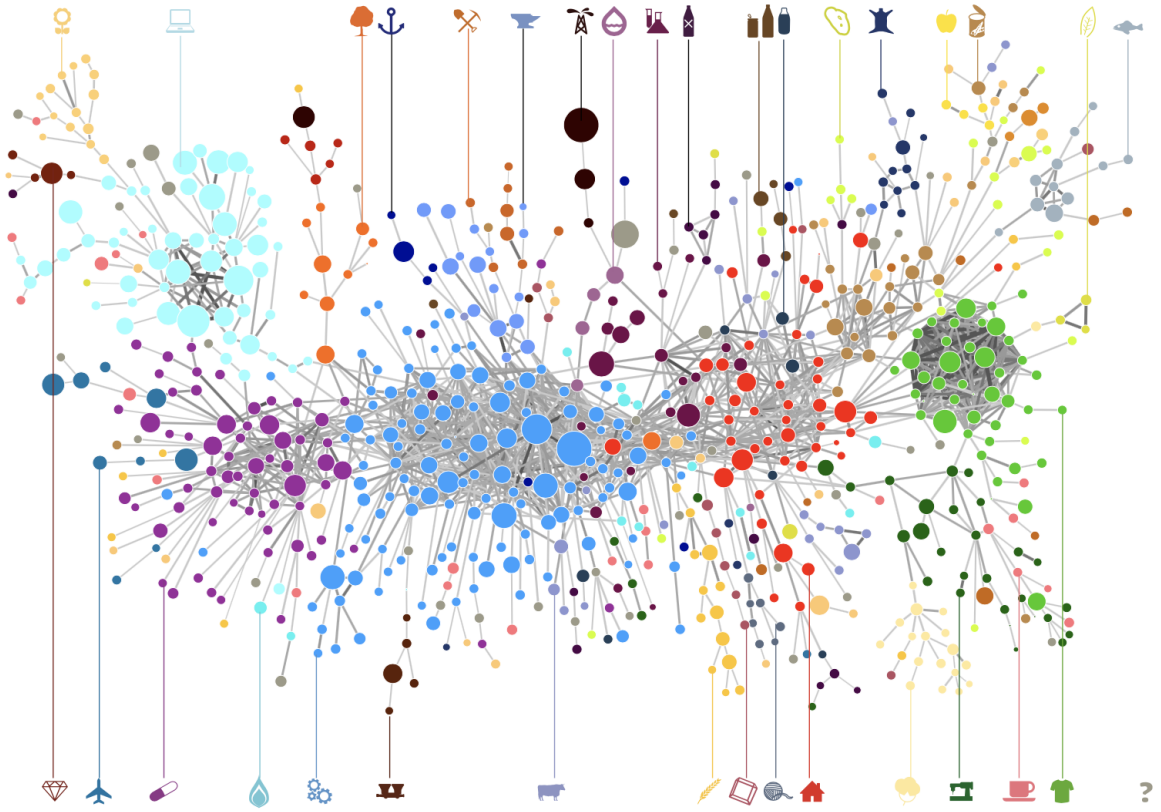

https://atlas.cid.harvard.edu/

# Optimal Industry Development Strategy Using Economic and Product Complexity

# Sweden

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# Optimal Industry Development Strategy for Sweden

## 0. Executive Summary

In this report, we aim to uncover the economic path Sweden went through during the period from 2013 to 2021. Specifically, we dive into the topic through a macroeconomic overview of Sweden 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, Sweden demonstrated a moderate level of economic growth with an average annual GDP growth rate of 3.44% between 2013 and 2018 and 5.77% between 2019 and 2021, concurrent with a decrease in economic complexity, similar to other developed economies.

The lack of progress during the period, we believe, can be partially explained through analysis of the economic and product complexity structure of Sweden 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 Sweden consistently relied on developing the Services and Utilities in 2013-2018 and Animal By-products in 2019-2021 and Machinery and Construction industries in both periods, 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 a sensitivity analysis of major industry groups, Sweden can further its gains by prioritizing High-Complexity Products and Transportation in 2018. Three years later, in 2021, its focus should have shifted to Energy, Drilling, and Mining, which was a more developed industry at the time. We further note that Sweden has a slightly mismatched development strategy that indicates a low level (compared to other developed countries) of structural optimality on the complexity level, having an adjusted R-square of around 0.516% in 2018 and 1.6% in 2021, demonstrating an improvement in development. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Sweden 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 following showed a mixed progress in Sweden's economic growth. Its GDP continued to grow, albeit at a slower pace, but it saw a significant decline in the ECI, similar to other peer countries. Its current strategy still has the viable potential to increase its performance and optimize its structure further.

# 1. Report Overview

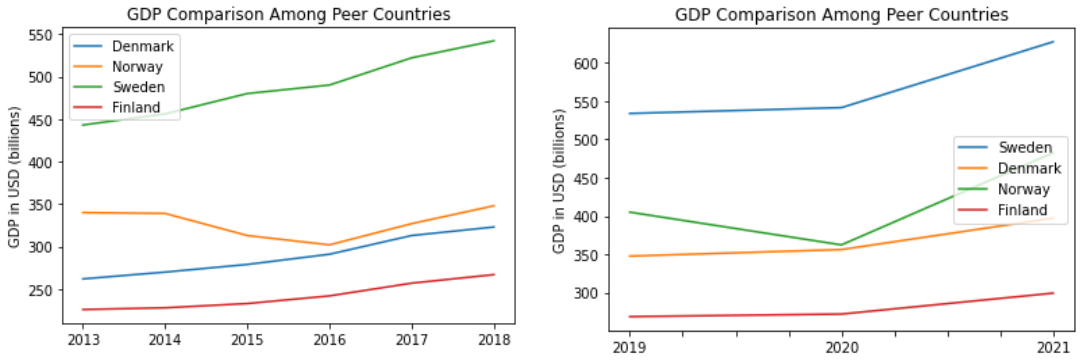
In this report, we aim to uncover the economic path Sweden went through during the period from 2019 to 2021, before and after the COVID pandemic, compared to its performance from 2013 to 2018. Specifically, we dive into the topic through a macroeconomic overview of Sweden from the perspective of Gross 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 Sweden during the period based on quantitative measures such as Product Complexity Index (PCI) and Product Family Complexity Index (PfCI), followed by a detailed analysis of how such changes have matched with development strategies as quantitatively measured by opportunity gains on an industry-level. We conclude our report with macro-level results and predictions of Sweden, 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 1a illustrates the time-series GDP results for Sweden and three of its peer countries (Norway, Sweden, Finland) from 2013-2018. Sweden displays consistent, upward growth over the period, which is similar to Finland and Sweden, but different from the volatile, up-and-down GDP growth of Norway. Sweden is in the upper tier of average annual GDP growth rate among its Scandinavian peers; its AAGR of 3.44% is clearly above that of Norway (0.54%) and Finland (2.84%) and comparable to that of Sweden (3.57%).

Figure 1b shows the GDP levels for Sweden and the same 3 peer countries from 2019 to 2021. Similar to the other countries, Sweden displayed little change in GDP between 2019 and 2020 with all GDPs rebounding in 2021. Over these three years, Sweden had moderate average annual GDP growth rate of 5.77% compared to Denmark (4.66%), Norway (7.55%), and Finland (3.76%).



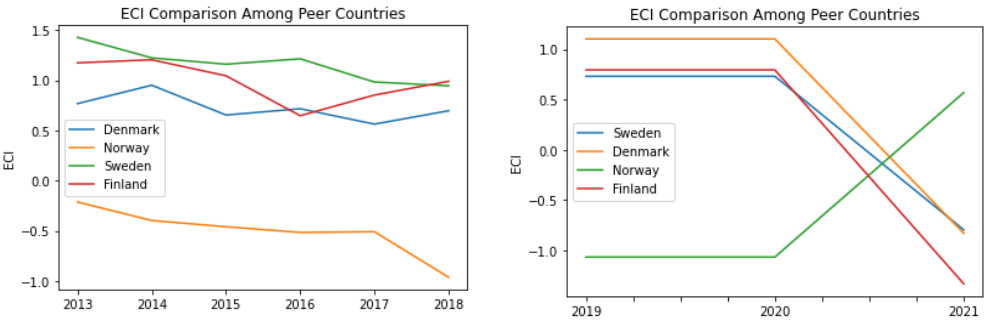

Figures 1a and 1b. GDP Comparison Among Peer Countries (left: 2013-2018; right: 2019-2021)

