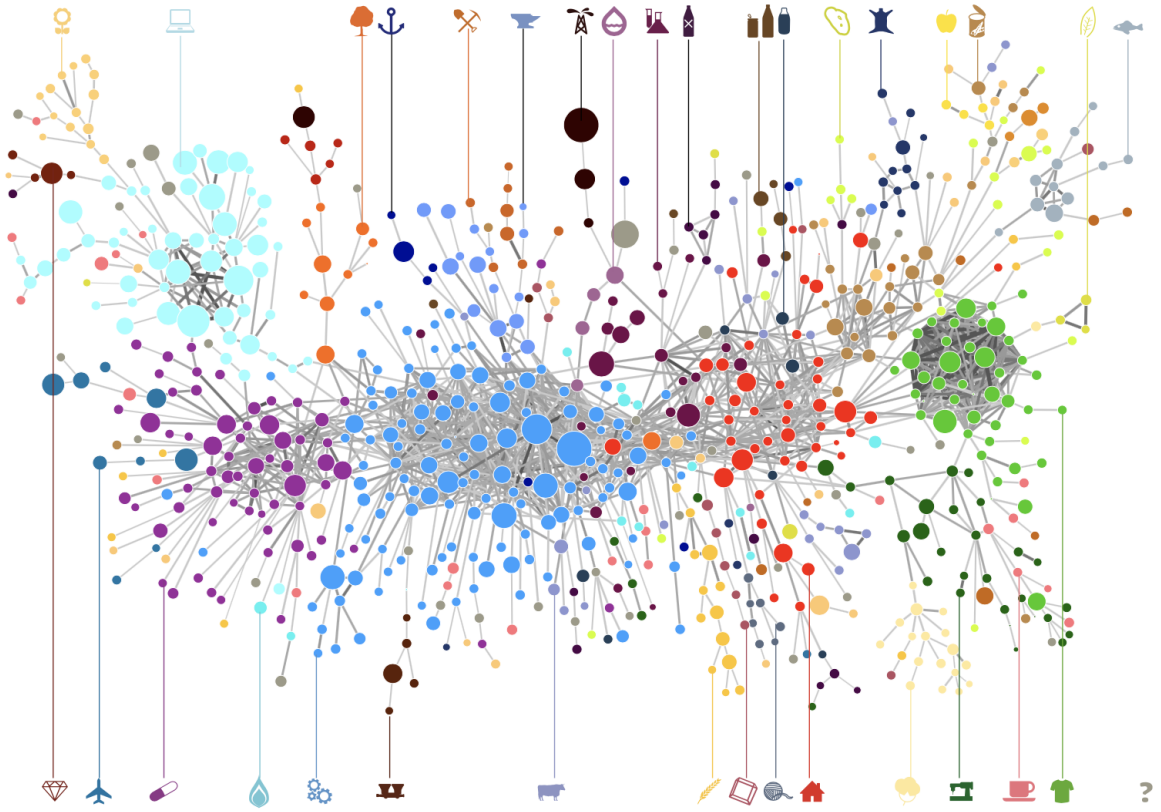

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Optimal Industry Development Strategy Using Economic and Product Complexity

Morocco

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Optimal Industry Development Strategy for Morocco

0. Executive Summary

In this report, we aim to uncover the economic path Morocco went through during the period from 2013 to 2018. Specifically, we dive into the topic through a macroeconomic overview of Morocco 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, Morocco demonstrated a low level of economic growth with an annual GDP growth rate of 3.2%, concurrent with a decrease in economic complexity as compared with other major economies in Africa.

The level of economic progress during the period, we believe, can be partially explained through analysis of the economic and product complexity structure of Morocco 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 Morocco invested heavily in developing Animals and By-products, Clothing and Accessories and Textiles during the period, while its emerging peers and developed 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, Morocco can further its gains by prioritizing High-complexity Products, Services and Utilities, and Food and Preparations. We further note that Morocco has a slightly mismatched development strategy that indicates a moderate level of structural optimality on the complexity level, having an adjusted R-square of around 4.5%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Morocco indeed has a suboptimal 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.

1. Report Overview

In this report, we aim to uncover the economic path Morocco went through during the period from 2013 to 2018. Specifically, we dive into the topic through a macroeconomic overview of Morocco 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 Morocco 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 Morocco, 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 5th largest economy in Africa by GDP, Morocco has a GDP of 106 billion USD in 2013 and 117 billion USD in 2018, exhibiting a promising level of economic output. Figure 1 illustrates the time-series GDP results for top African countries from 1999-2018, and Morocco ranks among its counterparts as a major African economy. The period from 2013 to 2018 seems to be a stable period for Morocco in terms of GDP growth as compared with its emerging peers. During the six years, Morocco exhibited an annual GDP growth of 3.2%, slightly above the annual growth rates of the other five leading African economies, which have an arithmetic average growth rate of 0.8%. The mild economic growth during the period, we believe, can be reflected through changes in ECI and PCI, and can be further explained by mismatched production strategies adopted by Morocco during the period, which we will expand at the later stage of the report.

