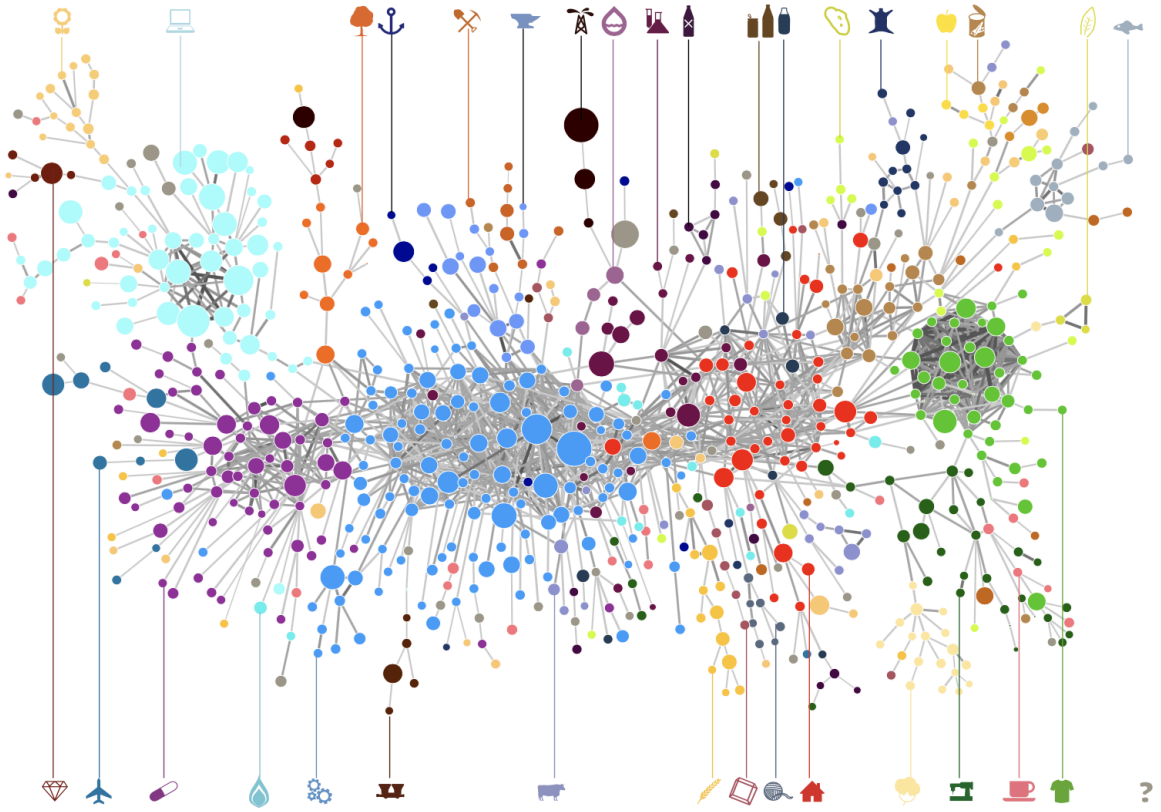

https://atlas.cid.harvard.edu/

# Optimal Industry Development Strategy Using Economic and Product Complexity

# Malaysia

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# Optimal Industry Development Strategy for Malaysia

## 0. Executive Summary

In this report, we aim to uncover the economic path Malaysia went through during the period from 2009 to 2014, and 2019 to 2022. Specifically, we dive into the topic through a macroeconomic overview of Malaysia from the perspective of Gross Domestic Product (GDP) and Economic Complexity Index (ECI), which reflect countries' production capability and production structure, respectively. We find that during the period of our interest, Malaysia demonstrated a high level of economic growth with an average annual GDP growth rate of 10.8% between 2009 and 2014 and 6.51% between 2019 and 2022, with a similar economic complexity compared to other major emerging economies.

The mixed progress during the period, we believe, can be partially explained through the analysis of the economic and product complexity structure of Malaysia on the industry group level, as well as the declining macro and microeconomic strategies. The product classification system we adopt allows us to measure the realized industry development for various industry groups and to observe that Malaysia regressed in developing most of its industries during the period while its emerging counterparts and economies around the globe also adopted complex and progressive paths with variable degrees of success.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups, there was no immediate need of reform in 2014 because no industry had a positive opportunity. In 2022, its focus should have shifted to the Services and Utilities industry, which is also one of the more developed industries at the time. We further note that Malaysia has a slightly mismatched development strategy that indicates a higher level (compared to other emerging countries) of structural optimality on the complexity level, having an adjusted R-square of around 0.108 in 2014 and a much higher score of 0.170 in 2022, demonstrating improvement in development. Since a significant positive correlation exists between GDP growth and the structural optimality index of an economy as we define and calculate, Malaysia indeed has a positive growth experience as compared with fast-growing economies both on a regional scale and on a global scale and has the potential to further its economic gains through industrial structure optimization as suggested in the paper.

The years between 2019 and 2022 showed a significant improvement in Malaysia's economic growth, boosting its position on the global scale. Its GDP recovered to above the pre-pandemic levels while ECI decreased, particularly compared to its peer countries. Its current strategy still has the viable potential upside to increase its performance and optimize its structure further.

# 1. Report Overview

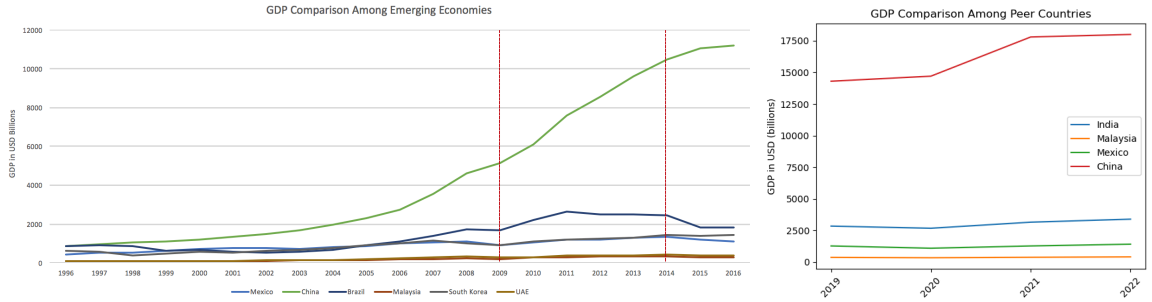
In this report, we aim to uncover the economic path Malaysia went through during the period from 2019 to 2022, before and after the COVID pandemic, compared to its performance from 2009 and 2014, before and after the Economic Transformation Programme. Specifically, we dive into the topic through a macroeconomic overview of Malaysia from the perspective of Gross Domestic Product (GDP) and Economic Complexity Index (ECI), which reflect countries' production capability and production structure, respectively. We then analyze the industrial framework and changes of Malaysia during the period based on quantitative measures such as the Product Complexity Index (PCI) and Product Family Complexity Index (PfCI), followed by a detailed analysis of how such changes have matched with development strategies as quantitatively measured by opportunity gains on an industry-level. We conclude our report with macro-level results and predictions of Malaysia, as deduced from regression models we have established on a global scale, which take into account countries' stances in their product space.

## 2. Macroeconomic Results

### 2.1 GDP Ranking and Changes

Figure 1a illustrates the time-series GDP results for Malaysia and its peer countries from 2009 to 2014. The annual growth rate of 10.8% exceeds the annual growth rate of the other five leading emerging economies, which have a geometric average growth rate of 9.2% and an arithmetic average growth rate of 9.5%. When compared to more developed economies globally, the annual growth rate of 10.8% becomes even more impressive, particularly considering that countries like the USA saw an annual GDP increase of only around 3.9% during the same period. We believe that this rapid economic growth is reflected in the changes in both the Economic Complexity Index (ECI) and the Product Complexity Index (PCI), and can be further explained by the strategic production decisions made by Malaysia between 2009 and 2014.