## 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.

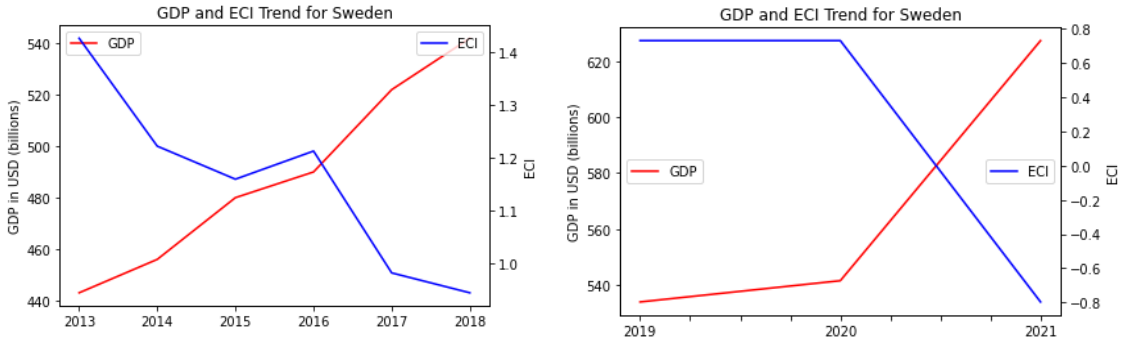
Similar to the rest of its Scandinavian peers, Sweden exhibits a decrease in terms of its production capability from 2013 to 2018; this decrease (-33.82%) is noticeably lower than that of Norway (-351.33%) and clearly larger than that of Sweden (-9.25%) and Finland (-15.68%).

The comparable countries maintain a small change in ECI level between 2019 and 2020, with a sharp change between 2020 and 2021. Sweden exhibits a significant decrease in production capability in 2021, perhaps the result of its laissez-faire approach to pandemic economics. Sweden has seen a -209% decrease in its ECI, which is less drastic than Finland's (-267%), but worse than Denmark (-175%) and Norway (153%).




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

Figure 3a and 3b offers a further comparison of GDP Growth and ECI over the time span from 2013 to 2021 for Sweden. The increase in GDP growth during the period from 2013 to 2018 is accompanied by a decrease in ECI. We observe similar behavior in 2019 to 2021. The results show that the economic growth experienced by Sweden during the period from 2013 to 2021 is not very consistent with the predictions by ECI and that Sweden regressed in effectively developing a competitive product space that helps to accumulate complicated knowledge and technology. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of Sweden's production structure and its product space designs in the next few chapters.




Figures 3a and 3b. GDP Growth and ECI for Sweden (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 labelled from 010000-999999, with the first two-digits representing a general category to which the product belongs. Based on the 99 categories as extracted from the label, we further group the products into 18 most widely-accepted industries, as summarized in Table 1.

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

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

Table 1: Categorization of Products

We further observe a positive correlation between the GDP and the export of High-complexity Products. A higher adjusted R-square exists between GDP and High-complexity Products exports, indicating that more successful economics, as measured by GDP, tend to be those that are capable of producing and exporting High-complexity

Products as we define them. The Figure 3 and 4 show the OLS results in a universe of 107 and 21 typical countries respectively.

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

Figure 3: OLS Regression Results of GDP against Percentage Volume of Exports

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

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

### 3.2 Realized Industry Development

Based on the product categorization aforementioned, we aim to capture Sweden'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 in developing products within that group. Defining this net distance change as the Realized Industry Development (RID), our export data allow us to calculate and compare the RID of Sweden 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. It is notable that the number of industries with positive RID has increased from 2 to 17 from 2018 to 2021.

| Category | RID |
|---|---|
| Daily Instruments | -0.067471 |
| Wood Products | -0.066058 |
| Transportation | -0.063235 |
| Animals and By-products | -0.053071 |
| Textile | -0.048206 |
| Vegetables, Fruits and Plants | -0.042810 |
| High-complexity Products | -0.037505 |
| Energy Drilling and Mining | -0.035290 |
| Raw Manufacturing | -0.034899 |
| Food and Preparations | -0.034334 |
| Chemicals | -0.032798 |
| Precious Stones | -0.017838 |
| Clothing and Accessories | -0.017477 |
| Metals | -0.014987 |
| Chemical Manufacturing | -0.006544 |
| Weapons | -0.005280 |
| Machinery and Construction | 0.041436 |
| Services and Utilities | 0.077150 |

| Category | RID |
|---|---|
| Chemicals | -0.001530 |
| Wood Products | 0.000232 |
| Metals | 0.002633 |
| Weapons | 0.006583 |
| Vegetables, Fruits and Plants | 0.006788 |
| Transportation | 0.007435 |
| Chemical Manufacturing | 0.008777 |
| Textile | 0.011949 |
| Services and Utilities | 0.012558 |
| High-complexity Products | 0.014936 |
| Clothing and Accessories | 0.016797 |
| Raw Manufacturing | 0.017091 |
| Energy Drilling and Mining | 0.018734 |
| Food and Preparations | 0.020613 |
| Daily Instruments | 0.021722 |
| Precious Stones | 0.023933 |
| Machinery and Construction | 0.025720 |
| Animals and By-products | 0.034339 |

Table 2: Realized Industry Development (RID) of Sweden

### 3.3 Regional and Global Comparison

Tables 4a-4b below summarize how the production strategy adopted by Sweden compares with selected leading economies in the world across different years, as measured in RID. Leading economies such as France, the United States and Germany gave a considerable level of attention to more advanced product groups such as Weapons and High-Complexity Products in 2018 and Services and Utilities, Precious Stones, and High-Complexity Products in 2021.

| Ranking | France | the UK | Germany |
|---|---|---|---|
| 1 | High-complexity Products | Services and Utilities | High-complexity Products |
| 2 | Chemical Manufacturing | Weapons | Transportation |
| 3 | Daily Instruments | Raw Manufacturing | Wood Products |
| 4 | Animals and By-products | Precious Stones | Metals |
| 5 | Food and Preparations | Animals and By-products | Food and Preparations |

Table 4a. RID Comparison across Leading Economies (2018)

| Ranking | France | the UK | Germany |
|---|---|---|---|
| 1 | Services and Utilities | Precious Stones | Daily Instruments |
| 2 | Precious Stones | High-complexity Products | Transportation |
| 3 | High-complexity Products | Services and Utilities | Chemicals |
| 4 | Energy Drilling and Mining | Energy Drilling and Mining | Chemical Manufacturing |
| 5 | Machinery and Construction | Wood Products | Clothing and Accessories |

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

Tables 4c-4d further examine Sweden's development strategy against those of emerging economies on a global scale. Reasonably, emerging economies such as China, South Korea, and Singapore, have devoted the majority of their efforts to intermediate industry groups, showing drastic shifts in strategies over the course of three years.

| Ranking | China | South Korea | Singapore |
|---|---|---|---|
| 1 | High-complexity Products | Transportation | Transportation |
| 2 | Transportation | Textile | High-complexity Products |
| 3 | Machinery and Construction | High-complexity Products | Precious Stones |
| 4 | Energy Drilling and Mining | Chemical Manufacturing | Daily Instruments |
| 5 | Daily Instruments | Machinery and Construction | Services and Utilities |

Table 4c. RID Comparison across Emerging Economies (2018)

