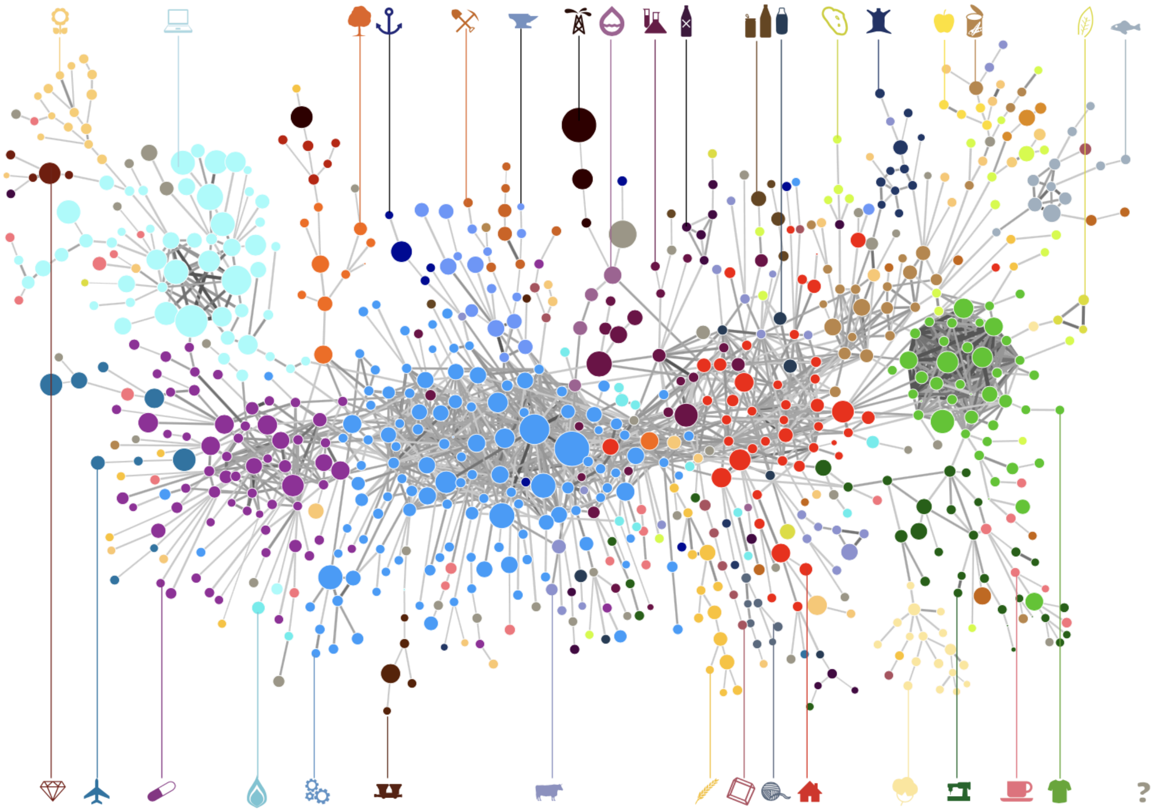

https://atlas.cid.harvard.edu/

Optimal Industry Development Strategy Using Economic and Product Complexity

Vietnam

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The Economic Complexity Lab - Columbia University

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Optimal Industry Development Strategy for Vietnam

0. Executive Summary

In this report, we aim to uncover the economic path Vietnam went through during the period from 2019 to 2022, including the impacts of the COVID-19 pandemic. Specifically, we dive into the topic through a macroeconomic overview of Vietnam 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, Vietnam demonstrated a moderate level of economic growth with an average annual GDP growth rate of 5.28% between 2019 and 2022, but with a decreased economic complexity; a trend consistent with other lower-middle income economies.

The mixed progress during the period, we believe, can be partially explained through the analysis of the economic and product complexity structure of Vietnam on the industry group level, as well as the improved 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 Vietnam regressed in developing most of its industries during the period while its developed 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, Vietnam could further its gains by prioritizing Food and Preparations, Animals and By-products, and Precious Stones in 2022. We further note that Vietnam has a slightly mismatched development strategy that indicates an above-average level (compared to other developed countries) of structural optimality on the complexity level, having an adjusted R-square of around 16.7% in 2022. Since a significant positive correlation exists between GDP growth and the structural optimality index of an economy as we define and calculate, Vietnam's relatively high optimality level may in part account for its continued GDP growth during the pandemic. Still, Vietnam has the potential to further its economic gains through industrial structure optimization as suggested in the paper.