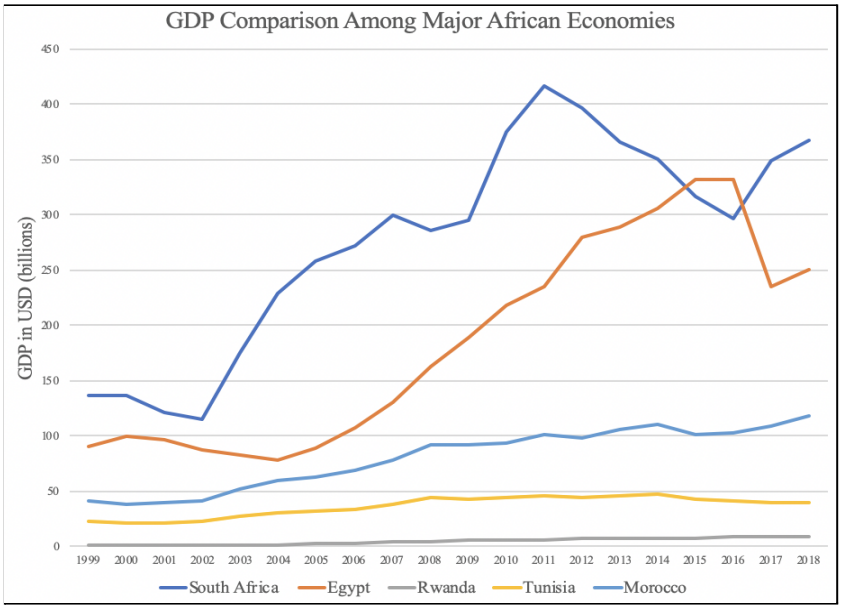


Figure 1: GDP Comparison Among Major African Economies

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 similar pattern for Morocco. As illustrated in Figure 2 below, Morocco exhibits a mild decrease in terms of its production capability from 2013 to 2018, as measured by ECI. This is in direct contrast to countries such as South Africa and Egypt, which demonstrate a disadvantage over Morocco in both the GDP and the ECI indicators.

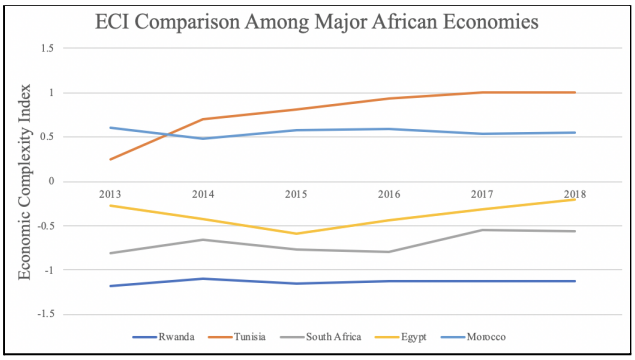


Figure 2: ECI Comparison

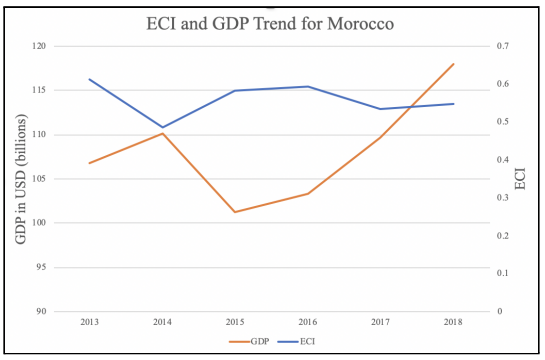


Figure 3: GDP and ECI (Morocco)

Figure 3 offers a further comparison of GDP and ECI over the time span from 2013 to 2018 for Morocco. Based on statistical analysis, ECI is a significant covariate for GDP with an adjusted R-square of 11.8%. Over this time period, the mild economic growth is accompanied by a relatively stable ECI, showing that the mild economic growth experienced by Morocco during the period from 2013 to 2018 can be attributed to its ineffectiveness of the country in developing a more 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 Morocco'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 Morocco'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 Morocco 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, Morocco has focused on products with a moderate level of complexity and those requiring intermediate skills.

Rank	Category	RID	Rank	Category	RID
1	Daily Instruments	-0.011	10	Vegetables, Fruits and Plants	0.018
2	Clothing and Accessories	-0.005	11	Metals	0.020
3	Animals and By-products	0.000	12	Energy Drilling and Mining	0.021
4	High-complexity Products	0.002	13	Chemical Manufacturing	0.023
5	Textile	0.009	14	Food and Preparations	0.024
6	Wood Products	0.014	15	Raw Manufacturing	0.026
7	Transportation	0.016	16	Chemicals	0.038
8	Precious Stones	0.017	17	Weapons	0.038
9	Machinery and Construction	0.018	18	Services and Utilities	0.065

Table 2: Realized Industry Development (RID) of Morocco

3.3 Regional and Global Comparison

Table 3 and 4 below summarize how the production strategy adopted by Morocco compares with leading economies and a selected group of emerging economies in the world, as measured in RID. It can be directly observed that Morocco 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 Morocco'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 Morocco 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, Morocco 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	Morocco	Egypt	South Africa
1	Machinery and Construction	Weapons	High-complexity Products
2	Services and Utilities	Daily Instruments	Machinery and Construction
3	Weapons	Services and Utilities	Animals and By-products
4	Daily Instruments	Machinery and Construction	Transportation
5	Energy Drilling and Mining	High-complexity Products	Services and Utilities
6	Precious Stones	Transportation	Daily Instruments
7	Textile	Animals and By-products	Clothing and Accessories
8	Food and Preparations	Vegetables, Fruits and Plants	Chemicals
9	Animals and By-products	Food and Preparations	Chemical Manufacturing
10	Vegetables, Fruits and Plants	Energy Drilling and Mining	Raw Manufacturing
11	Chemicals	Chemicals	Textile
12	Chemical Manufacturing	Chemical Manufacturing	Vegetables, Fruits and Plants
13	Clothing and Accessories	Raw Manufacturing	Food and Preparations
14	Transportation	Wood Products	Energy Drilling and Mining
15	Wood Products	Clothing and Accessories	Wood Products
16	Raw Manufacturing	Textile	Metals
17	High-complexity Products	Metals	Weapons
18	Metals	Precious Stones	Precious Stones
ECI	0.639107694	-0.264921964	-0.80405844