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

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

# 4. Product Space Design

## 4.1 Suggested Development Vector

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

| Ranking | Singapore | Japan | China | Germany | Republic of Korea | Sweden |
|---|---|---|---|---|---|---|
| 1 | Chemicals | Chemicals | Raw Manufacturing | Chemical Manufacturing | Services and Utilities | Energy Drilling and Mining |
| 2 | Transportation | Metals | Clothing and Accessories | Wood Products | Chemicals | Animals and By-products |
| 3 | High-complexity Products | Machinery and Construction | Textile | Metals | Raw Manufacturing | Chemical Manufacturing |
| 4 | Services and Utilities | Transportation | Machinery and Construction | Machinery and Construction | Textile | Raw Manufacturing |
| 5 | Machinery and Construction | Weapons | Transportation | Transportation | Metals | Wood Products |
| 6 | Daily Instruments | Daily Instruments | Weapons | Weapons | Transportation | Metals |
| 7 | Weapons | High-complexity Products | Daily Instruments | High-complexity Products | Daily Instruments | Machinery and Construction |
| 8 | Textile | Services and Utilities | High-complexity Products | Services and Utilities | High-complexity Products | High-complexity Products |
| 9 | Chemical Manufacturing | Precious Stones | Precious Stones | Energy Drilling and Mining | Weapons | Services and Utilities |
| 10 | Raw Manufacturing | Energy Drilling and Mining | Services and Utilities | Precious Stones | Energy Drilling and Mining | Vegetables, Fruits and Plants |
| 11 | Clothing and Accessories | Textile | Chemicals | Textile | Chemical Manufacturing | Weapons |
| 12 | Metals | Clothing and Accessories | Energy Drilling and Mining | Clothing and Accessories | Precious Stones | Precious Stones |
| 13 | Wood Products | Chemical Manufacturing | Chemical Manufacturing | Chemicals | Machinery and Construction | Textile |
| 14 | Precious Stones | Animals and By-products | Wood Products | Animals and By-products | Clothing and Accessories | Clothing and Accessories |
| 15 | Animals and By-products | Wood Products | Animals and By-products | Vegetables, Fruits and Plants | Wood Products | Food and Preparations |
| 16 | Food and Preparations | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Food and Preparations | Animals and By-products | Chemicals |
| 17 | Energy Drilling and Mining | Food and Preparations | Metals | Daily Instruments | Food and Preparations | Daily Instruments |
| 18 | Vegetables, Fruits and Plants | Raw Manufacturing | Food and Preparations | Raw Manufacturing | Vegetables, Fruits and Plants | Transportation |
| ECI | 2.751108815 | 2.170299638 | 1.96086598 | 1.937171566 | 1.7759805 | 1.427489164 |

Table 5a. Opportunity Gain Ranking on a Comparable Scale (2013)

| Ranking | Singapore | Japan | China | Germany | Republic of Korea | Sweden |
|---|---|---|---|---|---|---|
| 1 | Energy Drilling and Mining | Chemicals | Chemicals | Chemical Manufacturing | Services and Utilities | Energy Drilling and Mining |
| 2 | Chemicals | Metals | Raw Manufacturing | Machinery and Construction | Chemicals | Clothing and Accessories |
| 3 | Machinery and Construction | Machinery and Construction | Clothing and Accessories | Transportation | Raw Manufacturing | Textile |
| 4 | Transportation | Transportation | Textile | Daily Instruments | Textile | Vegetables, Fruits and Plants |
| 5 | High-complexity Products | Weapons | Machinery and Construction | High-complexity Products | Metals | Animals and By-products |
| 6 | Services and Utilities | Daily Instruments | Transportation | Services and Utilities | Transportation | Chemical Manufacturing |
| 7 | Weapons | High-complexity Products | Weapons | Chemicals | Daily Instruments | Raw Manufacturing |
| 8 | Textile | Services and Utilities | Daily Instruments | Textile | High-complexity Products | Wood Products |
| 9 | Precious Stones | Textile | High-complexity Products | Weapons | Weapons | Metals |
| 10 | Chemical Manufacturing | Precious Stones | Precious Stones | Clothing and Accessories | Clothing and Accessories | Machinery and Construction |
| 11 | Clothing and Accessories | Clothing and Accessories | Services and Utilities | Precious Stones | Precious Stones | Weapons |
| 12 | Daily Instruments | Energy Drilling and Mining | Energy Drilling and Mining | Raw Manufacturing | Energy Drilling and Mining | High-complexity Products |
| 13 | Animals and By-products | Animals and By-products | Wood Products | Wood Products | Chemical Manufacturing | Precious Stones |
| 14 | Metals | Wood Products | Animals and By-products | Energy Drilling and Mining | Wood Products | Chemicals |
| 15 | Raw Manufacturing | Chemical Manufacturing | Metals | Animals and By-products | Animals and By-products | Food and Preparations |
| 16 | Wood Products | Food and Preparations | Chemical Manufacturing | Metals | Food and Preparations | Services and Utilities |
| 17 | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Food and Preparations | Vegetables, Fruits and Plants | Daily Instruments |
| 18 | Food and Preparations | Raw Manufacturing | Food and Preparations | Vegetables, Fruits and Plants | Machinery and Construction | Transportation |
| ECI | 2.112887919 | 1.979430054 | 1.700687855 | 2.959929484 | 1.648971597 | 0.944644245 |

Table 5b. Opportunity Gain Ranking on a Comparable Scale (2018)

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

Table 5c. Opportunity Gain Ranking on a Comparable Scale (2021)

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 Sweden compares with a selected group of comparable and leading economies in the world, with the industry groups ranked in decreasing order of significance. We focus on SDV results for 2018 because they give the most accurate snapshot of complexity for global comparison in the absence of the irregular effects of the COVID-19 pandemic observed in 2021.

Dark blue indicates positive opportunity gain, light blue indicates zero opportunity gains, and white indicates negative opportunity gains. The result shows that leading countries barely have any industries with positive opportunity gain. In other words, those countries are already in the most stable and efficient economic structure. Without the necessity of economic transition, those countries merely need to maintain a steady and balanced economic development. In contrast, countries listed in Table 5a and 5b have nearly half of industries with positive opportunity gain. While the economies with absolute negative ECI, such as South Africas and Colombia, all need to develop High-complexity Products, Machinery and Construction and Daily Instruments, those with median ECI are facing a more complicated and diverse situation, such as Italy and Spain.

It can be concluded that Sweden is categorized to be a highly complex country as compared with the world's leading economies and other major economies in Europe.

| 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 Typical 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:

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

Subject to

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

$$x \succcurlyeq 0$$

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

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

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

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

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

In this way, we can obtain a further sighted greedy algorithm. Also, the number of parts that we would like to separate the budget into also matters. In order to solve this problem, we added a stabilizer on top of the enhanced greedy algorithm, by running the algorithm for different 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 for the budget. To deal with the surplus, we just add it to the product which needs the least amount of dollar to make $M_{cp}$ = 1, (i.e., the smallest amount of required export increase).

**Interpretation:**

For the purpose of a clear explanation of the line charts, we try to 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

Figures 4a-4c show an economic panel for Sweden in 2013, 2018, and 2021. We can see that for different percentages of heuristic total export growth, the ECIs of Sweden actually have similar amounts of increments. Overall, 5, 10, 15, and 20 percent export growth result in a similar ECI improvement pattern, which starts from around 1.43 and ends at around 1.68.

For 2013, among all four cases (5, 10, 15 and 20 percent export growth), machinery and construction and transportation account for the allocation portfolio. Compared with the solution of other countries, it is obvious that there is not so much room for ECI improvement, which can be reasoned by the pretty well-rounded economic structure of Sweden. Therefore, carrying on the current production pattern is sufficient for maintaining the ECI at an advanced level. Additionally, given that there is a pretty developed economic structure, Sweden should focus more on the development of machinery and construction and transportation, which can be beneficial for the production of other industries. A more detailed numerical representation of the portfolio is shown in Table 8a.

