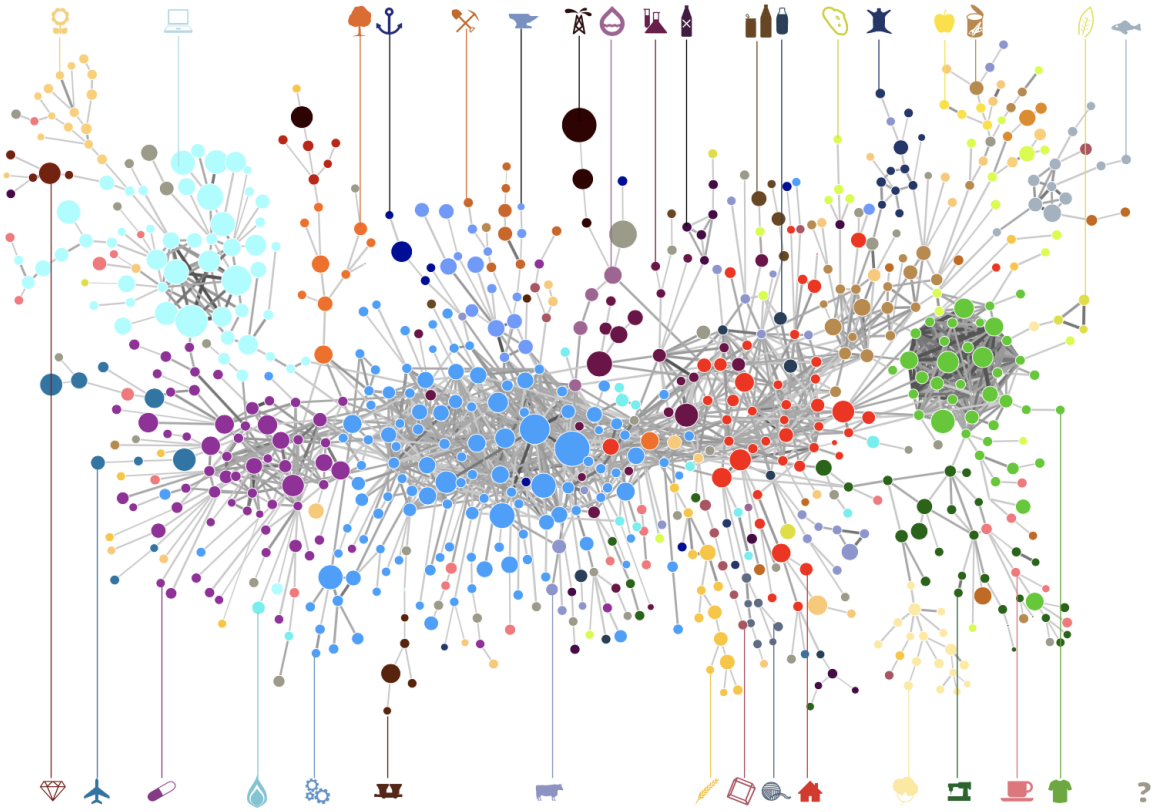


https://atlas.cid.harvard.edu/

Optimal Industry Development Strategy Using Economic and Product Complexity

Chile

—

The Economic Complexity Lab - Columbia University

Alexandra Garcia, Kelly Mi, Margarita Demkina, Allison Lin, Helena Yang, Jane Zhang, Daniel Xu, Ryo Shibata, Haoxian Chen, Davepriyan Gunaratnam, Rohan Macherla, Ajit Akole, Shomik Ghose, Alex Wei-Liang Ku, Sannidhya Modi, Xilin Wang

Optimal Industry Development Strategy for Chile

0. Executive Summary

In this report, we aim to uncover the economic path Chile went through during the period from 2013 to 2022. Specifically, we dive into the topic through a macroeconomic overview of Chile from the perspective of Gross Domestic Product (GDP) and Economic Complexity Index (ECI), which reflect countries' production capability and production structure, respectively. We divide the period into two subperiods: 2013-2018 and 2019-2022. These subperiods are meant to capture differences in pre- and post-pandemic economic progress and resulting optimal development path. We find that during the period of our interest, Chile demonstrated a moderate level of economic growth with an average annual GDP growth rate of 3.09% between 2013 and 2018 and 2.78% between 2019 and 2021, with a increased economic complexity compared to other major emerging economies.

The moderate progress during this period, we believe, can be partially explained through analysis of the economic and product complexity structure of Chile 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 Chile consistently relied on developing the Services and Utilities and Transportation industries in 2013 to 2018, and Precious Stones and Machinery and Construction in 2019 to 2022 while its developed counterparts and emerging economies around the globe adopted much more complex and progressive paths.

