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EXECUTIVE SUMMARY

- MANUFACTURING is shown to be the sector that wields the highest output multiplier effect in Penang. This is mainly due to its various substantial links to a multitude of other industries throughout the economy.

- And within that sector, it is the E&E and optical industries that exhibit larger output multipliers than other industries.

- These are part of the results attained when Penang Institute applied an Input-Output model upon Penang's economy. This model illustrates the array of economic transactions between different sectors over a given period of time, and is useful in evaluating the quantum effects wrought by a positive or negative change in activities within a given economy.

- The I-O analysis for Penang is based on data from the national level, and adopts the format provided by Penang Institute's Penang SEED document published in 2023, wherein three scenarios for Penang's future were presented.

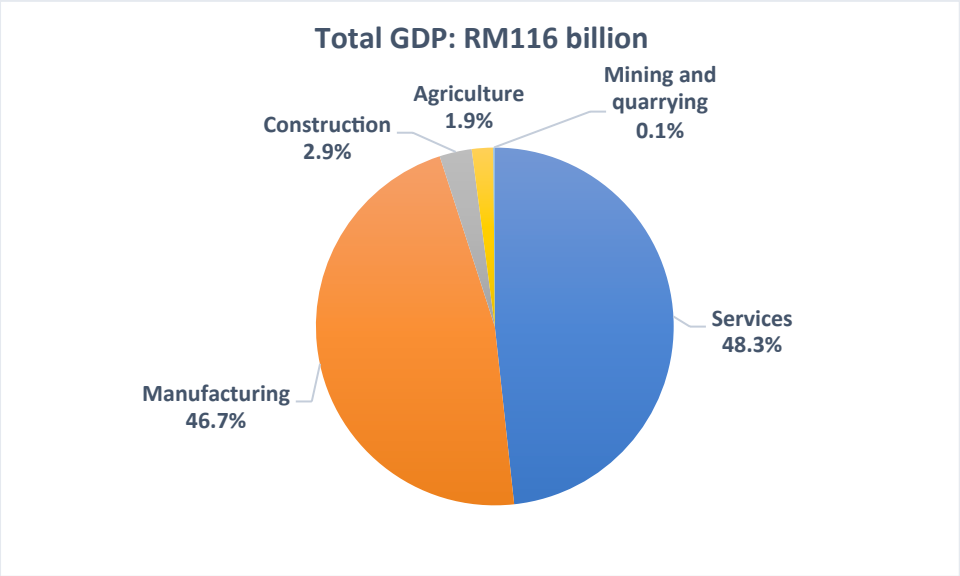
- The analysis shows that, in the best-case scenario, by 2028, the total gross output of Penang will be about RM31.07 billion higher compared to the reference scenario. In the third scenario—the conservative, worse-case one—the total gross output of the state for 2028 is estimated to be RM19.11 billion lower compared to the reference scenario. This indicates that the conservative scenario is an outcome to be avoided.

- All in all, it is clear that developing a long-term *sustainable economic growth plan* is crucial for Penang thrive to expectations. Such a plan should include investments in innovation, technology, and human capital, adoption of sustainable practices, addressing of future challenges, and the fostering of national and international collaborations.

1. Introduction

Penang's economy has been growing at an average of 5.1% over the past nine years (2016-2023). From 2020 to 2022, Penang's GDP growth rate outpaced Malaysia's. With 13.3% economic growth achieved in 2022, Penang recorded the highest growth among Malaysian states. This remarkable economic growth was mainly due to the 15.9% and 11.5% growth rate in the manufacturing and services sectors, respectively. However, in 2023, Penang's GDP growth rate dramatically dropped to 3.3%; this was mainly due to a significant drop in the manufacturing (-0.5%) and services (6%) sectors' growth rate. Overall, the economic structure of Penang is mainly manufacturing and services-oriented. In 2023, the manufacturing sector accounted for 46.5% of Penang's GDP, while 48% was from the services sector. The construction (2.9%), agriculture (1.9%), and mining and quarrying (0.1%) sectors, on the other hand, have been less significant – in total accounting for less than 5% of the state's GDP (Figure 1). The manufacturing, services and agriculture are key economic sectors, and are also the main focus of the Penang State Government in enhancing growth.

Figure 1: Percentage share to Penang's GDP by sector, 2023



Source: Department of Statistics Malaysia.

The manufacturing sector plays a key role in Penang's economic growth, with Electronics and Electrical (E&E) and optical products having the largest share (74%). In 2023, the drop in the growth rate of the manufacturing sector was primarily due to a 0.8% decrease in E&E and optical products mainly as a consequence of lower external demand.

Besides its significant share in GDP, the manufacturing sector makes remarkable contributions to external trade and job creation, and is an important source of innovation and competitiveness. In 2023, approved manufacturing investment generated 17,623 new jobs, with foreign investment being the major driver. E&E constituted the top products for both domestic and foreign companies; despite the challenging external environment and the poor global demand for electronic components, about 86% of the total approved manufacturing investment in 2023 were related to E&E products.

Meanwhile, the services sector was recorded as the largest contributor to the state's GDP in 2023. Here, it has been the wholesale trade and retail, food & beverage and accommodation subsector that

contributed the most (15.5%) to the GDP. Since the reopening of domestic and international borders over the past two years, the tourism sub-sector has been recovering. Strong growth was registered in 2022 (11.5%), but this dropped significantly to 6% in 2023. This was mainly due to a sharp decline in the wholesale & retail trade, food & beverage and accommodation sub-sectors (decreased by 10 percentage points compared to 2022).

Considering Penang's highly industrialised nature and limited land size, the agriculture sector contributes very little to Penang's GDP. Despite that, the sector plays an important role in overall growth through providing raw materials to resource-based industries such as the food manufacturing sector. It is also an important component of the economy, providing employment for thousands of people and contributing to food security. To ensure that Penang's economic growth and development will remain robust and resilient for the long term, sustainable growth in key economic sectors such as these, however relatively small they may appear, is essential.