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

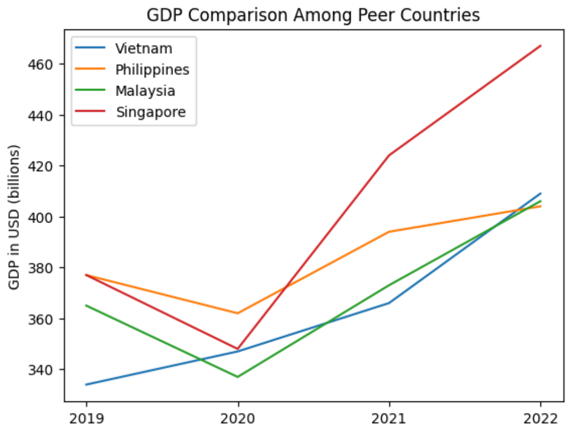
1. Report Overview

In this report, we aim to uncover the economic path Vietnam went through during the period from 2019 to 2022, including the COVID-pandemic. Specifically, we dive into the topic through a macroeconomic overview of Vietnam 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 Vietnam 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 Vietnam, 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 illustrates the time-series GDP results for Vietnam and three of its peer countries, the Philippines, Malaysia, and Singapore, from 2019 to 2022. Unlike the other countries, Vietnam displayed a constant upward trend over this period, including in 2020 despite COVID-19. Vietnam's average annual GDP growth rate 5.28%, which puts it lower than Singapore's 6.07% but higher than Malaysia's 2.96% and the Philippine's 1.85%.

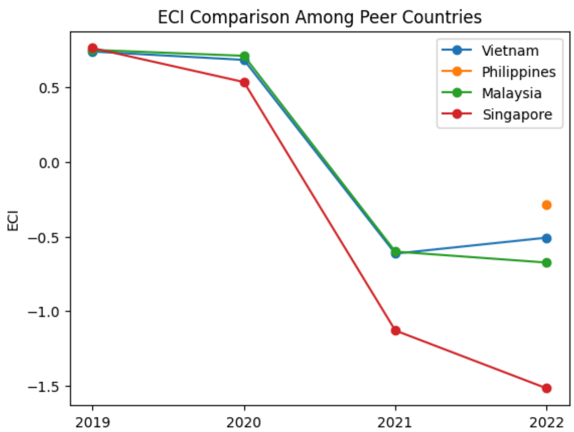


Figures 1. GDP Comparison Among Peer Countries (2019-2022)

2.2 ECI Ranking and Changes

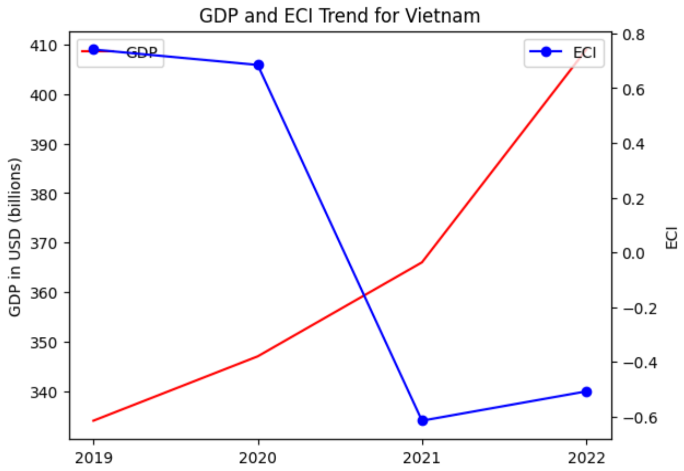
The Economic Complexity Index (ECI), as defined by Ricardo Hausmann and Cesar Hidalgo in 2009 to explain the knowledge accumulated in a country's population, is illustrated in Figures 2.

As shown, Vietnam exhibits a large decrease in production capability from 2019 to 2022. Vietnam and its peers are in a weak position relative to the rest of the world in terms of ECI. Vietnam, Malaysia, and Singapore all saw precipitous ECI drops after 2020 and have yet to recover. Still, Vietnam's change of-168% is not quite as bad as Singapore's -299%, or Malaysia's -190%. These decreases in ECI may be explained by the detrimental impact of COVID-19 on specific industries such as accommodation and food services, and manufacturing.