Based on our analysis of the opportunity gain and sensitivity analysis of major industry groups, Chile could further its gains by prioritizing Services and Utilities and Chemical Manufacturing and Precious Stones in 2018. Its development strategy in recent years is partially aligned with our previous recommendations, especially with Precious Stones, which we attribute to the increase in ECI. Four years later, in 2022, its focus should shift to Machinery and Construction and continue investing in Precious Stones. We further note that Chile has a slightly mismatched but improving development strategy that indicates a moderate level (compared to other emerging countries) of structural optimality on the complexity level, having an adjusted R-square of around 3.34% in 2018 and a much higher score of 11.3% in 2022, demonstrating improvement in development. Since a significant positive correlation exists between GDP growth and the structural optimality index of an economy as we define and calculate, Chile indeed has an optimal 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 four years between 2019 and 2022 showed a significant improvement in Chile's economic growth, boosting its position on the global scale. Its GDP recovered to above the pre-pandemic levels, and it saw a significant boost in the ECI, particularly compared to its peer countries. Its current strategy still has the viable potential upside to increase its performance and optimize its structure further.

1. Report Overview

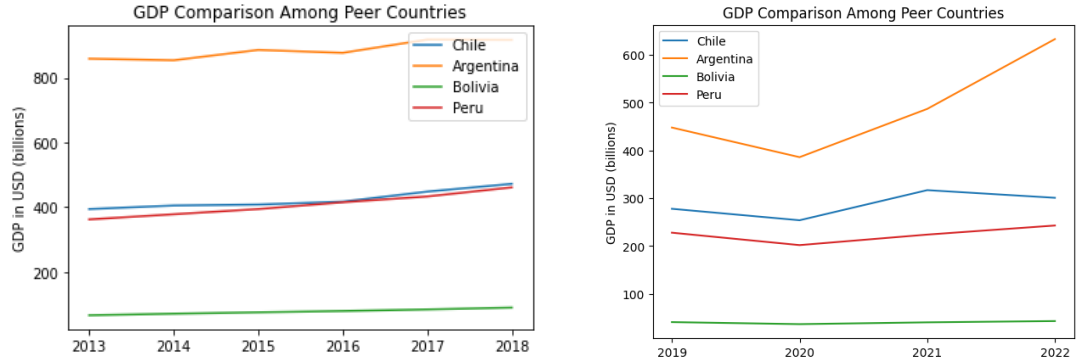
In this report, we aim to uncover the economic path Chile went through during the period from 2019 to 2022, after the COVID pandemic, compared to its performance from 2013 to 2018, before the pandemic. Specifically, we dive into the topic through a macroeconomic overview of Chile from the perspective 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 Chile 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 Chile, 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 Chile and three of its peer countries (the Argentina, Bolivia, and Peru) from 2013-2018. Chile displays consistent growth in small increments, a pattern similar to its peers with the exception of Argentina, which is slightly more volatile. Chile's average annual growth rate of 3.09% over the five-year period is distinctly lower than both its closest peer, Peru (4.13%), and the lower-magnitude-GDP Bolivia (5.29%). However, its growth rate is much closer to these two countries than to Argentina (1.12%).

Figure 1b shows the GDP levels for Chile and the same peer countries from 2019 to 2022. Similar to the other countries, Chile displayed a drop in GDP from 2019 to 2020 because of the pandemic, with all GDPs rebounding in 2021. Over these three years, Chile's average annual GDP growth rate (2.78%) is moderate, as it is greater than Peru's rate (1.99%) and Bolivia's (1.62%) but less than Argentina's (10.58%). It is notable that only Chile's GDP dropped in 2022, possibly due to changes in presidency and political unrest.



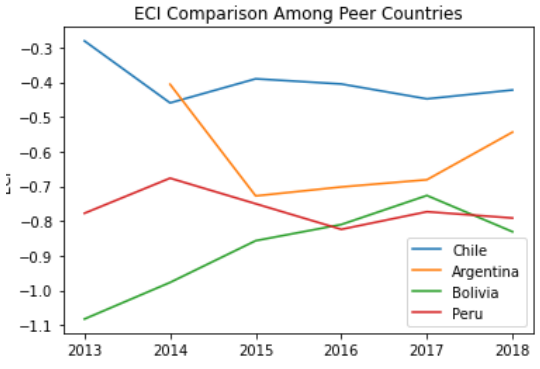
Figures 1a and 1b. GDP Comparison Among Peer Countries (left: 2013-2018; right: 2019-2022)

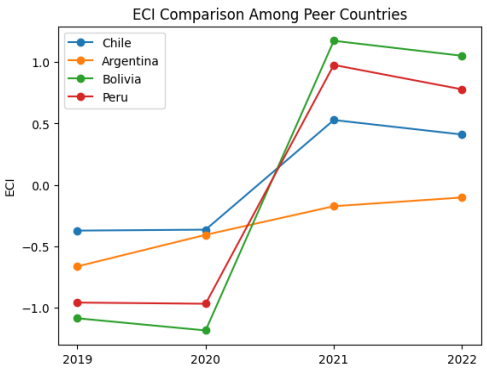
2.2 ECI Ranking and Changes

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 2a and 2b.

As illustrated in Figure 2a below, Chile exhibits a significant decrease (-50.24% ECI change) in terms of its production capability from 2013 to 2018, which is similar to Argentina (-33.91%) but sharply lower than both Peru (-1.76%) and Bolivia (23.23%). The large ECI (and ECI change) contrast between Chile and Peru, which are peers in terms of GDP, is vital to note.