To clarify the development strategy of Penang, the state government introduced the Penang Strategy for Economic Ecosystem Development (Penang SEED) in 2023. This aims to achieve greater growth momentum from 2023 to 2028, focusing on Penang2030's Theme B: *Upgrade the Economy to Raise Household Incomes*. Being an open trade-oriented economy, Penang is highly dependent on its external environment, and designing hypothetical scenarios about possible future events can help the state explore diverse outcomes, prepare for future uncertainties and risks, and identify opportunities.

Penang SEED imagined three hypothetical scenarios, namely best-case, reference and conservative, or worse-case, to project the key economic indicators from 2023 to 2028 (Penang SEED, 2023). This study examines changes in GDP and gross output by sector under each of the hypothetical scenarios proposed by Penang SEED. To do so, Penang's Input-Output (I-O) model was constructed and the output multiplier effect of economic sectors in Penang was estimated therewith.

2. Data and Methodology

The methodology of this study involves I-O modelling and economic impact analysis. An I-O table was built for Penang to determine the transactions between economic sectors for a given period of time. It was then used for the economic impact analysis.

2.1. Data Collection

Since I-O tables at the state level are not available, the national I-O table was applied and regionalised in order to construct Penang's I-O table so that it corresponds as far as possible to the industrial structure of the state. Additionally, the study also incorporated other required secondary data (national and state level) such as gross output, intermediate input, value added and GDP published by the Department of Statistics Malaysia (DOSM) in 2021[1].

Five sectors and 24 sub-sectors or industries were considered for I-O table generation (Table 1).

[1] Based on the latest available data at the time of writing.

Table 1: Sectors and sub-sectors considered for I-O table

No.	Sector	Sub-sector
1	Agriculture	Crops
		Livestock
		Forestry
		Fishing and Aquaculture
2	Mining and quarrying	Mining and quarrying
3	Manufacturing	Food processing, transport equipment, other manufacturing and repair
		Beverage, tobacco, textiles, wearing products, wood and paper products
		Petroleum, chemical, rubber, plastic & metal products
		E&E and optical
4	Construction	Construction
5	Services	Utilities
		Transportation
		Information
		Wholesale and retail trade
		Food and beverage
		Accommodation
		Finance
		Real estate
		Professional services
		Education services
		Health and social work services
		Arts, entertainment and recreation
		Government services
		Other services

2.2. Methodology

2.2.1. Generating Penang's Input-Output Table

Given the resources available, the national I-O table is regionalised to estimate Penang's I-O table. A simple and common way of regionalising a national I-O table is to use location quotients (LQs) (Flegg & Tohmo, 2013). The simple LQ (SLQ) and the cross-industry LQ (CILQ) are the two most widely used LQs. They are defined as:

$$SLQ_i \equiv \frac{RE_i/TRE}{NE_i/TNE} \equiv \frac{RE_i}{NE_i} \times \frac{TNE}{TRE} \quad (1)$$

$$CILQ_{ij} \equiv \frac{SLQ_i}{SLQ_j} \equiv \frac{RE_i/NE_i}{RE_j/NE_j} \quad (2)$$

where RE_i represents regional output in supplying sector i; and NE_i represents the corresponding national figure. RE_j and NE_j are defined analogously for purchasing sector j. TRE and TNE are the respective regional and national totals. However, SLQ and CILQ tend to overstate regional sectoral multipliers. To overcome this issue, Flegg's LQ (FLQ) formula was proposed, which takes regional size into account (Flegg et al., 1995; Flegg & Webber, 1997 and 2000). The FLQ is formulated as follows:

$$FLQ_{ij} = CILQ_{ij} \times \lambda^* \qquad \text{for } i \neq j \quad (3)$$

$$FLQ_{ij} = SLQ_i \times \lambda^* \qquad \text{for } i = j \quad (4)$$

where:

$$\lambda^* = [log_2(1 + TRE/TNE)]^\delta \quad (5)$$

Here $0 \leq \delta < 1$ is a parameter that controls the degree of convexity. Although FLQ can yield more accurate results than the SLQ and CILQ, it still has some shortcomings. One of the possible shortcomings of the FLQ is a rise in the magnitude of regional input coefficients due to regional specialisation, which might cause them to surpass the corresponding national coefficients. Hence, the FLQ formula is reformulated to the augmented Flegg's location quotient (AFLQ) by adding a specialisation term (Flegg & Webber, 2000). At the moment, the AFLQ is one of the most accurate LQ-based methods. The study, therefore, uses the AFLQ formula to estimate the state's input coefficients from national data input coefficients. The AFLQ is defined as:

$$AFLQ_{ij} = FLQ_{ij} \times \lambda^* \times [log_2(1 + SLQ_j)] \quad (6)$$

AFLQ-generated coefficients are then used as the initial values in applying the cross-entropy (CE) method to balance the I-O table.

2.2.2. Multiplier Effect and Impact Analysis

The multiplier effect is often applied to economic effects. By implementing I-O analysis, multipliers can be computed to estimate the impact of changes brought about by external shocks and policy changes (Miller & Blair, 2009). The output multiplier measures changes in an economy's gross output due to a change in final demand[2] for the goods of a particular industry.

The output multiplier for a specific economic sector is defined as the total output requirements in all sectors of the economy that are needed to support a unit of final demand of that specific sector. For example, for one Ringgit of economic activity, the output multiplier measures the combined effect of a one Ringgit change in its sales on the output of all local industries.

The output multiplier is calculated by using the Leontief inverse matrix $(I-A)^{-1}$, which is associated with the exogenous final demand, where I is the identity matrix and A is the input coefficient matrix.

The estimated multiplier can then be used for economic impact analysis, where the contribution of certain industries to the state's economy or the effects of a specific policy can be assessed.

2.2.3. Scenario Analysis

The generated I-O table is then used as an analytical tool for scenario analysis. The scenario analysis measures the changes in gross output and GDP by sector based on three scenarios[3]:

Scenario 1: Conservative

- Achieving 3.5% GDP growth annually from 2024-2028

Scenario 2: Reference

- Maintaining 4.4% GDP growth annually from 2024-2028

Scenario 3: Best-case

- Achieving 5.8% GDP growth annually from 2024-2028

[2] All changes in consumer purchases are considered final-demand changes.
[3] Scenarios are mainly adapted from Penang SEED.

