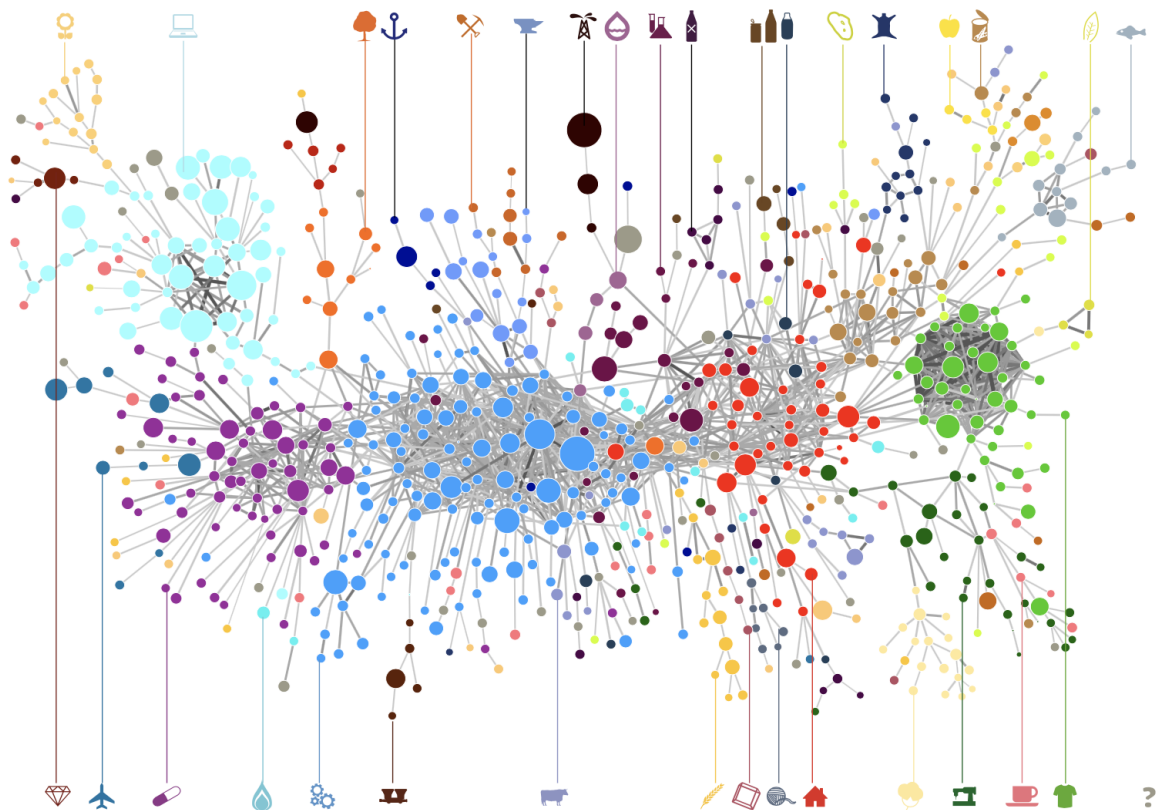




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Optimal Industry Development Strategy Using Economic and Product Complexity

Togo

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Optimal Industry Development Strategy for Togo

0. Executive Summary

In this report, we aim to uncover the economic path Togo went through during the period from 2019 to 2022. Specifically, we dive into the topic through a macroeconomic overview of Togo 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, Togo demonstrated a low level of economic growth with an average annual GDP growth rate of 3.43% between 2019 and 2022, with a decreased economic complexity compared to other major economies.

The negative progress during the period, we believe, can be partially explained through the analysis of the economic and product complexity structure of Togo on the industry group level, as well as the stagnant 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 Togo regressed in developing most of its industries during the end of the observed 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, Togo could further its gains by prioritizing Energy Drilling and Mining, Metals, and Weapons in 2022. We further note that Togo has a heavily mismatched development strategy that indicates a low level (compared to other emerging countries) of structural optimality on the complexity level, having an adjusted R-square of around 0.342 in 2022. Since a significant positive correlation exists between GDP growth and the structural optimality index of an economy as we define and calculate, Togo 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.

The three years between 2019 and 2022 showed a significant improvement in Togo's economic growth, boosting its position on the global scale. Its GDP recovered to above the pre-pandemic levels, and it saw a significant boost in the ECI, 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 Togo went through during the period from 2019 to 2022, before and after the COVID pandemic. Specifically, we dive into the topic through a macroeconomic overview of Togo 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 Togo 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 Togo, 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 1 shows the GDP levels for Togo and its peer countries (Nigeria, Ethiopia, and Burkina Faso) from 2019 to 2021. Similar to the other countries, Togo displayed a drop in GDP from 2019 to 2020 because of the pandemic, with all GDPs rebounding in 2021. Over these three years, Togo's average annual GDP growth rate (3.43%) is in the middle, as it is the same as Nigeria's rate (3.43%), greater than Burkina Faso's rate (1.91%) but less than Ethiopia's rate (5.77%).

