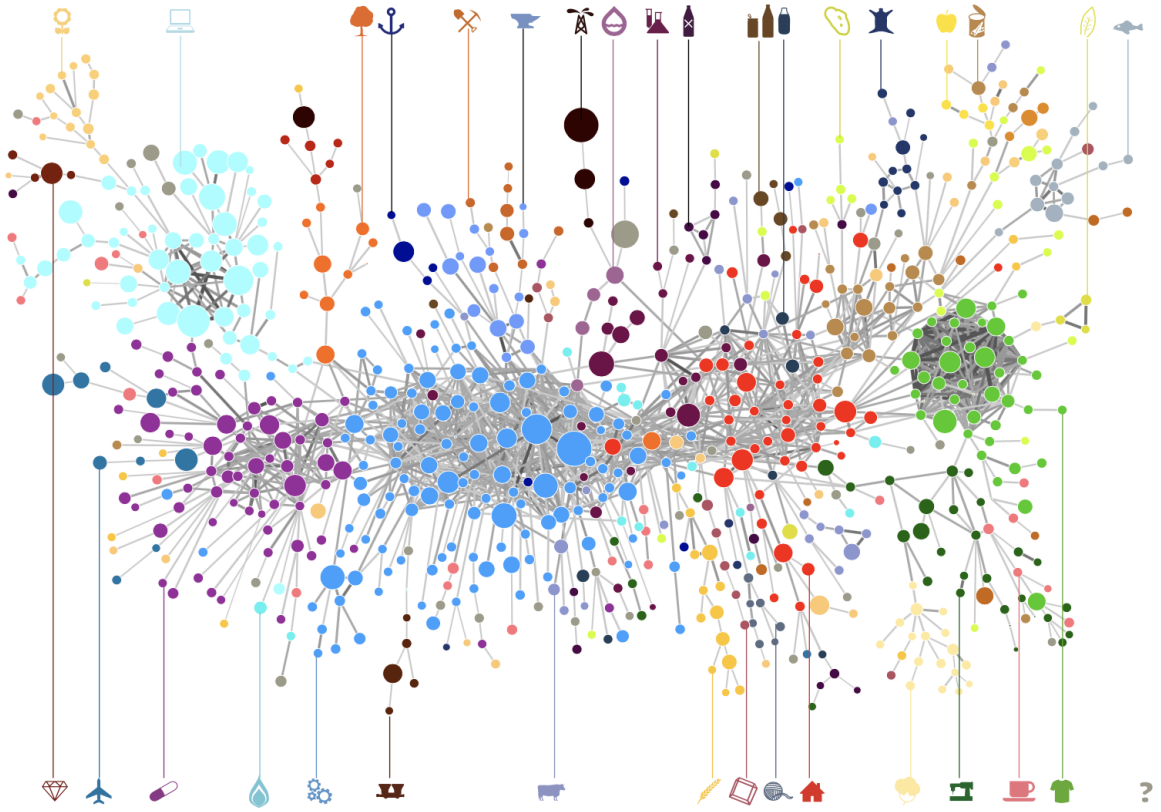

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Optimal Industry Development Strategy Using Economic and Product Complexity

United Arab Emirates

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Optimal Industry Development Strategy for UAE

0. Executive Summary

In this report, we aim to uncover the economic path UAE went through during the period from 2013 to 2018. Specifically, we dive into the topic through a macroeconomic overview of UAE 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, UAE demonstrated a promising level of economic growth with an annual GDP growth rate of 2.0%, but this is concurrent with a slight decrease in economic complexity as compared with other major economies in the region.

The level of economic progress made during the period, we believe, can be largely explained through analysis of the economic and product complexity structure of UAE 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 UAE invested heavily in developing Services and Utilities, Vegetables and Food industries during the period, while its regional peers and emerging economies around the globe have adopted much more complex and progressive paths.

Based on our analysis of the opportunity gain and a sensitivity analysis of major industry groups, UAE can further its gains by focusing on Chemicals and Wood Products industries. We further note that UAE has a mismatched development strategy that indicates a particularly low level of structural optimality, having an adjusted R-square of merely -5.9%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, the growth we see in UAE during the period may not be sustainable as compared with fast-growing economies both on a regional scale and on a global scale, and UAE has the potential to further its economic gains through industrial structure optimization as suggested in the paper.

1. Report Overview

In this report, we aim to uncover the economic path UAE went through during the period from 2013 to 2018. Specifically, we dive into the topic through a macroeconomic overview of UAE 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 UAE during the period based on quantitative measures such as 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 UAE, 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

As the 29th largest economy in the world by GDP in 2018, UAE has a GDP of 390 billion USD in 2013 and 414 billion USD in 2018, exhibiting a promising level of economic output. Figure 1 illustrates the time-series GDP results for major emerging economies from 1999-2018, and UAE ranks among its peers as a small but growing economy in terms of both GDP and GDP growth. From 2013 to 2018, UAE achieved an annual growth of 2% in GDP. This number is slightly below the annual growth rate of the other five leading emerging economies, which have a geometric average growth rates of 2.4% and an arithmetic average growth rate of 2.3%. Compared with more developed economies on a global scale, the annual growth rate of 2% is also slightly lower since countries such as the United States have an annual GDP increase of around 4% during the same period. The mild economic growth, we believe, can be reflected through changes in ECI and PCI, and can be further explained by a set of production strategies adopted by UAE from 2013 to 2018, which we will expand at the later stage of the report.