3. Penang's Input-Output Model

Penang's I-O table provides a detailed picture of the flow of products and resources between industries. Figure 2 illustrates the economic network and transactions between five economic sectors (i.e., agriculture, mining and quarrying, manufacturing, construction and services) in Penang in 2021. It shows that the manufacturing sector, for instance, used RM167.4 billion, RM16.6 billion, RM1.1 billion, RM280.2 million, and RM187.4 million worth of goods from itself, the services, agriculture, construction, and mining and quarrying, respectively, in producing RM238.1 billion of manufacturing output in 2021. In fact, the manufacturing sector's demand for inputs was directly proportional to the output of that sector.

The agriculture, manufacturing and construction sectors, in turn, rely heavily on inputs from the manufacturing sector. In addition, the manufacturing sector is the second highest input provider for the services and mining and quarrying sectors. It shows the importance of the manufacturing sector throughout the economy, as well as its critical role in growth.

Gross output for each economic sector can be calculated as the sum of the intermediate demand and the total final demand for its output (Table 2). Total gross output throughout the economy is estimated to be about RM311.7 billion in 2021. The manufacturing sector contributed the most to the total gross output in Penang with about RM238.11 billion output in 2021, representing 76.38% of the total gross output of the state. The main industry that contributed most to the total gross output of the manufacturing sector in Penang was E&E and optical industry (71%).

Penang's estimated I-O model for 24 sub-sectors is provided in Appendix A. It indicates the 24 industries buying inputs (down the column) and selling output (across the row).

Figure 2: Economic transactions between five economic sectors in Penang, 2021 (RM million)

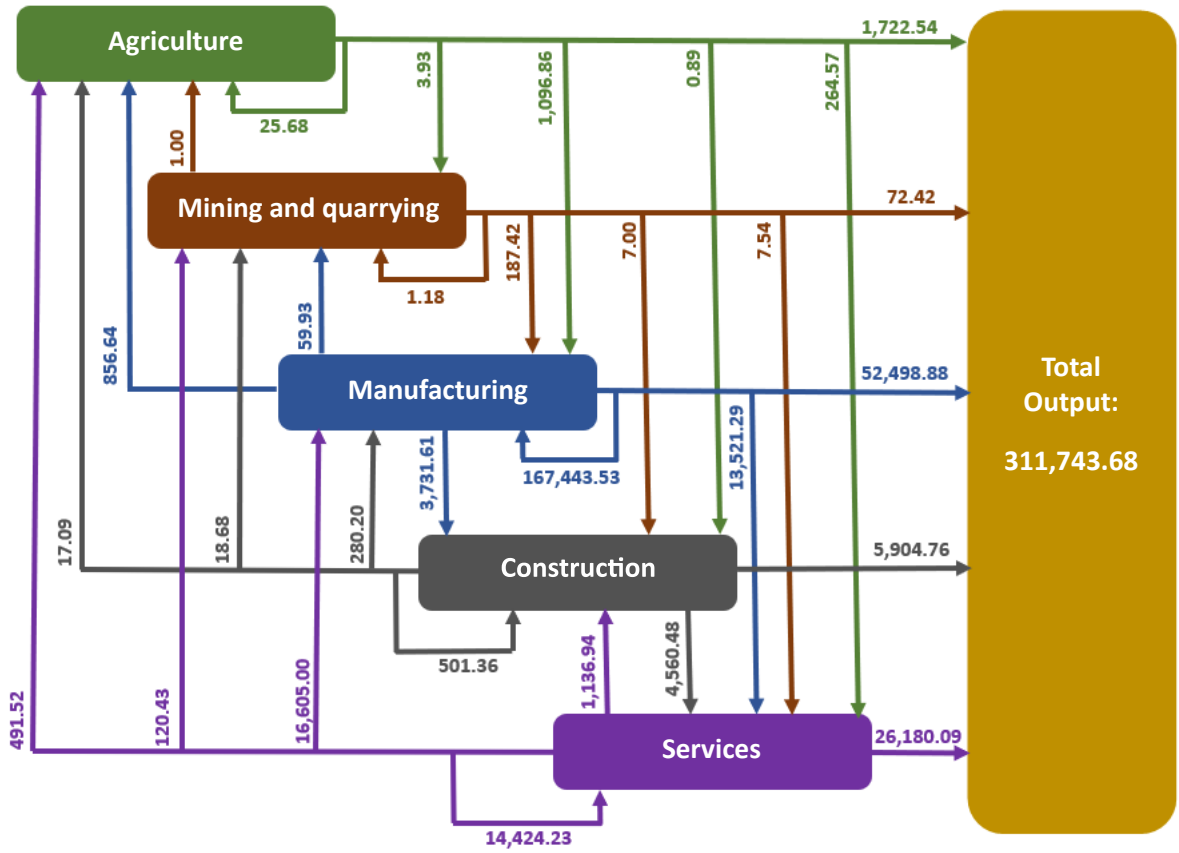


Table 2: Penang's estimated I-O table by sector, 2021 (RM million)

	Intermediate Demand	Final Demand	Total Output
Agriculture	1,391.93	1,722.54	3,114.47
Construction	5,377.80	5,904.76	11,282.56
Manufacturing	185,613.00	52,498.88	238,111.88
Mining and quarrying	204.15	72.42	276.57
Services	32,778.11	26,180.09	58,958.20
Total	225,365.00	86,378.68	311,743.68

4. Output Multiplier Effect

The Leontief Inverse matrix was used to calculate the output multiplier. Appendix B shows the inverse matrix for 24 industries in Penang in 2021. Each element of the Leontief Inverse matrix shows the value of the purchase required from sector i to produce one Ringgit worth of output in sector j. For instance, values of the E&E and optical industry (S9) show that, for a one-ringgit increase in final demand for the state's E&E and optical industry, petroleum, chemical, rubber, plastic & metal products (S8) and utilities (S10) industries, for example, are required to raise their output by RM0.21 and RM0.03, respectively.