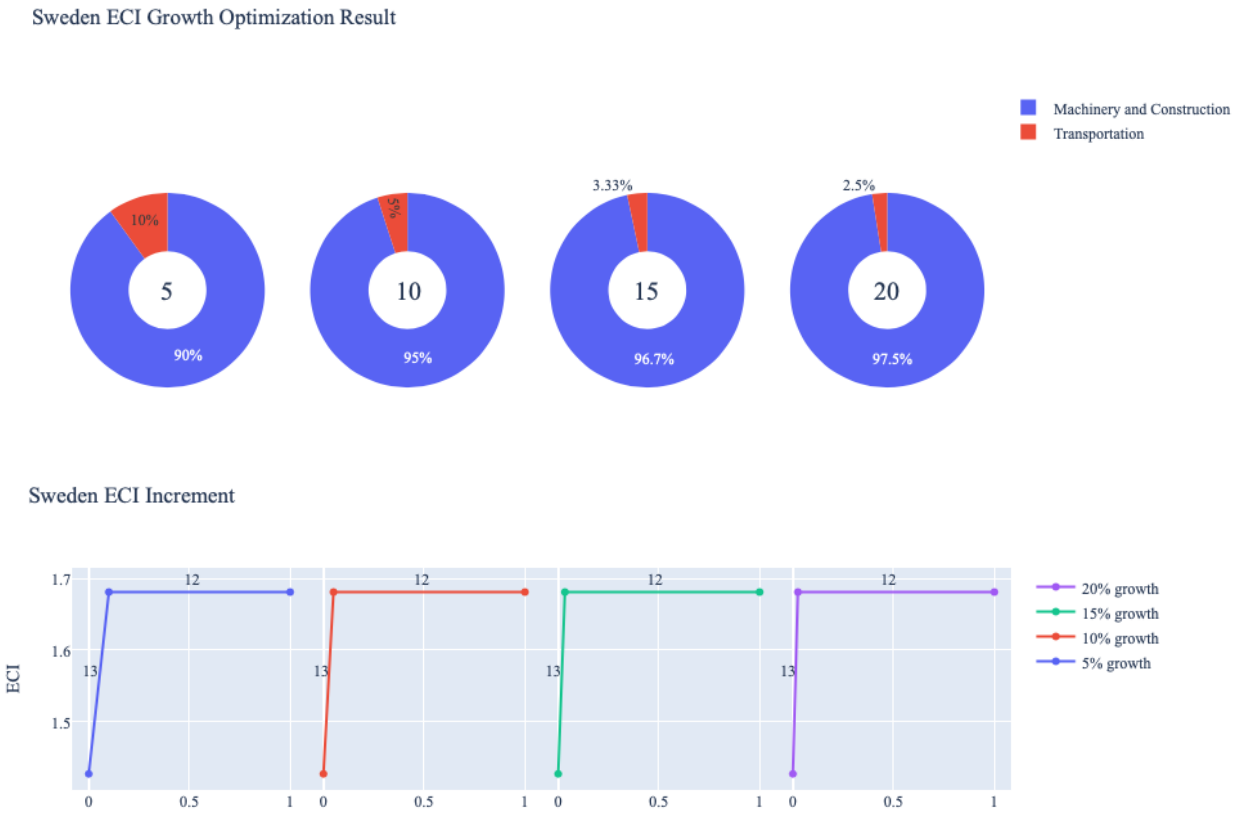



Figure 4a. Greedy-Based ECI Improvement Results of Sweden with Different Budgets (2013)

| | Sweden (2013) | | | |
|---|---|---|---|---|
| Original ECI | | 1.43 | | |
| Heuristic Export Growth | 5% | 10% | 15% | 20% |
| Machinery and Construction | 1.09E+10 | 2.30E+10 | 3.51E+10 | 4.72E+10 |
| Transportation | 1.21E+09 | 1.21E+09 | 1.21E+09 | 1.21E+09 |
| Increased ECI | 1.68 | 1.68 | 1.68 | 1.68 |

Table 8a. Portfolio of Sweden (2013)

For further suggestions on Sweden's development, we also offer the optimization result of Sweden based on export data in 2018. Below is the economic panel for Sweden in 2018. We can see that there is a similar pattern for the ECI improvement trajectories, which is that the improvements in 5, 10, 15 and 20 percent export growth all result in the ECI growth from 0.94 to 1.35. Again, since Sweden is a pretty developed economic entity, the optimization result is sparse and there are not so many suggestions for future development in terms of ECI improvement. However, one difference between 2013 and 2018 is that machinery and construction, which accounts for most of the portfolio in 2013, is now replaced by high-complexity products. This can be resulted by the growing demand of technology innovation in nowadays society. A more detailed numerical representation of the portfolio is shown in Table 8b.

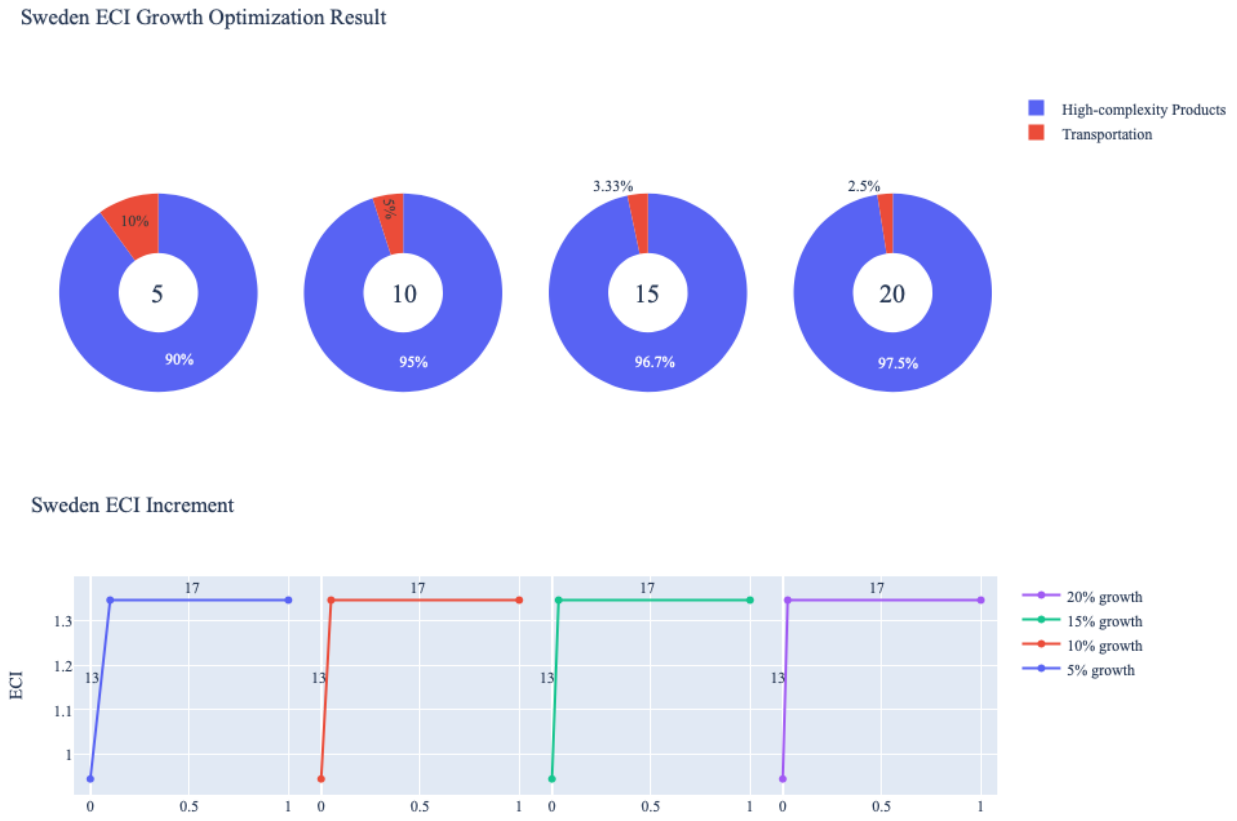



Figure 4b. Greedy-Based ECI Improvement Results of Sweden with Different Budgets (2018)

| | Sweden (2018) | | | |
|---|---|---|---|---|
| Original ECI | | 1.29 | | |
| Heuristic Export Growth | 5% | 10% | 15% | 20% |
| Transportation | 1.22E+09 | 1.22E+09 | 1.22E+09 | 1.22E+09 |
| High-complexity Products | 1.10E+10 | 2.32E+10 | 3.53E+10 | 4.75E+10 |
| Increased ECI | 1.35 | 1.35 | 1.35 | 1.35 |

Table 8b. Portfolio of Sweden (2018)

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 Energy, Drilling, and Mining, followed by Vegetables, Fruits, and Plants, Energy, Drilling, and Mining, and Animals and By-products for 10, 15, and 20 percent export growth respectively. These strategies go in line with the suggested trajectories based on ECI. Compared to 2013 and 2018, the post-pandemic recommendation portfolio for 2021 is much more diverse which agrees with the decline in Sweden's ECI. Many of Sweden's industries advanced in the past couple of years, as indicated by the positive RIDs, however, many industries still have potential for further growth. A more detailed numerical representation of the portfolio for Sweden is shown in Table 8c.