Ranking	Morocco	Egypt	South Africa
1	Machinery and Construction	Animals and By-products	High-complexity Products
2	Services and Utilities	Weapons	Transportation
3	Weapons	Daily Instruments	Animals and By-products
4	Daily Instruments	Transportation	Machinery and Construction
5	Textile	High-complexity Products	Clothing and Accessories
6	Energy Drilling and Mining	Machinery and Construction	Daily Instruments
7	Food and Preparations	Vegetables, Fruits and Plants	Services and Utilities
8	Precious Stones	Food and Preparations	Raw Manufacturing
9	Animals and By-products	Energy Drilling and Mining	Textile
10	Vegetables, Fruits and Plants	Chemicals	Chemical Manufacturing
11	Chemicals	Chemical Manufacturing	Vegetables, Fruits and Plants
12	Chemical Manufacturing	Raw Manufacturing	Food and Preparations
13	Clothing and Accessories	Wood Products	Energy Drilling and Mining
14	Transportation	Clothing and Accessories	Chemicals
15	Wood Products	Textile	Wood Products
16	Metals	Metals	Metals
17	Raw Manufacturing	Precious Stones	Weapons
18	High-complexity Products	Services and Utilities	Precious Stones
ECI	0.550638433	-0.230682768	-0.579490971

Table 5: Opportunity Gain Ranking on a Regional 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 Morocco compares with a selected group of regional economies 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 Morocco shares the characters of developing countries, with a premature economics structure that leans towards basic to intermediate level industries.

Ranking	USA	Germany	Singapore	Japan
1	Energy Drilling and Mining	Chemical Manufacturing	Chemicals	Chemicals
2	Precious Stones	Wood Products	Transportation	Metals
3	Animals and By-products	Metals	High-complexity Products	Machinery and Construction
4	Vegetables, Fruits and Plants	Machinery and Construction	Services and Utilities	Transportation
5	Food and Preparations	Transportation	Machinery and Construction	Weapons
6	Chemicals	Weapons	Daily Instruments	Daily Instruments
7	Chemical Manufacturing	High-complexity Products	Weapons	High-complexity Products
8	Raw Manufacturing	Services and Utilities	Textile	Services and Utilities
9	Wood Products	Energy Drilling and Mining	Chemical Manufacturing	Precious Stones
10	Machinery and Construction	Precious Stones	Raw Manufacturing	Energy Drilling and Mining
11	Weapons	Textile	Clothing and Accessories	Textile
12	Daily Instruments	Clothing and Accessories	Metals	Clothing and Accessories
13	High-complexity Products	Chemicals	Wood Products	Chemical Manufacturing
14	Services and Utilities	Animals and By-products	Precious Stones	Animals and By-products
15	Clothing and Accessories	Vegetables, Fruits and Plants	Animals and By-products	Wood Products
16	Metals	Food and Preparations	Food and Preparations	Vegetables, Fruits and Plants
17	Textile	Daily Instruments	Energy Drilling and Mining	Food and Preparations
18	Transportation	Raw Manufacturing	Vegetables, Fruits and Plants	Raw Manufacturing
ECI	1.220401303	1.937171566	2.751108815	2.154947

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 $||x_p - x_0||_1$.

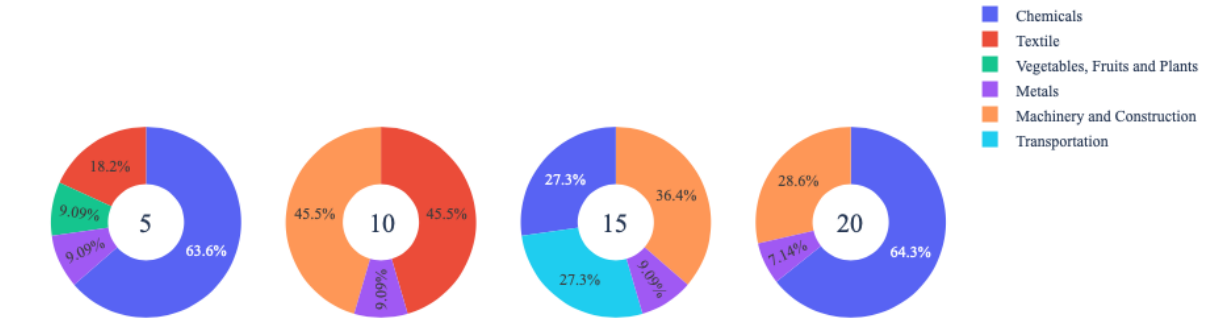
In this way, we can obtain a further sighted greedy algorithm. Also, the number of parts that we would like to separate the budget into also matters. In order to solve this problem, we added a stabilizer on top of the enhanced greedy algorithm, by running the algorithm for different number of parts and 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).