Figure 1b shows the GDP levels for Malaysia and its peer countries (India, Mexico, and China) from 2019 to 2022. Similar to the other countries, Malaysia displayed a drop in GDP from 2019 to 2020 because of the pandemic, with all GDPs rebounding in 2022. Over these three years, Malaysia's average annual GDP growth rate (6.51%) is low, less than India's (8.53%), Mexico's (9.18%), and China's (7.4%).



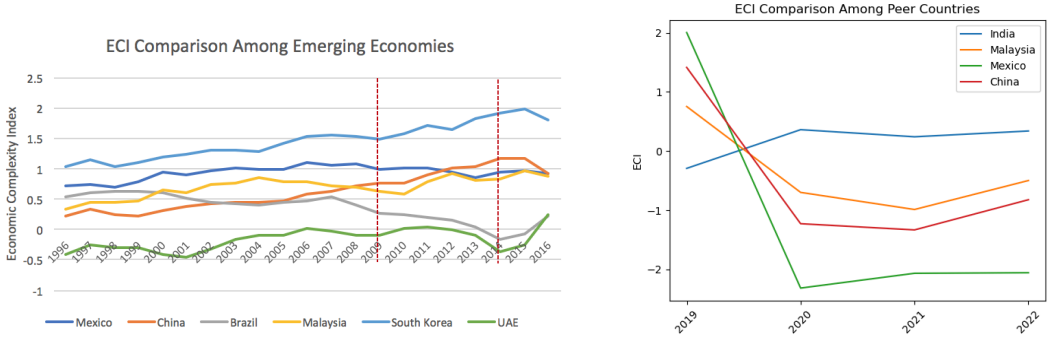

Figures 1a and 1b. GDP Comparison Among Peer Countries (left: 1996-2016; right: 2019-2022)

### 2.2 ECI Ranking and Changes

The Economic Complexity Index (ECI), as defined by Ricardo Hausmann and Cesar Hidalgo in 2009 to explain the knowledge accumulated in a country's population, is illustrated in Figures 2a and 2b.

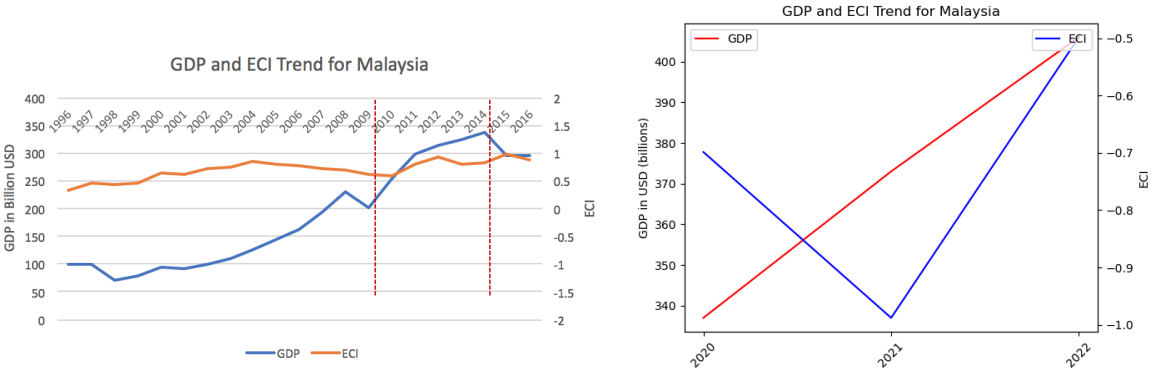
As shown, Malaysia exhibits a noticeable increase in production capability from 2009 to 2014. This is in direct contrast to countries such as Brazil and Mexico, which demonstrate a disadvantage in both ECI growth rate and GDP growth rate.

The comparable countries show similar changes in ECI level between 2019 and 2020, with small increases in after 2020. Malaysia exhibits a large decrease in production capability in 2020 due to the pandemic, and is still in the process of recovery. Malaysia has seen a -166.2% increase in its ECI, which is greater than Mexico's (-202.7%), but less than India's (215.84%).




Figures 2a and 2b. ECI Comparison Among Peer Countries (left: 2009-2014; right: 2019-2022)

Figures 3a and 3b offer a further comparison of GDP Growth and ECI over the time span from 2009 to 2014 for Malaysia. Similar to the GDP drop and further increase from 2009 to 2014 the GDP growth during the period from 2019 to 2022 is accompanied by a similarly volatile increase in ECI. The results show that the economic growth experienced by Malaysia during the period from 2009 to 214 is consistent with the predictions by ECI and that Malaysia made moderate progress towards effectively developing a competitive product space that helps to accumulate complicated knowledge and technology. For the period 2020 to 2022, the ECI followed GDP trends, which can be interpreted as advancements in production. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of Malaysia's production structure and its product space designs in the next few sections.




Figures 3a and 3b. GDP Growth and ECI for Malaysia (left: 2009-2014; right: 2020-2022)

# 3. Production Analysis

## 3.1 Product Categorization

Our main data source in this research is the UN Comtrade Website (https://comtrade.un.org), which provides us with valuable information on countries' export values on an annual basis, including highly specific export data for more than 5000 categories of products. In order to have a holistic vision of the product space of a country, however, a level of categorization is required. Products in our data source are labeled from 010000-999999, with the first two digits representing a general category to which the product belongs. Based on the 99 categories extracted from the label, we further group the products into the 18 most widely-accepted industries, as summarized in Table 1.

Note that the High-complexity Products industry group is not a distinct industry but rather an aggregated industry that encompasses the most complicated products from the most technologically-advanced industries (as measured by PCI). This industry serves as an indicator for us to quantitatively evaluate how well a country has performed in developing cutting-edge technologies and closing its technological gap with advanced economies, which has become a topic of wide concern today. Indeed, when we rank the 18 categories based on PfCI (an equivalent concept of PCI as calculated based on the 18 categorized product groups), the High-complexity Products industry has the highest PfCI among all industry groups.

| Category | Description |
|---|---|
| **Animals and By-products** | All kinds of meat, livestock and related by-products |
| **Vegetables, Fruits and Plants** | All kinds of plants, edible vegetables and fruits |
| **Food and Preparations** | Edible preparations, raw cooking materials and appliances |
| **Clothing and Accessories** | All kinds of fabrics, filament, clothing and accessories |
| **Textiles** | All kinds of textile articles and related products |
| **Wood Products** | Book, paper and other elementary products related to wood |
| **Metals** | Mining of all sorts of raw Metals |
| **Refined and Processed Stones** | Refined or processed stone products such as pearl and ceramics |
| **Energy Drilling and Mining** | Mining industry for energy, minerals, stone materials, etc. |
| **Daily Instruments** | Basic daily instruments such as sport requisites, timing and measuring tools |
| **Raw Manufacturing** | Basic products made from plastic, rubber, leather, etc. |
| **Chemical Manufacturing** | Advanced chemical products and pharmaceutical products |
| **Chemicals** | Raw chemical materials and by-products |
| **Machinery and Construction** | Machinery and mechanical appliances, including electrical equipment |
| **Transportation** | Vehicles and locomotives including aircraft, ship, railway, etc. |
| **Weapons** | Explosives, arms and ammunition |
| **Services and Utilities** | Financial, business, legal, communication, travel Services and Utilities, etc. |
| **High-complexity Products** | Agglomeration of advanced products with highest PCIs |

Table 1. Categorization of Products

We further observe a positive correlation between the GDP and the export of High-complexity Products. A higher adjusted R-square exists between GDP and High-complexity Products exports, indicating that more successful economics, as measured by GDP, tend to be those that are capable of producing and exporting High-complexity Products as we define them. Tables 2a and 2b show the OLS results in a universe of 107 and 21 typical countries respectively.