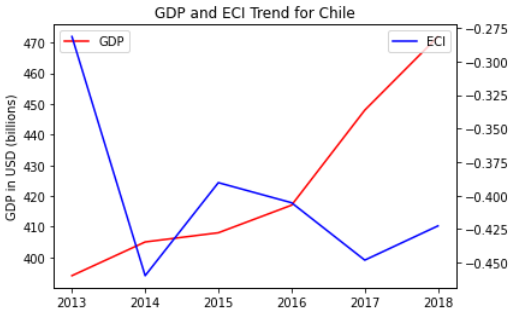
The comparable countries maintain a small change in ECI level between 2019 and 2020, with a sharp change between 2020 and 2021. Chile exhibits a large increase in production capability in 2021 to levels not seen prior, with a fiscal stimulus worth 4.7% of its GDP in response to the pandemic being one of the reasons. Chile has seen a 209.9% increase in its ECI, which is greater than Bolivia''s (196.67%), Peru's (181.1%), and Argentina's (86.46%).

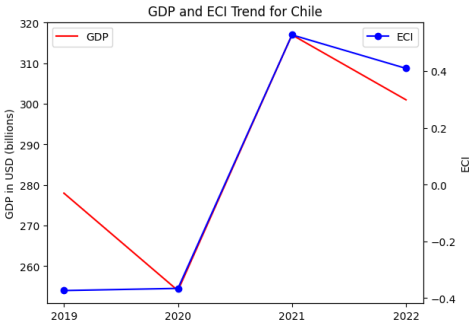




Figures 2a and 2b. ECI Comparison Among Peer Countries (left: 2013-2018; right: 2019-2022)

Figure 3a and 3b offers a further comparison of GDP Growth and ECI over the time span from 2013 to 2022 for Chile. The increasing-higher-rate increase in GDP growth during the period from 2013 to 2018 is accompanied by a volatile eventual decrease in ECI. The results show that the economic growth experienced by Chile during the period from 2013 to 2018 is partially consistent with the predictions by ECI and that Chile's ability to develop a competitive product space that helped to accumulate complicated knowledge and technology declined as growth occurred. Unlike the volatile changes in GDP and ECI from 2013-2018, Chile experience more cohesive, positive growth between 2019-2022. It made strong progress towards effectively developing a competitive product space that helps to accumulate complicated knowledge and technology. For the period 2019 to 2022, the ECI followed GDP trends, which can be interpreted as advancements in production. In order to provide a more concrete answer to why this has happened, we will dive into an analysis of Chile's production structure and its product space designs in the next few chapters.





Figures 3a and 3b. GDP Growth and ECI for Chile (left: 2013-2018; right: 2019-2021)

3. Production Analysis

3.1 Product Categorization

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

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

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

Table 1. Categorization of Products

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

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

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

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

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

3.2 Realized Industry Development

Based on the aforementioned product categorization, we aim to capture Chile's realized industry production strategy between 2013 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 Chile and the 18 product groups in 2022 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 remained the same from from 2018 to 2022.

Category	RID (2022)	RID (2018)
Daily Instruments	-0.028890	-0.010713
Chemicals	0.008113	0.015096
Weapons	-0.078197	-0.039482
Wood Products	0.001685	-0.002953
Transportation	0.003401	0.050262
Machinery and Construction	0.031155	0.004316
Metals	-0.012544	-0.001646
Raw Manufacturing	-0.008961	0.002679
Services and Utilities	0.007982	0.064776
Clothing and Accessories	-0.004641	-0.011321
Chemical Manufacturing	-0.015455	-0.011543
Food and Preparations	-0.007814	0.014151
Textile	0.020613	0.008212
High-complexity Products	-0.023593	0.039611
Vegetables, Fruits and Plants	0.022655	0.031425
Animals and By-products	0.014762	-0.001498
Energy Drilling and Mining	0.000120	-0.029164
Precious Stones	0.036037	-0.029164

Table 3. Realized Industry Development (RID) of Chile

3.3 Regional and Global Comparison

3.3 Regional and Global Comparison

Tables 4a-4b below summarize how the production strategy adopted by Chile compares with 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 further examines Chile'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
1	Chemicals	Transportation
2	Daily Instruments	High-complexity Products
3	Transportation	Energy Drilling & Mining
4	Raw Manufacturing	Machinery& Construction
5	Weapons	Chemical Manufacturing

Table 4b. RID Comparison across Emerging Economies (2022)

Tables 4c-4d further examine Chile's development strategy against those of emerging economies from the previous time period.