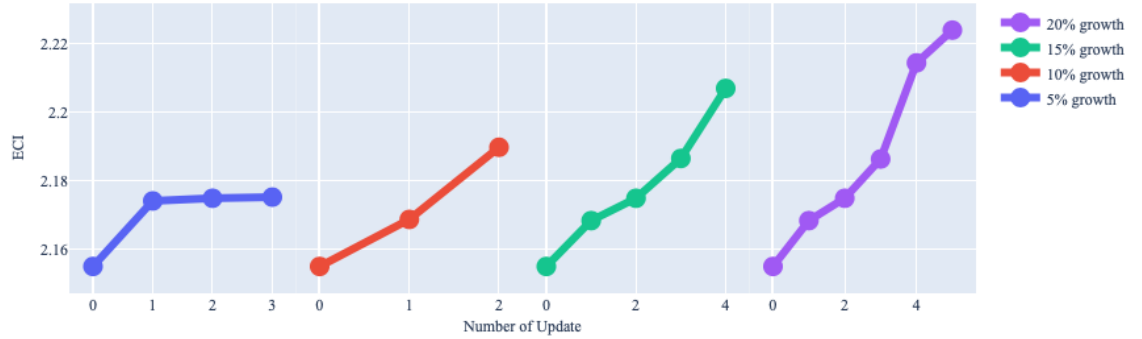
Economic Panel:

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

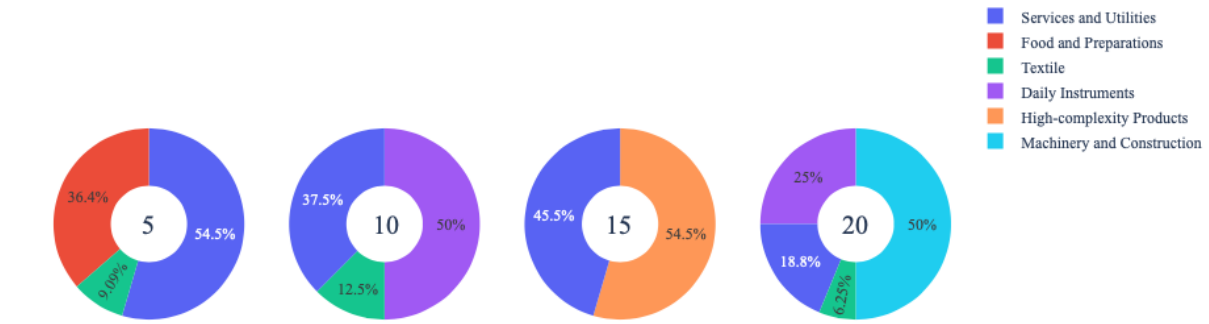


Japan (2013)				
Total Export in 2013 (US. $)	1.17E+12			
Original ECI	2.155			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	5.86E+10	1.17E+11	1.76E+11	2.35E+11
Metals(US. $)	5.33E+09	1.07E+10	1.60E+10	1.68E+10
Transportation(US. $)	0.00E+00	0.00E+00	4.80E+10	0.00E+00
Chemicals(US. $)	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

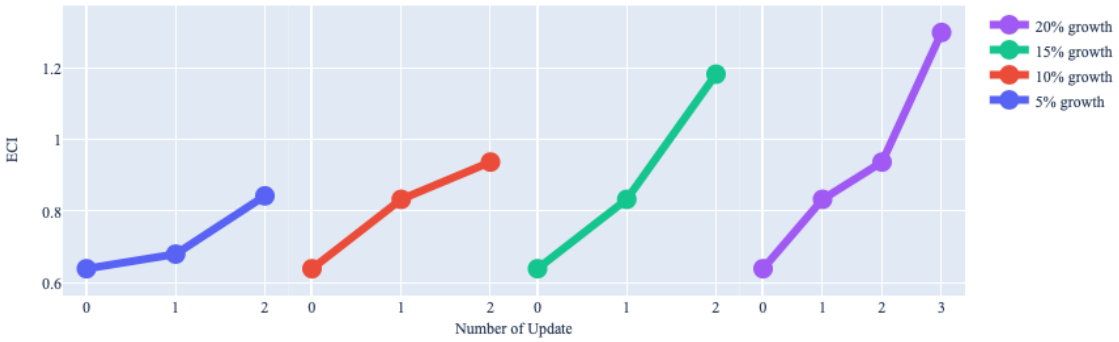
Interpretation:

Below is the economic panel for Morocco in 2013. We can see that for different percentages of heuristic total export growth, the ECI of Morocco has different performance. From all the four line graphs, we see that Morocco 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, Morocco still has great room to improve. For the case of 5 percent growth, the ECI increment is because of services industry, and food products. For the case of 10 percent growth, the ECI increment is attributed to daily instruments and services industry. For the case of 15 percent growth, services industry and high-complexity products result in an increment of ECI. For the case of 20 percent growth, the ECI increment is because of services industry, daily instrument and machinery and construction.