| | High-complexity Products | Food and Preparations | Animals and By-products |
|---|---|---|---|
| Adj. R-squared | 0.075 | 0.006 | 0.002 |
| F-statistic | 9.556 | 1.638 | 1.175 |
| No. Observations | 107 | 107 | 107 |

Table 2a. OLS Regression Results of GDP against Percentage Volume of Exports

| | High-complexity Products | Food and Preparations | Animals and By-products |
|---|---|---|---|
| Adj. R-squared | 0.149 | 0.003 | -0.012 |
| F-statistic | 4.510 | 1.059 | 0.7542 |
| No. Observations | 21 | 21 | 21 |

Table 2b. OLS Regression Results of GDP against Volume of Percentage Exports

### 3.2 Realized Industry Development

Based on the aforementioned product categorization, we aim to capture Malaysia's realized industry production strategy between 2014 and 2022 on a complexity level. In Hausmann and Hidalgo (2009), distance is defined to be a measure of how far a country is from a certain product, not in its product space. We extend this concept to all product groups and quantify how technically equipped a country is to develop the corresponding product groups. In other words, the shorter the distance between a country and a product group, the more capable a country is of developing products within that group. Defining this net distance change as the Realized Industry Development (RID), our export data allow us to calculate and compare the RID of Malaysia and the 18 product groups in 2022 and 2014 through the difference, where a positive RID indicates a shortening of the distance (i.e., advancement of the industry), and a negative RID indicates the reverse. It is notable that the number of industries with positive RID has increased drastically between 2014 and 2022.

| Category | RID (2022) | RID (2014) |
|---|---|---|
| Daily Instruments | 0.056 | -0.033 |
| Chemicals | 0.019 | -0.023 |
| Weapons | 0.037 | -0.028 |
| Wood Products | -0.025 | -0.044 |
| Transportation | 0.063 | -0.066 |
| Machinery and Construction | 0.027 | -0.099 |
| Metals | 0.021 | -0.032 |
| Raw Manufacturing | 0.052 | -0.048 |
| Services and Utilities | 0.053 | -0.107 |
| Clothing and Accessories | 0.032 | -0.043 |
| Chemical Manufacturing | 0.06107 | -0.088 |
| Food and Preparations | -0.005 | -0.024 |
| Textile | -0.003 | -0.077 |
| High-complexity Products | 0.062 | -0.114 |
| Vegetables, Fruits and Plants | 0.006 | -0.018 |
| Animals and By-products | -0.001 | -0.031 |
| Energy Drilling and Mining | 0.026 | 0.010 |
| Precious Stones | 0.029 | 0.015 |

Table 3. Realized Industry Development (RID) of Malaysia

### 3.3 Regional and Global Comparison

Tables 4a-4b below summarize how the production strategy adopted by Malaysia compares with selected leading economies in the world across different years, as measured in RID. Leading economies such as Germany, France, and Canada gave a considerable level of attention to more advanced product groups such as High-complexity Products in 2018 and Transportation in 2022.

| Ranking | France | the UK | Germany |
|---|---|---|---|
| 1 | High-complexity Products | Services and Utilities | High-complexity Products |
| 2 | Chemical Manufacturing | Weapons | Transportation |
| 3 | Daily Instruments | Raw Manufacturing | Wood Products |
| 4 | Animals and By-products | Precious Stones | Metals |
| 5 | Food and Preparations | Animals and By-products | Food and Preparations |

Table 4a: RID Comparison across Leading Economies (2018)

| Ranking | Canada | Germany |
|---|---|---|
| 1 | Energy Drilling and Mining | Daily Instruments |
| 2 | Animals and By-products | Chemicals |
| 3 | Vegetables, Fruits and Plants | Transportation |
| 4 | High-complexity Products | Chemical Manufacturing |
| 5 | Wood Products | Metals |

Table 4b: RID Comparison across Leading Economies (2022)

Tables 4c-4d further examine Malaysia's development strategy against those of emerging economies on a global scale. Reasonably, emerging economies such as China, South Korea, and Singapore have devoted the majority of their efforts to intermediate industry groups, showing moderate shifts in strategies over the course of four years.

| Ranking | China | South Korea | Singapore |
|---|---|---|---|
| 1 | High-complexity Products | Transportation | Transportation |
| 2 | Transportation | Textile | High-complexity Products |
| 3 | Machinery and Construction | High-complexity Products | Precious Stones |
| 4 | Energy Drilling and Mining | Chemical Manufacturing | Daily Instruments |
| 5 | Daily Instruments | Machinery and Construction | Services and Utilities |

Table 4c: RID Comparison across Emerging Economies (2018)

| Ranking | China | South Korea | Singapore |
|---|---|---|---|
| 1 | Daily Instruments | Chemicals | Transportation |
| 2 | Chemicals | Daily Instruments | Weapons |
| 3 | Raw Manufacturing | Metals | High-complexity Products |
| 4 | Metals | Raw Manufacturing | Energy Drilling and Mining |
| 5 | Machinery and Construction | Machinery and Construction | Machinery and Construction |

Table 4d: RID Comparison across Emerging Economies (2022)

# 4. Product Space Design

## 4.1 Suggested Development Vector

As outlined above, distance gives us an idea of how far each new product is from a country's current mix of exports. As defined in Hausmann and Hidalgo (2009), distance is "the weighted proportion of products connected to goods p that country c is not exporting, i.e., MCP = 0." Based on this definition, the distance between a country and any product that the country is currently exporting (i.e., the country is a significant exporter of the product as compared to the global average) is zero. Similarly, opportunity gain quantifies the contribution of a new product in terms of opening up the doors to more and more complex products. Intuitively, a product that a country is currently exporting (i.e., MCP = 1) has an opportunity gain of zero. An unreasonable investment in a certain product p would lead to a relative decrement in the export of more profitable products and therefore lead to a negative opportunity gain of product p. The opportunity gain is not the only estimator of a country's level of economic development. However, among countries with comparable economic strength, those having higher ECI, or in other words, more reasonable economic structures are often in better shape.

| Ranking | Mexico | Japan | South Korea | Germany | China | Malaysia | France |
|---|---|---|---|---|---|---|---|
| 1 | Vegetables, Fruits and Plants | Metals | Transportation | Energy Drilling and Mining | Energy Drilling and Mining | Vegetables, Fruits and Plants | Animals and By-products |
| 2 | Daily Instruments | Daily Instruments | Weapons | Wood Products | Clothing and Accessories | Energy Drilling and Mining | Food and Preparations |
| 3 | Machinery and Construction | Chemicals | Clothing and Accessories | Metals | Textiles | Daily Instruments | Raw Manufacturing |
| 4 | Transportation | Machinery and Construction | Refined and Processed Stones | Daily Instruments | Wood Products | Raw Manufacturing | Chemical Manufacturing |
| 5 | High-complexity Products | Transportation | Services and Utilities | Raw Manufacturing | Metals | Machinery and Construction | Transportation |
| 6 | Weapons | High-complexity Products | Animals and By-products | Chemical Manufacturing | Daily Instruments | High-complexity Products | Services and Utilities |
| 7 | Clothing and Accessories | Weapons | Wood Products | Chemicals | Raw Manufacturing | Chemicals | High-complexity Products |
| 8 | Chemical Manufacturing | Energy Drilling and Mining | Vegetables, Fruits and Plants | Machinery and Construction | Chemicals | Refined and Processed Stones | Energy Drilling and Mining |
| 9 | Chemicals | Chemical Manufacturing | Chemical Manufacturing | Transportation | Machinery and Construction | Weapons | Clothing and Accessories |
| 10 | Textiles | Clothing and Accessories | Raw Manufacturing | High-complexity Products | High-complexity Products | Animals and By-products | Chemicals |
| 11 | Services and Utilities | Refined and Processed Stones | Energy Drilling and Mining | Refined and Processed Stones | Refined and Processed Stones | Services and Utilities | Weapons |
| 12 | Refined and Processed Stones | Textiles | Machinery and Construction | Weapons | Weapons | Clothing and Accessories | Textiles |
| 13 | Animals and By-products | Services and Utilities | Food and Preparations | Clothing and Accessories | Services and Utilities | Food and Preparations | Vegetables, Fruits and Plants |
| 14 | Energy Drilling and Mining | Animals and By-products | Textiles | Services and Utilities | Animals and By-products | Metals | Refined and Processed Stones |
| 15 | Food and Preparations | Wood Products | Metals | Animals and By-products | Vegetables, Fruits and Plants | Chemical Manufacturing | Wood Products |
| 16 | Wood Products | Raw Manufacturing | High-complexity Products | Vegetables, Fruits and Plants | Chemical Manufacturing | Textiles | Metals |
| 17 | Raw Manufacturing | Food and Preparations | Daily Instruments | Textiles | Food and Preparations | Wood Products | Daily Instruments |
| 18 | Metals | Vegetables, Fruits and Plants | Chemicals | Food and Preparations | Transportation | Transportation | Machinery and Construction |
| ECI | 2.901 | 2.491 | 2.117 | 1.91 | 1.591 | 1.772 | 1.224 |