Figure 3 illustrates the output multiplier across five sectors. It represents the economic gain that each sector can possibly contribute to the entire economy of Penang resulting from an increase in their production. The manufacturing multiplier shows that an RM1 increase in the manufacturing sector output will induce an additional RM4.10 of output in the overall economy of the state. This is higher than in other sectors. This can be due to the various and substantial links that the manufacturing sector has with many other industries throughout the economy. It means that the sector's output stimulates more economic activity across society than any other sector. Essentially, every Ringgit of output in the sector generates a certain level of economic activity across society. These include sales and purchasing transactions, which would result in a direct and indirect need for resources and employment. Among the manufacturing sub-sectors, the E&E and optical industry has the highest output multiplier effect (5.57) (Appendix B). It indicates the importance of this industry to Penang's economy.

For every Ringgit of economic activity it generates, the mining and quarrying sector exhibits the second-highest output multiplier, generating RM3.38 worth of output in Penang's overall economy. Although mining and quarrying is a very small industry in Penang, the sector generates a higher output multiplier than other sectors (i.e., services, construction, and agriculture). This can be attributed to the high marginal returns associated with increased demand for output. The services sector recorded the third-highest output multiplier (2.87), and the utility sub-sector had the largest multiplier effect (4.30). The output multiplier effect of the construction sector (2.77) is slightly smaller than the services sector.

Despite the agriculture sector's overall low multiplier effect of 2.62, its forestry sub-sector stands out with a significantly higher multiplier of 7.5 This indicates that an increase in demand for forestry products leads to a disproportionately larger increase in economic activity, suggesting high marginal returns in this sub-sector.

Figure 3: Penang's estimated output multiplier by sector, 2021

5. Scenario Analysis

Scenario analysis helps policymakers design and develop proper strategies and policies. Changes in the state's GDP and total gross output are evaluated based on the hypothetical economic growth scenarios. Penang's I-O table is used to forecast the economic scenarios. In order to calculate changes in GDP, changes in final demand are calculated based on the three proposed scenarios. The inverted matrix is then used to compute changes in the gross output.

Scenario 1 (conservative): Achieving 3.5% GDP growth annually from 2024-2028

Under the conservative scenario, it is assumed that Penang is adversely affected by global economic development and the state mainly relies on its past policies to drive economic development (Penang SEED, 2023). Under this scenario, which is the worst-case scenario, the GDP is projected to grow by 3.5% annually from 2024 to 2028.

Table 3 presents the additional GDP required by each sector to achieve the conservative situation's target. For instance, it is estimated that an additional RM66.39 million (compared to 2023) of final demand or GDP is required to achieve 3.5% GDP growth in the agriculture sector in 2024. In order to maintain the 3.5% GDP growth until 2028, the agriculture sector's GDP needs to increase to RM2.59 billion[4]. As the contribution of the manufacturing and services sectors to the total GDP of Penang is higher, a greater increase in their final demand is expected, compared to other sectors.

[4] The GDP of the agriculture sector was RM2.23 billion in 2023. The RM2.59 billion is calculated by adding the absolute increments from 2024-2028 to the GDP of the agriculture sector in 2023.

Table 3: Absolute increments to Penang's GDP by sector under scenario 1 (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	66.39	68.71	71.12	73.61	76.19
Construction	275.62	285.27	295.25	305.58	316.28
Manufacturing	2,118.97	2,193.13	2,269.89	2,349.34	2,431.57
Mining and quarrying	2.92	3.02	3.13	3.24	3.35
Services	1,081.04	1,118.87	1,158.03	1,198.56	1,240.51

Table 4 indicates the projected gross output by sector in Penang from 2024 to 2028. Results show that if GDP grows by 3.5% in 2024, the gross output of the agriculture, construction, manufacturing, mining and quarrying, and services sectors will increase to RM3.64 billion, RM14.72 billion, RM286.07 billion, RM0.33 billion and RM71.72 billion, respectively. By 2028, the gross output of these sectors is estimated to increase to RM4.2 billion, RM16.89 billion, RM328.3 billion, RM0.38 billion, and RM82.30 billion, respectively.

Among sub-sectors, the E&E and optical industry is estimated to have the highest gross output.

Table 4: Projected gross output by sector in Penang under *Scenario 1* (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	3,639.45	3,766.83	3,898.67	4,035.13	4,176.36
Construction	14,715.77	15,230.82	15,763.90	16,315.64	16,886.68
Manufacturing	286,068.37	296,080.77	306,443.59	317,169.12	328,270.04
Mining and quarrying	333.83	345.51	357.60	370.12	383.07
Services	71,723.34	74,233.65	76,831.83	79,520.94	82,304.18

Scenario 2 (reference): Maintaining 4.4% GDP growth annually, 2024-2028

Under the reference or Business-As-Usual (BAU) scenario, the policy interventions and institutional reforms remain in place, and use the existing resources. It is estimated that under this scenario, GDP would expand at an annual rate of 4.4% from 2024 to 2028 (Penang SEED, 2023).

In order to maintain 4.4% GDP growth in 2024, RM83.46 million, RM346.49 million, RM2,663.85 million, RM3.67 million, and RM1,359.02 million should be added to the GDP of the agriculture, construction, manufacturing, mining and quarrying and services sectors, respectively (Table 5). To maintain the target until 2028, the absolute increments to the GDP of such sectors should be increased to RM99.15 million, RM411.62 million, RM3,164.54 million, RM4.36 million and RM1,614.46 million, respectively.

Table 5: Absolute increments to Penang's GDP by sector under *Scenario 2* (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	83.46	87.14	90.97	94.97	99.15
Construction	346.49	361.74	377.66	394.27	411.62
Manufacturing	2,663.85	2,781.06	2,903.42	3,031.17	3,164.54
Mining and quarrying	3.67	3.83	4.00	4.18	4.36
Services	1,359.02	1,418.81	1,481.24	1,546.42	1,614.46

Under scenario 2, in 2024, it is expected that the gross output of the agriculture, construction, manufacturing, mining and quarrying and services sectors will increase to RM3.67 billion, RM14.84 billion, RM288.56 billion, RM340 million, and RM72.35 billion, respectively. In 2028, the gross output for these sectors is estimated to reach RM4.36 billion, RM17.63 billion, RM342.79 billion, RM400 million and RM85.95 billion, respectively. As expected, the manufacturing sector will have the highest gross output, followed by the services sector. The E&E and optical sub-sector are expected to make up the highest gross output compared to other sub-sectors.

