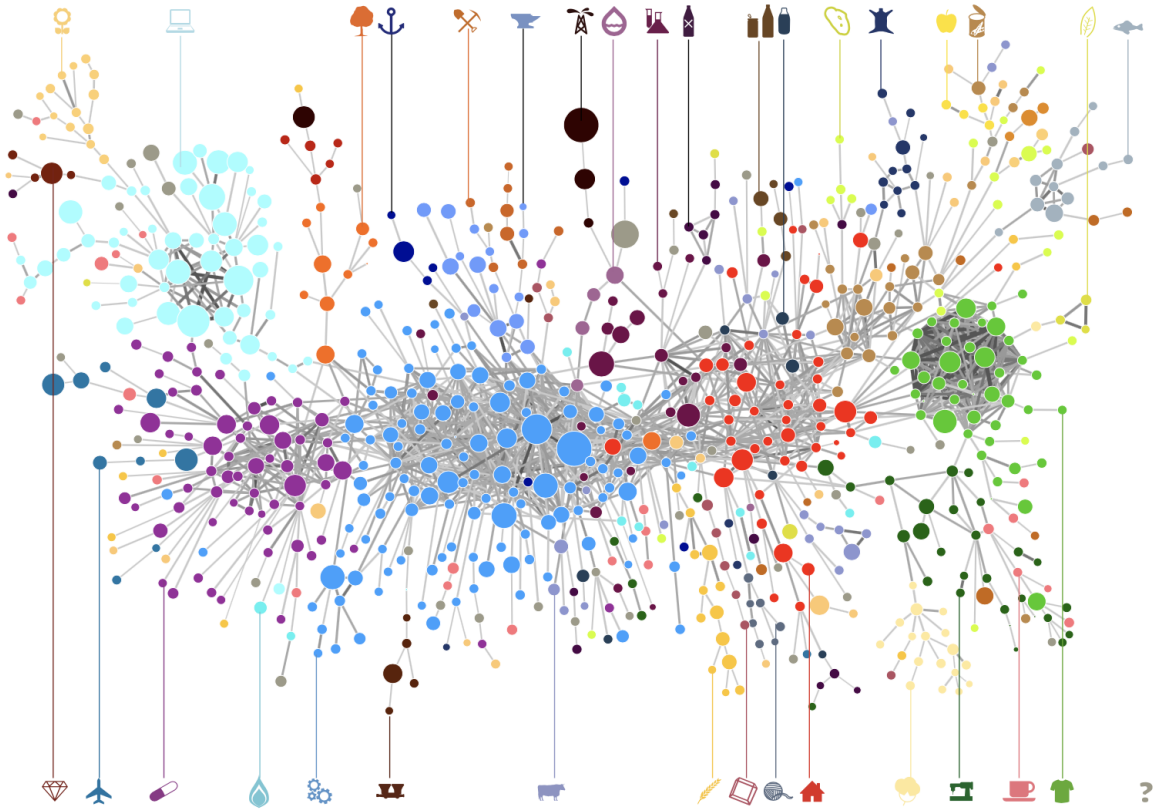

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Optimal Industry Development Strategy Using Economic and Product Complexity

Burkina Faso

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The Economic Complexity Lab - Columbia University

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Optimal Industry Development Strategy for Burkina Faso

0. Executive Summary

In this report, we aim to uncover the economic path Burkina Faso went through during the period from 2019 to 2022. Specifically, we dive into the topic through a macroeconomic overview of Burkina Faso 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, Burkina Faso demonstrated a low level of economic growth with an average annual GDP growth rate of 1.91% between 2019 and 2022, with an increased economic complexity compared to other major emerging economies.