Figures 2. ECI Comparison Among Peer Countries (2019-2022)

Figures 3 offer a further comparison of GDP Growth and ECI over the time span from 2019 to 2022 for Vietnam. The GDP growth is opposed by a decrease in ECI. The results show that the COVID-19 pandemic allowed Vietnam to increase its GDP, but did so through exports with lower diversity and higher ubiquity. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of Vietnam's production structure and its product space designs in the next few sections.



Figures 3. GDP Growth and ECI for Vietnam (2019-2022)

3. Production Analysis

3.1 Product Categorization

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

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

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

Table 1. Categorization of Products

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

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

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

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

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

3.2 Realized Industry Development

Based on the aforementioned product categorization, we aim to capture Vietnam's realized industry production strategy between 2019 and 2022 on a complexity level. In Hausmann and Hidalgo (2009), distance is defined to be a measure of how far a country is from a certain product, not in its product space. We extend this concept to all product groups and quantify how technically equipped a country is to develop the corresponding product groups. In other words, the shorter the distance between a country and a product group, the more capable a country is of developing products within that group. Defining this net distance change as the Realized Industry Development (RID), our export data allow us to calculate and compare the RID of Vietnam 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)
Raw Manufacturing	-0.02221
Weapons	-0.02235
Clothing and Accessories	-0.00626
Daily Instruments	-0.02436
Transportation	0.01074
High-complexity Products	0.04978
Chemicals	0.01413
Machinery and Construction	-0.04673
Textile	-0.00563
Metals	-0.01008
Services and Utilities	-0.01596
Food and Preparations	0.00075
Precious Stones	-0.01681
Animal and By-products	0.00177
Energy Drilling and Mining	-0.03033
Vegetables, Fruits and Plants	-0.01885
Chemical Manufacturing	-0.00487
Wood Products	0.03093

Table 3. Realized Industry Development (RID) of Vietnam

3.3 Regional and Global Comparison

Table 4a below summarize the production strategy adopted by selected leading economies in the world across different years, 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 Services and Utilities, Energy Drilling and Textiles in 2022.

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 & Construction	Clothing & Accessories	Clothing& Accessories
5	Animals and By-products	Wood Products	Transportation

Table 4a. RID Comparison across Leading Economies (2022)

Table 4b examines Vietnam'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, showing moderate shifts in strategies over the course of three years.

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

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.

Ranking	Vietnam	Malaysia	Phillipines	Singapore
1	Energy Drilling and Mining	Services and Utilities	High-complexity Products	Chemicals
2	Food and Preparations	Chemical Manufacturing	Services and Utilities	Transportation
3	Services and Utilities	High-complexity Products	Chemical Manufacturing	Daily Instruments
4	Precious Stones	Precious Stones	Daily Instruments	Precious Stones
5	High-complexity Products	Chemicals	Machinery and Construction	Services and Utilities
6	Chemical Manufacturing	Vegetables, Fruits and Plants	Chemicals	Chemical Manufacturing
7	Weapons	Animals and By-products	Weapons	Machinery and Construction
8	Chemicals	Machinery and Construction	Raw Manufacturing	High-complexity Products
9	Machinery and Construction	Wood Products	Vegetables, Fruits and Plants	Weapons
10	Metals	Textile	Food and Preparations	Raw Manufacturing
11	Animals and By-products	Food and Preparations	Transportation	Wood Products
12	Vegetables, Fruits and Plants	Energy Drilling and Mining	Wood Products	Clothing and Accessories
13	Raw Manufacturing	Raw Manufacturing	Metals	Metals
14	Wood Products	Metals	Clothing and Accessories	Textile
15	Clothing and Accessories	Transportation	Animals and By-products	Energy Drilling and Mining
16	Textile	Weapons	Precious Stones	Food and Preparations
17	Transportation	Daily Instruments	Textile	Animals and By-products
18	Daily Instruments	Clothing and Accessories	Energy Drilling and Mining	Vegetables, Fruits and Plants
ECI	**-0.507357**	**-0.674383**	**-0.287451**	**-1.517921**

Table 5. 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. Table 5 summarize how the SDV of Vietnam 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 Services and Utilities industries. It can be concluded that Vietnam shares the characteristics of developing countries, with a balanced economic structure that leans towards more complex industries. Given that its ECI has decreased over the past four years, there remains significant room for improvement.