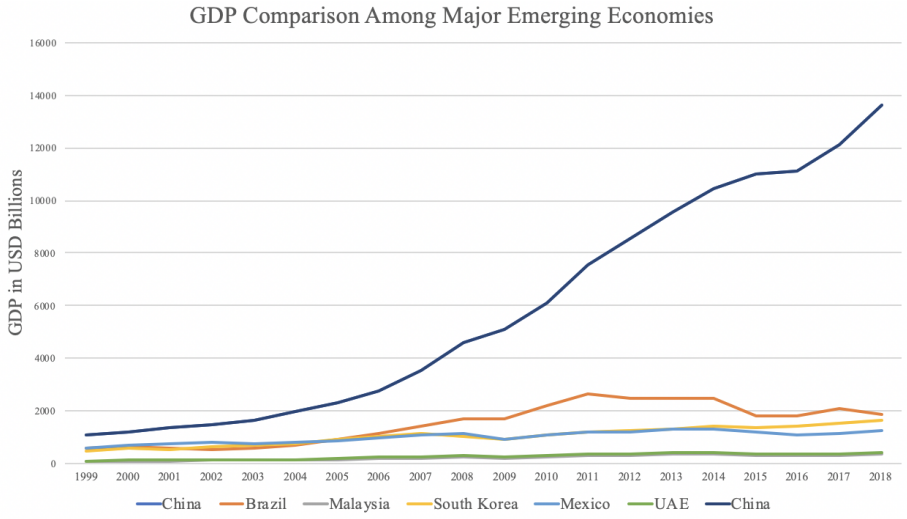


Figure 1: GDP Comparison Among Major Emerging Economies

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, exhibits a different pattern for UAE. As illustrated in Figure 2 below, UAE exhibits an increase in terms of its production capability from 2016 to 2018, as measured by ECI. This is in direct contrast to countries such as South Korea and China, which demonstrate an advantage in both ECI growth rate and GDP growth rate.

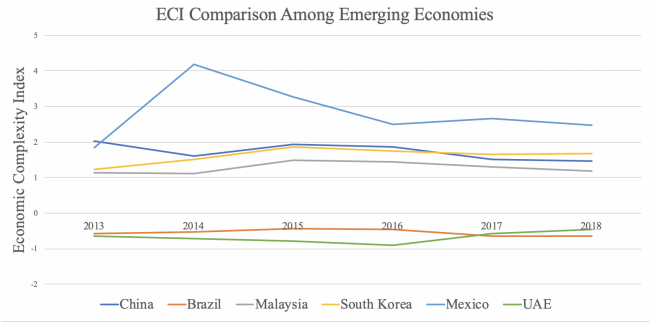


Figure 2: ECI Comparison

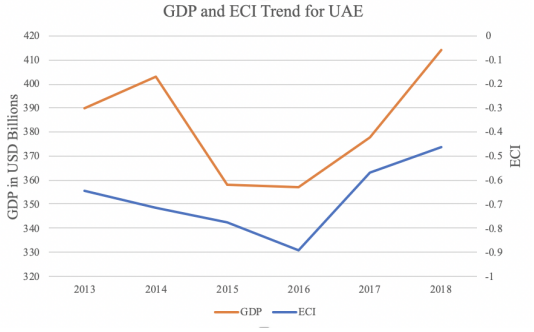


Figure 3: GDP and ECI (UAE)

Figure 3 offers a further comparison of GDP and ECI over the time span from 2013 to 2018 for UAE. Based on statistical analysis, ECI is a significant covariate for GDP with an adjusted R-square of 29.0%. During the period from 2013 to 2018, indeed, the ups and downs in GDP are consistent to the changes in ECI, indicting the potential that the mild economic growth experienced by UAE during the period from 2013 to 2018 might be sustainable if ECI could keep increasing, and UAE is effective in developing a competitive product space that helps to accumulate complicated knowledge and technology. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of UAE's production structure and its product space designs in the next few chapters.

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 labelled from 010000-999999, with the first two-digits representing a general category to which the product belongs. Based on the 99 categories as extracted from the label, we further group the products into 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 technical 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. The Figure 3 and 4 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

Figure 3: 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

Figure 4: OLS Regression Results of GDP against Volume of Percentage Exports

3.2 Realized Industry Development

Based on the product categorization aforementioned, we aim to capture UAE's realized industry production strategy between 2013 and 2018 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 in 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 RID of UAE and the 18 product groups in 2013 and 2018 through subtraction, where a positive RID indicates a shortening of the distance (i.e., advancement of the industry), and a negative RID indicates the reverse. As ranked in Table 2, during the period from 2013 to 2018, UAE has focused on products with a moderate level of complexity and those requiring intermediate skills.

Rank	Category	RID	Rank	Category	RID
1	Services and Utilities	-0.125	10	Energy Drilling and Mining	-0.016
2	Vegetables, Fruits and Plants	-0.036	11	Raw Manufacturing	-0.014
3	Food and Preparations	-0.029	12	Clothing and Accessories	-0.011
4	Precious Stones	-0.025	13	Weapons	-0.010
5	Metals	-0.025	14	Chemical Manufacturing	-0.008
6	Textile	-0.024	15	Daily Instruments	-0.005
7	Chemicals	-0.023	16	Machinery and Construction	0.005
8	Wood Products	-0.017	17	High-complexity Products	0.005
9	Animals and By-products	-0.016	18	Transportation	0.007

Table 2: Realized Industry Development (RID) of UAE

3.3 Regional and Global Comparison

Table 3 and 4 below summarize how the production strategy adopted by UAE compares with leading economies and a selected group of emerging economies in the world, as measured in RID. It can be directly observed that UAE focused on products with a lower complexity level, when compared against leading economies such as the United States and Germany, which gave a considerable level of attention to more advanced product groups such as clothing, services and utilities, and chemical manufacturing.