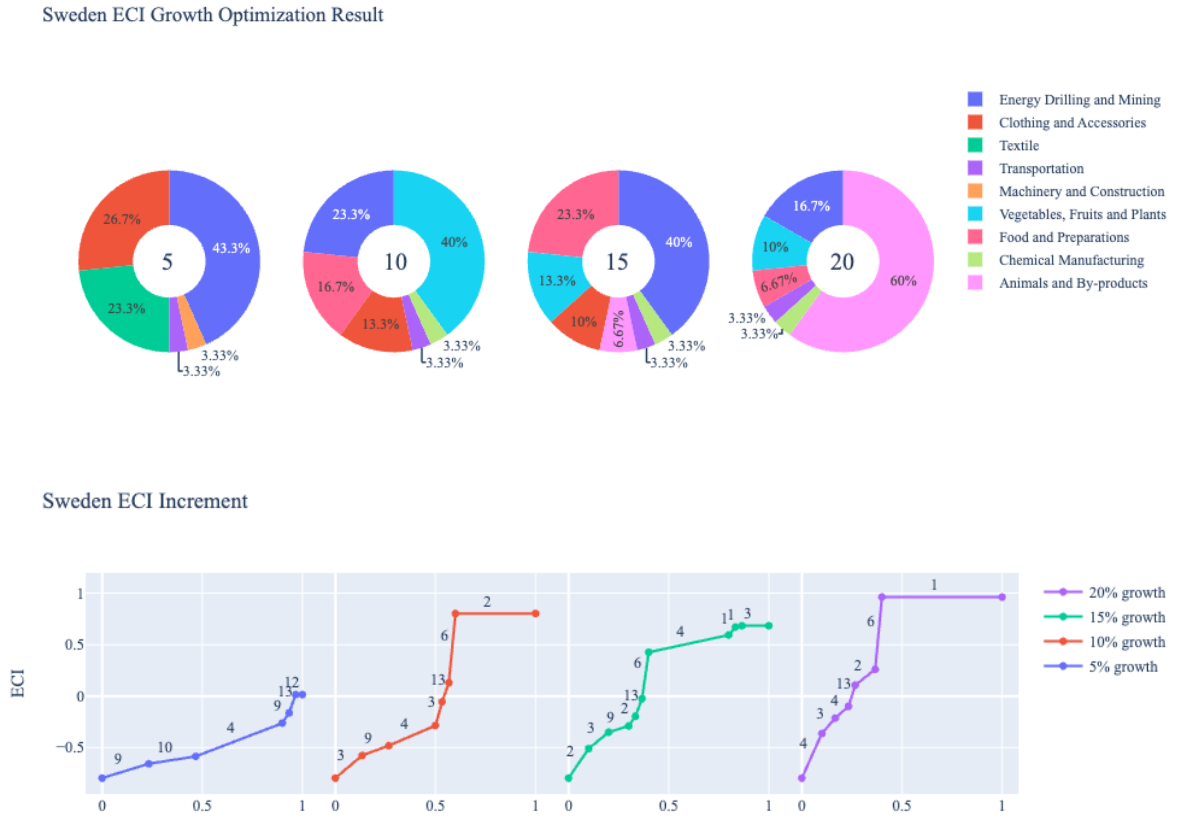



Figure 4c. Greedy-Based ECI Improvement Results of Sweden with Different Budgets (2021)

| | Sweden | | | |
|---|---|---|---|---|
| Original ECI | -0.8 | | | |
| Heuristic Export Growth | 5% | 10% | 15% | 20% |
| Animals and By-products | 0.00E+00 | 0.00E+00 | 4.03E+09 | 2.85E+10 |
| Vegetables, Fruits and Plants | 0.00E+00 | 9.48E+09 | 8.06E+09 | 4.74E+09 |
| Food and Preparations | 0.00E+00 | 3.95E+09 | 1.41E+10 | 3.16E+09 |
| Energy Drilling and Mining | 5.99E+09 | 5.53E+09 | 2.42E+10 | 7.90E+09 |
| Chemical Manufacturing | 0.00E+00 | 7.90E+08 | 2.02E+09 | 1.58E+09 |
| Clothing and Accessories | 3.69E+09 | 3.16E+09 | 6.05E+09 | 0.00E+00 |
| Textile | 3.23E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Machinery and Construction | 4.61E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Transportation | 4.61E+08 | 7.90E+08 | 2.02E+09 | 1.58E+09 |
| Increased ECI | 0.015 | 0.803 | 0.685 | 0.964 |

Table 8c. Portfolio of Sweden (2021)

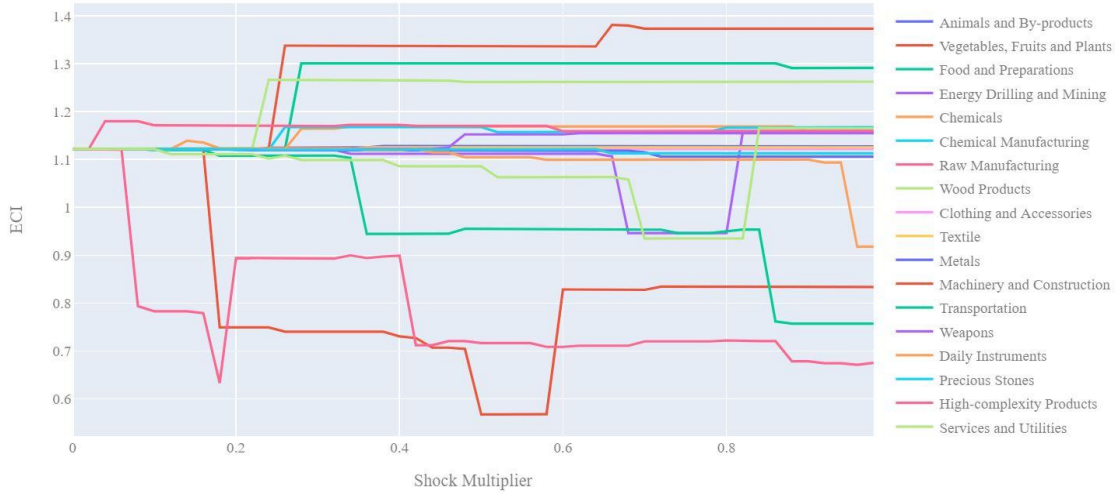
## 4.3 Sensitivity Analysis and Contingency Strategy

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

**ECI Sensitivity Graph**

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

The graphs are formulated as follows: There are four ECI Sensitivity graphs. The first two represent data from 2018. The first chart shows positive shocking in which export numbers are shocked upwards per industry. The X-axis is in terms of percentage shock per current dollar value of export. The Y-axis is the recalculated ECI level post-shocking. The second chart follows the same format except the X-axis represents negative shocking. In other words, exports for each industry are decremented and the ECI is accordingly recomputed. The final two sensitivity graphs show the same results using 2013 data. Below is an example of an ECI sensitivity graph.




Example 2018 (Incremental ECI Sensitivity)

**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 High Complexity Products and Food and Preparations 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 export of High Complexity Products and Food and Preparations 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 a 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 |

Example High-complexity Products 2018 (Incremental SDV Sensitivity)

## 4.3 Sensitivity Analysis Results and Interpretation

We examine Sweden's ECI Decremental and Incremental Sensitivity Charts for 2021. An increase in High-complexity Products will lead to the highest change in ECI, followed by Transportation. The strong sensitivity effect of manipulating both industries is consistent with previous years. For the negative shock cases, High-complexity products is also sensitive but small decreases in Services and Utilities and Chemical Manufacturing exports lead to a constant decrease in ECI. Compared to previous years, Sweden's ECI appears to be less sensitive to positive shocks while negative shocks are still sensitive.

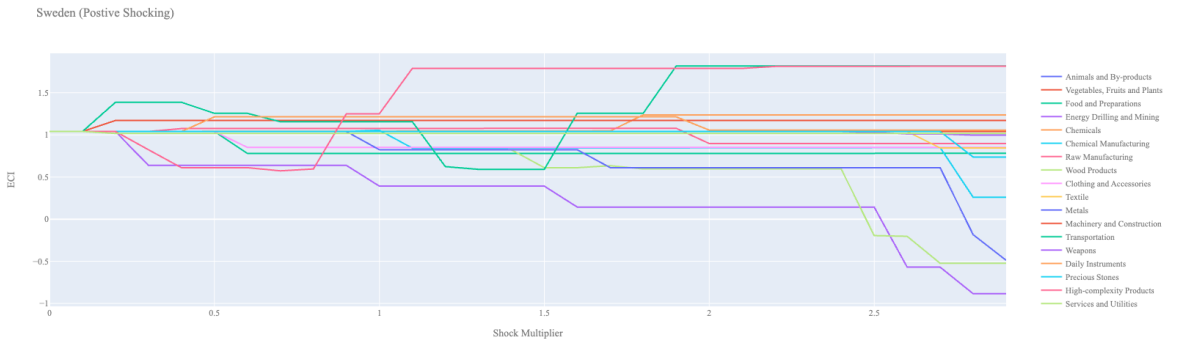



Figure 6a. Incremental ECI Sensitivity for Sweden (2021)