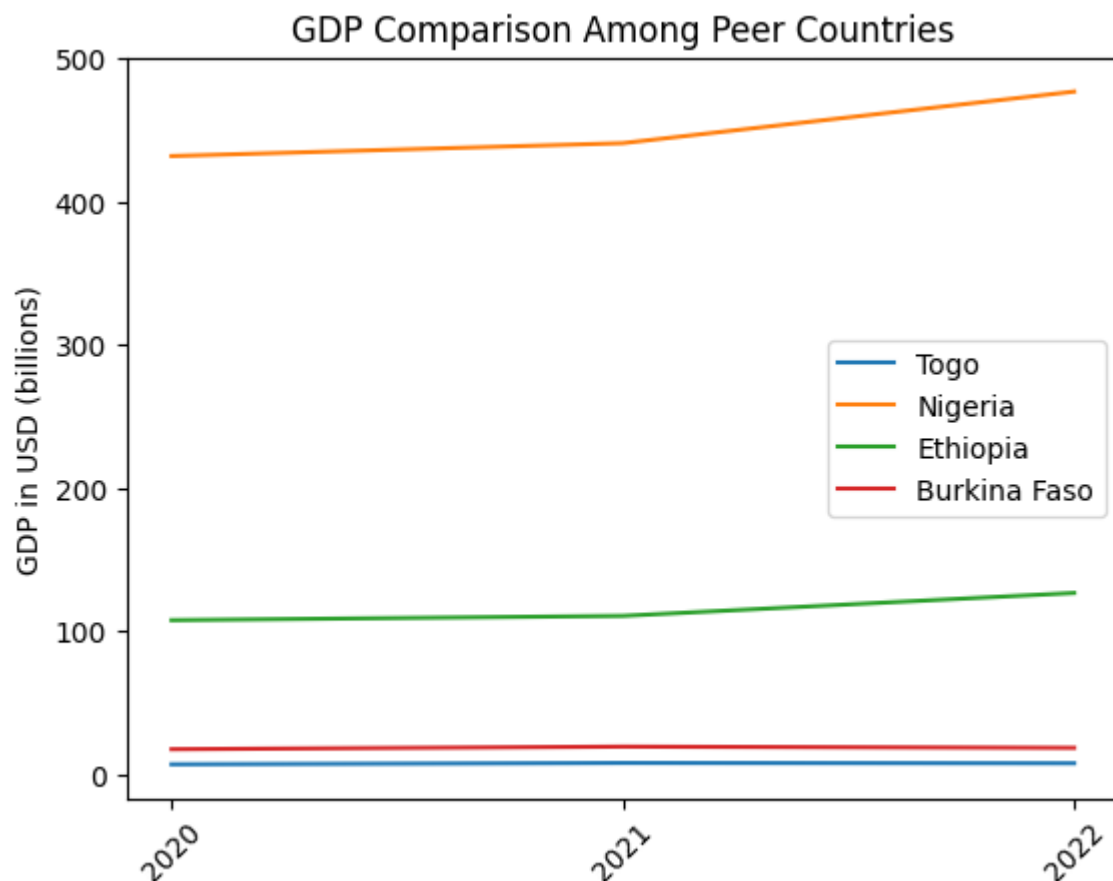
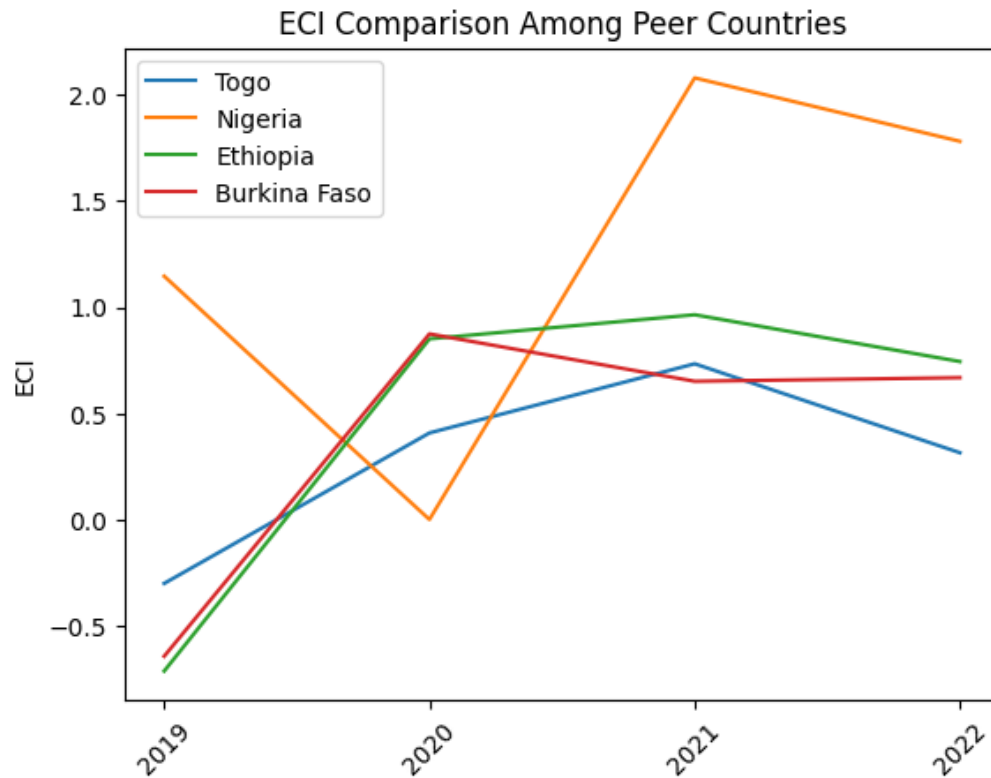