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

Table 6. SDV of Other Sample Countries (2013)

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:

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

$$\text{Subject to}$$

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

$$x \succcurlyeq 0$$

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

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

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

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

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

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

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

Economic Panel
As stated above, the enhanced greedy algorithm is developed mainly for solving the optimal allocation strategy. In order to visualize this allocation, an economic panel is created, consisting of a pie chart, a line chart and a table. First, a pie chart is used to show the percentage of each product in the optimal portfolio. The number located in the center of the circle denotes the heuristic growth of total export, which is also our budget. Each category in the chart has a determined percentage of the allocated budget. The lines below the pie charts show how the ECI changes during the searching process of the greedy algorithm. Even though sometimes an increase of the export by 15% or 20% does not seem reasonable to developed countries, 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 Vietnam in 2022. We can see that for different percentages of heuristic total export growth, the ECIs of Vietnam have highly varied industry distributions.

For 2022, in the case of 5 percent export growth, Food and Preparations and Animals and By-Products dominate, accounting for almost 90% of the budget. With a budget of 10 percent export growth, Precious Stones is the primary industry, with Food and Preparations as a secondary industry. For 15% and 20%, Food and Preparations and Precious Stones continue to hold the top two spots, while the other halves of the budgets are spread across various industries. These smaller industries include Animals and By-Products, Raw Manufacturing, and Textile. This suggests that the optimal products to invest into are dependent on the expected export growth. Given Vietnam's average GDP growth, Food and Preparations and Precious Stones seem to be the best industries to allocate resources towards. A more detailed numerical representation of the portfolio is shown in Table 8a. The increased ECI row of the table suggests that any increases in 10% and 15% yield the similar increases in ECI, while 5% is significantly worse, and 20% is significantly better, but less likely. This means that Vietnam should focus on 10%. Thus, for optimal development, it should invest firstly in Precious Stones, followed by Food and Preparations and Animals and By-Products.