Morocco ECI Growth Optimization Result



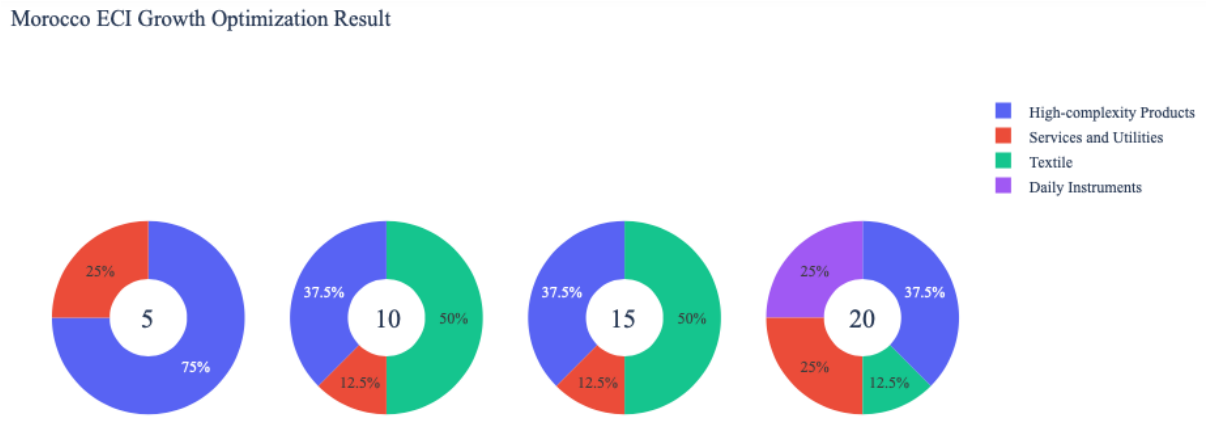
Morocco ECI Increment

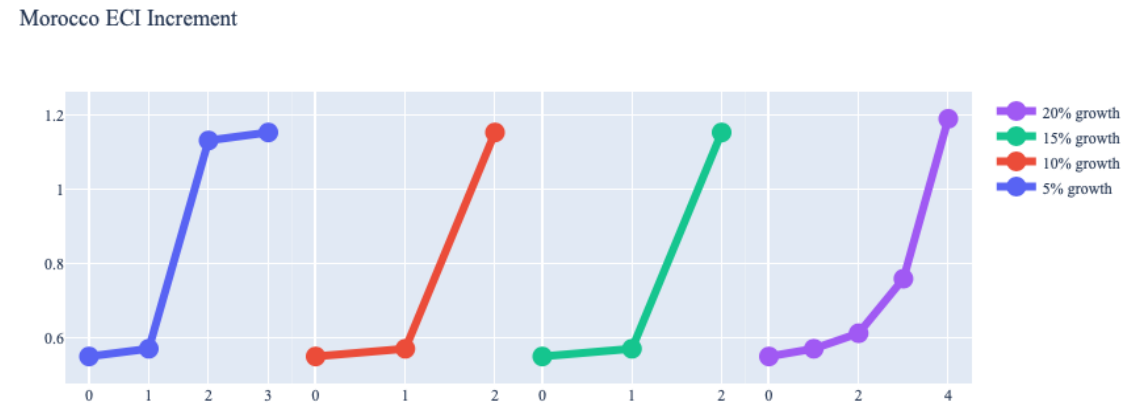


Morocco (2013)				
Total Export in 2013 (US. $)	2.90E+10			
Original ECI	0.639			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	1.45E+09	2.90E+09	4.36E+09	5.81E+09
Food and Preparations(US. $)	5.28E+08	0.00E+00	0.00E+00	0.00E+00
Daily Instruments(US. $)	0.00E+00	1.45E+09	0.00E+00	1.45E+09
Machinery and Construction(US. $)	0.00E+00	0.00E+00	0.00E+00	2.90E+09
Textile(US. $)	1.32E+08	3.63E+08	0.00E+00	3.63E+08
High-complexity Products(US. $)	0.00E+00	0.00E+00	2.38E+09	0.00E+00
Services and Utilities (US. $)	7.92E+08	1.09E+09	1.98E+09	1.09E+09
Increased ECI	0.843	0.937	1.183	1.299

For further suggestions on Morocco's development in the future. We also offer the optimization result of Morocco based on export data in 2018. Below is the economic panel for Morocco in 2018. We can see that for different percentages of heuristic total export growth, the ECI growth pattern of Morocco is a little different from the one in 2013. From all the four line graphs, we see that Morocco already obtains some great increment in terms of ECI. However, increasing the budget for too large an amount would not produce a higher and higher ECI. One thing to notice is that, even though the growth pattern does not change a lot, the eventual ending point is quite high, which doubles the original ECI. This means that in both short term, Morocco still has great room to improve. For the case of 5 percent export growth budget, the ECI has already increased a lot, meaning that it will not be too difficult for Morocco to develop into a more complex economic structure. Most of the increment is attributed to high-complexity products. For the 10, 15, and 20 percent of growth, it is all because of high-complexity products. Therefore, for future strategy, Morocco should

prioritize development of high-complexity products, which causes the greatest jump in all line graphs.