Table 5a. Opportunity Gain Ranking on a Comparable Scale (2014)

| Rank | India | Malaysia | Togo |
|---|---|---|---|
| 1 | Weapons | Services and Utilities | Weapons |
| 2 | Machinery and Construction | Chemical Manufacturing | Vegetables, Fruits and Plants |
| 3 | Food and Preparations | High-complexity Products | Machinery and Construction |
| 4 | Raw Manufacturing | Precious Stones | Wood Products |
| 5 | Wood Products | Chemicals | Services and Utilities |
| 6 | Services and Utilities | Vegetables, Fruits and Plants | Precious Stones |
| 7 | Daily Instruments | Animals and By-products | Chemicals |
| 8 | Transportation | Machinery and Construction | Daily Instruments |
| 9 | High-complexity Products | Wood Products | Metals |
| 10 | Animals and By-products | Textile | Transportation |
| 11 | Vegetables, Fruits and Plants | Food and Preparations | High-complexity Products |
| 12 | Energy Drilling and Mining | Energy Drilling and Mining | Animals and By-products |
| 13 | Chemicals | Raw Manufacturing | Food and Preparations |

| | | | |
|---|---|---|---|
| 14 | Chemical Manufacturing | Metals | Energy Drilling and Mining |
| 15 | Clothing and Accessories | Transportation | Chemical Manufacturing |
| 16 | Textile | Weapons | Raw Manufacturing |
| 17 | Metals | Daily Instruments | Clothing and Accessories |
| 18 | Precious Stones | Clothing and Accessories | Textile |
| **ECI** | **0.338973** | **-0.498173** | **0.315147** |

Table 5c. Opportunity Gain Ranking on a Comparable Scale (2022)

We define the ranking of opportunity gain for a country c, as the Suggested Development Vector (SDV) of c. Tables 5a-5c summarize how the SDV of Malaysia compares with a selected group of comparable and leading economies in the world, with the industry groups ranked in decreasing order of significance.

Dark blue indicates positive opportunity gains, light blue indicates zero opportunity gains, and white indicates negative opportunity gains. The result shows that leading countries barely have any industries with positive opportunity gain. In other words, those countries are already in the most stable and efficient economic structure. Without the necessity of economic transition, those countries merely need to maintain a steady and balanced economic development. In contrast, developing countries have nearly half of industries with positive opportunity gain and share common interests in Machinery and Construction. It can be concluded that Malaysia shares the characteristics of developing countries, with a balanced economic structure.

| Ranking | Thailand | Italy | Spain | United Arab Emirates |
|---|---|---|---|---|
| 1 | Animals and By-products | Energy Drilling and Mining | Energy Drilling and Mining | High-complexity Products |
| 2 | Food and Preparations | Precious Stones | Precious Stones | Transportation |
| 3 | Chemicals | Vegetables, Fruits and Plants | Weapons | Machinery and Construction |
| 4 | Raw Manufacturing | Animals and By-products | Textile | Daily Instruments |
| 5 | Textile | Food and Preparations | Chemicals | Chemicals |
| 6 | Machinery and Construction | Chemical Manufacturing | Daily Instruments | Weapons |
| 7 | Transportation | Raw Manufacturing | Animals and By-products | Textile |
| 8 | High-complexity Products | Wood Products | Vegetables, Fruits and Plants | Chemical Manufacturing |
| 9 | Energy Drilling and Mining | Clothing and Accessories | Food and Preparations | Raw Manufacturing |
| 10 | Vegetables, Fruits and Plants | Textile | Chemical Manufacturing | Energy Drilling and Mining |
| 11 | Precious Stones | Metals | Raw Manufacturing | Precious Stones |
| 12 | Weapons | Machinery and Construction | Wood Products | Services and Utilities |
| 13 | Clothing and Accessories | Daily Instruments | Clothing and Accessories | Metals |
| 14 | Services and Utilities | High-complexity Products | Metals | Clothing and Accessories |
| 15 | Wood Products | Weapons | Transportation | Wood Products |
| 16 | Metals | Chemicals | Services and Utilities | Animals and By-products |
| 17 | Chemical Manufacturing | Services and Utilities | Machinery and Construction | Vegetables, Fruits and Plants |
| 18 | Daily Instruments | Transportation | High-complexity Products | Food and Preparations |
| ECI | 1.68914409 | 1.179705915 | 0.45830144 | -0.734459148 |

Table 6. SDV of Other Sample Countries (2019)

### 4.2 Budgeted Industry Development Strategy and Interpretation

The optimal budgeted industry development strategy aims to solve the most efficient allocations under the budgeted constraint of different situations of heuristic total export growth. In order to obtain such an allocation portfolio, we formulate an optimization problem as the following:

$$\max_{x \in \mathbf{R}^{|P|}} \quad \left(\frac{k(x) - < k(x) >}{stdev(k(x))}\right)_C$$

Subject to

$$\sum_{p \in P} x_p \leq B$$

$$x \succcurlyeq 0$$

where k(x) is the second largest eigenvector of $M_{CC'}$ after adding $x$ to the original export vector, $C$ is the country that we are interested in, $P$ is the product space, $B$ is the heuristic budget.

If we can solve this problem, then we can know what the largest ECI to which a country can improve. Accordingly, the optimal solution $x$ * that we obtain here is exactly our optimal allocation. However, the biggest problem is that the objective function is not convex. Therefore, we cannot apply the classical tools for convex optimization to this problem. In order to solve this problem, our idea is to use a greedy algorithm. The way that we apply the greedy algorithm is that firstly we separate the total budget into k equal parts, and then for the first equal part we try to search for the product that can optimize our objective function by iterating through each $p \in P$. After we find the optimal product p for this equal part, we add the amount back to the export value of this product p and update the ECI for this country. If we observe that ECI does not change after iterating all the products, then we can add up one more equal part to invest. Until we find there is an ECI increment, we add the amount now to that product. The equal rest parts can be done in the same way.

By definition, a greedy algorithm is a kind of local search algorithm that is possible to run into a local minimum. Therefore, for local search algorithms, one typical way to keep it away from the local minimum is to enhance the vision of the algorithm by looking more steps forward. In our setting, whenever we obtain an increment of ECI, we mark down the required amount of export growth. Simultaneously, we continue searching for the next ECI increment point, compare the ratios of these two possibilities and pick the largest one. The ratio is defined as the following:

$$Ratio(p) = \frac{ECI_p - ECI_0}{||x_p - x_0||_1}$$

where $ECI_p$ is just the ECI of the country after adding some amount of export increment to product $p$, which is exactly the amount that is able to make ECI change. Also, we can express it in the way of $||x_p - x_0||_1$.