Figure 1. GDP Comparison Among Peer Countries (2019-2021)

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 Figure 2.

The comparable countries have a sharp change in ECI levels between 2019 and 2020, and level out from 2020 forward (excluding Nigeria). Togo exhibits a steady increase in production capability from 2019 to 2021 and a decrease in 2022, as a result of Russia's invasion of Ukraine. Togo has seen a 205.55% increase in its ECI, which is similar to Ethiopia's (204.55%) and Burkina Faso's (204.08%) but greater than Nigeria's (55.39%).



Figures 2a and 2b. ECI Comparison Among Peer Countries (2019-2021)

Figure 3 offers a further comparison of GDP Growth and ECI over the time span from 2019 to 2022 for Togo. The GDP growth during the period from 2020 to 2021 is accompanied by a similarly volatile increase in ECI. 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 Togo's production structure and its product space designs in the next few sections.

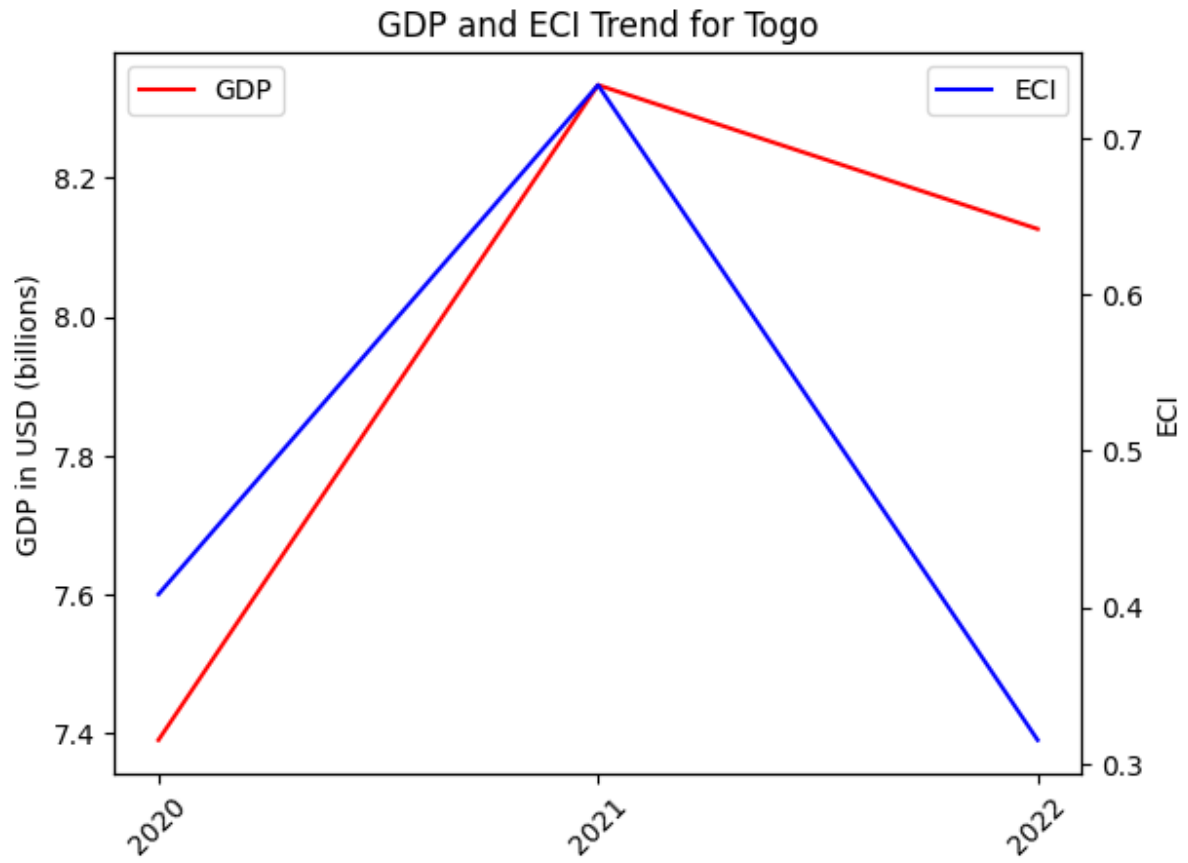


Figure 3. GDP Growth and ECI for Togo (2019-2021)

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 economies, 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 Togo's realized industry production strategy for 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 Togo and the 18 product groups in 2022 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.

Category	RID (2022)
Daily Instruments	-0.07885
Chemicals	-0.08869
Weapons	-0.03181
Wood Products	0.02788
Transportation	-0.06242
Machinery and Construction	-0.01864
Metals	-0.03772
Raw Manufacturing	-0.06080
Services and Utilities	-0.05030
Clothing and Accessories	-0.01366
Chemical Manufacturing	-0.03697
Food and Preparations	-0.02080
Textile	-0.02937
High-complexity Products	-0.10023
Vegetables, Fruits and Plants	-0.01306
Animals and By-products	-0.01222
Energy Drilling and Mining	-0.3248
Precious Stones	

Table 3. Realized Industry Development (RID) of Togo

3.3 Regional and Global Comparison

Table 4a below summarizes how the production strategy adopted by Burkina Faso compares with selected leading economies in the world in 2022, as measured in RID. Leading economies such as France, Greece, and Portugal gave a considerable level of attention to more advanced product groups such as High-complexity Products, Energy Drilling, and Transportation.