Ranking	France	US	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 4c. RID Comparison across Leading Economies (2018)

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 4d. RID Comparison across Emerging Economies (2018)

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	Spain	Portugal	Chile
1	Energy Drilling and Mining	Energy Drilling and Mining	Precious Stones
2	Precious Stones	Machinery and Construction	Machinery and Construction
3	Weapons	Precious Stones	Clothing and Accessories
4	Textile	High-complexity Products	Services and Utilities
5	Chemicals	Services and Utilities	High-complexity Products
6	Daily Instruments	Weapons	Daily Instruments
7	Animals and By-products	Transportation	Transportation
8	Vegetables, Fruits and Plants	Daily Instruments	Textile
9	Food and Preparations	Chemical Manufacturing	Chemical Manufacturing
10	Chemical Manufacturing	Chemicals	Animals and By-products
11	Raw Manufacturing	Animals and By-products	Vegetables, Fruits and Plants
12	Wood Products	Vegetables, Fruits and Plants	Food and Preparations
13	Clothing and Accessories	Food and Preparations	Energy Drilling and Mining
14	Metals	Raw Manufacturing	Chemicals
15	Transportation	Wood Products	Raw Manufacturing
16	Services and Utilities	Clothing and Accessories	Wood Products
17	Machinery and Construction	Textile	Metals
18	High-complexity Products	Metals	Weapons
ECI	0.45830144	-0.157783672	-0.281283555

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

Ranking	Spain	Portugal	Chile
1	Energy Drilling and Mining	Energy Drilling and Mining	Precious Stones
2	Precious Stones	Precious Stones	High-complexity Products
3	Weapons	Weapons	Transportation
4	Textile	Services and Utilities	Clothing and Accessories
5	Services and Utilities	Chemicals	Machinery and Construction
6	Chemicals	Chemical Manufacturing	Textile
7	Daily Instruments	Animals and By-products	Services and Utilities
8	Machinery and Construction	Vegetables, Fruits and Plants	Chemical Manufacturing
9	Animals and By-products	Food and Preparations	Daily Instruments
10	Vegetables, Fruits and Plants	Raw Manufacturing	Animals and By-products
11	Food and Preparations	Wood Products	Vegetables, Fruits and Plants
12	Chemical Manufacturing	Clothing and Accessories	Food and Preparations
13	Raw Manufacturing	Textile	Energy Drilling and Mining
14	Wood Products	Metals	Chemicals
15	Clothing and Accessories	Transportation	Raw Manufacturing
16	Metals	Daily Instruments	Wood Products
17	Transportation	Machinery and Construction	Metals
18	High-complexity Products	High-complexity Products	Weapons
ECI	0.168962035	0.272765537	-0.422599512

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

Rank	Chile	Argentina	Bolivia	Peru
1	Services and Utilities	Transportation	High-complexity Products	High-complexity Products
2	High-complexity Products	High-complexity Products	Services and Utilities	Services and Utilities
3	Precious Stones	Daily Instruments	Transportation	Transportation
4	Transportation	Machinery and Construction	Daily Instruments	Chemical Manufacturing
5	Daily Instruments	Chemicals	Chemical Manufacturing	Daily Instruments
6	Machinery and Construction	Chemical Manufacturing	Machinery and Construction	Textile
7	Chemical Manufacturing	Raw Manufacturing	Chemicals	Chemicals
8	Weapons	Weapons	Animals and By-products	Clothing and Accessories
9	Clothing and Accessories	Energy Drilling and Mining	Raw Manufacturing	Wood Products
10	Textile	Wood Products	Metals	Machinery and Construction
11	Raw Manufacturing	Clothing and Accessories	Wood Products	Raw Manufacturing
12	Animals and By-products	Animals and By-products	Clothing and Accessories	Animals and By-products
13	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants	Textile	Vegetables, Fruits and Plants
14	Food and Preparations	Food and Preparations	Vegetables, Fruits and Plants	Food and Preparations
15	Energy Drilling and Mining	Services and Utilities	Food and Preparations	Energy Drilling and Mining
16	Chemicals	Metals	Energy Drilling and Mining	Metals
17	Wood Products	Textile	Weapons	Weapons
18	Metals	Precious Stones	Precious Stones	Precious Stones
ECI	0.410178	-0.103375	1.052018	0.778455

Table 5c. Opportunity Gain Ranking on a Comparable Scale (2022)

We define the ranking of opportunity gain for a country c, as the Suggested Development Vector (SDV) of c. Tables 5a-5c summarize how the SDV of Chile 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 Chile shares the characteristics of developing countries, with a balanced economic structure that leans towards moderate complexity-level industries.

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:

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

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 to which a country can improve. Accordingly, the optimal solution x^* that we obtain here is exactly our optimal allocation. However, the biggest problem is that the objective function is not convex. Therefore, we cannot apply the classical tools for convex optimization to this problem. In order to solve this problem, our idea is to use a greedy algorithm. The way that we apply the

greedy algorithm is that firstly we separate the total budget into k equal parts, and then for the first equal part we try to search for the product that can optimize our objective function by iterating through each $p \in P$. After we find the optimal product p for this equal part, we add the amount back to the export value of this product p and update the ECI for this country. If we observe that ECI does not change after iterating all the products, then we can add up one more equal part to invest. Until we find there is an ECI increment, we add the amount now to that product. The equal rest parts can be done in the same way.