Ranking	France	The United States	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 3: RID Comparison across Leading Economies

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 4: RID Comparison across Emerging Economies

Table 4 further examines UAE's development strategy against those of emerging economies on a global scale. Reasonably, emerging economies such as China, South Korea, Singapore and India have devoted the majority of their efforts into intermediate industry groups while developed economies such as UAE should have relied more on advanced industry groups. This trend holds true in general, regardless of the continent or the time period, and serves as an indicator for which phase of development a country is currently in as evaluated from its production strategy. Based on this standard, UAE is indeed adopting a moderate but slightly out-of-phase strategy that seeks development in industry groups with a lower level of complexity than it should.

4. Product Space Design

4.1 Suggested Development Vector

As aforementioned, 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 in the product as compared to 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. And unreasonable investment on certain product p would lead to a relative decrement in 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 economics strength, those having higher ECI, or in other words, more reasonable economics structures are often in better shape.

Ranking	China	Indonesia	United Arab Emirates
1	Raw Manufacturing	Precious Stones	High-complexity Products
2	Clothing and Accessories	Machinery and Construction	Transportation
3	Textile	Food and Preparations	Machinery and Construction
4	Machinery and Construction	High-complexity Products	Daily Instruments
5	Transportation	Services and Utilities	Chemicals
6	Weapons	Metals	Weapons
7	Daily Instruments	Daily Instruments	Textile
8	High-complexity Products	Transportation	Chemical Manufacturing
9	Precious Stones	Chemicals	Raw Manufacturing
10	Services and Utilities	Chemical Manufacturing	Energy Drilling and Mining
11	Chemicals	Animals and By-products	Precious Stones
12	Energy Drilling and Mining	Vegetables, Fruits and Plants	Services and Utilities
13	Chemical Manufacturing	Energy Drilling and Mining	Metals
14	Wood Products	Raw Manufacturing	Clothing and Accessories
15	Animals and By-products	Wood Products	Wood Products
16	Vegetables, Fruits and Plants	Clothing and Accessories	Animals and By-products
17	Metals	Textile	Vegetables, Fruits and Plants
18	Food and Preparations	Weapons	Food and Preparations
ECI	1.96086598	-0.298641635	-0.734459148

Ranking	China	Indonesia	United Arab Emirates
1	Chemicals	Precious Stones	High-complexity Products
2	Raw Manufacturing	High-complexity Products	Transportation
3	Clothing and Accessories	Machinery and Construction	Machinery and Construction
4	Textile	Chemicals	Daily Instruments
5	Machinery and Construction	Chemical Manufacturing	Chemicals
6	Transportation	Transportation	Weapons
7	Weapons	Services and Utilities	Textile
8	Daily Instruments	Daily Instruments	Chemical Manufacturing
9	High-complexity Products	Animals and By-products	Raw Manufacturing
10	Precious Stones	Vegetables, Fruits and Plants	Energy Drilling and Mining
11	Services and Utilities	Food and Preparations	Precious Stones
12	Energy Drilling and Mining	Energy Drilling and Mining	Services and Utilities
13	Wood Products	Raw Manufacturing	Clothing and Accessories
14	Animals and By-products	Wood Products	Metals
15	Metals	Clothing and Accessories	Wood Products
16	Chemical Manufacturing	Textile	Animals and By-products
17	Vegetables, Fruits and Plants	Metals	Food and Preparations
18	Food and Preparations	Weapons	Vegetables, Fruits and Plants
ECI	1.700687855	-0.4615811	-0.490703037

Table 5: Opportunity Gain Ranking on a Comparable Scale for 2013(up) and 2018(down)

We define the ranking of opportunity gain for a country c, as the Suggested Development Vector (SDV) of c. Table 5 and 6 summarize how the SDV of UAE 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 gain, 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 industrial manufacturing and High-complexity Products industries. It can be concluded that UAE shares the characteristics of developing countries, with a premature economics structure that leans towards intermediate-level industries.

Ranking	Machinery and Construction	Singapore	Japan	Germany
1	Vegetables, Fruits and Plants	Chemicals	Chemicals	Chemical Manufacturing
2	Machinery and Construction	Transportation	Metals	Wood Products
3	Transportation	High-complexity Products	Machinery and Construction	Metals
4	High-complexity Products	Services and Utilities	Transportation	Machinery and Construction
5	Services and Utilities	Machinery and Construction	Weapons	Transportation
6	Chemicals	Daily Instruments	Daily Instruments	Weapons
7	Textile	Weapons	High-complexity Products	High-complexity Products
8	Weapons	Textile	Services and Utilities	Services and Utilities
9	Daily Instruments	Chemical Manufacturing	Precious Stones	Energy Drilling and Mining
10	Chemical Manufacturing	Raw Manufacturing	Energy Drilling and Mining	Precious Stones
11	Clothing and Accessories	Clothing and Accessories	Textile	Textile
12	Raw Manufacturing	Metals	Clothing and Accessories	Clothing and Accessories
13	Food and Preparations	Wood Products	Chemical Manufacturing	Chemicals
14	Animals and By-products	Precious Stones	Animals and By-products	Animals and By-products
15	Metals	Animals and By-products	Wood Products	Vegetables, Fruits and Plants
16	Wood Products	Food and Preparations	Vegetables, Fruits and Plants	Food and Preparations
17	Precious Stones	Energy Drilling and Mining	Food and Preparations	Daily Instruments
18	Energy Drilling and Mining	Vegetables, Fruits and Plants	Raw Manufacturing	Raw Manufacturing
ECI	2.753793255	2.751108815	2.154947	1.937171566

Table 6: Opportunity Gain Ranking on a Global Scale

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 that a country can improve to. 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 on this problem. In order to solve this problem, our idea is to use greedy algorithm. The way that we apply 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 rest equal parts can be done in the same way.