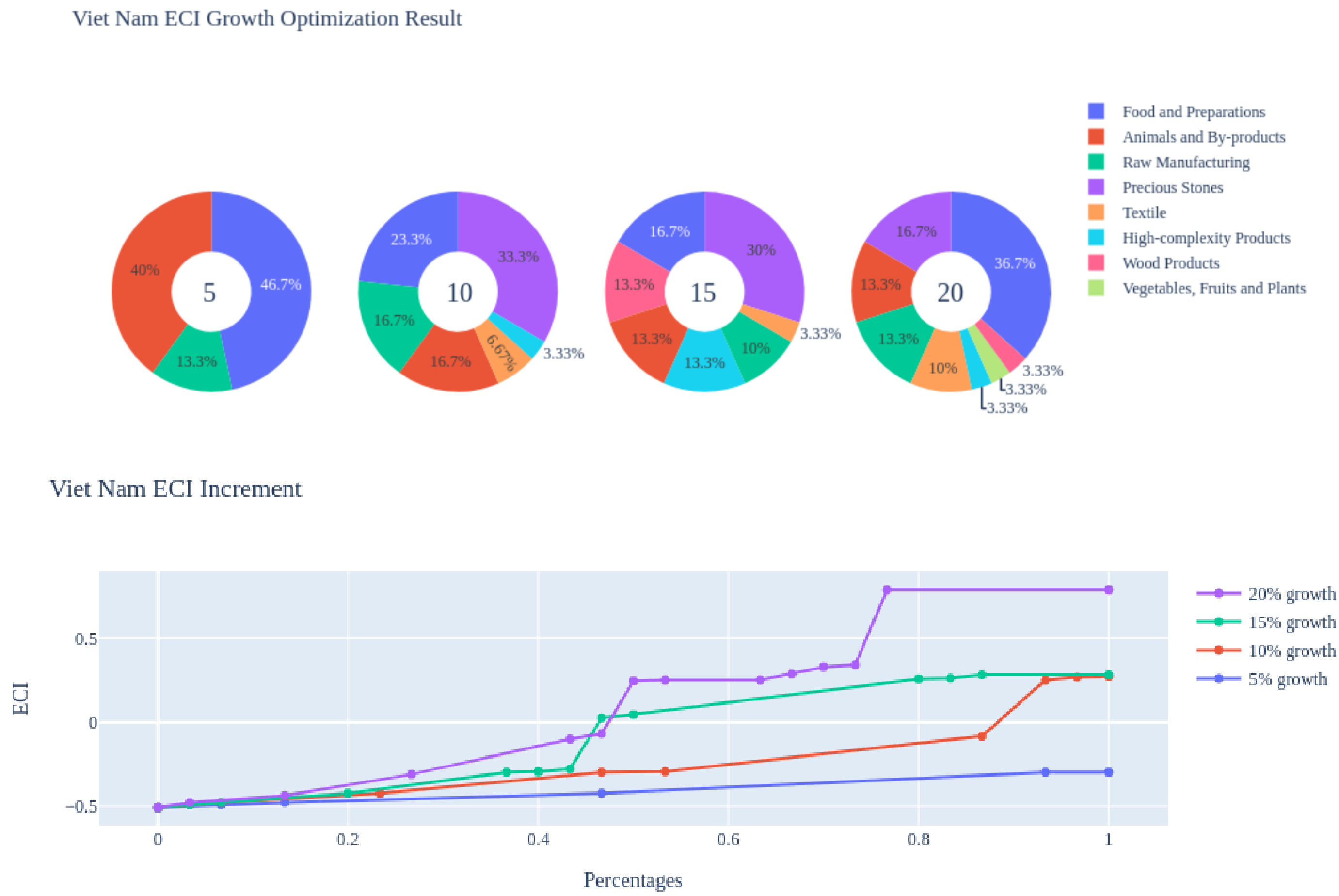


Figure 4. Greedy-Based ECI Improvement Results of Vietnam with Different Budgets (2022)

Vietnam (2022)				
Original ECI		**-0.507357**		
Heuristic Export Growth	**5%**	**10%**	**15%**	**20%**

Animals and By-products	1.13E+10	1.29E+10	2.04E+10	1.72E+10
Vegetables, Fruits and Plants	0.00E+00	0.00E+00	0.00E+00	4.30E+09
Food and Preparations	1.32E+10	1.80E+10	2.55E+10	4.73E+10
Raw Manufacturing	3.78E+09	1.29E+10	1.53E+10	1.72E+10
Wood Products	0.00E+00	0.00E+00	2.04E+10	4.30E+09
Textile	0.00E+00	5.16E+09	5.09E+09	1.29E+10
Precious Stones	0.00E+00	2.58E+10	4.58E+10	2.15E+10
High-complexity Products	0.00E+00	2.58E+09	2.04E+10	4.30E+09
Increased ECI	**-0.2975581694**	**0.2722269482**	**0.2818825559**	**0.7863401772**

Table 8a. Portfolio of Vietnam (2022)

4.3 Sensitivity Analysis

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

ECI Sensitivity Graph

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

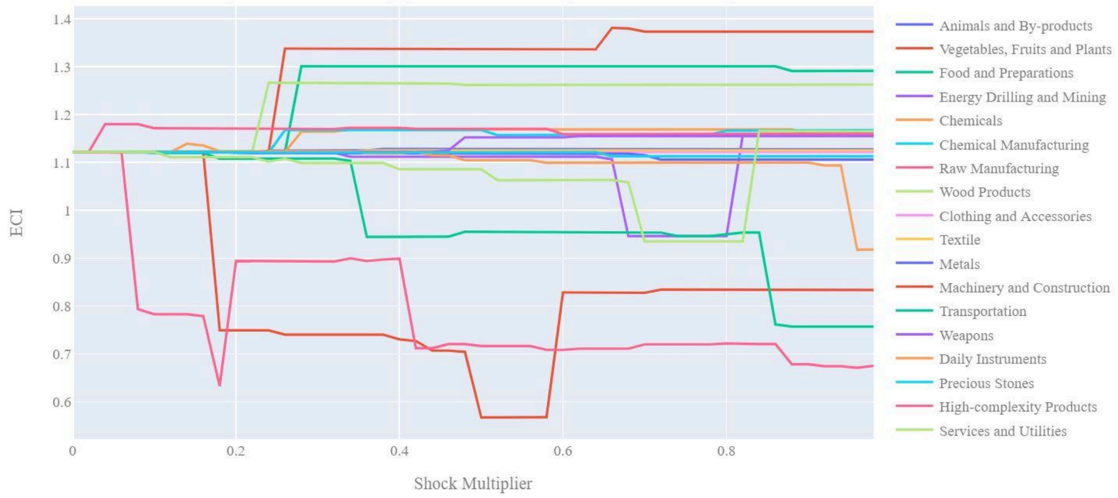


Figure 5. Sample ECI Sensitivity Graph (2018)

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

4.3 Sensitivity Analysis Results and Interpretation

We examine Vietnam's ECI Decremental and Incremental Sensitivity Charts for 2022. An increase in Precious Stones will lead to the highest change in ECI, followed by Food and Preparations and Animals and By-Products. The significance of Chemicals and Clothing and Accessories, not captured in the greedy algorithm, suggests that these are also critical to increasing ECI and consequently developing Vietnam's economy. Food and Preparations also shows a significant impact on ECI given a positive shock, which is consistent with previous analyses. For the negative shock cases, Metals and Machinery and Mining appear to be most important. The rest of the industries do not appear to have the same level of sensitivity. This suggests that even in economic downturns, Vietnam should continue to invest in Metals and Machinery and Mining to avoid additional decreases in ECI.