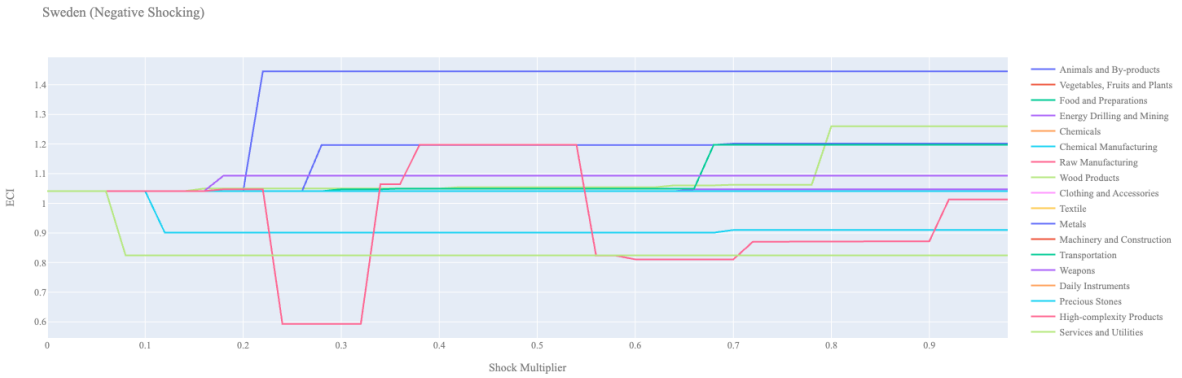



Figure 6b. Decremental ECI Sensitivity for Sweden (2021)

Below is Sweden's 2018 ECI Sensitivity Charts. Firstly in the positive chart, we notice immediately that an immediate increase in Transportation exports leads to a marginal increase in ECI. Larger increases in High complexity Products could lead to very large increases in ECI. A 50% increase in High Complexity Products would lead to almost a 1 unit increase in ECI.

Next we consider Sweden's 2018 Negative Shock chart. Interestingly we see that a decrease in export in the majority of industries actually leads to an increase in ECI. This would seem to suggest that Sweden currently operates with a suboptimal mix of industries and decreasing across the board combined with an increase in High Complexity Products could drastically increase the ECI score of the nation.

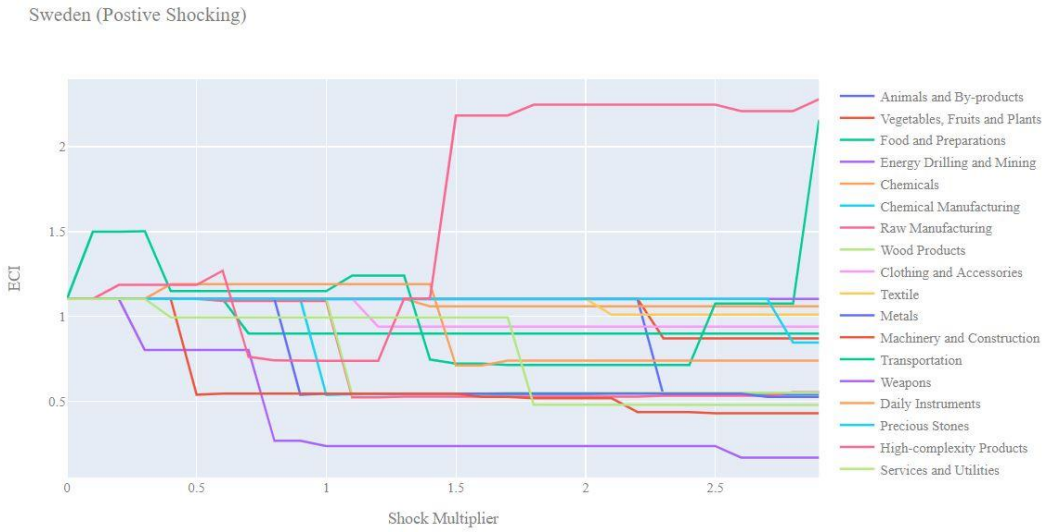



Figure 7a. Incremental ECI Sensitivity for Sweden (2018)

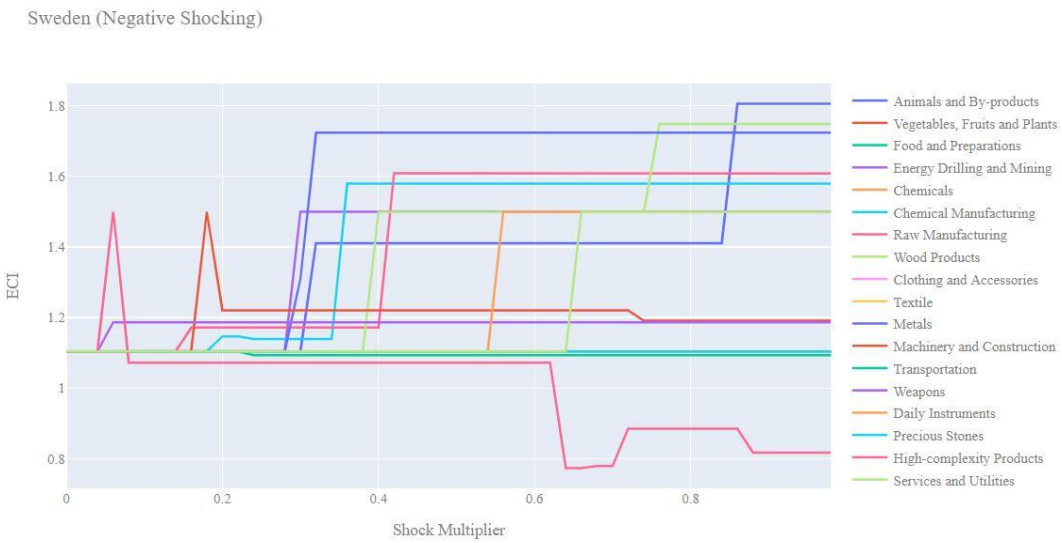



Figure 7b. Decremental ECI Sensitivity for Sweden (2018)

Next we consider the 2013 ECI Sensitivity graphs (Figures 8a and 8b). We see that in the positive shocking case, the landscape of ECI sensitivity has not altered significantly over the five year period. High complexity products seem to offer the best ECI growth prospects. Increases in Transportation seems to offer the most immediate increase in ECI score.

In the 2013 negative shocking case, we see that again that decreases in most industries lead to an increase in the ECI score. This suggests that Sweden is not drastically altered the composition of its industries over this five year period.

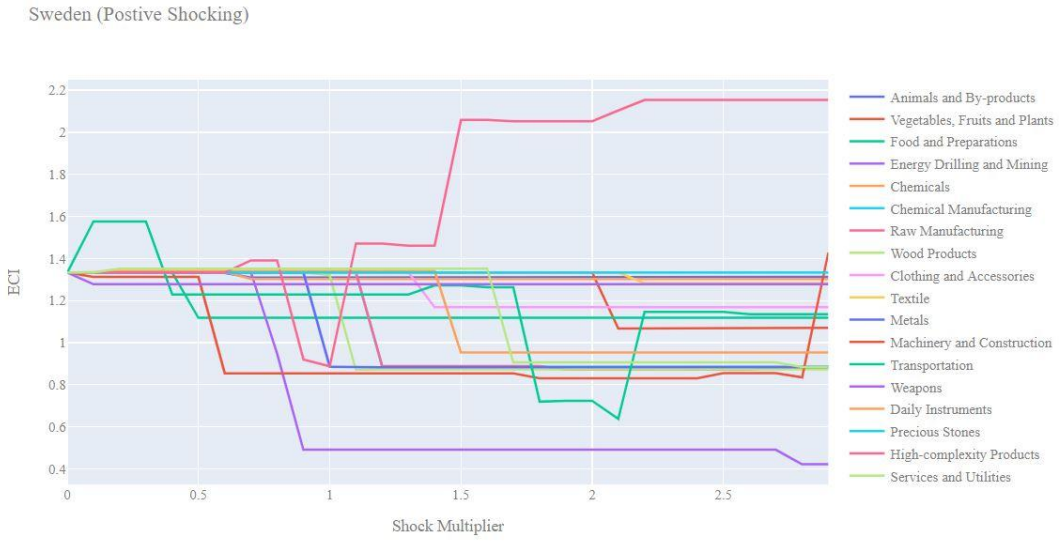



Figure 8a. Incremental ECI Sensitivity for Sweden (2013)