Morocco (2018)				
Total Export in 2018 (US. $)	4.11E+10			
Original ECI	0.55			
Heuristic Export Growth (%)	5%	10%	15%	20%
Heuristic Export Growth (US. $)	2.05E+09	4.11E+09	6.16E+09	8.21E+09
Textile (US. $)	0.00E+00	2.05E+09	3.08E+09	1.03E+09
Daily Instruments (US. $)	0.00E+00	0.00E+00	0.00E+00	2.05E+09
High-complexity Products (US. $)	1.54E+09	1.54E+09	2.31E+09	3.08E+09
Services and Utilities (US. $)	5.13E+08	5.13E+08	7.70E+08	2.05E+09
Increased ECI	1.15	1.15	1.19	1.19

4.3 Sensitivity Analysis

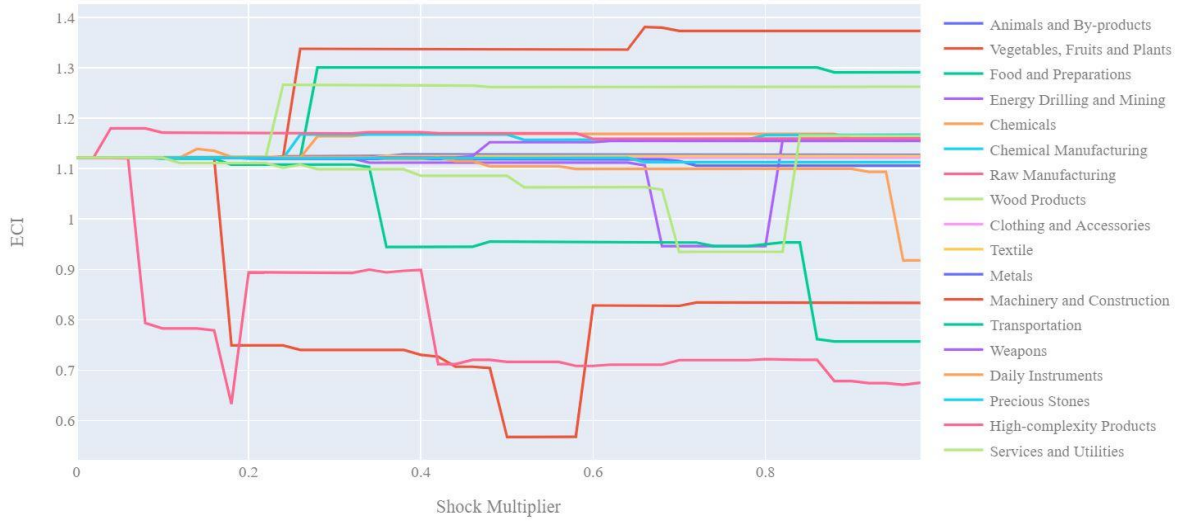
In the following section our broad aim is to understand how sensitive Morocco is to changes in export in various industries. While the Economic Complexity Index has been shown to contain valuable information about the economic strength/capacity of a country, little has been said as to the stability of 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.

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.

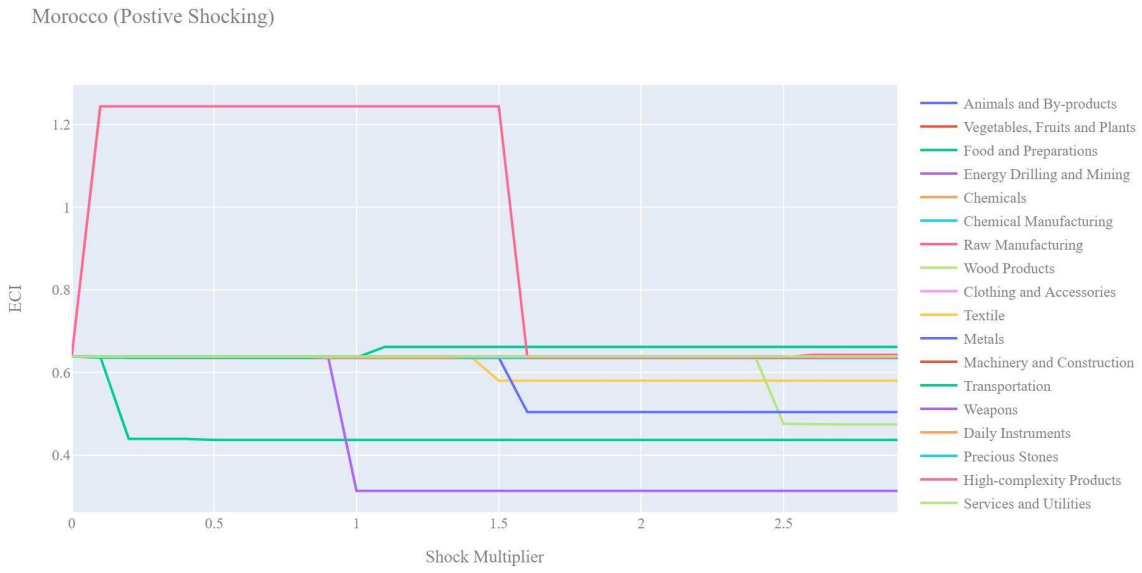


Example 2018 (Incremental ECI Sensitivity)