Ranking	France	Greece	Portugal
1	Services and Utilities	Energy Drilling	Textile
2	Precious Stones	Wood Products	Fruit and Plants
3	High-complexity Products	Services and Utilities	Daily Instruments
4	Machinery and Construction	Clothing and Accessories	Clothing and Accessories
5	Animals and By-products	Wood Products	Transportation

Table 4b. RID Comparison across Leading Economies (2021)

Table 4 further examines Togo's development strategy against those of emerging economies on a global scale. Reasonably, emerging economies such as China and Singapore have devoted the majority of their efforts to intermediate industry groups.

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

Table 4d. RID Comparison across Emerging Economies (2021)

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.

Rank	Togo	Burkina Faso	Ethiopia
1	Vegetables, Fruits and Plants	High-complexity Products	High-complexity Products
2	Services and Utilities	Services and Utilities	Services and Utilities
3	Precious Stones	Transportation	Transportation
4	High-complexity Products	Daily Instruments	Daily Instruments
5	Transportation	Chemical Manufacturing	Machinery and Construction
6	Machinery and Construction	Machinery and Construction	Chemical Manufacturing
7	Weapons	Chemicals	Chemicals
8	Wood Products	Raw Manufacturing	Weapons
9	Daily Instruments	Energy Drilling and Mining	Raw Manufacturing
10	Chemicals	Clothing and Accessories	Energy Drilling and Mining
11	Metals	Animals and By-products	Wood Products
12	Animals and By-products	Wood Products	Textile
13	Food and Preparations	Metals	Precious Stones
14	Energy Drilling and Mining	Vegetables, Fruits and Plants	Metals
15	Chemical Manufacturing	Food and Preparations	Animals and By-products
16	Raw Manufacturing	Textile	Vegetables, Fruits and Plants
17	Clothing and Accessories	Weapons	Food and Preparations
18	Textile	Precious Stones	Clothing and Accessories
ECI	0.3151	0.6682	0.7441

Table 5a. 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 Togo 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 High-complexity Products and Transportation industries. It can be concluded that Togo shares the characteristics of developing countries, with a balanced economic structure that leans towards intermediate-level industries.