The mixed progress during the period, we believe, can be partially explained through the analysis of the economic and product complexity structure of Burkina Faso 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 Burkina Faso regressed in developing most of its industries during the period while its/emerging counterparts and economies around the globe also adopted complex and progressive paths with variable degrees of success.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups, Burkina Faso could further its gains by prioritizing Energy Drilling and Mining, Metals, and Textiles in 2022. We further note that Burkina Faso 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 0.002716 in 2022. Since a significant positive correlation exists between GDP growth and the structural optimality index of an economy as we define and calculate, Burkina Faso 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 Burkina Faso'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 Burkina Faso 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 Burkina Faso 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 Burkina Faso 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 Burkina Faso, 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 Burkina Faso and its peer countries (Nigeria, Ethiopia, and Togo) from 2019 to 2021. Similar to the other countries, Burkina Faso displayed a drop in GDP from 2019 to 2020 because of the pandemic, with all GDPs rebounding in 2021. Over these three years, Burkina Faso's average annual GDP growth rate (1.91%) is the lowest, as it is less than Nigeria's (3.43%), Ethiopia's (5.77%), and Togo's rates (3.43%).

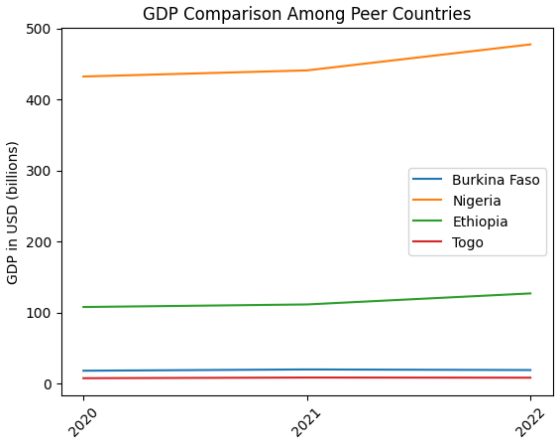
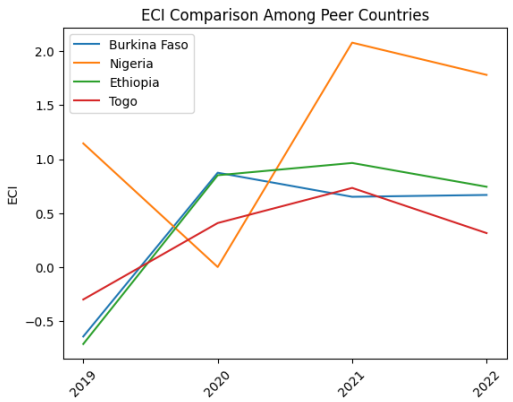


Figure 1. GDP Comparison Among Peer Countries 2019-2021

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 Figures 2a and 2b.

The comparable countries have a sharp change in ECI levels between 2019 and 2020, and level out from 2020 forward (excluding Nigeria). Burkina Faso exhibits a large increase in production capability in 2020, with participation in the International Monetary Fund's Extended Credit Facility being one of the reasons. Burkina Faso has seen a 204.08% increase in its ECI, which is similar to Ethiopia's (204.55%) and Togo's (205.18%) but greater than Nigeria's (55.39%).



Figures 2a and 2b. ECI Comparison Among Peer Countries (left: 2013-2018; right: 2019-2021)

Figure 3 offers a further comparison of GDP Growth and ECI over the time span from 2020 to 2022 for Burkina Faso. The GDP growth during the period from 2020 to 2022 is accompanied by a decrease in ECI. The ECI did not follow GDP trends, which can be interpreted as increased developments in already existing industries. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of Burkina Faso's production structure and its product space designs in the next few sections.

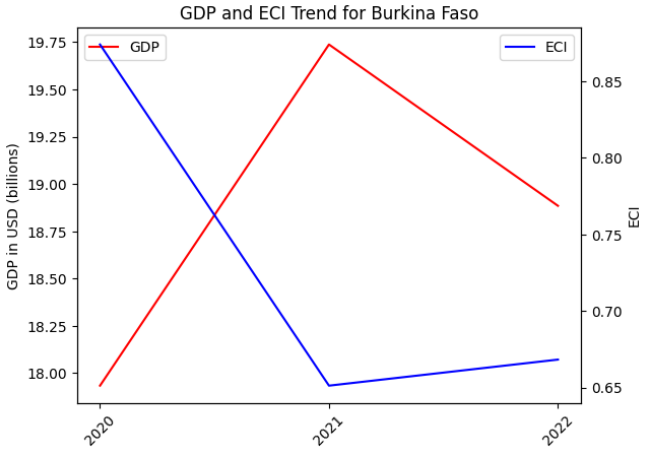


Figure 3. GDP Growth and ECI for Burkina Faso (left: 2013-2018; right: 2019-2021)

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 economics, as measured by GDP, tend to be those that are capable of producing and exporting High-complexity Products as we define them. Tables 2a and 2b show the OLS results in a universe of 107 and 21 typical countries respectively.