In this way, we can obtain a further sighted greedy algorithm. Also, the number of parts that we would like to separate the budget into also matters. In order to solve this problem, we added a stabilizer on top of the enhanced greedy algorithm by running the algorithm for different numbers of parts and selecting the portfolio with the largest ECI increment and most complex economic structure.

Besides, it is quite common that there is a surplus in the budget. To deal with the surplus, we just add it to the product which needs the least amount of dollars to make $M_{cp} = 1$ (i.e., the smallest amount of required export increase).

**Economic Panel**

As stated above, the enhanced greedy algorithm is developed mainly for solving the optimal allocation strategy. In order to visualize this allocation, an economic panel is created, consisting of a pie chart, a line chart and a table. First, a pie chart is used to show the percentage of each product in the optimal portfolio. The number located in the center of the circle denotes the heuristic growth of total export, which is also our budget. Each category in the chart has a determined percentage of the allocated budget. The lines below the pie charts show how the ECI changes during the searching process of the greedy algorithm. Even though sometimes an increase of the export by 15% or 20% does not seem reasonable to developed countries, yet it can also give a sense of how a country should develop in the long term. Eventually, the graph in the end is just for numerical explanation for the pie charts.

**Interpretation**

For the purpose of a clear explanation of the line charts, we label all the products in Table 7. Please refer to this table when trying to understand the investment trajectories in the line charts.

| Label | Product Names |
|---|---|
| 1 | Animal and By-products |
| 2 | Vegetables, Fruits and Plants |
| 3 | Food and Preparations |
| 4 | Energy Drilling and Mining |
| 5 | Chemicals |
| 6 | Chemical Manufacturing |
| 7 | Raw Manufacturing |
| 8 | Wood Products |
| 9 | Clothing and Accessories |
| 10 | Textile |
| 11 | Metals |
| 12 | Machinery and Construction |
| 13 | Transportation |
| 14 | Weapons |
| 15 | Daily Instruments |
| 16 | Precious Stones |
| 17 | High-complexity Products |
| 18 | Services and Utilities |

Table 7. Products Labeling

Figure 4 shows an economic panel for Malaysia in 2022. We can see that for different percentages of heuristic total export growth, the ECIs of Malaysia actually have different increments. For 2022, a 5 percent increase in export would emphasize Animals and By-products, followed by Machinery and Construction, Precious Stones, and Textiles for 10,

15, and 20 percent export growth respectively. These strategies go in line with the suggested trajectories based on ECI. The patterns observed in the indicator improvements suggest that as the export growth increases, the focus should shift from lower complexity sectors, such as Animals and By-products, to more complex and value-added industries, such as Machinery and Construction, and eventually to high-value sectors like Precious Stones and Textiles. This progression aligns with the overall goal of enhancing Malaysia's economic complexity.A more detailed numerical representation of the portfolio for Malaysia is shown in Table 8.

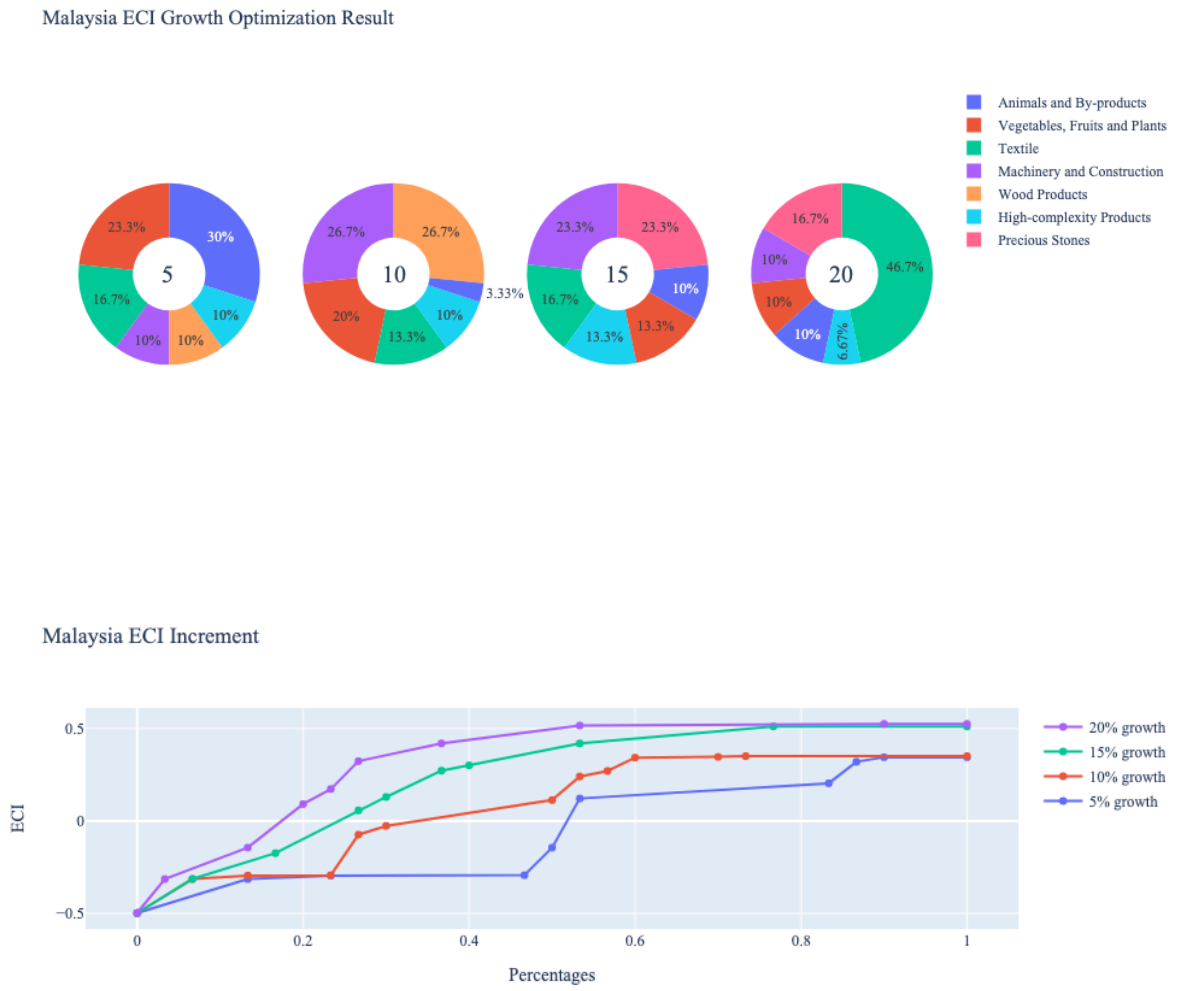



Figure 4. Greedy-Based ECI Improvement Results of Malaysia with Different Budgets (2022)

| **Malaysia (2022)** | | | | |
|---|---|---|---|---|
| **Original ECI** | | -0.498173 | | |
| **Heuristic Export Growth** | **5%** | **10%** | **15%** | **20%** |
| Animals and By-products | 1.28E10 | 2.00E+09 | 6.01E+09 | 8.52E+09 |
| Vegetables, Fruits and Plants | 9.94E+09 | 1.20E+10 | 8.02E+09 | 8.52E+09 |
| Wood Products | 4.26E+09 | 1.60E+10 | 0.00E+00 | 0.00E+00 |
| Textile | 7.10E+09 | 8.01E+09 | 1.00E+10 | 3.97E+10 |
| Machinery and Construction | 4.26E+09 | 1.60E+10 | 1.40E+10 | 8.52E+09 |
| **Increased ECI** | **0.345** | **0.351** | **0.512** | **0.525** |

Table 8. Portfolio of Malaysia (2022)

### 4.3 Sensitivity Analysis and Contingency Strategy

In the following section, our broad aim is to understand how sensitive Malaysia is to changes in export in various industries. While the Economic Complexity Index has been shown to contain valuable information about the economic strength/capacity of a country, little has been said as to the stability of the measure itself. We seek to uncover the main drivers of stability under a country's ECI score and better understand longer-term projections for ECI growth. Additionally, gaining an intuition on the industries that are bolstering an economy and the industries that offer the greatest return per unit of investment is best done through visualization of industry-specific sensitivity. To this end, we have developed two categories of sensitivity analysis.