Rank	Italy	France	Nigeria
1	Energy Drilling and Mining	Energy Drilling and Mining	High-complexity Products
2	Vegetables, Fruits and Plants	Textile	Services and Utilities
3	Precious Stones	Precious Stones	Transportation
4	Animals and By-products	Animals and By-products	Daily Instruments
5	Weapons	Vegetables, Fruits and Plants	Chemical Manufacturing
6	Food and Preparations	Food and Preparations	Machinery and Construction
7	Chemical Manufacturing	Chemicals	Chemicals
8	Raw Manufacturing	Chemical Manufacturing	Weapons
9	Wood Products	Raw Manufacturing	Raw Manufacturing
10	Clothing and Accessories	Wood Products	Energy Drilling and Mining
11	Textile	Clothing and Accessories	Metals
12	Metals	Metals	Wood Products
13	Machinery and Construction	Weapons	Clothing and Accessories
14	Daily Instruments	High-complexity Products	Precious Stones
15	High-complexity Products	Machinery and Construction	Animals and By-products
16	Chemicals	Transportation	Food and Preparations
17	Transportation	Daily Instruments	Textile
18	Services and Utilities	Services and Utilities	Vegetables, Fruits and Plants
ECI	-0.8255	-0.5021	1.780

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:

$$\begin{aligned} & \text{Max}_{x \in \mathbf{R}^{|P|}} \left(\frac{k(x) - \langle k(x) \rangle}{\text{stdev}(k(x))} \right)_C \\ & \text{Subject to} \\ & \sum_{p \in P} x_p \leq B \\ & x \succeq 0 \end{aligned}$$

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:

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

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 Togo in 2022. We can see that for different percentages of heuristic total export growth, the ECIs of Togo actually have similar increments. This is attributed to the fact that the budget allocation is very similar for all four percentages, resulting in similar ECI increment paths.

For 2013, in the case of 5 percent, 10 percent, 15 percent, and 20 percent export growth, the portfolio is made up of Precious Stones and Vegetables, Fruits and Plants. As percentages increase, the proportion of Vegetables, Fruits and Plants decrease.. A more detailed numerical representation of the portfolio is shown in Table 8a.

Togo ECI Growth Optimization Result



Figure 4a. Greedy-Based ECI Improvement Results of Togo with Different Budgets (2013)

Togo (2022)				
Original ECI	0.315147			
Heuristic Export Growth	5%	10%	15%	20%
Vegetables, Fruits and Plants	12569255.4	13280722.7	9011918.96	11383476.6
Precious Stones	113123298	185930117	261345650	330120821
Increased ECI	0.76244745	0.76244745	0.76244745	0.76244745

Table 8a. Portfolio of Togo (2022)

4.3 Sensitivity Analysis and Contingency Strategy

In the following section, our broad aim is to understand how sensitive Togo 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.

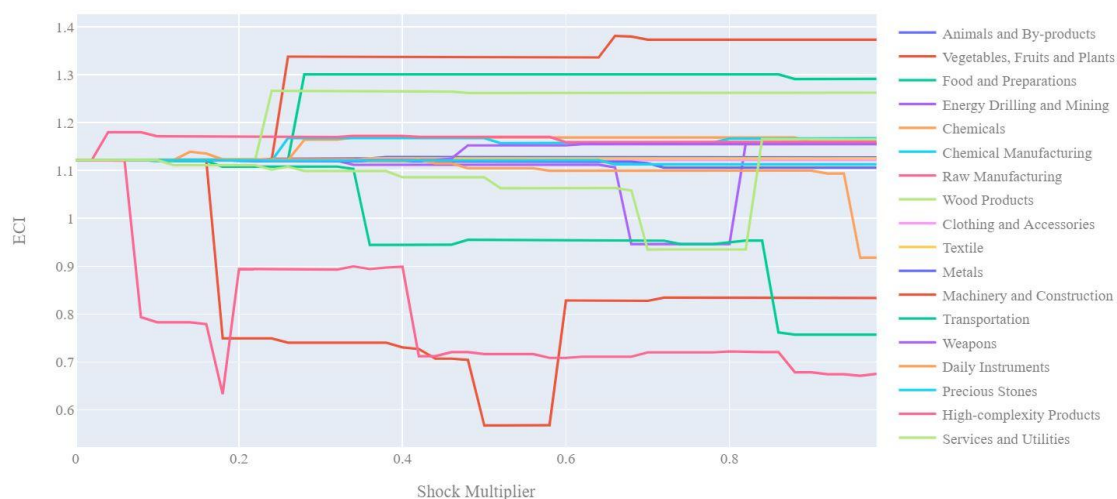


Figure 5. Sample ECI Sensitivity Graph (2018)