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

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

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

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

3.2 Realized Industry Development

Based on the aforementioned product categorization, we aim to capture Burkina Faso's realized industry production strategy between 2013 and 2021 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 Burkina Faso and the 18 product groups in 2021 and 2018 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	0.012358
Chemicals	-0.02544
Weapons	-0.00946
Wood Products	0.015585
Transportation	0.029002
Machinery and Construction	0.030353
Metals	0.004478
Raw Manufacturing	-0.01008
Services and Utilities	0.06661
Clothing and Accessories	0.009969
Chemical Manufacturing	-0.0187
Food and Preparations	0.011176
Textile	-0.0203
High-complexity Products	0.008756
Vegetables, Fruits and Plants	-0.00164
Animals and By-products	0.021719
Energy Drilling and Mining	0.016279
Precious Stones	0.039432

Table 3. Realized Industry Development (RID) of Burkina Faso

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 4a. RID Comparison across Leading Economies (2022)

Table 4b further examines Burkina Faso'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 4b. RID Comparison across Emerging Economies (2022)

4. Product Space Design

4.1 Suggested Development Vector

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

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

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 Burkina Faso 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 Burkina Faso 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:

$$\begin{aligned} \underset{x \in \mathbf{R}^{|P|}}{\text{Max}} \quad & (\frac{k(x) - < k(x) >}{stdev(k(x))})_C \\ \text{Subject to} \quad & \\ & \sum_{p \in P} x_p \leq B \\ & x \succcurlyeq 0 \end{aligned}$$

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:

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

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 Burkina Faso in 2022. We can see that for different percentages of heuristic total export growth, the ECIs of Burkina Faso actually have different increments. The 20% and 15% percentages were able to obtain similar ECI levels, whereas 5% and 10% obtained less.

To compare with the performance in 2013 and 2018, we also re-examine suggested strategies for 2021. For 2021, a 5 percent increase in export would emphasize Machinery and Construction, followed by Animals and By-products, and Energy Drilling and Mining for 10, 15, and 20 percent export growth. These strategies go in line with the suggested trajectories based on ECI. Though 15% and 20% were able to obtain similar ECIs, 15% obtained it by adding Animals and By-products, whereas Energy Drilling and Mining made up that proportion instead. A more detailed numerical representation of the portfolio for Burkina Faso is shown in Table 8c.

Figure 4. Greedy-Based ECI Improvement Results of Burkina Faso with Different Budgets (2021)

Burkina Faso (2022)				
Original ECI			**0.6682**	
Heuristic Export Growth	**5%**	**10%**	**15%**	**20%**
Animals and By-products	84397596.4	0	138105158	0

Energy Drilling and Mining	0	429660491	759578367	1132462293
Machinery and Construction	145777666	30690035	138105158	125829144
Increased ECI	**0.70547552**	**0.85804611**	**0.90462761**	**0.91223767**

Table 8. Portfolio of Burkina Faso (2022)