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

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

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

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

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

Economic Panel

As stated above, the enhanced greedy algorithm is developed mainly for solving the optimal allocation strategy. In order to visualize this allocation, an economic panel is created, consisting of a pie chart, a line chart and a table. First, a pie chart is used to show the percentage of each product in the optimal portfolio. The number located in the center of the circle denotes the heuristic growth of total export, which is also our budget. Each category in the chart has a determined percentage of the allocated budget. The lines below the pie charts show how the ECI changes during the searching process of the greedy algorithm. Even though sometimes an increase of the export by 15% or 20% does not seem reasonable to developed countries, yet it can also give a sense of how a country should develop in the long term. Eventually, the graph in the end is just for numerical explanation for the pie charts.

Interpretation

For the purpose of a clear explanation of the line charts, we label all the products in Table 7. Please refer to this table when trying to understand the investment trajectories in the line charts.

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

Table 7. Products Labeling

Figures 4a-4c show an economic panel for Chile in 2013, 2018, and 2022. We can see that for different percentages of heuristic total export growth, the ECIs of Chile actually have different increments. Across all 3 years, an increase in investments corresponds to an increase in the number of industries. We note that Services and Utilities are a strong focus in 2013 and 2018 but do not appear in 2022. Instead, Chile should invest in Precious Stones and Textiles, which are lower-complexity industries

For 2013, 5 percent export growth results in a ECI improvement pattern starting from around -0.28 and ends at around 0.02. As the budget is increased to 10 percent export growth, the ECI of Chile can achieve a slightly higher level, which is around 0.16. With much more growth budget, like 15 or 20 percent growth, Chile is able to achieve an even much higher stage, which is around 0.41.

For the case of 5 percent export growth, clothing and accessories, services and utilities account for most of the portfolio. For 10 percent export growth, the portfolio becomes more diverse. In addition to the products mentioned before, chemicals and daily instruments are added as main components as well. With 15 percent growth, one of the main factors in the portfolio of 10 percent growth budget, daily instruments, is replaced by machinery and construction. When the budget increases to 20 percent, the portfolio becomes pretty comprehensive, which mainly contains chemicals, animal and by-products, textile and machinery and construction etc. In these four ECI improvement trajectories, we also notice that the largest improvement comes from raw manufacturing, suggesting that with a low

economic improvement anticipation, Chile should focus more on developing these products. A more detailed numerical representation of the portfolio is shown in Table 8a.

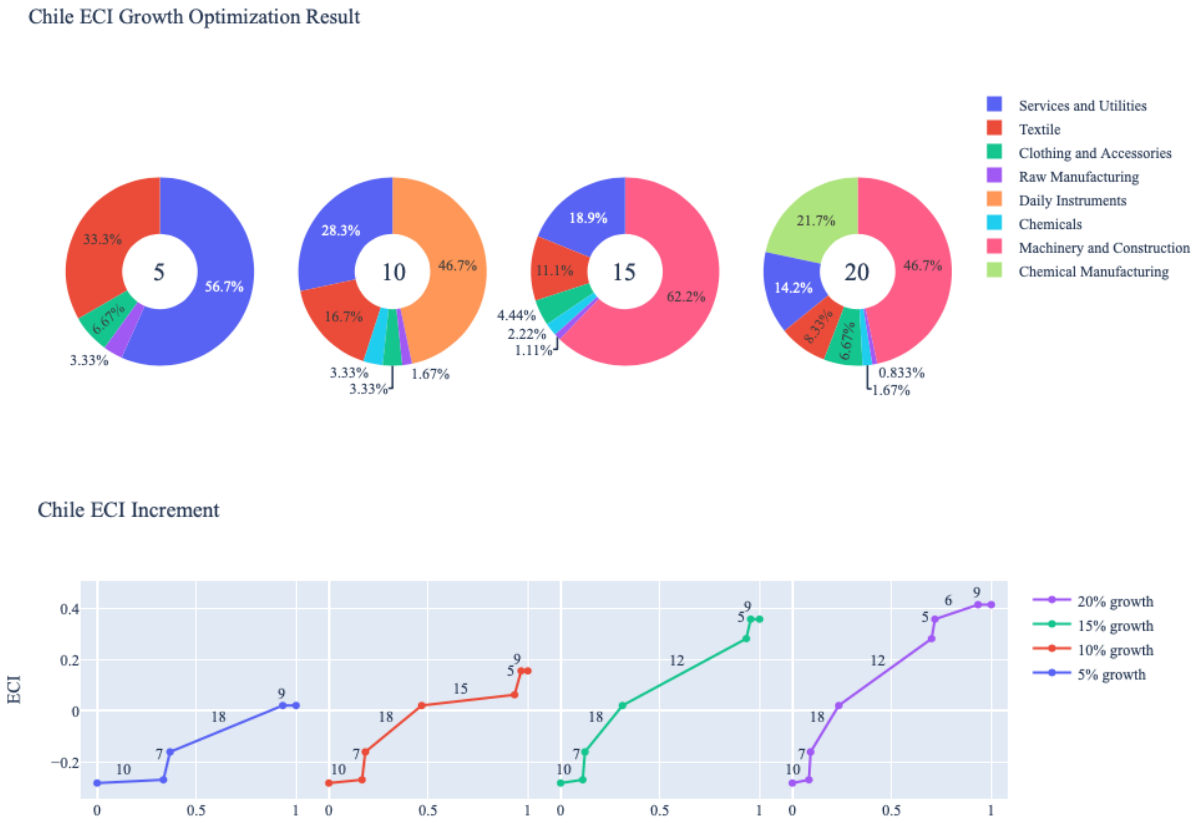


Figure 4a. Greedy-Based ECI Improvement Results of Chile with Different Budgets (2013)