The graphs are formulated as follows. There are six ECI Sensitivity graphs, two for each of the following years: 2021, 2018, and 2013. 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 Energy Drilling and Mining and Services and Utilities 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 the export of Energy Drilling and Mining and Services and Utilities 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 an 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 Togo's ECI Decremental and Incremental Sensitivity Charts for 2021. An increase in Vegetables, Fruits and Plants will lead to the highest change in ECI, followed by Energy Drilling and Mining and High-complexity Products. For the negative shock cases, Chemical Manufacturing becomes most impactful. The rest of the industries do not appear to have the same level of sensitivity.

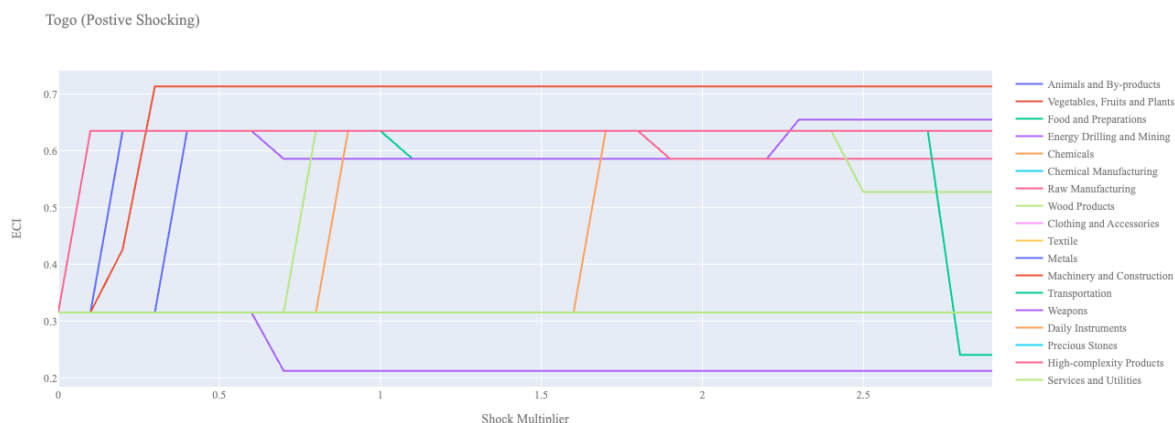


Figure 6a. Incremental ECI Sensitivity for Togo (2022)

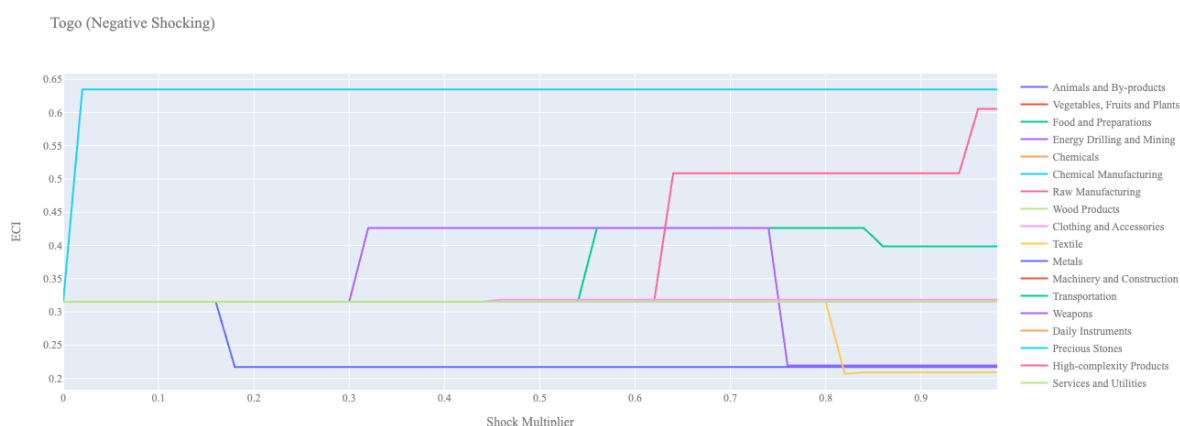


Figure 6b. Decremental ECI Sensitivity for Togo (2022)

Below we see the SDV sensitivity charts for Vegetables, Fruits and Plants (Table 11). Togo's SDV is quite insensitive to changes in Vegetables, Fruits and Plants since this does not seem to be a key industry for the Togo economy. In both the positive and negative SDV sensitivity chart we see that the SDV does not change for any level of shock to the export level of Vegetables, Fruits and Plants.