Table 6: Projected gross output by sector in Penang under *Scenario 2* (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	3,671.10	3,832.63	4,001.27	4,177.32	4,361.12
Construction	14,843.73	15,496.86	16,178.72	16,890.58	17,633.77
Manufacturing	288,555.93	301,252.39	314,507.49	328,345.82	342,793.04
Mining and quarrying	336.73	351.54	367.01	383.16	400.02
Services	72,347.02	75,530.29	78,853.62	82,323.18	85,945.40

Scenario 3 (best-case): Achieving 5.8% GDP growth annually, 2024-2028

The best-case scenario involves Penang successfully attracting high-value investments, particularly in advanced technologies and digital industries. By leveraging its strengths and investing in talent development, Penang can solidify its position as a regional hub for innovation and technological advancement. This is an optimistic outlook. Under this scenario, GDP is estimated to grow by 5.8% annually from 2024 to 2028 (Penang SEED, 2023).

The absolute increments to Penang's GDP by sector under the best-case scenario are presented in Table 7. As expected, the manufacturing sector, followed by the services sector, will have the highest increments to the GDP from 2024 to 2028. Table 8 shows the increase in gross output from 2024 to 2028 as a result of 5.8% GDP growth rate. Like *Scenarios 1* and *2*, among sub-sectors, the E&E and optical industry will experience the highest gross output from 2024 to 2028.

Table 7: Absolute increments to Penang's GDP by sector under *Scenario 3* (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	110.02	116.40	123.15	130.29	137.85
Construction	456.74	483.23	511.26	540.91	572.29
Manufacturing	3,511.43	3,715.10	3,930.57	4,158.55	4,399.74
Mining and quarrying	4.84	5.12	5.42	5.73	6.06
Services	1,791.43	1,895.33	2,005.26	2,121.57	2,244.62

Table 8: Projected gross output by sector in Penang under *Scenario 3* (RM million), 2024-2028

	2024	2025	2026	2027	2028
Agriculture	3,720.33	3,936.11	4,164.40	4,405.94	4,661.48
Construction	15,042.79	15,915.27	16,838.35	17,814.98	18,848.25
Manufacturing	292,425.45	309,386.13	327,330.52	346,315.69	366,402.00
Mining and quarrying	341.24	361.04	381.98	404.13	427.57
Services	73,317.19	77,569.58	82,068.62	86,828.60	91,864.66

By 2028, the total gross output of Penang is expected to increase to RM432.02 billion, RM451.13 billion, and RM482.20 billion under the conservative, reference and best-case scenarios, respectively (Table 9). An increase in gross output raises the income of individuals, which in turn would result in additional demand for commodities, and therefore further increases in gross output. This is called a positive feedback effect. Results show that by 2028, in the best-case scenario, the total gross output of the state would be about RM31.07 billion higher compared to the reference scenario. Yet, the total gross output of the state is estimated to be RM19.11 billion lower in the conservative (worse-case) scenario compared to the reference scenario for the same year. It indicates that the conservative scenario is an outcome to be avoided.

Table 9: Total gross output under three hypothetical scenarios (RM billion), 2024-2028

	2024	2025	2026	2027	2028
Conservative	376.48	389.66	403.30	417.41	432.02
Reference	379.75	396.46	413.91	432.12	451.13
Best-case	384.85	407.17	430.78	455.77	482.20

6. Policy Measures to Maintain a Long-Term Growth Rate

As an export-oriented economy, Penang is vulnerable to external shocks. For instance, global economic uncertainties and continuing geopolitical tensions pose challenges to the development of the state, especially its manufacturing sector. In addition, Penang's economy can be vulnerable to spikes in international commodity prices, particularly in the agriculture sector due to its high import dependency on essential inputs. Climate-related risks (e.g., extreme weather events) also present significant challenges to the state's economic growth.

The high output multiplier effect of the manufacturing sector compared to other sectors shows that the sector plays a critical role in Penang's economy. The growth of the manufacturing sector is also linked to the growth of other sectors; for instance, as the manufacturing output grows, it needs more inputs from sectors such as agriculture and services. Additionally, it creates jobs and investment opportunities in all the sectors that apply its products, such as services and construction. Further strengthening and developing the manufacturing sector would therefore improve diversification and upgrade other sectors such as the agriculture sector, and also increase demand for higher value-added services.

Developing a long-term sustainable economic growth plan is crucial. This includes investing in innovation, technology and human capital, adopting sustainable practices, addressing future challenges, and fostering national and international collaborations. Proposed policy measures to maintain a long-term growth rate are presented below.

- ***Invest in innovation***
  Innovation drives economic growth (Maradana, et al., 2017), boosts productivity, increases consumer confidence and spending, enhances profits for businesses, creates new jobs and allows companies to stay relevant. Innovative technologies help generate greater output with the same input. Technologies such as Artificial Intelligence (AI) can open up new avenues for products and services, and holds the potential to accelerate innovation. Despite government attempts to integrate AI across sectors, the usage of AI among businesses in Malaysia is still low. According to a survey conducted by OPPOTUS in 2023-2024, only 18% of businesses in the manufacturing sector and 12% in the services sector use AI technology in their operations (OPPOTUS, 2024). This can be due to the lack of information on technology, the cost of technology/innovation, and the lack of skilled workers. Government policies should therefore continue fostering innovation by minimising the impact of the main barriers. There is a need to equip the economy with appropriate tools and policies. For instance, providing resources for research and development (R&D), as well as creating incentives for businesses, especially Small and Medium-sized Enterprises (SMEs), can help them invest in new technologies, products and services.