	Chile (2013)			
Original ECI		-0.28		
Heuristic Export Growth	5%	10%	15%	20%
Chemicals	0.00E+00	2.72E+08	2.72E+08	2.72E+08
Chemical Manufacturing	0.00E+00	0.00E+00	0.00E+00	3.53E+09
Raw Manufacturing	1.36E+08	1.36E+08	1.36E+08	1.36E+08
Clothing and Accessories	2.72E+08	2.72E+08	5.43E+08	1.09E+09
Textile	1.36E+09	1.36E+09	1.36E+09	1.36E+09
Machinery and Construction	0.00E+00	0.00E+00	7.60E+09	7.60E+09
Daily Instruments	0.00E+00	3.80E+09	0.00E+00	0.00E+00
Services and Utilities	2.31E+09	2.31E+09	2.31E+09	2.31E+09
Increased ECI	0.02	0.16	0.36	0.41

Table 8a. Portfolio of Chile (2013)

For further suggestions on Chile's development in the future. We also offer the optimization result based on its export data in 2018. Below is the economic panel for Chile in 2018. With 5 percent export growth, Chile should mainly focus on developing clothing and accessories as well as services and utilities, which is similar to the result in 2013. As the budget grows to 10 percent, the main components contain precious stones, raw manufacturing, chemical manufacturing and services and utilities. For situations with higher budgets of investment, like 15 or 20 percent growth, although improvement patterns are similar, the portfolio obtained from a higher budget tends to be more comprehensive. With 15 percent export growth, the main components in the portfolio include daily instruments, chemical manufacturing and services and utilities. However, for the case of 20 percent growth, the

allocation puts more weight on services and utilities, rather than daily instruments. A more detailed numerical representation of the portfolio is shown in Table 9.

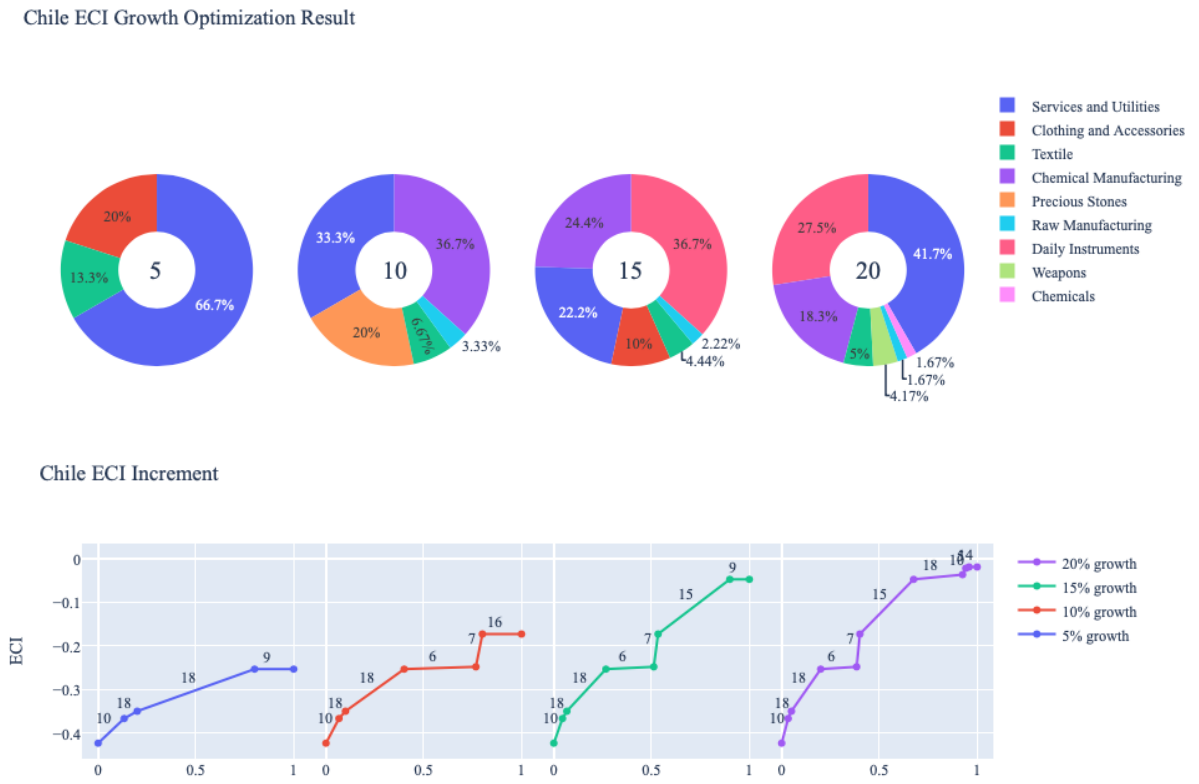


Figure 4b. Greedy-Based ECI Improvement Results of Chile with Different Budgets (2018)