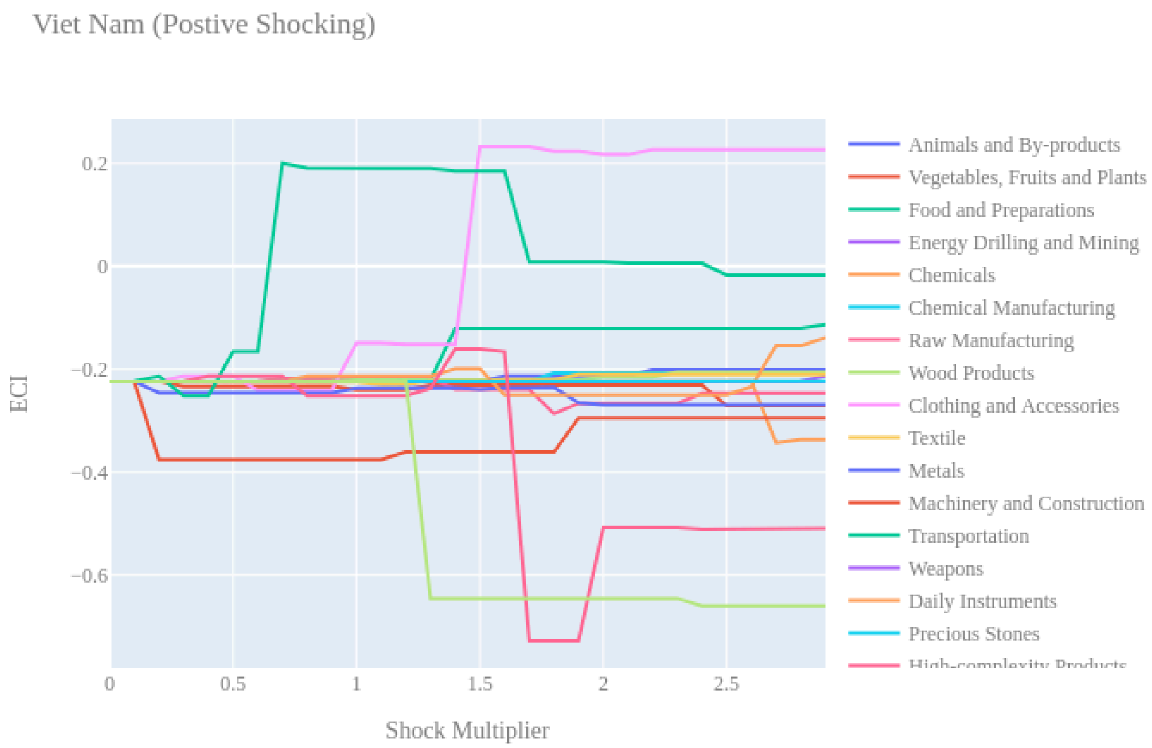


Figure 6a. Incremental ECI Sensitivity for Vietnam (2022)