- ***Boost skills development***
  Skills development is highly required to drive technological progress and productivity. Finding suitable talent is one of the main issues faced by companies in Penang, particularly SMEs. Therefore, there is a vital need to enhance companies' access to talent pools. Furthermore, investing in skills and training would prevent skills depreciation and encourage upskilling or reskilling workers, especially SMEs. Promoting university-business collaborations can also help to facilitate industry applications of innovation and technologies in order to enhance skills development.

- ***Promote sustainable and resilient economic growth***

Economic growth needs to be inclusive and sustainable to ensure inclusive benefits and minimal negative environmental impact. Rapid economic growth can deplete natural resources and significantly damage the environment. The economy depends heavily on natural resources (e.g., water and energy) to produce goods and provide services. To promote sustainability, it is important to encourage better efficiencies in using natural resources, reducing waste and consuming energy. Investment in clean, green, efficient and inclusive economic growth is therefore required. Moreover, integrating environmental, social and governance (ESG) practices by businesses into natural resources management would also help to achieve resilient and sustainable economic growth. For this purpose, ESG-related information disclosed by companies is crucial. According to a study conducted by Penang Institute, the overall ESG disclosure level among Public Listed Companies (PLCs) based in Penang is high (Vaghefi, 2023). In fact, a majority of companies have performed better in disclosing governance indicators (77.1% fully disclosed) compared to social (22.3%) and environmental (17.5%) factors. Improving social and environmental reporting can lead to higher confidence among investors and better business relationships while supporting sustainable development.

- ***Enhance the competitiveness of SMEs***

  Competitiveness is vital for economic growth as it motivates businesses to increase productivity, and enhance innovation, R&D and product quality (Vîrjan, et al., 2023). Since SMEs are the lifeblood of Penang's economy, enhancing their competitiveness would help to maintain high employment and income generation. Facilitating digitisation and automation, financing technology, boosting digital skills, and strengthening export competitiveness are vital matters to consider.

- ***National and international collaborations***

  National collaboration such as partnership between government agencies, universities, and enterprises would foster economic growth through leveraging resources, building capacity, enabling knowledge transfer, enhancing market access, and coordinating policies. Additionally, it has been proven that international collaborations facilitate technology transfer, knowledge exchange, as well as mutual economic growth (Lusha, 2024). For example, through international collaborations, businesses can access new markets, technologies, and talent. This can in turn expand their operations, boost their productivity, increase their revenue, and create new jobs. Collaboration between universities, enterprises, and governments can lead to innovation and creativity, especially when it comes to global economic challenges.

Uncertainties and Limitations of the Study

Building I-O tables, especially at the regional or state level, involves inherent uncertainty and imprecision (Kowalewski, 2009). Data availability and quality on the state level have been some of the main restrictions of this study. An accurate regional I-O table needs extensive and expensive surveying. Hence, this study adopted a non-survey method instead, using the national table as a basis. Adopting exactly the same sectoral classification as the national I-O table was not possible. Therefore, some economic sub-sectors needed to be aggregated, assuming each sub-sector produces a homogenous product output. This assumption on homogeneity might affect the accuracy of the results as some information might have been lost by aggregation.

It is therefore important to note that the results of this study are just estimations. For future studies, partial survey techniques can be applied to improve the accuracy of the regional or state I-O table, and key local industries can be surveyed, especially for information on financial transactions.