4.3 Sensitivity Analysis and Contingency Strategy

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

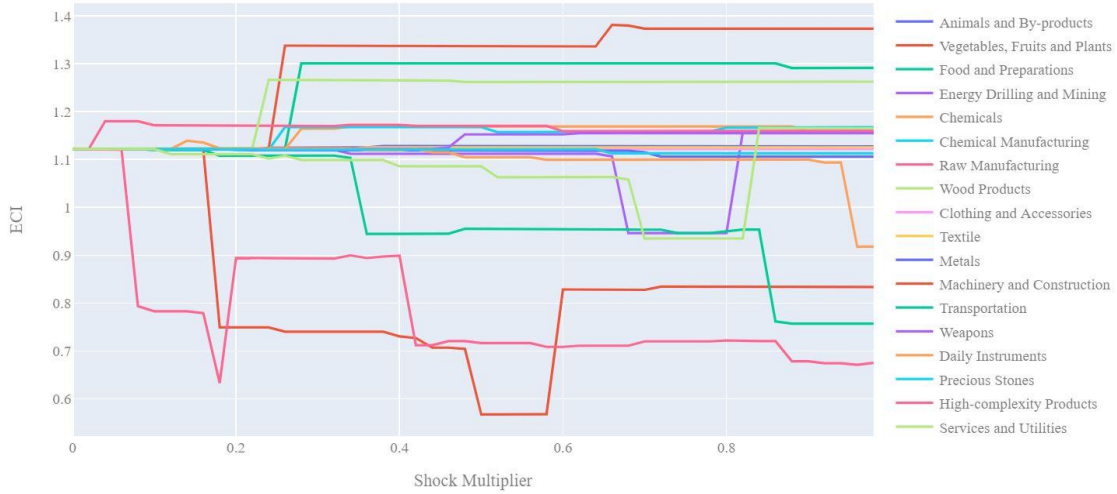


Figure 5. Sample ECI Sensitivity Graph (2018)

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 Burkina Faso's ECI Decremental and Incremental Sensitivity Charts for 2021. An increase in Energy Drilling and Mining will lead to the highest change in ECI, followed by Textiles. For the negative shock cases, Weapons becomes most impactful. The rest of the industries do not appear to have the same level of sensitivity.

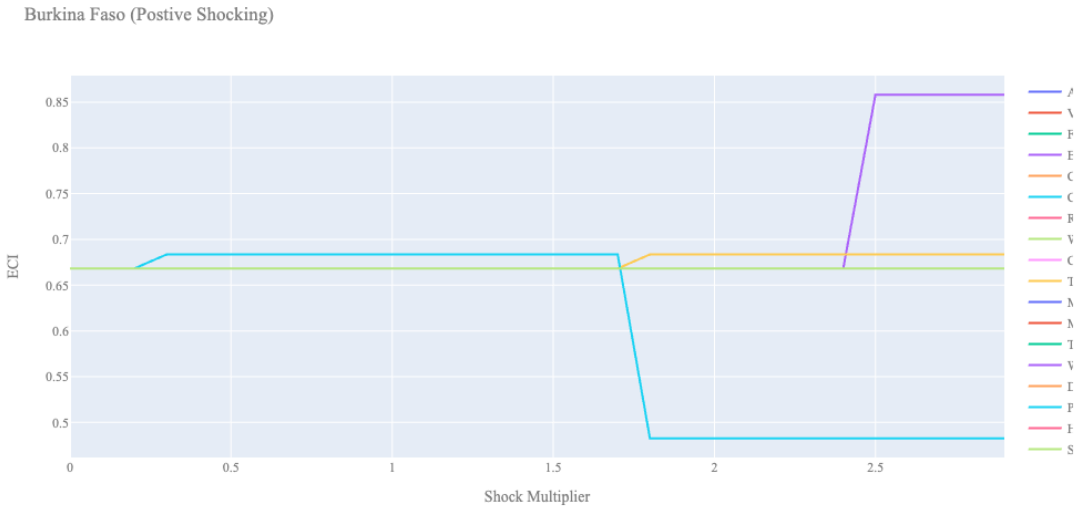


Figure 6a. Incremental ECI Sensitivity for Burkina Faso (2021)