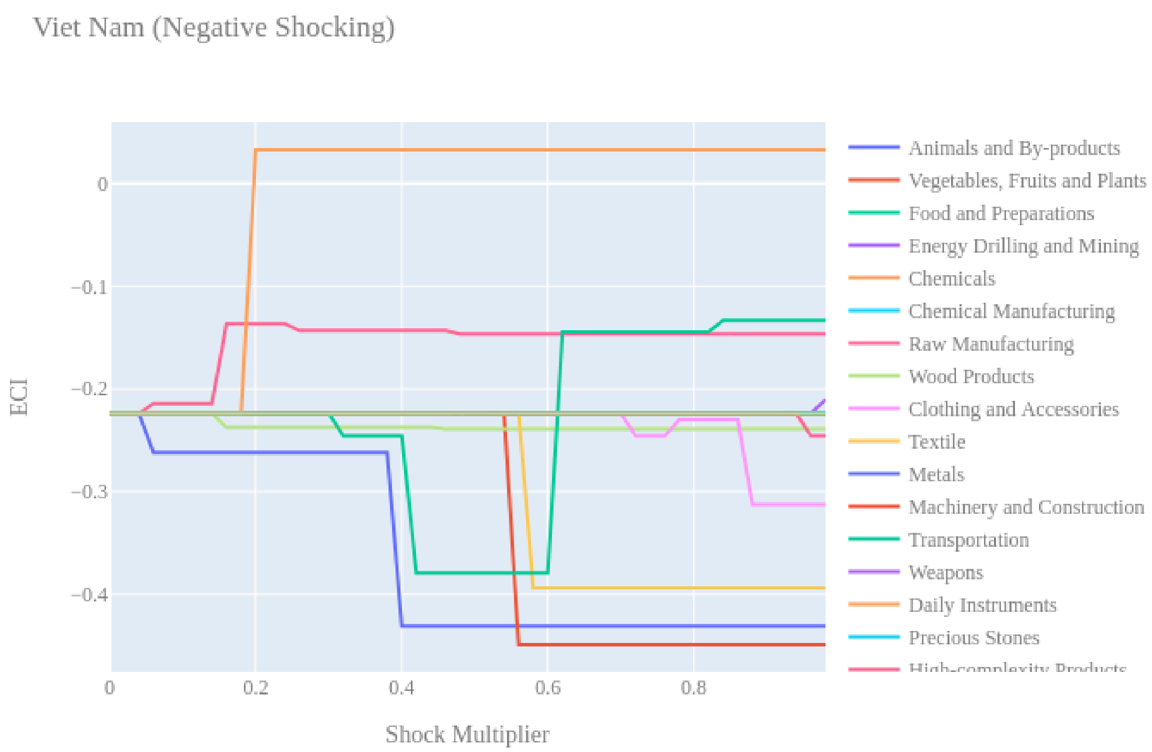


Figure 6b. Decremental ECI Sensitivity for Vietnam (2021)

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 5.4% level and achieving an adjusted R^2 of 4.5%. In other words, the more a country develops, as suggested by calculations on a complexity level, the better economic outcomes it achieves.

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

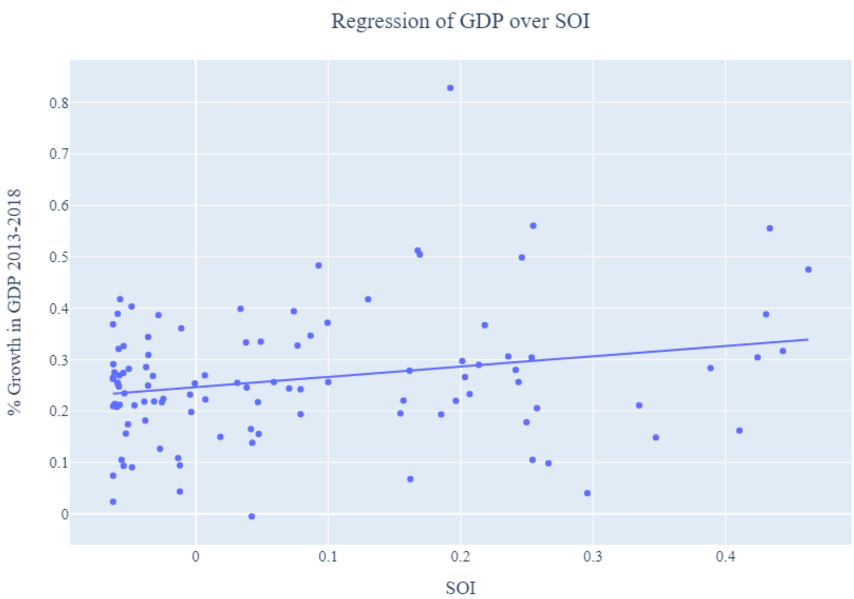


Figure 9. Regression of Five-Year GDP Growth over SOI (2013-2018)

5.2 SOI of Vietnam and Its Implications

During the first examined period, Vietnam, for instance, has an elevated level of structural optimality as compared with its developing 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), Vietnam demonstrates an above-average level of correlation with the suggested developmental path, having an adjusted R-square of around 16.7%.