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Appendix A

Penang's estimated I-O model (RM million), 2021

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24
S1	1.51	0.38	0.38	0.17	0.53	316.70	7.64	5.85	0.10	0.38	0.19	0.21	0.09	43.79	4.33	0.05	0.33	1.09	2.17	0.00	0.00	0.00	0.09	0.00
S2	2.91	4.85	1.13	0.58	1.54	599.48	3.54	4.03	0.42	1.12	0.64	0.70	0.39	83.46	50.39	0.30	1.00	2.79	5.07	0.00	0.00	0.14	0.40	0.00
S3	7.37	0.16	3.16	0.21	0.63	0.84	73.01	0.60	0.16	0.45	0.24	0.26	0.12	17.29	0.07	0.08	0.39	0.77	3.37	0.00	0.00	0.00	0.13	0.00
S4	1.04	0.35	0.89	0.59	1.22	82.49	0.79	0.89	0.32	0.88	0.50	0.54	0.29	10.00	27.13	0.22	0.78	0.83	1.62	0.00	0.00	0.09	0.30	0.00
S5	0.45	0.11	0.32	0.13	1.18	2.88	0.12	184.34	0.08	1.14	0.15	0.17	7.00	3.98	0.02	0.03	0.27	0.18	1.52	0.00	0.00	0.00	0.07	0.00
S6	46.29	557.91	13.30	35.74	23.81	3,410.22	433.59	1,596.39	813.54	26.34	654.15	40.88	134.02	1,390.06	1,107.27	20.58	35.75	59.39	311.13	13.38	10.86	10.24	21.06	27.88
S7	3.68	16.39	1.08	1.24	5.54	180.91	4,241.19	832.53	576.20	2.76	75.29	92.01	495.16	772.99	55.96	14.14	60.12	28.82	173.01	5.36	1.12	1.48	8.93	9.02
S8	93.26	35.59	14.77	32.51	22.97	1,765.72	851.45	13,265.47	3,112.60	866.05	758.86	149.31	2,461.31	1,294.61	77.33	4.88	26.41	161.63	347.07	2.47	7.20	4.18	31.68	6.62
S9	2.19	0.64	1.21	0.84	7.61	1,061.06	1,020.41	1,616.66	132,665.60	71.88	59.07	439.67	641.12	2,927.58	35.41	0.32	341.94	85.07	683.25	11.70	21.57	0.45	28.35	46.75
S10	12.87	5.31	0.61	2.04	2.80	419.64	179.79	1,172.94	396.88	254.29	28.94	63.55	24.17	646.21	52.83	11.67	35.61	29.28	111.28	10.02	6.10	6.90	13.48	10.10
S11	8.84	11.59	2.32	2.81	7.90	372.31	95.18	812.36	590.00	61.20	209.19	23.98	146.61	193.10	30.05	2.07	26.35	15.01	111.82	1.39	1.29	0.84	2.30	9.48
S12	5.70	3.62	1.05	0.80	3.50	152.70	39.11	133.79	56.13	59.01	134.02	1,909.67	100.42	578.27	22.33	14.13	229.05	45.95	249.10	6.41	0.85	18.32	244.69	13.12
S13	1.58	4.59	9.63	1.29	18.68	13.16	0.65	39.85	226.53	1,532.52	20.08	358.45	501.36	1,513.42	2.52	9.60	362.15	430.85	303.85	5.50	1.62	3.04	10.52	6.37
S14	52.80	58.11	10.94	14.95	30.10	1,527.83	483.99	4,485.80	2,713.65	329.58	230.33	70.24	528.72	410.56	140.76	7.08	61.55	75.10	271.29	7.31	7.26	4.61	11.31	8.35
S15	39.82	17.83	5.28	6.80	11.08	256.81	29.29	188.61	43.02	9.04	251.80	164.56	11.63	26.15	176.98	3.09	191.84	19.46	368.14	13.99	4.52	18.01	10.24	25.31
S16	2.62	0.91	1.66	1.07	2.48	0.76	0.79	2.09	0.62	1.63	0.96	20.07	0.60	1.65	18.42	1.87	22.35	8.25	30.16	0.73	0.36	0.40	1.13	1.43
S17	33.65	16.43	5.19	4.62	6.43	172.33	50.87	366.98	239.01	61.43	47.11	299.51	148.34	692.66	12.26	2.00	231.26	86.76	219.88	1.13	2.97	8.27	23.68	1.61
S18	11.48	1.89	2.02	2.71	4.58	75.60	26.43	137.68	79.24	5.85	30.50	33.04	30.19	452.10	37.63	1.84	51.90	16.14	152.77	2.91	0.85	1.49	3.11	5.58
S19	20.38	14.70	2.15	5.56	7.88	367.18	101.19	515.34	243.66	87.18	165.56	234.55	100.15	404.00	29.91	8.94	995.47	78.23	315.32	6.94	2.99	23.86	17.19	6.22
S20	8.23	2.97	7.02	3.75	9.57	3.31	3.49	6.96	2.77	7.00	4.12	4.52	2.60	5.80	1.97	2.07	6.24	2.96	6.41	2.43	0.69	1.21	2.67	4.30
S21	8.12	2.93	6.93	3.70	9.45	3.24	3.43	6.87	2.74	6.91	4.07	4.37	2.56	5.73	1.94	2.04	6.16	4.63	10.68	0.44	137.00	1.19	2.63	0.19
S22	3.25	1.16	2.77	1.47	3.78	1.30	1.37	2.75	1.08	6.63	1.66	1.87	1.01	2.29	3.18	10.12	2.46	1.68	16.20	3.83	28.69	3.65	1.46	8.24
S23	1.48	0.51	1.49	0.65	1.73	0.68	0.61	1.25	0.47	90.04	52.30	100.62	34.74	54.92	0.66	1.76	32.48	6.87	46.85	1.20	0.80	1.12	206.68	7.55
S24	16.45	5.95	14.04	7.51	19.13	6.60	6.99	13.92	5.55	14.00	8.25	9.00	5.20	11.61	3.95	4.15	12.48	5.82	12.58	5.94	1.21	2.44	5.34	7.61
Total Output	380.05	2,312.50	45.53	376.39	276.57	18,096.50	12,143.71	38,812.24	169,059.44	3,454.65	3,482.77	7,566.30	11,282.56	13,808.26	3,744.39	311.68	4,100.31	3,196.32	4,377.09	2,031.52	1,472.80	393.21	2,528.92	8,489.98

S1 Crops
S2 Livestock
S3 Forestry
S4 Fishing and Aquaculture
S5 Mining and quarrying
S6 Food processing, transport equipment, other manufacturing and repair
S7 Beverage, tobacco, textiles, wearing products, wood and paper products
S8 Petroleum, chemical, rubber, plastic & metal products
S9 E&E and optical
S10 Utilities
S11 Transportation
S12 Information
S13 Construction
S14 Wholesale and Retail Trade
S15 Food and Beverage
S16 Accommodation
S17 Finance
S18 Real Estate
S19 Professional Services
S20 Education services
S21 Health and social work services
S22 Arts, Entertainment and Recreation
S23 Other services
S24 Government Services