However, as is known to all, greedy algorithm is a kind of local search algorithm, which is pretty possible to run into a local minimum. Therefore, for local search algorithms, one typical way is 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 $||x_p - x_0||_1$.

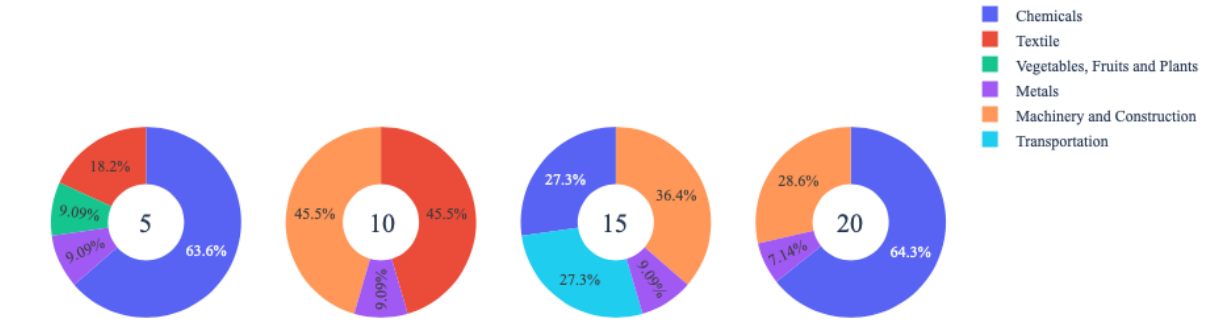
In this way, we can obtain a further sighted greedy algorithm. Also, the number of parts that we would like to separate the budget into also matters. In order to solve this problem, we added a stabilizer on top of the enhanced greedy algorithm, by running the algorithm for different number of parts and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

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

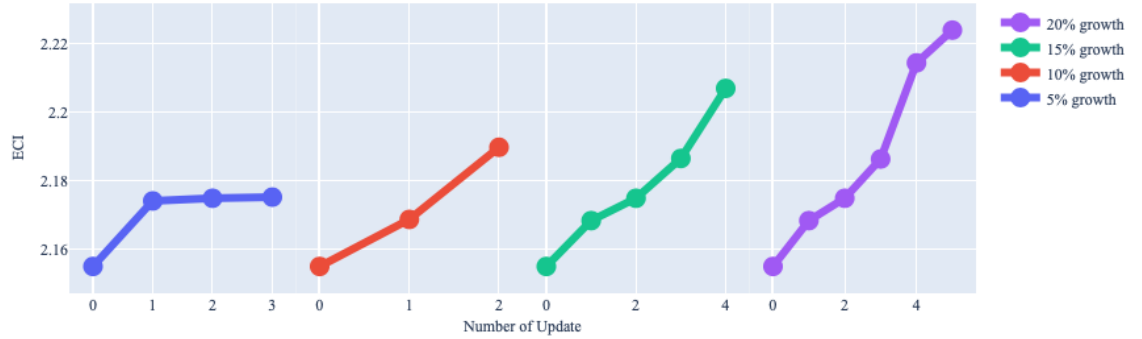
Economic Panel:

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. Firstly, 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. For example, for the first pie chart below, it shows we should allocate 25% for food and preparations, animals and by-products, and chemicals. In addition, we should allocate 12.5% for raw manufacturing and chemical manufacturing. The lines below the pie charts show how the ECI changes during the searching process of the greedy algorithm. For example, in the last pie chart, we can see there are three components, but there are four increments in the last line chart. That is just because many equalized amounts have been invested in high-complexity products. Even though sometimes people may feel 15% and 20% is nonsense 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.

Japan ECI Growth Optimization Result



Japan ECI Increment

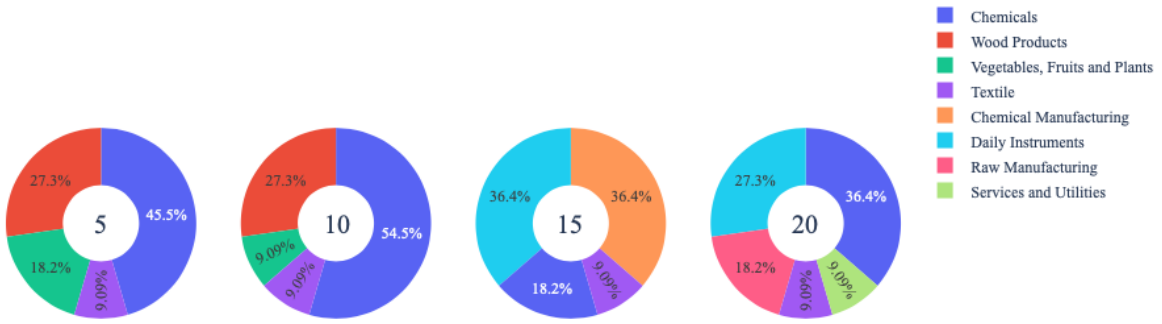


Japan (2013)				
Total Export in 2013 (US. $)	1.17E+12			
Original ECI	2.155			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	5.86E+10	1.17E+11	1.76E+11	2.35E+11
Metals(US. $)	5.33E+09	1.07E+10	1.60E+10	1.68E+10
Transportation(US. $)	0.00E+00	0.00E+00	4.80E+10	0.00E+00
Chemicals(US. $)	3.73E+10	0.00E+00	4.80E+10	1.51E+11
Machinery and Construction(US. $)	0.00E+00	5.33E+10	6.40E+10	6.70E+10
Textile(US. $)	1.07E+10	5.33E+10	0.00E+00	0.00E+00
Vegetables, Fruits and Plants(US. $)	5.33E+09	0.00E+00	0.00E+00	0.00E+00
Increased ECI	2.175	2.190	2.207	2.224