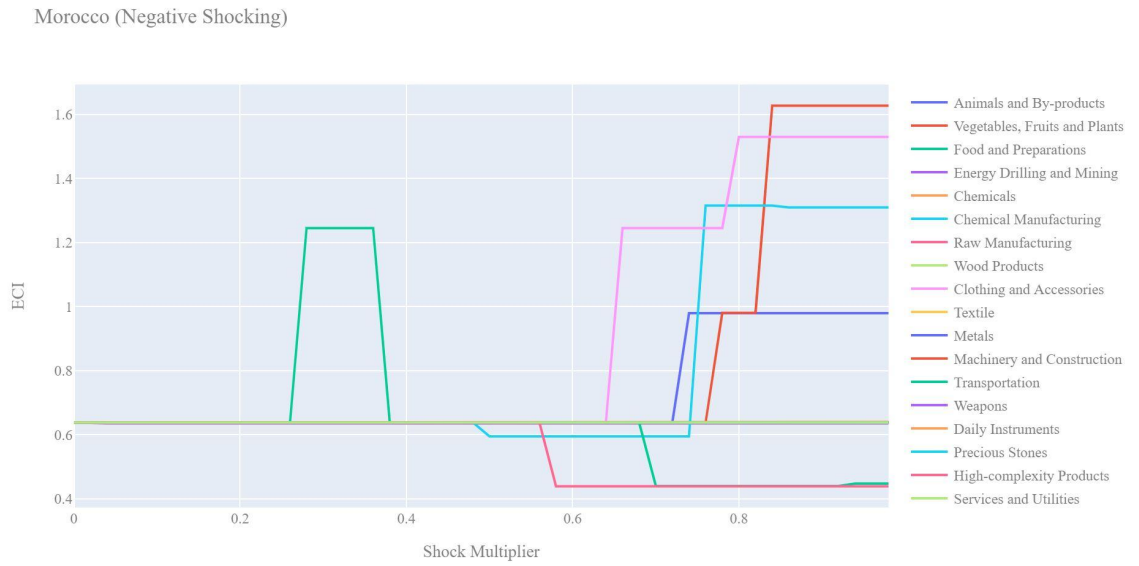
4.3 Sensitivity Analysis Results and Interpretation

Below is Morocco's 2018 ECI Sensitivity Charts. Firstly in the positive chart, we notice immediately that increase in exports in High Complexity Products lead to very fast expansion in ECI which plateaus around a level of 1.2. All other industries tend to not greatly affect the ECI level making it fairly clear which industry to pursue. In fact an increase in Food and Preparation as well as Energy and Drilling actually marginally decrease ECI levels.

Next we consider Morocco's 2018 Negative Shock chart. We can see that Morocco is fairly insensitive to the majority of its industries. However once we reach the -80% range of shocking we start to see upwards spikes in ECI which signifies that the current industries that Morocco is operating is most likely optimal for economic development in the context of economic complexity.



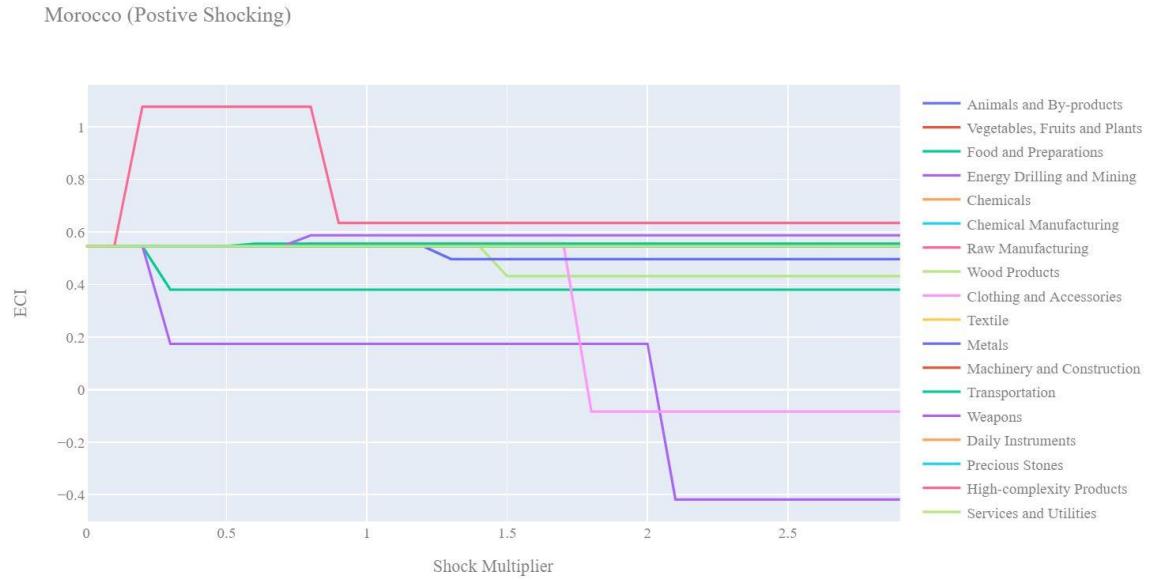
Morocco 2018 (Incremental ECI Sensitivity)