**ECI Sensitivity Graph**

First, in order to assess the effect particular industries have on each respective country, we developed ECI Sensitivity graphs (Figure 5). We use the shocking methodology to increment or decrement an industry's export level by a certain percentage and recalculate the ECI, all else being equal. While freezing the export dynamics of the rest of the world and enacting an instantaneous shock in export for a particular industry and country may not reflect real-life dynamics, what it does offer us is an understanding of a country's level of dependency on an industry in the context of ECI. The shocking is done in small percentage increments in order to smooth out the resulting curve. Additionally, a recurring theme one will see is that for most industries, a breaking point occurs where the ECI either jumps upwards or downwards, creating a hockey stick shape rather than a linear trend. While the inflection point may not be accurate in the context of real life, comparing the various inflection points across industries can give us valuable insight.

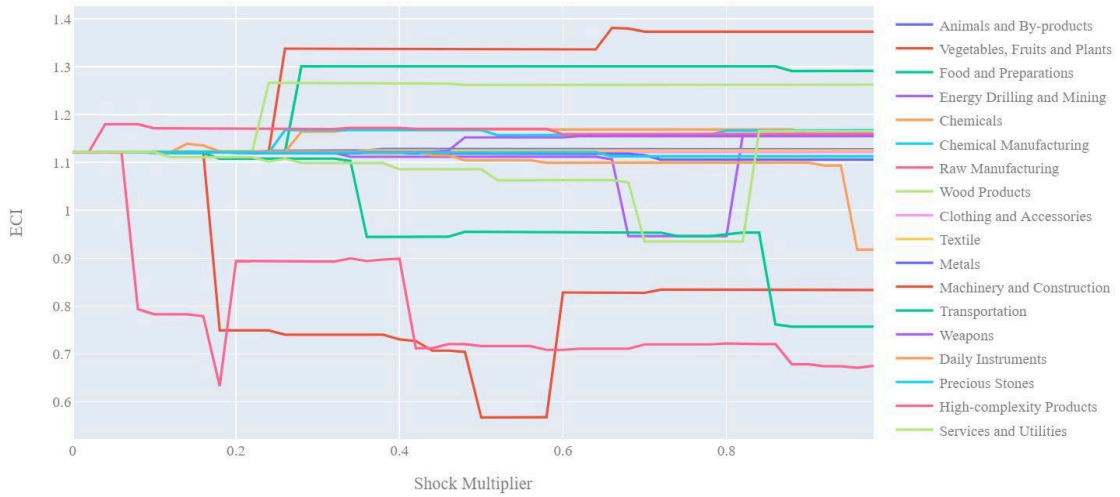



Figure 5. Sample ECI Sensitivity Graph (2018)

The graphs are formulated as follows. The first chart, Incremental ECI Sensitivity, shows positive shocking in which export numbers are shocked upwards per industry. The X-axis is

in terms of percentage shock per current dollar value of export. The Y-axis is the recalculated ECI level post-shocking. The second chart, Decremental ECI Sensitivity, follows the same format except the X-axis represents negative shock. In other words, exports for each industry are decremented, and the ECI is accordingly recomputed.

**SDV Sensitivity**

Secondly, we analyze the sensitivity of the SDV to changes in export levels. The goal is to understand how export level changes for a particular industry can affect the marginal opportunity gain for other industries. We will be using specifically High Complexity Products and Food and Preparations as our base industries. We will be increasing or decreasing the absolute export level in both of these industries and observing the effects on the SDV.
When the opportunity gain of an industry is negative, the SDV sensitivity approximates how an over-development of the industry jeopardizes the economic structure of a country. When the opportunity gain of the industry is zero, the SDV sensitivity determines whether the further development of the industry shapes the country with a better economic structure and predicts how the SDV would change accordingly. Specifically, as we reduce the export of such an industry to 25%-50% of its original value, a few other industries originally with negative opportunity gain could likely become profitable.
Similar to the ECI sensitivity graphs above, we will be shocking export of High Complexity Products and Food and Preparations in small percentage increments. A new SDV, represented by a new column in the charts, is recorded only when a certain level of shock changes the structure of the SDV. In effect we are incrementing or decrementing export levels of two industries until the marginal opportunity gain of any industry changes in category (positive, negative, or neutral). Below is an example of a SDV Sensitivity chart with Positive Shocking. Industries with positive marginal opportunity gain are colored blue, neutral is colored white and negative is colored red.

| | 0.0% | 10.0% | 30.0% | 50.0% | 80.0% | 100.0% | 120.0% |
|---|---|---|---|---|---|---|---|
| 0 | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Chemicals | Chemicals | Chemicals | Machinery and Construction |
| 1 | Daily Instruments | Daily Instruments | Daily Instruments | Services and Utilities | Services and Utilities | Daily Instruments | Chemicals |
| 2 | Weapons | Weapons | Weapons | Textile | Textile | Textile | Daily Instruments |
| 3 | Transportation | Transportation | Transportation | Weapons | Daily Instruments | Services and Utilities | Services and Utilities |
| 4 | Machinery and Construction | Machinery and Construction | Machinery and Construction | Transportation | High-complexity Products | Transportation | Transportation |
| 5 | Metals | Metals | High-complexity Products | Machinery and Construction | Transportation | Chemical Manufacturing | Textile |
| 6 | High-complexity Products | High-complexity Products | Chemicals | High-complexity Products | Machinery and Construction | Weapons | Chemical Manufacturing |
| 7 | Chemicals | Services and Utilities | Services and Utilities | Daily Instruments | Chemical Manufacturing | High-complexity Products | Weapons |
| 8 | Services and Utilities | Chemicals | Textile | Chemical Manufacturing | Weapons | Machinery and Construction | High-complexity Products |
| 9 | Textile | Textile | Chemical Manufacturing | Precious Stones | Clothing and Accessories | Clothing and Accessories | Clothing and Accessories |
| 10 | Chemical Manufacturing | Chemical Manufacturing | Precious Stones | Clothing and Accessories | Precious Stones | Precious Stones | Raw Manufacturing |
| 11 | Precious Stones | Precious Stones | Clothing and Accessories | Vegetables, Fruits and Plants | Raw Manufacturing | Raw Manufacturing | Precious Stones |
| 12 | Clothing and Accessories | Clothing and Accessories | Raw Manufacturing | Raw Manufacturing | Wood Products | Metals | Wood Products |
| 13 | Raw Manufacturing | Raw Manufacturing | Metals | Metals | Metals | Wood Products | Metals |
| 14 | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Wood Products | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining |
| 15 | Wood Products | Wood Products | Wood Products | Energy Drilling and Mining | Animals and By-products | Animals and By-products | Animals and By-products |
| 16 | Animals and By-products | Animals and By-products | Animals and By-products | Animals and By-products | Vegetables, Fruits and Plants | Food and Preparations | Food and Preparations |
| 17 | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants |
| ECI | 2.261503667 | 2.520234671 | 3.08896214 | 3.452901685 | 4.299466299 | 4.439916975 | 5.069638102 |

Table 9. Sample Incremental SDV Sensitivity for High-Complexity Products (2018)