Vietnam ranks well among all countries in terms of SOI and has made a strong rate of economic progress among its emerging peers from 2019 to 2022 with a 5-year GDP growth rate of 5.28%, which is consistent with the regression result in Figure 4b. Specifically, Vietnam's slow economic progress from 2019-2022 can be at least partially explained by a development strategy that demonstrates a considerable but not perfect level of matches with our suggested developmental path. In specific, Vietnam invested heavily in High Complexity Products, while it should have focused more on industry groups such as Precious Stones.

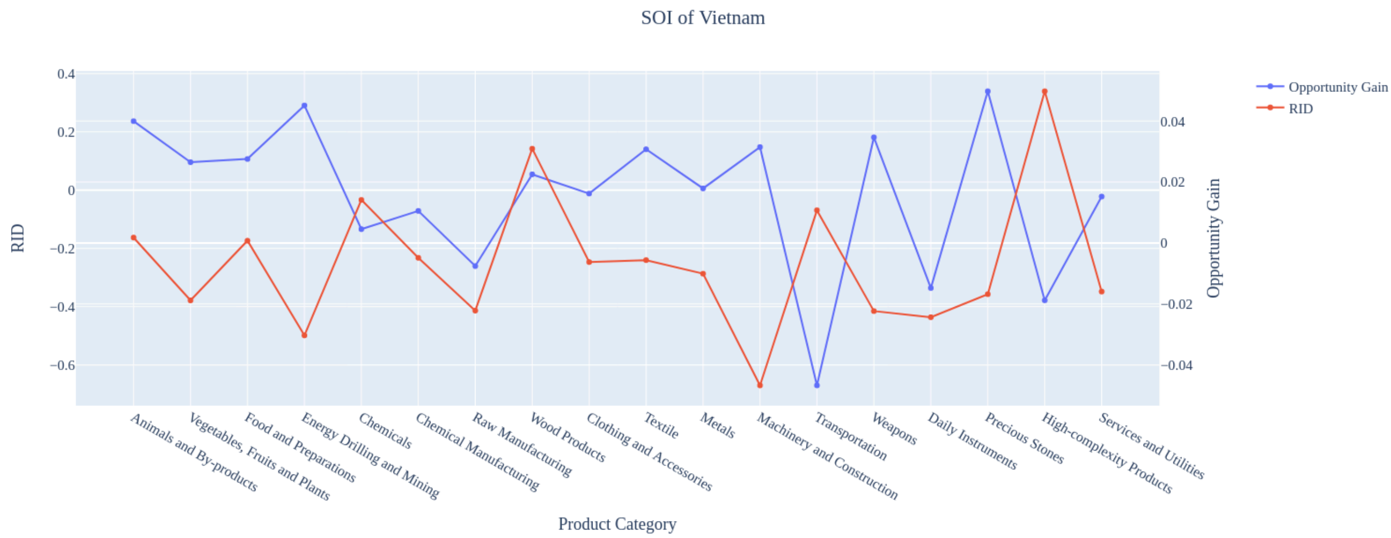


Figure 10a. SOI of Vietnam (20 19-2022)

6. Concluding Remarks

In conclusion, Vietnam has demonstrated a moderate level of economic growth in terms of annual GDP increase during the period from 2019 to 2022, while its ECI has followed an inverse trend, falling sharply after 2020, in a similar pattern to other lower-middle income countries.

We believe that the mixed progress during this period can be partially explained through the analysis of the economic and product complexity structure of Vietnam 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 Vietnam regressed in developing most of its industries during the period. Despite its overall loss of economic complexity, Vietnam's ECI has shown a slight uptick recently, which indicates that they may be on track to recovering to pre-pandemic levels, assuming they target the correct industries.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups for 2019-2022, Vietnam can further its gains by prioritizing Precious Stones, Food and Preparations, and Animals and By-Products. We further note that Vietnam has a slightly mismatched development strategy that indicates an above-average level (compared to other developing countries) of structural optimality on the complexity level, having an adjusted R-square of around 16.7%. Since a positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, this relatively high level of optimality may in part explain why Vietnam's GDP fared better than most other countries in 2020. Still, there is the potential to further its economic gains through industrial structure optimization as suggested in the paper.

We infer that during the COVID-19 period, Vietnam sacrificed economic complexity, making less diverse and more ubiquitous exports, in exchange for maintaining its GDP in the short-term. To continue their growth, Vietnam's allocation of resources should remain similar; there are a couple industries where spending should be significantly reduced, but this money can be reallocated to all other industries in roughly the current ratio. With the revised focus, Vietnam has further potential to advance its economic growth to maintain its position among other countries to continue its ongoing economic expansion.

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