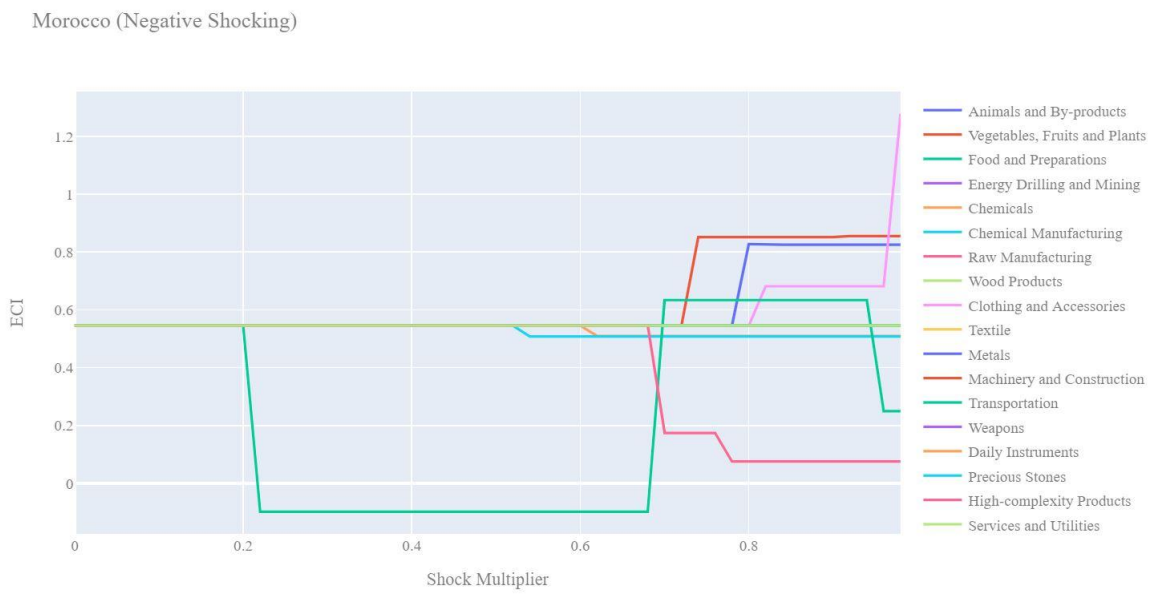
Morocco 2018 (Decremental ECI Sensitivity)

Next we consider the 2013 ECI Sensitivity graphs. We see that the profile in the positive shocking case is very similar to the 2018 sensitivity graph. More focus on High Complexity Products lead to a higher ECI while as Food and Preparation as well as Energy and Drilling marginally decrease ECI levels.

In the 2013 negative shocking case, we see that again Morocco is fairly sensitive to decreases in export in Transportation products. In fact a decrease of about 20% brings the ECI down to negative levels. We see that in the 2018 chart this major sensitivity to Transportation is not present, which implies that the Moroccan economy has become less reliant on Transportation to bolster its ECI.



Morocco 2013 (Incremental ECI Sensitivity)



Morocco 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 Morocco and Its Implications

Morocco, for instance, has a relatively low level of structural optimality as compared with its African 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), Morocco demonstrates a moderate level of correlation with the suggested developmental path, having an adjusted R-square of around -6.2%. Morocco ranks in 105th place among all observed countries in terms of SOI and has slow economic progress among its African peers from 2013 to 2018 with an annual growth rate of 26.5%, which is consistent with the regression result in Figure 6. This is in direct contrast to emerging economies such as Turkey, where there is a high SOI of around 21.8% and a corresponding GDP growth of 36.7%, making it one of the fastest developing economies during the period. In sum, Morocco's slower economic progress from 2013 to 2018 can be at least partially explained by a mismatched development strategy that demonstrates a considerable level of deviations from our suggested developmental path.

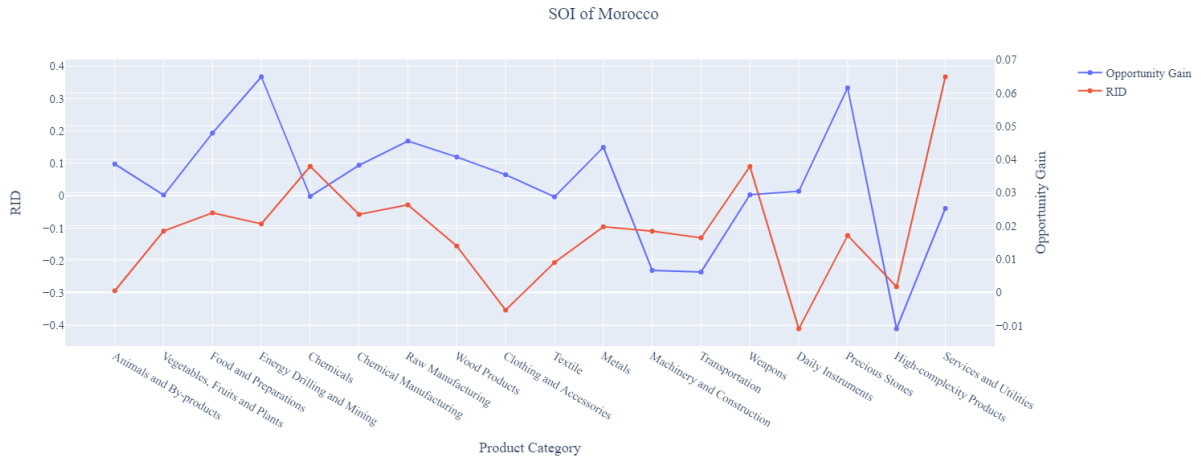


Figure 7: SOI for Morocco (2013-2018)

6. Concluding Remarks

In conclusion, Morocco has demonstrated a low level of economic growth in terms of GDP during the period from 2013 to 2018, concurrent with a stagnation in economic complexity as compared with other major African economies.

The level of economic progress during the period, we believe, can be partially explained through analysis of the economic and product complexity structure of Morocco 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 Morocco invested heavily in developing Animals and By-products, Clothing and Accessories and Textiles during the period, while its emerging peers and developed 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, Morocco can further its gains by prioritizing High-complexity Products, Services and Utilities, and Food and Preparations. We further note that Morocco has a slightly mismatched development strategy that indicates a moderate level of structural optimality on the complexity level, having an adjusted R-square of around 4.5%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Morocco indeed has a suboptimal 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.

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