	Chile (2018)			
Original ECI		-0.42		
Heuristic Export Growth	5%	10%	15%	20%
Chemicals	0.00E+00	0.00E+00	0.00E+00	3.14E+08
Chemical Manufacturing	0.00E+00	2.94E+09	2.94E+09	3.45E+09
Raw Manufacturing	0.00E+00	2.67E+08	2.67E+08	3.14E+08
Clothing and Accessories	8.02E+08	0.00E+00	1.20E+09	0.00E+00
Textile	5.34E+08	5.34E+08	5.34E+08	9.42E+08
Weapons	0.00E+00	0.00E+00	0.00E+00	7.85E+08
Daily Instruments	0.00E+00	0.00E+00	4.41E+09	5.18E+09
Precious Stones	0.00E+00	1.60E+09	0.00E+00	0.00E+00
Services and Utilities	2.67E+09	2.67E+09	2.67E+09	7.85E+09
Increased ECI	-0.25	-0.17	-0.05	-0.02

Table 8b. Portfolio of Chile (2018)

To compare with the performance in 2013 and 2018, we also re-examine suggested strategies for 2022. For 2022, a 5 percent increase in export would emphasize Precious Stones and Textiles, followed by Chemicals for 10, 15, and 20 percent export growth, and Food and Prepartions for 15 and 20 percent. These strategies go in line with the suggested trajectories based on ECI. The appearance of Chemicals in high growth percents suggests that Chile is a rapidly advancing country that has opportunity to develop high-complexity industries if it continues. A more detailed numerical representation of the portfolio for Chile is shown in Table 8c.

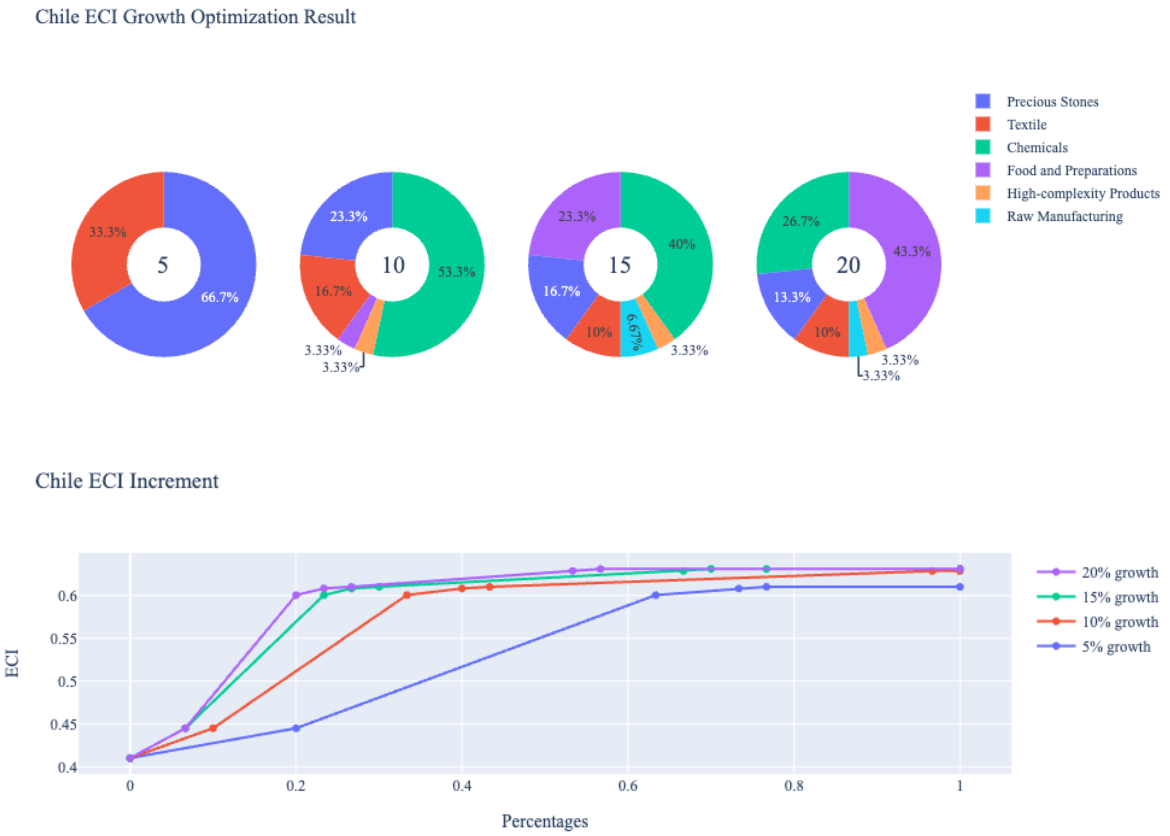


Figure 4c. Greedy-Based ECI Improvement Results of Chile with Different Budgets (2022)