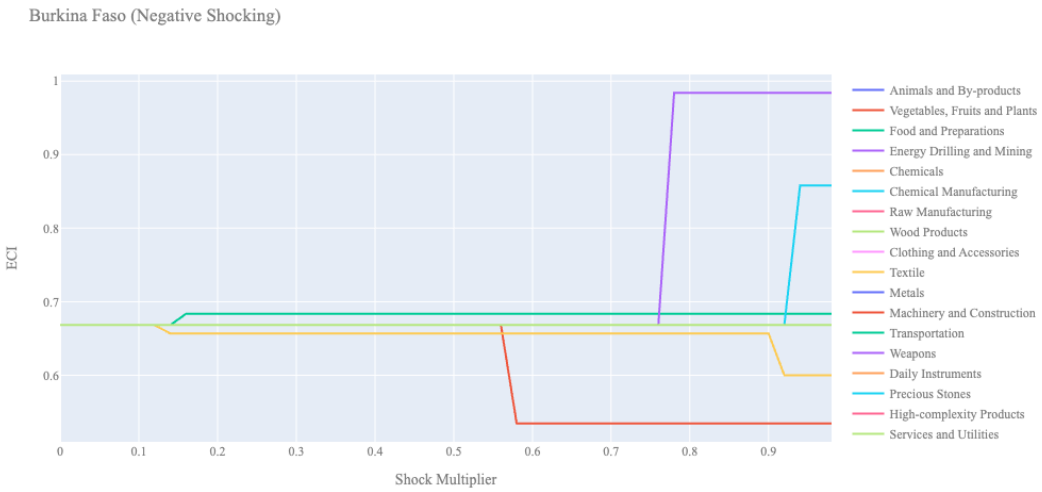


Figure 6b. Decremental ECI Sensitivity for Burkina Faso (2021)

Below we see the SDV sensitivity charts for Energy Drilling and Mining (Table 11). Burkina Faso's SDV is quite insensitive to changes in Energy Drilling and Mining since this does not

seem to be a key industry for the Burkina Faso 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 Energy Drilling and Mining.

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

Rank	Incremental	Decremental
1	High-complexity Products	High-complexity Products
2	Services and Utilities	Services and Utilities
3	Transportation	Transportation
4	Daily Instruments	Daily Instruments
5	Chemical Manufacturing	Chemical Manufacturing
6	Machinery and Construction	Machinery and Construction
7	Chemicals	Chemicals
8	Raw Manufacturing	Raw Manufacturing
9	Energy Drilling and Mining	Energy Drilling and Mining
10	Clothing and Accessories	Clothing and Accessories
11	Animals and By-products	Animals and By-products
12	Wood Products	Wood Products
13	Metals	Metals
14	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants
15	Weapons	Weapons
16	Precious Stones	Precious Stones
17	Food and Preparations	Food and Preparations
18	Textile	Textile
ECI	**0.6682431561**	**0.6682431561**

Table 11. Burkina Faso’s SDV Sensitivities for Energy Drilling and Mining (2022)

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

17	Food and Preparations	Food and Preparations
18	Textile	Textile
ECI	**0.6682431561**	**0.6682431561**

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

4.4 Contingency Strategy

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

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

Table 13. Burkina Faso's Contingency Strategy (2018)

5. Macro-level Predictions

5.1 Structural Optimality Index

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

After obtaining this measure for all countries in our database, we further regress countries' five-year economic growth, which is defined as the percent increase in GDP (USD), over their SOI. Figure 9 illustrates the regression output, which shows a strong positive correlation between countries' SOI and their five-year GDP growth, significant at the 15.7% level and achieving an adjusted R^2 of 56.6%. In other words, the more a country develops, as suggested by calculations on a complexity level, the better economic outcomes it achieves.

Table 14: OLS Regression Results	
Dep. Variable: GDP	**F-Statistic:** 4.920
R^2: 0.711	**Prob (F-Stat):** 0.157
Adj R^2: 0.566	**No. Observations:** 4