Considering the Services and Utilities SDV sensitivity charts (Table 12), we see that Togo again is fairly insensitive to this industry. The industries that have positive opportunity gain and negative opportunity gain for Togo are unchanged by shocks to the Services and Utilities industry.

Rank	Incremental	Decremental
1	Services and Utilities	Vegetables, Fruits and Plants
2	High-complexity Products	Services and Utilities
3	Precious Stones	Precious Stones
4	Chemical Manufacturing	High-complexity Products
5	Daily Instruments	Transportation
6	Wood Products	Machinery and Construction

7	Machinery and Construction	Weapons
8	Chemicals	Wood Products
9	Weapons	Daily Instruments
10	Transportation	Chemicals
11	Metals	Metals
12	Animals and By-products	Animals and By-products
13	Vegetables, Fruits and Plants	Clothing and Accessories
14	Clothing and Accessories	Raw Manufacturing
15	Raw Manufacturing	Chemical Manufacturing
16	Energy Drilling and Mining	Energy Drilling and Mining
17	Food and Preparations	Food and Preparations
18	Textile	Textile
ECI	0.7131317726	0.3151470064

Table 11. Togo's SDV Sensitivities for Vegetables, Fruits and Plants (2022)

Rank	Incremental	Decremental
1	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants
2	Services and Utilities	Services and Utilities
3	Precious Stones	Precious Stones
4	High-complexity Products	High-complexity Products
5	Transportation	Transportation
6	Machinery and Construction	Machinery and Construction
7	Weapons	Weapons
8	Wood Products	Wood Products
9	Daily Instruments	Daily Instruments
10	Chemicals	Chemicals
11	Metals	Metals
12	Animals and By-products	Animals and By-products
13	Clothing and Accessories	Clothing and Accessories
14	Raw Manufacturing	Raw Manufacturing
15	Chemical Manufacturing	Chemical Manufacturing
16	Energy Drilling and Mining	Energy Drilling and Mining
17	Food and Preparations	Food and Preparations
18	Textile	Textile
ECI	0.3151470064	0.3151470064

Table 12. Togo's SDV Sensitivities for Services and Utilities (2022)

4.4 Contingency Strategy

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

Product Names	0	1	2
Animal and By-products	Services and Utilities	High-complexity Products	Transportation
Vegetables, Fruits and Plants	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Food and Preparations	Precious Stones	Services and Utilities	Wood Products
Energy Drilling and Mining	Precious Stones	Services and Utilities	Wood Products

Chemicals	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Chemical Manufacturing	Services and Utilities	High-complexity Products	Vegetables, Fruits and Plants
Raw Manufacturing	Services and Utilities	High-complexity Products	Transportation
Wood Products	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Clothing and Accessories	Services and Utilities	High-complexity Products	Vegetables, Fruits and Plants
Textile	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Metals	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Machinery and Construction	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Transportation	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Weapons	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Daily Instruments	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Precious Stones	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
High-complexity Products	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones
Services and Utilities	Vegetables, Fruits and Plants	Services and Utilities	Precious Stones

Table 13. Togo's Contingency Strategy (2022)

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 negative correlation between countries’ SOI and their five-year GDP growth, significant at the 64% level and achieving an adjusted R^2 of -0.312%. In other words, the more a country develops, as suggested by calculations on a complexity level, the worse economic outcomes it achieves.

Table 14: OLS Regression Results	
Dep. Variable: GDP	F-Statistic: 0.2874
R ² : 0.126	Prob (F-Stat): 0.646
Adj R ² : -0.312	No. Observations: 4