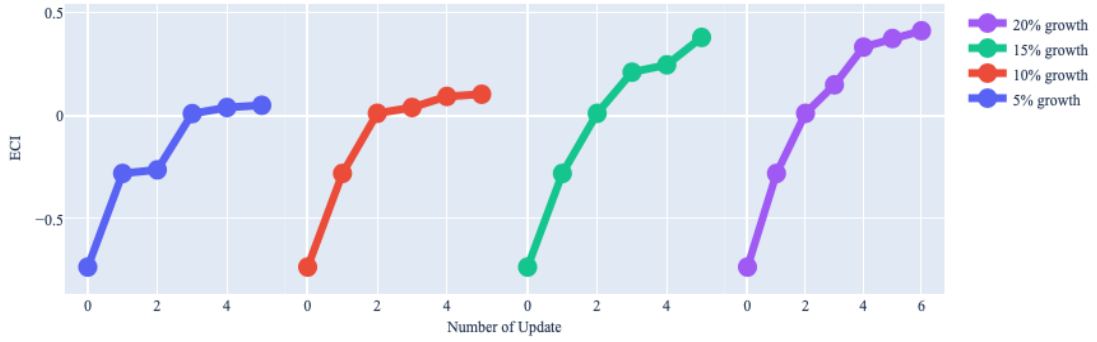
Interpretation:

Below is the economic panel for the United Arab Emirates in 2013. We can see that for different percentages of heuristic total export growth, the ECI of the United Arab Emirates has different performance. From all the four line graphs, we see that United Arab Emirates already obtains some great increment in terms of ECI. Most importantly, the higher the budget is, the greater the ECI will be. This means that in both short term and long term, the United Arab Emirates still has great room to improve. For the 5 and 10 percent growth, their patterns are similar. The increment of ECI attributes to the textile, chemicals, and vegetables. All of these are pretty fundamental products. Afterwards, for the 15 and 20 percent growth, the growth pattern becomes stronger for South Africa, mainly because of the introduction of daily instruments as well as services and utilities.

United Arab Emirates ECI Growth Optimization Result



United Arab Emirates ECI Increment

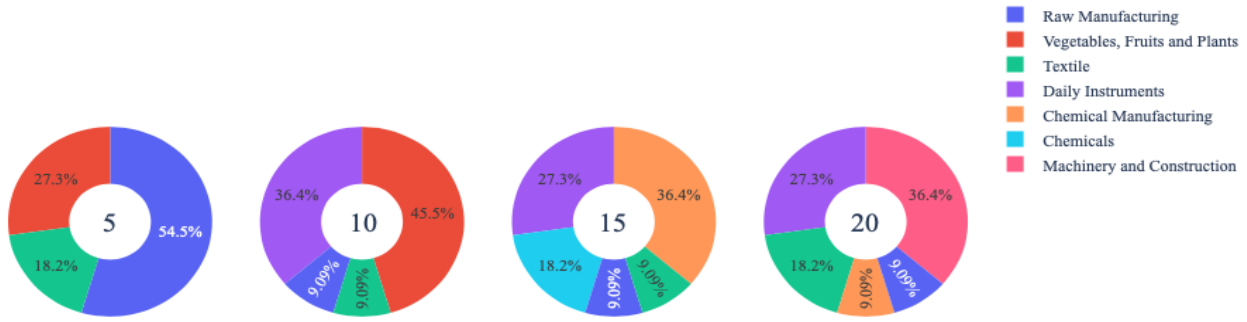


UAE (2013)				
Total Export in 2013 (US. $)	3.98E+11			
Original ECI	-0.734			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	1.99E+10	3.98E+10	5.97E+10	7.97E+10
Chemical Manufacturing(US. $)	0.00E+00	0.00E+00	2.17E+10	0.00E+00
Chemicals(US. $)	9.05E+09	2.17E+10	1.09E+10	2.90E+10
Daily Instruments(US. $)	0.00E+00	0.00E+00	2.17E+10	2.17E+10
Raw Manufacturing(US. $)	0.00E+00	0.00E+00	0.00E+00	1.45E+10
Textile(US. $)	1.81E+09	3.62E+09	5.43E+09	7.24E+09
Services and Utilities (US. $)	0.00E+00	0.00E+00	0.00E+00	7.24E+09
Wood Products(US. $)	5.43E+09	1.09E+10	0.00E+00	0.00E+00
Vegetables, Fruits and Plants(US. $)	3.62E+09	3.62E+09	0.00E+00	0.00E+00
Increased ECI	0.050	0.103	0.379	0.411