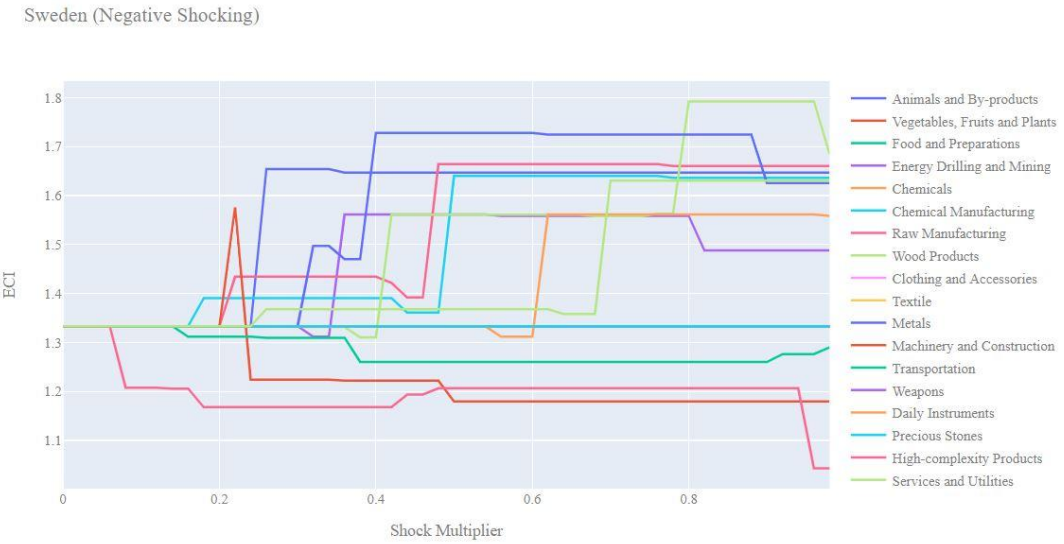



Figure 8b. Decremental ECI Sensitivity for Sweden (2013)

Below we see the SDV sensitivity charts for High Complexity Products. Sweden's SDV is quite sensitive to changes in High Complexity products since the Swedish economy is highly dependent on the export of products that are produced from this industry. As exports in High

Complexity Products are positively shocked, more industries become attractive, showing positive opportunity gains. Vegetables, Fruits, and Plants seem to be a very attractive industry for Sweden to expand in given an increase in High Complexity Product exports. In the Negative SDV sensitivity High Complexity chart we see that any level of downturn only exposes Vegetables, Fruits, and Plants as a worthwhile replacement.

Considering the Food and Preparation SDV sensitivity chart, we see that Sweden is quite insensitive to changes in this industry most likely due to this industry not being a major source of export for Sweden.

| | 0.0% | 20.0% | 60.0% | 70.0% | 80.0% | 130.0% | 150.0% |
|---|---|---|---|---|---|---|---|
| 0 | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Machinery and Construction |
| 1 | Animals and By-products | Animals and By-products | Animals and By-products | Machinery and Construction | Machinery and Construction | Machinery and Construction | Chemicals |
| 2 | High-complexity Products | High-complexity Products | Metals | Services and Utilities | Services and Utilities | Chemicals | Daily Instruments |
| 3 | Chemical Manufacturing | Chemical Manufacturing | Chemical Manufacturing | Transportation | Chemicals | Services and Utilities | Services and Utilities |
| 4 | Weapons | Raw Manufacturing | Wood Products | Chemicals | Transportation | Transportation | Transportation |
| 5 | Raw Manufacturing | Wood Products | High-complexity Products | High-complexity Products | Daily Instruments | Daily Instruments | Textile |
| 6 | Machinery and Construction | Machinery and Construction | Machinery and Construction | Chemical Manufacturing | High-complexity Products | Textile | Chemical Manufacturing |
| 7 | Metals | Metals | Services and Utilities | Wood Products | Wood Products | High-complexity Products | Weapons |
| 8 | Wood Products | Services and Utilities | Chemicals | Animals and By-products | Animals and By-products | Wood Products | High-complexity Products |
| 9 | Services and Utilities | Chemicals | Transportation | Metals | Metals | Animals and By-products | Wood Products |
| 10 | Chemicals | Transportation | Daily Instruments | Daily Instruments | Textile | Weapons | Vegetables, Fruits and Plants |
| 11 | Transportation | Daily Instruments | Textile | Textile | Weapons | Chemical Manufacturing | Clothing and Accessories |
| 12 | Textile | Textile | Weapons | Weapons | Chemical Manufacturing | Clothing and Accessories | Raw Manufacturing |
| 13 | Daily Instruments | Weapons | Precious Stones | Precious Stones | Clothing and Accessories | Precious Stones | Precious Stones |
| 14 | Precious Stones | Precious Stones | Clothing and Accessories | Clothing and Accessories | Precious Stones | Raw Manufacturing | Metals |
| 15 | Clothing and Accessories | Clothing and Accessories | Raw Manufacturing | Raw Manufacturing | Raw Manufacturing | Metals | Energy Drilling and Mining |
| 16 | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Animals and By-products |
| 17 | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations |
| ECI | 1.1036637 | 1.186211156 | 1.269629153 | 0.762899061 | 0.741785491 | 1.106939205 | 2.184626657 |

Sweden High-complexity Products 2018 (Incremental SDV Sensitivity)

| | -0.0% | -6.0% | -8.0% | -64.0% | -72.0% | -88.0% |
|---|---|---|---|---|---|---|
| 0 | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants |
| 1 | Animals and By-products | Animals and By-products | Animals and By-products | Animals and By-products | Animals and By-products | Services and Utilities |
| 2 | High-complexity Products | Wood Products | Wood Products | Wood Products | Raw Manufacturing | Metals |
| 3 | Chemical Manufacturing | Chemical Manufacturing | Chemical Manufacturing | Energy Drilling and Mining | Daily Instruments | Energy Drilling and Mining |
| 4 | Weapons | Weapons | Weapons | Weapons | Weapons | Chemical Manufacturing |
| 5 | Raw Manufacturing | Transportation | Transportation | Transportation | Transportation | Raw Manufacturing |
| 6 | Machinery and Construction | Machinery and Construction | Machinery and Construction | Machinery and Construction | Machinery and Construction | Wood Products |
| 7 | Metals | Metals | Metals | Metals | Metals | Animals and By-products |
| 8 | Wood Products | Raw Manufacturing | Raw Manufacturing | Chemical Manufacturing | Energy Drilling and Mining | Machinery and Construction |
| 9 | Services and Utilities | High-complexity Products | Services and Utilities | Raw Manufacturing | Chemical Manufacturing | Transportation |
| 10 | Chemicals | Services and Utilities | High-complexity Products | Services and Utilities | Wood Products | Weapons |
| 11 | Transportation | Chemicals | Chemicals | High-complexity Products | Services and Utilities | Daily Instruments |
| 12 | Textile | Textile | Textile | Chemicals | High-complexity Products | High-complexity Products |
| 13 | Daily Instruments | Daily Instruments | Daily Instruments | Textile | Chemicals | Chemicals |
| 14 | Precious Stones | Precious Stones | Precious Stones | Daily Instruments | Textile | Textile |
| 15 | Clothing and Accessories | Clothing and Accessories | Clothing and Accessories | Precious Stones | Precious Stones | Precious Stones |
| 16 | Energy Drilling and Mining | Energy Drilling and Mining | Energy Drilling and Mining | Clothing and Accessories | Clothing and Accessories | Clothing and Accessories |
| 17 | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations | Food and Preparations |
| ECI | 1.1036637 | 1.498950796 | 1.071777097 | 0.773020483 | 0.884987828 | 0.817159127 |

Sweden High-complexity Products 2018 (Decremental SDV Sensitivity)

| | 0.0% | 70.0% |
|---|---|---|
| 0 | Vegetables, Fruits and Plants | Vegetables, Fruits and Plants |
| 1 | Animals and By-products | Animals and By-products |
| 2 | High-complexity Products | Wood Products |
| 3 | Chemical Manufacturing | Food and Preparations |
| 4 | Weapons | Weapons |
| 5 | Raw Manufacturing | Chemical Manufacturing |
| 6 | Machinery and Construction | Machinery and Construction |
| 7 | Metals | Metals |
| 8 | Wood Products | Raw Manufacturing |
| 9 | Services and Utilities | High-complexity Products |
| 10 | Chemicals | Services and Utilities |
| 11 | Transportation | Chemicals |
| 12 | Textile | Transportation |
| 13 | Daily Instruments | Textile |
| 14 | Precious Stones | Daily Instruments |
| 15 | Clothing and Accessories | Precious Stones |
| 16 | Energy Drilling and Mining | Clothing and Accessories |
| 17 | Food and Preparations | Energy Drilling and Mining |
| ECI | 1.1036637 | 0.899183933 |