**Contingency Plan**

The Contingency Plan aims to present a set of solutions with respect to upheavals in different industries. Instead of compensating for the declining production directly, the best strategy is to develop those incipiently profitable industries. In this manner, we can derive a contingency

strategy for countries to deal with possible abrupt declines of crucial industries. In some cases, the SDV remains unchanged even when a zero-opportunity-gain industry declines to 20% in terms of export. We can then conclude the industry is not indispensable to the country. As a clarification, the three consecutive N/As mean that the country doesn't even need to respond to a collapse in the industry. Countries tend to have distinct solutions to the ups and downs of the same industry. To create the contingency strategy table, we decrease the export level for each industry in the country's current production space by 60% respectively. The three highest-ranking industries in the new SDV are then returned.

| Product Names | 0 | 1 | 2 |
|---|---|---|---|
| Animal and By-products | Services and Utilities | Daily Instruments | Weapons |
| Vegetables, Fruits and Plants | Services and Utilities | Daily Instruments | Weapons |
| Food and Preparations | Services and Utilities | Daily Instruments | Weapons |
| Energy Drilling and Mining | Services and Utilities | Daily Instruments | Weapons |
| Chemicals | Services and Utilities | Daily Instruments | Weapons |
| Chemical Manufacturing | Services and Utilities | Daily Instruments | Weapons |
| Raw Manufacturing | Services and Utilities | Daily Instruments | Weapons |
| Wood Products | Services and Utilities | Daily Instruments | Weapons |
| Clothing and Accessories | Services and Utilities | Daily Instruments | Weapons |
| Textile | Services and Utilities | Daily Instruments | Weapons |
| Metals | Services and Utilities | Daily Instruments | Weapons |
| Machinery and Constructions | Services and Utilities | Daily Instruments | Weapons |
| Transportation | Services and Utilities | Raw Manufacturing | Daily Instruments |
| Weapons | Services and Utilities | Daily Instruments | Transportation |
| Daily Instruments | Services and Utilities | Weapons | Transportation |
| Precious Stones | Services and Utilities | Daily Instruments | Weapons |
| Daily Instruments | Services and Utilities | Daily Instruments | Weapons |
| Services and Utilities | Daily Instruments | Weapons | Transportation |

Table 10. Sample Contingency Strategy (2018)

### 4.3 Sensitivity Analysis Results and Interpretation

We examine Malaysia's ECI Decremental and Incremental Sensitivity Charts for 2022. An increase in Vegetables, Fruits, and Plants will lead to the highest change in ECI, followed by Food and Preparataions. For the negative shock cases, Energy, Drilling and Mining becomes most impactful, a new trend from previous years, followed by Food and Preparation. The rest of the industries do not appear to have the same level of sensitivity.


Figure 6a. Incremental ECI Sensitivity for Malaysia (2022)

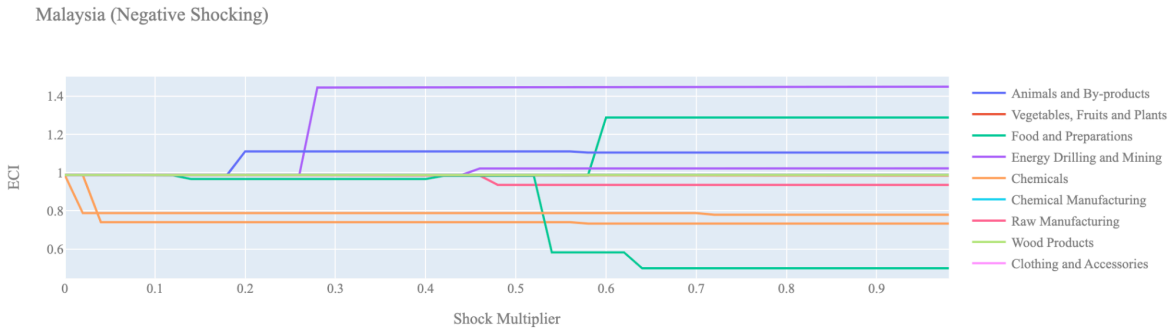



Figure 6b. Decremental ECI Sensitivity for Malaysia (2022)

### 4.4 Contingency Strategy

Decreasing export of each industry in Malaysia's current production space by 60% respectively, we derive the contingency strategy shown below.

| | 0 | 1 | 2 |
|---|---|---|---|
| **Animals and By-products** | Machinery and Construction | High-complexity Products | Transportation |
| **Vegetables, Fruits and Plants** | Vegetables, Fruits and Plants | High-complexity Products | Machinery and Construction |
| **Food and Preparations** | Machinery and Construction | High-complexity Products | Transportation |
| **Energy Drilling and Mining** | High-complexity Products | Machinery and Construction | Transportation |
| **Chemicals** | High-complexity Products | Machinery and Construction | Transportation |
| **Chemical Manufacturing** | High-complexity Products | Machinery and Construction | Transportation |
| **Raw Manufacturing** | Machinery and Construction | High-complexity Products | Transportation |
| **Wood Products** | Machinery and Construction | High-complexity Products | Transportation |
| **Clothing and Accessories** | Transportation | High-complexity Products | Machinery and Construction |
| **Textile** | High-complexity Products | Transportation | Machinery and Construction |
| **Metals** | High-complexity Products | Machinery and Construction | Transportation |
| **Machinery and Construction** | High-complexity Products | Machinery and Construction | Transportation |
| **Transportation** | High-complexity Products | Machinery and Construction | Transportation |
| **Weapons** | High-complexity Products | Machinery and Construction | Transportation |
| **Daily Instruments** | High-complexity Products | Machinery and Construction | Transportation |
| **Precious Stones** | High-complexity Products | Machinery and Construction | Transportation |
| **High-complexity Products** | High-complexity Products | Machinery and Construction | Transportation |
| **Services and Utilities** | High-complexity Products | Machinery and Construction | Transportation |

Table 13. Malaysia's Contingency Strategy (2018)

# 5. Macro-level Predictions

## 5.1 Structural Optimality Index

ECI sensitivity described in the section before has proven to be a significant factor in deciding the economic outcomes of countries. In order to quantitatively evaluate how effective our development strategies are and how deviations from the suggested developmental path will lead to suboptimal growth results, we define the measure – Structural Optimality Index (SOI) – on a country level as the Adjusted R-Square obtained from regressing the country's realized industry development over the suggested development strategy. Both strategies are quantified in nature, with the realized development represented by increasing export in every major industry group and the suggested development strategy represented by the opportunity gains of developing the corresponding industry groups as calculated in previous sections. The adjusted R-square from the regression thus provides us with a quantified measure of how the development path adopted by the country has fitted with/differed from calculations on a complexity level.

After obtaining this measure for all countries in our database, we further regress countries' five-year economic growth, which is defined as the percent increase in GDP (USD), over their SOI. Figure 9 illustrates the regression output, which shows a strong positive correlation between countries' SOI and their five-year GDP growth, significant at the 1% level and achieving an adjusted $R^2$ of 4.5%. In other words, the more a country develops, as suggested by calculations on a complexity level, the better economic outcomes it achieves.

| **Table 14: OLS Regression Results** | |
|---|---|
| **Dep. Variable:** GDP | **F-Statistic:** 5.963 |
| **$R^2$:** 0.054 | **Prob (F-Stat):** 0.0163 |
| **Adj $R^2$:** 0.045 | **No. Observations:** 106 |