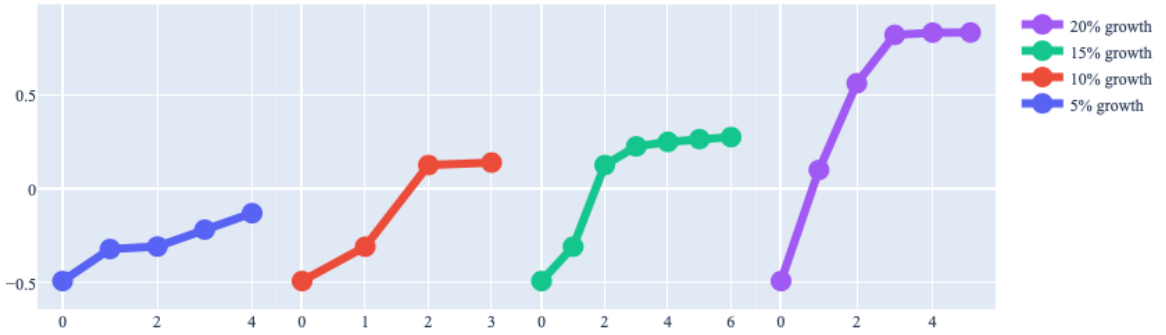
For further suggestions on the United Arab Emirates' development in the future. We also offer the optimization result based on export data in 2018. Below is the economic panel for the United Arab Emirates in 2018. We can see that for different percentages of heuristic total export growth, the ECI growth pattern of the United Arab Emirates is similar to the one in 2013. From all the four line graphs, we see that United Arab Emirates already obtains some great increment in terms of ECI. Most importantly, the higher the budget is, the greater the ECI will be. This means that in both short term and long term, the United Arab Emirates still has great room to improve. For the case of 5 percent export growth budget, the ECI does not increase so much. Most of the increment is attributed to textile and raw manufacturing. For the case of 10 percent, increase of daily instrument construction boosts the ECI. For the case of 15 and 20 percent, the result shows that adding machinery and chemical manufacturing as a growth component can bring lots of gains in ECI. Therefore, for future strategy, the United

Arab Emirates should prioritize development of daily instruments, which causes the greatest jump in the last three line graphs. And then machinery and transportation and chemical manufacturing. in order to optimize ECI.

United Arab Emirates ECI Growth Optimization Result



United Arab Emirates ECI Increment



UAE (2018)				
Total Export in 2018 (US. $)	4.54E+11			
Original ECI	- 0.49			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	2.27E+10	4.54E+10	6.82E+10	9.09E+10
Vegetables, Fruits and Plants (US. $)	6.20E+09	2.07E+10	0.00E+00	0.00E+00
Chemicals (US. $)	0.00E+00	0.00E+00	1.24E+10	0.00E+00
Chemical Manufacturing (US. $)	0.00E+00	0.00E+00	2.48E+10	8.26E+09
Raw Manufacturing (US. $)	1.24E+10	4.13E+09	6.20E+09	8.26E+09
Textile (US. $)	4.13E+09	4.13E+09	6.20E+09	1.65E+10
Machinery and Construction (US. $)	0.00E+00	0.00E+00	0.00E+00	3.30E+10
Daily Instruments (US. $)	0.00E+00	1.65E+10	1.86E+10	2.48E+10
Increased ECI	- 0.13	0.14	0.28	0.83

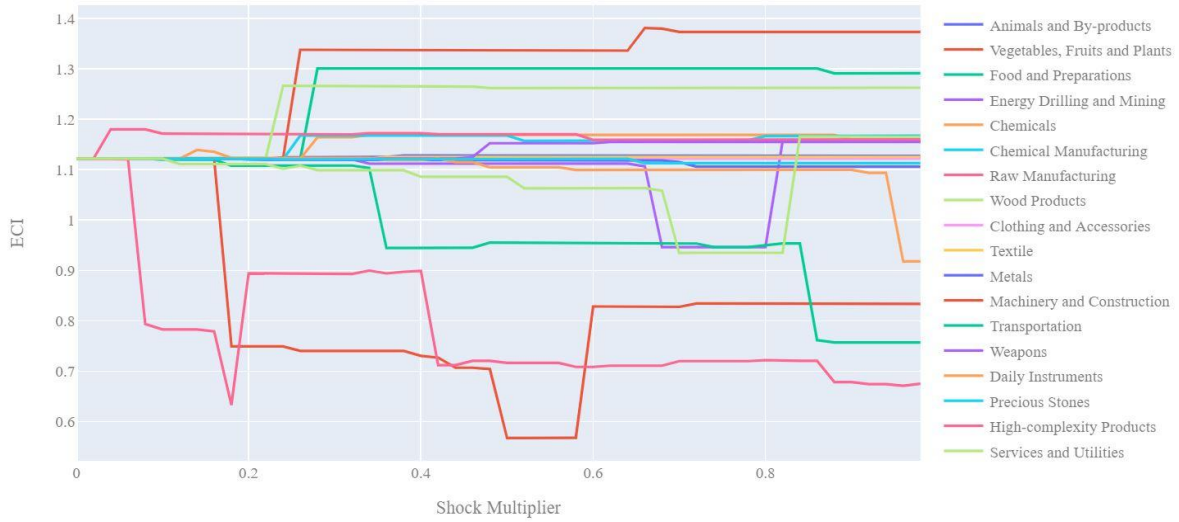
4.3 Sensitivity Analysis

In the following section our broad aim is to understand how sensitive the UAE 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

Firstly, in order to assess the effect particular industries have on each respective country, we developed ECI Sensitivity graphs. We use 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 context of real life, comparing the various inflection points across industries can give us valuable insight.

The graphs are formulated as follows: There are four ECI Sensitivity graphs. The first two represent data from 2018. The first chart 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 follows the same format except the X-axis represents negative shocking. In other words, exports for each industry are decremented and the ECI is accordingly recomputed. The final two sensitivity graphs show the same results using 2013 data. Below is an example of an ECI sensitivity graph.