Sweden Food & Preparations 2018 (Incremental SDV Sensitivity)

| | -0.0% |
|---|---|
| 0 | Vegetables, Fruits and Plants |
| 1 | Animals and By-products |
| 2 | High-complexity Products |
| 3 | Chemical Manufacturing |
| 4 | Weapons |
| 5 | Raw Manufacturing |
| 6 | Machinery and Construction |
| 7 | Metals |
| 8 | Wood Products |
| 9 | Services and Utilities |
| 10 | Chemicals |
| 11 | Transportation |
| 12 | Textile |
| 13 | Daily Instruments |
| 14 | Precious Stones |
| 15 | Clothing and Accessories |
| 16 | Energy Drilling and Mining |
| 17 | Food and Preparations |
| ECI | 1.1036637 |

Sweden Food & Preparations 2018 (Decremental SDV Sensitivity)

## 4.4 Contingency Strategy

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

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

Sweden Contingency Strategy 2018

# 5. Macro-level Predictions

## 5.1 Structural Optimality Index

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

After obtaining this measure for all countries in our database, we further regress countries' five-year economic growth, which is defined as the percent increase in GDP (USD), over their SOI. Figure 6 illustrates the regression output, which shows a strong positive correlation between countries' SOI and their five-year GDP growth, significant at the 1% level and achieving an adjusted $R^2$ of 4.5%. In other words, the more a country develops as suggested by calculations on a complexity level, the better economic outcomes it achieves.

| Table 18: OLS Regression Results | |
|---|---|
| **Dep. Variable:** GDP | **F-Statistic:** 5.963 |
| **$R^2$:** 0.054 | **Prob (F-Stat):** 0.0163 |
| **Adj $R^2$:** 0.045 | **No. Observations:** 106 |


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

**5.2 SOI of Sweden and Its Implications**

Sweden, for instance, has a lower level of structural optimality as compared with its developed peers. As the regression in Figure 10a suggests (the orange curve represents export increase and the blue curve stands for opportunity gain of the corresponding industry), Sweden demonstrates a low level of correlation with the suggested developmental path, having an adjusted R-square of around 0.516%. Sweden ranks in the third quartile among all countries in terms of SOI and has made an average rate of economic progress among its emerging peers from 2013 to 2018 with a 5-year GDP growth rate of 23.2%, which is consistent with the regression result in Figure 6. This is in direct contrast to emerging economies such as Turkey, where there is high SOI of around 21.8% and a corresponding GDP growth of 36.7% from 2013 to 2018, making it one of the fastest developing economies during the period. In sum, Sweden's stable economic progress from 2013 to 2018 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, Sweden invested heavily in the Services/Utilities and Machinery/Construction industries, while it should have focused more on moderately complex industry groups such as Energy Drilling/Mining.

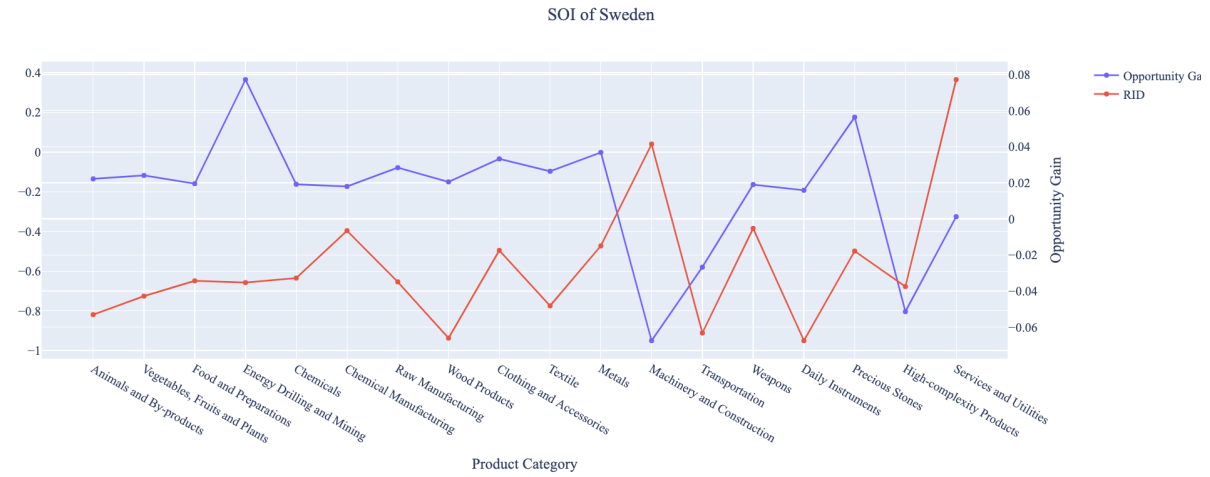



Figure 10a. SOI of Sweden (2013-2018)

For the 2019-2021 years, Sweden has a strong presence in the Animal and By-products and Machinery and Construction industries. The former seems to be overdeveloped when considering the lower opportunity gain relative to RID, however, the latter presents a good opportunity for further investment. It also could consider Energy, Drilling, and Mining and Weapons to improve its growth. Sweden has seen an average growth in GDP over those three years of 5.77%, compared to 23.2% for the average yearly growth for the five years prior.

Although higher than before, its adjusted R-squared value of 1.6% still indicates a low correlation between the GDP growth and the implemented development path. Progress is slow on a global scale during this period, but Sweden demonstrates a higher ability to adjust to negative economic shocks by improving SOI and increasing GDP growth than it did between 2013 and 2018.

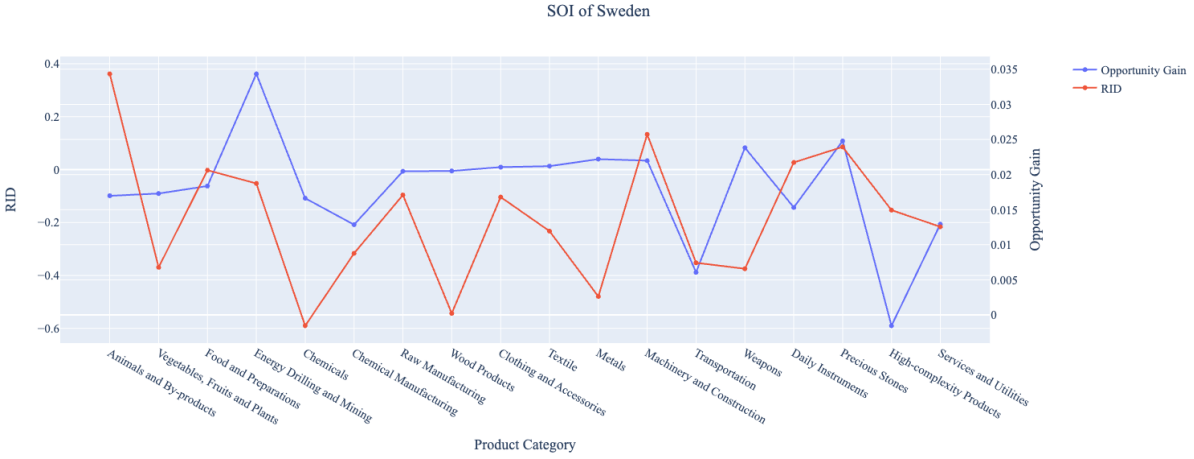



Figure 10b. SOI of Sweden (2019-2021)

## 6. Concluding Remarks

In conclusion, Sweden has demonstrated a moderate level of economic growth in terms of annual GDP increase during the period from 2013 to 2018, concurrent with a decrease in economic complexity as compared with other developed economies. For 2019-2021, the growth in GDP has decreased alongside a large decrease in ECI, in line with its comparable countries and higher than some of the leading economies in the world.

We believe that the lack of progress during the first period , we believe, can be partially explained through the analysis of the economic and product complexity structure of Sweden 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 Sweden consistently relied on developing the Services and Utilities and Machinery and Construction 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 a sensitivity analysis of major industry groups for 2013-2018, Sweden can further its gains by prioritizing High-Complexity Products and Transportation. We further note that Sweden has a mismatched development strategy that indicates a low level (compared to other developed countries) of structural optimality on the complexity level, having an adjusted R-square of around 0.516%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Sweden 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, Sweden performed weaker than before and moderately compared to other countries. We infer that during the COVID-19 period, while Sweden did not completely shut down its economy, it focused on developing an assortment of low and high complexity industries that were not aligned with the optimal portfolio. We note that Sweden did increase its investment in our earlier recommendations, High-complexity Products and Transportation, demonstrated by positive RIDs in 2021, however, it focused more on other industries, such as Animals and By-Products and Machinery and Construction. The ECI suggests that greater growth could have been achieved through Energy, Drilling, and Mining. The slow growth corresponded to an increase in the adjusted R-squared value to 1.6% in 2021 from 0.516% in 2018, demonstrating the pursued strategies contributed to the GDP. With the revised focus, Sweden 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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