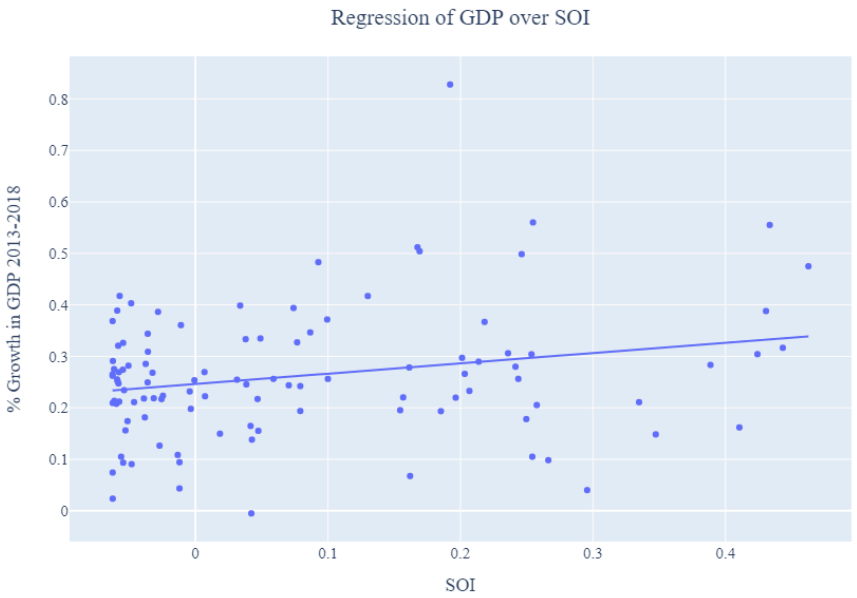



Figure 9. Regression of Five-Year GDP Growth over SOI (2013-2018)

### 5.2 SOI of Malaysia and Its Implications

During the first examined period, Malaysia, for instance, has a moderate level of structural optimality as compared with its developed peers. As the regression in Figure 10a suggests (the red curve represents export increase and the blue curve stands for opportunity gain of the corresponding industry), Malaysia demonstrates a moderate level of correlation with the suggested developmental path, having an adjusted R-square of around 0.108.

Malaysia ranks the 42nd place among all countries in terms of SOI and has an annual growth rate of 10.8% from 2009 to 2014, which is consistent with the regression result in Figure 6. This is in direct contrast to developed economies such as UK, where there is low SOI of around 6.5% and a corresponding annual growth rate around 2%, ranking it a slow-developing economy during the period. In sum, Malaysia's amazing economic progress from 2009 to 2014 can be at least partially explained by a nearly optimal development strategy that demonstrates a considerable level of matches with our suggested developmental path.

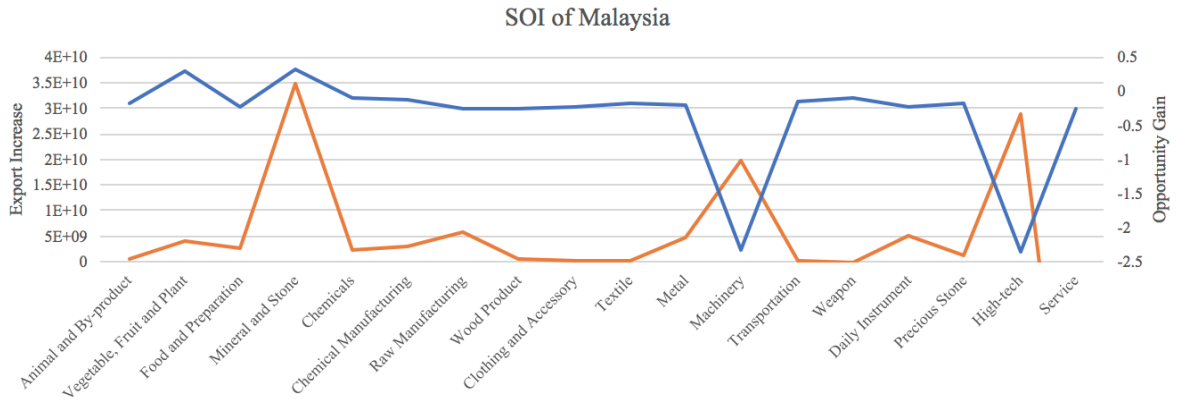



Figure 10a. SOI of Malaysia (2009-2014)

For the 2019-2022 years, Malaysia has a strong presence in the Services and Utilities industries, which presents a good opportunity for further investment. It also could consider Machinery and Construction to improve its growth. Malaysia has seen a high growth in GDP over those three years of 6.51% anually, though lower than that of the previous period.

Higher than before, its adjusted R-squared value of 0.170 indicates a high correlation between the GDP growth and the implemented development path. Progress is slow on a global scale during this period, but Malaysia demonstrates a comparable ability to adjust to negative economic shocks by improving SOI and increasing GDP growth than it did between 2009 and 2014.

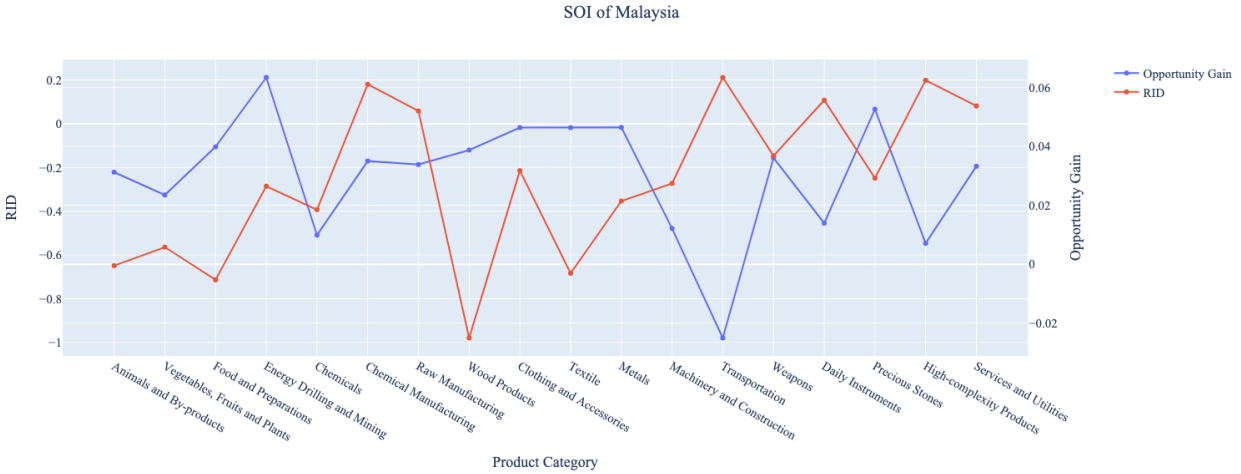



Figure 10b. SOI of Malaysia (2019-2022)

## 6. Concluding Remarks

In conclusion, Malaysia has demonstrated a high level of economic growth in terms of annual GDP increase during the period from 2009 to 2014, concurrent with an increase in economic complexity as compared with major emerging economies. For 2019-2022, the growth in GDP has decreased alongside a decrease boost in ECI, in line with many peer economies across the world.

We believe that the progress during the first period can be partially explained through the analysis of the economic and product complexity structure of Malaysia on the industry group level. The product classification system we adopt allows us to measure the realized industry development for various industry groups and to observe that Malaysia progressed in developing many industries, more than other emerging economies.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups for 2009-2014, Malaysia could have stayed optimal with its current industry structure and there is no immediate need of reform because no industry has a positive opportunity gain at its current stage. We further note that Malaysia has a slightly mismatched development strategy that indicates a moderate level of fitness with the strategy calculated on a complexity level, having an adjusted R-square of around 10.8%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Malaysia indeed adopted a promising but not perfect development plan as compared with other emerging economies both on a regional scale and on a global scale, and has the potential to further its economic gains through industrial structure balancing as suggested in the paper.

During the second examined period from 2019 to 2022, Malaysia performed weaker than before and compared to other countries, particularly China. We infer that during the COVID-19 period, Malaysia focused on developing lower complexity industries, in line with lower demand for these industries given the global economic downturn. We also note that Malaysia has increased its investment in the sectors identified earlier while leaving some room for strategic improvement. The ECI suggests that greater growth could have been achieved through Machinery and Construction, and Food and Preparation industries. The surprising growth also increased the adjusted R-squared value to 0.108 in 2022 from 0.108 in 2014, demonstrating the pursued strategies contributed to the GDP. With the revised focus, Malaysia has further potential to advance its economic growth to maintain its position among other countries to continue its ongoing economic expansion.

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