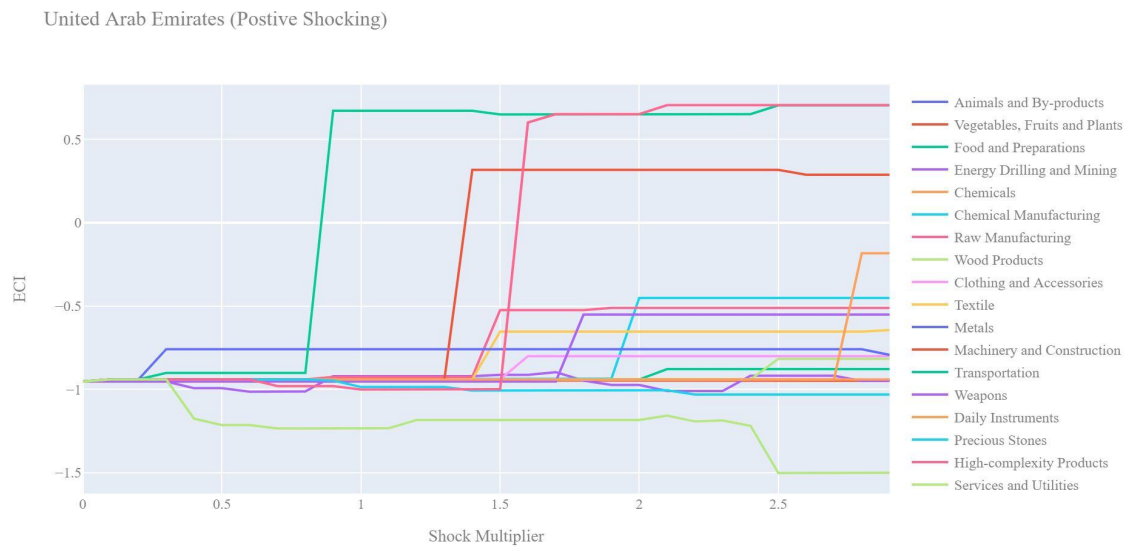


Example 2018 (Incremental ECI Sensitivity)

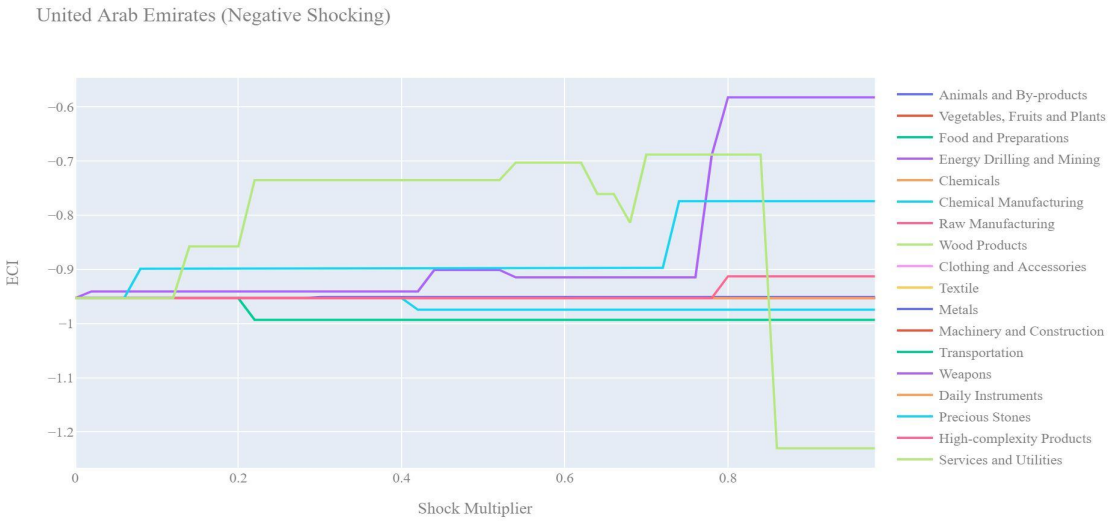
4.3 Sensitivity Analysis Results and Interpretation

Below is UAE's 2018 ECI Sensitivity Charts. Firstly in the positive chart, we notice immediately that increase in exports in High Complexity Products, Machinery and Construction, and Transportation lead to very fast expansion in ECI. That being said both Machinery and High Complexity Products require over a 125% increase in export to experience the ECI improvement. Transportation requires a 75% increase in export to improve ECI. While this is lower than the other two industries, these expansion rates are relatively high in the context of what is feasible in the short term. All other industries tend to not greatly affect the ECI level making it fairly clear which industries to pursue.

Next we consider UAE's 2018 Negative Shock chart. Interestingly we see that decreasing absolute export levels in Services and Utilities, Precious Stones, and Energy & Drilling all improve ECI. Services and Utilities in particular begins to improve ECI with only a 15% drop in export. the UAE is fairly insensitive to drawdowns in other industries.



United Arab Emirates 2018 (Incremental ECI Sensitivity)

