeconomy.

Multiplier Analysis

Central to any analysis related to measure the contribution of an activity are economic multipliers, which are derived from the inverse coefficients or total requirements table. In developing multipliers of Malaysian Bioeconomy, the following procedures are followed. First, Malaysian input-output transaction table is aggregated to 6 sectors. Followed by, the construction of direct requirements matrix. Then, direct and indirect requirement matrixes construction is done. In step four, we develop the direct, indirect, and induced requirement matrix. Sectoral multipliers are derived in step 5.

The 120X120 sectors of Malaysian Bioeconomy transactions table has been aggregated into 6X6 sectors. The sectors were aggregated based on the industrial classification and nature of each sector. These sectors are Agriculture, Forestry & Logging, Fishing, Rest of the sectors (ROS) (Such as Mining etc.), Manufacturing, and services. This means that the input-output transactions table that has been considered in this study includes: (1) One hundred and twenty processing sectors; (2) six final demand sectors; and (3) five payment sectors. The equation can be expressed as:

$$X_{120 \times 1} = A_{120 \times 120}^d * X_{120 \times 120} + F_{120 \times 1} \quad (4)$$

Where,

$X_{120 \times 1}$ = the vector of gross output produced by each of 120 sectors for the Malaysian economy,

$A_{120 \times 120}^d$ = the direct requirements (input coefficients) matrix for 120 sectors, which represents domestic production,

$X_{120 \times 120}$ = the diagonal matrix with each of 120 sectors gross output on the diagonal,

$F_{120 \times 1}$ = the vector of final demand sold by 120 sectors,

The matrix of input coefficients, “Ad120X120” represents only the direct effects of any change in Bioeconomy revenue. To reflect the direct and indirect effects, the matrix of input coefficients must be subtracted from an identity matrix and then, the results are inverted as:

$$X_{120 \times 1} = (I_{120 \times 120} - A^d_{120 \times 120})^{-1}(F_{120 \times 1}) \quad (5)$$

Where,

$I_{120 \times 120}$ = a 120X120 identity matrix,

$X_{120 \times 1}$, $A_{120 \times 120}$, $F_{120 \times 1}$ = as per equation (1),

$(I_{120 \times 120} - A_{120 \times 120})^{-1}$ = the direct and indirect requirements matrix for 120 sectors.

Revenue of Bioeconomy generates income for the economy. According to Keynes, if a certain amount of income due to an exogenous expenditure were injected into an economy, consumer spending would increase by less than the injection of income (Miernyk, 1965). In the same way, an increase in household income (wages and salaries) resulting from expenditure would lead to a rise in household consumption. This increase in household consumption provides further impetus to the economic activity, such as income, employment and business turnover. This is known as induced effect of spending on Bioeconomy products.

Therefore, this study expanded the input-output technique through the inclusion of the household sector as one of the processing sectors. Because of the inequality between the sum of compensation of employee and the sum of private consumption in the Malaysian input-output transaction table, it is necessary to make a reconciliation of the household row and the column totals by adjusting some of the other entries in the payment and final demand sectors (Miernyk, 1965).

Once this adjustment has been made, the new matrix of technical coefficients yields a new Leontief inverse matrix as

$$X_{121 \times 1} = (I_{121 \times 121} - A^d_{121 \times 121})^{-1}(F_{121 \times 1}) \quad (6)$$

Where,

$X_{121 \times 1}$ = the vector of gross output produced by each of 121 sectors including the household sector,

$A_{121 \times 121}$ = the new direct requirements matrix for 121 sectors including the household sector,

$F_{121 \times 1}$ = the vector of final demand sold by 121 sectors,

$(I_{121 \times 121} - A_{d121 \times 121})^{-1}$ = the direct + indirect + induced requirements matrix with being the household sector endogenous.