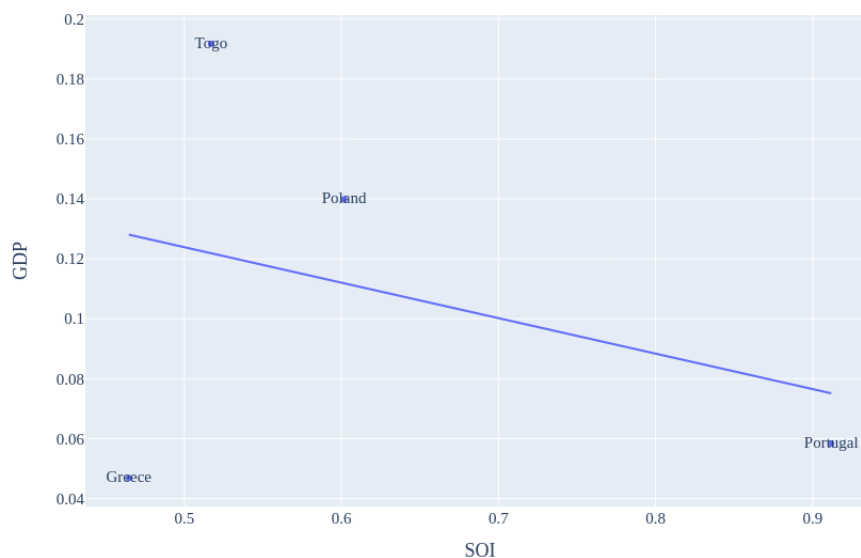


Figure 9. Regression of Five-Year GDP Growth over SOI (2019-2022)

5.2 SOI of Togo and Its Implications

During the first examined period, Togo, for instance, has a low 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), Togo demonstrates a low level of correlation with the suggested developmental path, having an adjusted R-square of around 0.324.

For the 2019-2022 years, Togo has a strong presence in the Energy Drilling and Mining and Wood Products industries, which Energy Drilling and Mining presents a good opportunity for further investment, whereas Wood Products seem to be overdeveloped when considering their lower opportunity gain relative to RID. It also could consider Metals, Weapons, and Precious Stones to improve its growth. Togo has seen an average growth in GDP of 3.43% over those three years.

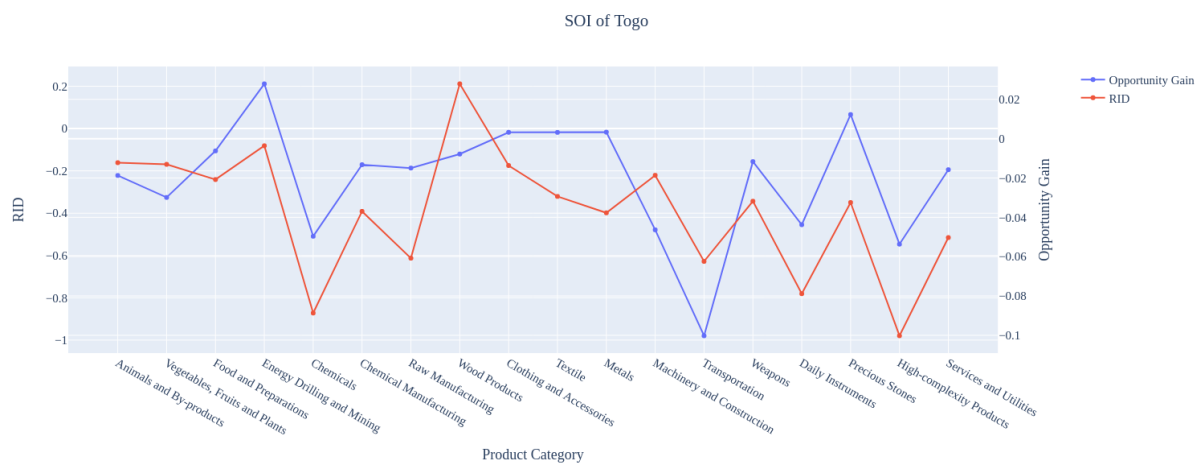


Figure 10b. SOI of Togo (2019-2022)

6. Concluding Remarks

In conclusion, Togo has demonstrated a low level of economic growth in terms of annual GDP increase during the period from 2019-2022, concurrent with an decrease in economic complexity as compared with major emerging economies.

We believe that the mixed progress during the first period can be partially explained through the analysis of the economic and product complexity structure of Togo 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 Togo regressed in developing most of its industries during the period, while its developed counterparts and emerging economies around the globe adopted much more complex and progressive paths.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups for 2019-2022, Togo can further its gains by prioritizing Energy Drilling and Mining, Metals, and Weapons. We further note that Togo has a heavy mismatch that indicates a low level (compared to other developed countries) of structural optimality on the complexity level, having an adjusted R-square of around 34.2%. Since a low correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Togo 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.

During the second examined period from 2019 to 2022, Togo performed much weaker than before and compared to other countries, particularly Ethiopia. We infer that during the COVID-19 period, Togo focused on developing lower complexity industries, in line with lower demand for these industries given the global economic downturn. We also note that Togo has increased its investment in the sectors identified earlier, leading to a strong boost. The ECI suggests that greater growth could have been achieved through Energy Drilling and Mining, followed by Metals and Weapons. With the revised focus, Togo has further potential to advance its economic growth to maintain its position among other countries to continue its post-pandemic recovery.

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