Appendix B

Leontief Inverse Matrix

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24
S1	1.01171	0.00652	0.02395	0.00390	0.00668	0.02428	0.00402	0.00411	0.00181	0.00379	0.00776	0.00155	0.00217	0.00794	0.00960	0.00292	0.00302	0.00197	0.00551	0.00034	0.00042	0.00183	0.00072	0.00016
S2	0.02417	1.01437	0.05741	0.00843	0.01533	0.04643	0.00649	0.00777	0.00350	0.00750	0.01591	0.00347	0.00418	0.01533	0.03022	0.00642	0.00687	0.00414	0.01197	0.00075	0.00087	0.00456	0.00160	0.00035
S3	0.02241	0.00062	1.07762	0.00110	0.00359	0.00136	0.01053	0.00121	0.00059	0.00144	0.00134	0.00063	0.00104	0.00286	0.00087	0.00116	0.00119	0.00080	0.00223	0.00008	0.00008	0.00040	0.00027	0.00003
S4	0.00632	0.00199	0.02655	1.00275	0.00625	0.00670	0.00124	0.00131	0.00058	0.00152	0.00300	0.00086	0.00073	0.00229	0.00999	0.00167	0.00174	0.00086	0.00264	0.00016	0.00017	0.00121	0.00043	0.00007
S5	0.00482	0.00081	0.01343	0.00154	1.00610	0.00203	0.00165	0.00835	0.00112	0.00453	0.00297	0.00089	0.00296	0.00252	0.00113	0.00094	0.00141	0.00121	0.00241	0.00010	0.00015	0.00057	0.00037	0.00004
S6	0.34316	0.34024	0.70547	0.17031	0.21474	1.33396	0.13466	0.16241	0.07385	0.14087	0.37773	0.06379	0.08603	0.22371	0.44535	0.13207	0.12403	0.07014	0.22660	0.01624	0.01962	0.08494	0.03044	0.00774
S7	0.10525	0.03582	0.21029	0.03343	0.08814	0.06671	1.57564	0.09929	0.05145	0.10802	0.10144	0.05605	0.11123	0.15148	0.06030	0.09871	0.08618	0.04927	0.13040	0.00774	0.00621	0.02932	0.01882	0.00321
S8	0.65639	0.13252	1.08609	0.22311	0.32112	0.34050	0.29738	1.70379	0.21289	0.76027	0.55729	0.14894	0.45746	0.40080	0.19364	0.14543	0.21557	0.20197	0.36717	0.01692	0.02672	0.09598	0.06114	0.00764
S9	0.85573	0.26914	1.64152	0.27692	0.64227	0.75522	0.92683	0.77695	4.90110	0.88283	0.70828	0.62098	0.64231	1.54267	0.42632	0.29406	0.96856	0.40149	1.33547	0.06015	0.11662	0.23240	0.18552	0.03906
S10	0.09835	0.02323	0.12726	0.02678	0.04747	0.06249	0.05088	0.08031	0.03023	1.13258	0.05880	0.02908	0.03275	0.09032	0.04531	0.05956	0.04289	0.02771	0.07028	0.00768	0.00842	0.03320	0.01380	0.00233
S11	0.06813	0.02075	0.13515	0.02248	0.05560	0.04878	0.03243	0.05457	0.02921	0.06151	1.09859	0.01825	0.03502	0.04701	0.03078	0.02122	0.03436	0.01939	0.05939	0.00252	0.00346	0.01311	0.00642	0.00198
S12	0.08169	0.01856	0.14703	0.02095	0.05406	0.04302	0.02854	0.04016	0.01833	0.07514	0.09541	1.36127	0.03440	0.09437	0.03196	0.08215	0.12473	0.03858	0.12207	0.00673	0.00528	0.08096	0.14835	0.00319
S13	0.13118	0.03036	0.42811	0.03774	0.13867	0.06815	0.05376	0.08439	0.04219	0.58013	0.08237	0.10444	1.08968	0.20550	0.04825	0.08334	0.17081	0.17639	0.16356	0.00926	0.00902	0.04605	0.02643	0.00304
S14	0.31916	0.08748	0.57513	0.10060	0.21210	0.19717	0.14505	0.25816	0.12549	0.27631	0.21551	0.06692	0.14079	1.16445	0.12845	0.08035	0.11473	0.08194	0.19335	0.01091	0.01552	0.05289	0.02605	0.00431
S15	0.15277	0.02107	0.20398	0.03143	0.06618	0.03841	0.01845	0.02604	0.01048	0.02939	0.10860	0.04561	0.01496	0.02863	1.06773	0.02610	0.09196	0.01893	0.12076	0.00890	0.00657	0.06367	0.01286	0.00388
S16	0.01102	0.00104	0.04478	0.00369	0.01083	0.00144	0.00126	0.00129	0.00055	0.00219	0.00245	0.00492	0.00089	0.00206	0.00608	1.00715	0.00923	0.00356	0.00974	0.00051	0.00045	0.00249	0.00129	0.00023
S17	0.14515	0.02220	0.21895	0.02858	0.05576	0.04041	0.02828	0.04388	0.02152	0.06551	0.05247	0.07139	0.03518	0.08793	0.02542	0.02568	1.09868	0.04522	0.09221	0.00278	0.00546	0.03806	0.02201	0.00112
S18	0.05684	0.00800	0.09240	0.01505	0.03213	0.01873	0.01356	0.02008	0.00954	0.02191	0.02746	0.01406	0.01278	0.04821	0.02074	0.01384	0.03317	1.01270	0.05384	0.00245	0.00200	0.01144	0.00476	0.00107
S19	0.14167	0.02918	0.19979	0.03880	0.07446	0.06184	0.04085	0.05832	0.02627	0.08609	0.10343	0.07534	0.03923	0.08669	0.03983	0.05621	0.31050	0.05198	1.13582	0.00650	0.00765	0.08746	0.02292	0.00205
S20	0.02710	0.00193	0.17065	0.01075	0.03654	0.00179	0.00272	0.00155	0.00059	0.00369	0.00269	0.00151	0.00105	0.00211	0.00160	0.00760	0.00302	0.00160	0.00319	1.00130	0.00069	0.00372	0.00149	0.00055
S21	0.02960	0.00213	0.18551	0.01172	0.03976	0.00202	0.00300	0.00176	0.00067	0.00412	0.00305	0.00171	0.00119	0.00242	0.00180	0.00832	0.00363	0.00239	0.00474	0.00035	1.10276	0.00413	0.00164	0.00007
S22	0.01245	0.00098	0.07435	0.00481	0.01611	0.00110	0.00139	0.00099	0.00039	0.00321	0.00170	0.00110	0.00064	0.00136	0.00173	0.03377	0.00265	0.00117	0.00541	0.00200	0.02178	1.01014	0.00094	0.00102
S23	0.01535	0.00264	0.05614	0.00479	0.01315	0.00568	0.00449	0.00648	0.00288	0.03918	0.02415	0.02310	0.00716	0.01254	0.00409	0.01118	0.01801	0.00607	0.02055	0.00121	0.00135	0.00729	1.09235	0.00119
S24	0.05417	0.00386	0.34121	0.02151	0.07304	0.00358	0.00543	0.00310	0.00118	0.00738	0.00538	0.00300	0.00210	0.00422	0.00321	0.01524	0.00602	0.00316	0.00632	0.00312	0.00125	0.00749	0.00298	1.00098
Output Multiplier	4.32045	2.07157	7.50154	2.07965	3.15703	3.16822	3.38309	3.44317	5.56522	4.29173	3.65239	2.71583	2.75384	4.22321	2.63118	2.19983	3.46696	2.21947	4.13931	1.16558	1.36125	1.90582	1.68061	0.08433