Tools of Analysis

One of the most powerful mathematical analytical tool named MATLAB has been used to compute the new Leontief inverse matrix, $(I_{121 \times 121} - A_{d121 \times 121})^{-1}$ which would measure the direct, indirect, and induced effects of any change in expenditure or revenue in the Malaysian Bioeconomy. Once the direct, indirect, and induced requirements matrix has been estimated, the output, income, employment, value-added, and import multipliers can be derived for each of six Bioeconomic sectors. The output multiplier shows how much one additional unit of spending or revenue increases the level of output in the Malaysian economy. By denoting the direct, indirect, and induced requirements matrix of $(I - Ad)^{-1}$ as “M”, the output multipliers for each of six sectors can be calculated as:

$$O_{1 \times 6} = i_{1 \times 6} * M_{6 \times 6} \quad (6)$$

Note of Normal and Ratio Multiplier

When comparing the use of normal multipliers against ratio multipliers, the measurement of normal multipliers is considered to be more valuable if the objective is to estimate overall benefit. The reason is that they are able to offer a great deal of detail on to what extent a unit of revenue earned by Bio-economic sectors helps in generating a certain amount of income, output, employment etc. On the other hand, ratio multipliers approach enables us to gauge only the extent of the importance of secondary effect of the Bioeconomy revenue in generating output or income to the direct output or income received. The ratio multipliers reflect the intersectoral/interlinkage relationship of a sector with the rest of the sectors. Therefore, this study has taken the scope of estimating both normal and ratio multipliers.

The calculation of “normal” multiplier is done by adding the effects at direct, indirect, and induced levels. And, the ratio multipliers are categorised into two types. The first type is known as “Type I ratio multiplier” calculated as the ratio of the direct plus indirect effects to the direct effect. The other one is defined as “Type II ratio multiplier” estimated by the ratio of the direct plus indirect plus induced effects to the direct effect. Ranking of sectors are done since the procedure of ranking allows identification of the key and favorable sectors of an economy.

The normal multipliers are more important for policy making than the ratio multipliers since they only shows the degree of intersectoral relationship of sectors.

Limitations of I-O Model

The limitation of I-O model is its assumptions. The input-output model used in study is static model in nature. The model is constructed based upon four fundamental assumptions:

1. The direct technical coefficients are fixed. In other words, production responds to a fixed input-output ratio. This implies the change in the levels of inputs always that leads to the change, in the same proportion, in the level of output over time. This assumption also implies that, when technology remains constant, no external or internal economies or diseconomies exist, and no substitution effects occur due to changes in relative prices or availability of new inputs. The production functions yield under constant returns to scale for each sector.

Though technical coefficient is assumed to be fixed, it has been found that this technique provides a comparatively reliable short-term economic forecast. This is because, economists believe that technological changes affect the effectiveness of the input-output models over time, therefore, periodic adjustments of the coefficient table or the creation of a new table to reflect changes of structure that occurred in the economy, is recommended.

2. There is no problem of aggregation bias in combining sectors into industries or disaggregation of sectors. This assumption implies that sectors within an industry are homogenous and different from sectors in other industries; and each sector produces one homogenous good or service. Also, if coefficients represent the value of production of all sectors of the corresponding industry, input-output analysis will indicate average conditions of sectors of each industry. Finally, the problem of aggregation bias can be reduced by increasing the number of sectors.

3. There are inelastic product demand functions but supply functions of factors are assumed to be elastic in all sectors of the economy. This means that the requirements for additional output to meet any increase in final demand must always be supplied by the previous input sectors without any shortages.

4. The input-output model is based on linear homogeneous consumption functions. This implies that, if the number of households' increases, consumption also increases in the same proportions as in the previous period.

Concerning the restrictive assumptions of the model reflects the fact that the production of goods and services does not face supply constraints of economic resources while production takes place under constant returns to scale. The model is more flexible and reliable for economic impact analysis in the sense that, the model considers the average and marginal propensity to consumption or import is identical. The assumptions were taken into account to evaluate the economic impact of Bio-economy revenue appropriately. They also help to refrain from complexity of the real world and enable researchers to deal with the problem at hand.

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