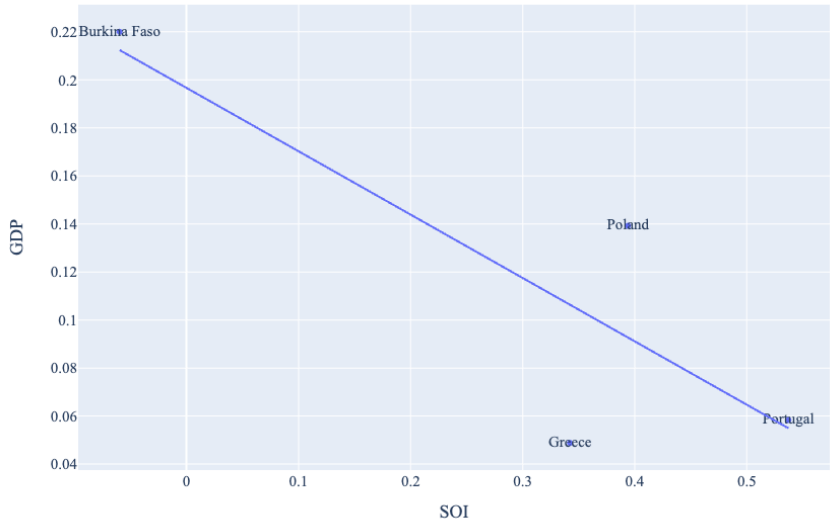


Figure 9. Regression of Five-Year GDP Growth over SOI (2019-2022)

5.2 SOI of Burkina Faso and Its Implications

During the first examined period, Burkina Faso, 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), Burkina Faso demonstrates a low level of correlation with the suggested developmental path, having an adjusted R-square of around 0.002716.

For the 2019-2021 years, Burkina Faso has a strong presence in the Precious Stones and Services and Utilities industries, which Precious Stones presents a good opportunity for further investment, whereas Services and Utilities seems to be overdeveloped when considering their lower opportunity gain relative to RID. It also could consider Energy Drilling and Mining, Metals, and Textiles to improve its growth. Burkina Faso has seen an average growth in GDP over those three years of 1.91%.

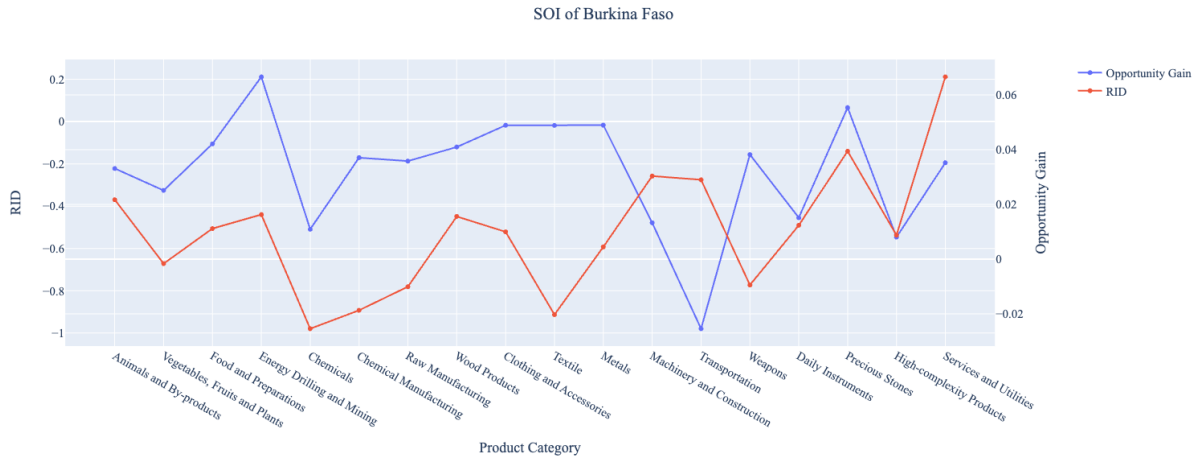


Figure 10b. SOI of Burkina Faso (2019-2022)

6. Concluding Remarks

In conclusion, Burkina Faso has demonstrated a low level of economic growth in terms of annual GDP increase during the period from 2019 to 2022, concurrent with an increase in economic complexity as compared with major developed 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 Burkina Faso 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 Burkina Faso 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 2013-2018, Burkina Faso can further its gains by prioritizing Energy Drilling and Mining, Metals, and Textiles.. We further note that Burkina Faso 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 0.2716%. Since a significant low correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Burkina Faso 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 2021, Burkina Faso performed much weaker than before and compared to other countries, particularly Ethiopia. We infer that during the COVID-19 period, Burkina Faso focused on developing lower complexity industries, in line with lower demand for these industries given the global economic downturn. The ECI suggests that greater growth could have been achieved through High-complexity Products and Transportation. With the revised focus, Burkina Faso 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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