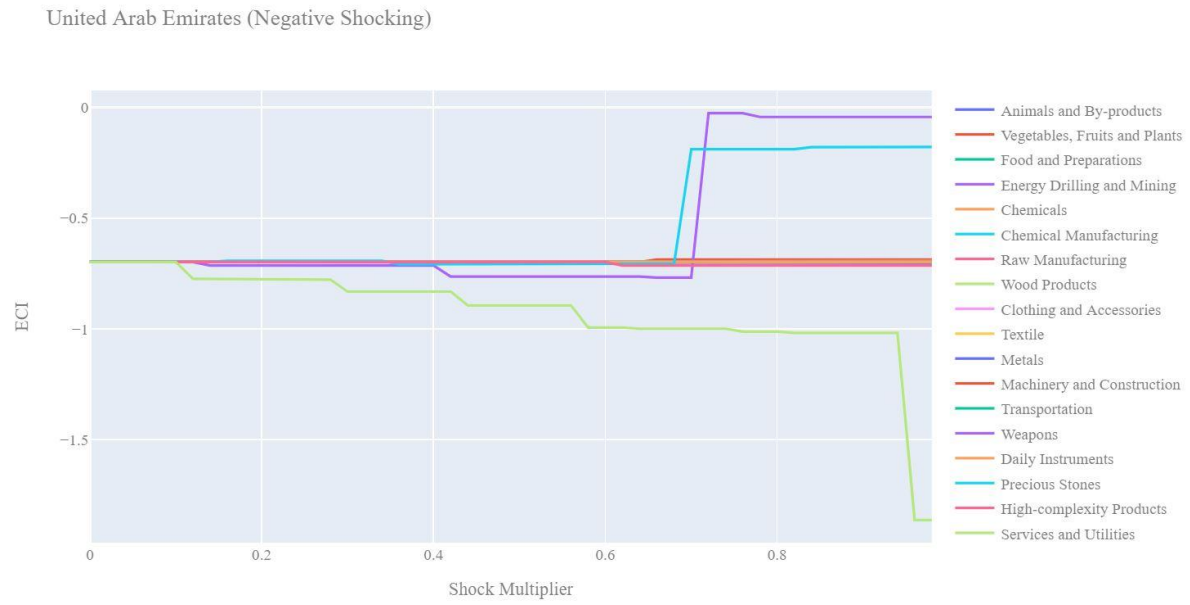


United Arab Emirates 2018 (Decremental ECI Sensitivity)

Next we consider the 2013 ECI Sensitivity graphs. We see interestingly the industries that cause positive move in the ECI are different from the 2018 case. Increases of exports in Textile and Metals cause ECI escalation. Once again export increases in Services and Utilities hurt the overall ECI score.

In the 2013 negative shocking case, we see that UAE is highly insensitive to drawdowns in the majority of industries. That being said, after experiencing 60% or above negative shocks, Precious Stones, and Energy & Drilling improve the ECI to the breakeven level.

United Arab Emirates 2013 (Incremental ECI Sensitivity)



United Arab Emirates 2013 (Decremental ECI Sensitivity)

5. Macro-level Predictions

5.1 Structural Optimality Index

Indeed, such choice of prioritization 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 export increase 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 6 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 18: 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 2: Regression of Five-year GDP Growth over SOI

5.2 SOI of UAE and Its Implications

UAE, for instance, has a particularly low level of structural optimality as compared with its emerging peers. As the regression in Figure 7 suggests (the orange curve represents export increase and the blue curve stands for opportunity gain of the corresponding industry), UAE demonstrates a low level of correlation with the suggested developmental path, having an

adjusted R-square of merely -5.9%. UAE ranks the 101th place among all countries in terms of SOI and has a 5-year GDP growth rate of 25.5% from 2013 to 2018, which is faster than the prediction by regression result in Figure 6 and thus may not be sustainable in the long run. This is in direct contrast to emerging economies such as Turkey, where there is high SOI of around 21.8% and a corresponding GDP growth of 36.7% from 2013 to 2018, making it one of the fastest developing economies during the period. In sum, UAE's mismatched development strategy may pose a concern for its development in the long run. Specifically, UAE invested little in most industries, except Services and Utilities.

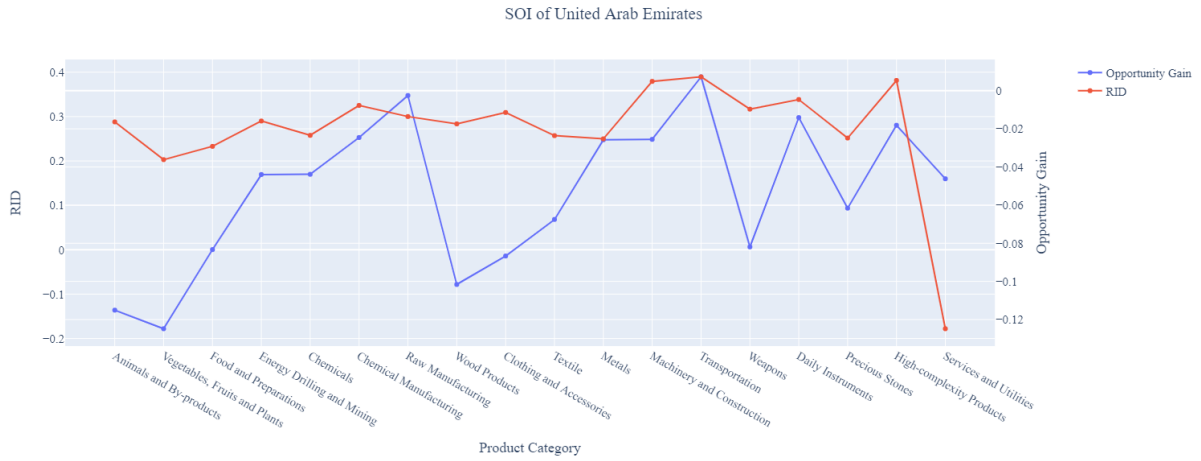


Figure 7: SOI of UAE (2013-2018)

6. Concluding Remarks

In conclusion, UAE has demonstrated a promising level of economic growth in terms of GDP during the period from 2013 to 2018, but this is concurrent with a decrease in economic complexity as compared with other major economies in the region.

The level of economic progress made during the period, we believe, can be largely explained through analysis of the economic and product complexity structure of UAE 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 UAE invested heavily in developing Services and Utilities, Vegetables and Food industries during the period, while its regional peers and emerging economies around the globe have adopted much more complex and progressive paths.

Based on our analysis of the opportunity gain and a sensitivity analysis of major industry groups, UAE can further its gains by focusing on Chemicals and Wood Products industries. We further note that UAE has a mismatched development strategy that indicates a particularly low level of structural optimality, having an adjusted R-square of merely -5.9%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, the growth we see in UAE during the period may not be sustainable as compared with fast-growing economies both on a regional scale and on a global scale, and UAE has the potential to further its economic gains through industrial structure optimization as suggested in the paper.

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