Chile (2022)				
Original ECI		**0.410178**		
Heuristic Export Growth	**5%**	**10%**	**15%**	**20%**
Food and Preparations	0.00E+00	3.65E+08	5.24E+09	9.49E+09
Chemicals	0.00E+00	5.84E+09	8.98E+09	5.84E+09
Raw Materials	0.00E+00	0.00E+00	1.50E+09	7.30E+08
Textile	3.10E+09	1.83E+09	2.25E+09	2.19E+09
Precious Stone	6.21E+09	2.56E+09	3.74E+09	2.92E+09
High-complexity Products	0.00E+00	3.65E+08	7.49E+08	7.30E+08
Increased ECI	**0.61025234**	**0.62874075**	**0.63118791**	**0.63118791**

Table 8c. Portfolio of Chile (2022)

4.3 Sensitivity Analysis and Contingency Strategy

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

visualization of industry-specific sensitivity. To this end, we have developed two categories of sensitivity analysis.

ECI Sensitivity Graph

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

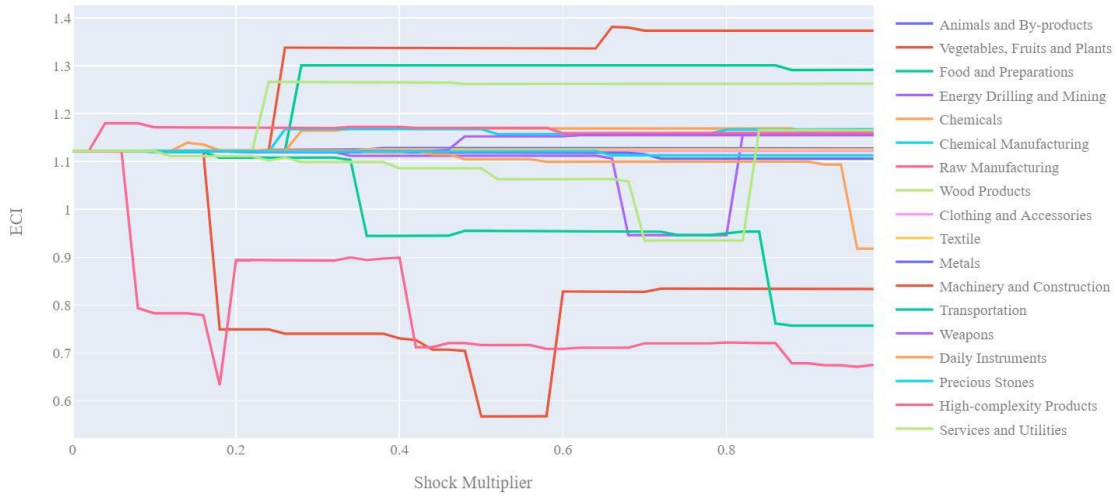


Figure 5. Sample ECI Sensitivity Graph (2018)

The graphs are formulated as follows. There are six ECI Sensitivity graphs, two for each of the following years: 2022, 2018, and 2013. The first chart, Incremental ECI Sensitivity, shows positive shocking in which export numbers are shocked upwards per industry. The X-axis is in terms of percentage shock per current dollar value of export. The Y-axis is the recalculated ECI level post-shocking. The second chart, Decremental ECI Sensitivity, follows the same format except the X-axis represents negative shock. In other words, exports for each industry are decremented, and the ECI is accordingly recomputed.

SDV Sensitivity

Secondly, we analyze the sensitivity of the SDV to changes in export levels. The goal is to understand how export level changes for a particular industry can affect the marginal

opportunity gain for other industries. We will be using specifically 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 the 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 an SDV Sensitivity chart with Positive Shocking. Industries with positive marginal opportunity gain are colored blue, neutral is colored white, and negative is colored red.

	0.0%	10.0%	30.0%	50.0%	80.0%	100.0%	120.0%
0	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants	Chemicals	Chemicals	Chemicals	Machinery and Construction
1	Daily Instruments	Daily Instruments	Daily Instruments	Services and Utilities	Services and Utilities	Daily Instruments	Chemicals
2	Weapons	Weapons	Weapons	Textile	Textile	Textile	Daily Instruments
3	Transportation	Transportation	Transportation	Weapons	Daily Instruments	Services and Utilities	Services and Utilities
4	Machinery and Construction	Machinery and Construction	Machinery and Construction	Transportation	High-complexity Products	Transportation	Transportation
5	Metals	Metals	High-complexity Products	Machinery and Construction	Transportation	Chemical Manufacturing	Textile
6	High-complexity Products	High-complexity Products	Chemicals	High-complexity Products	Machinery and Construction	Weapons	Chemical Manufacturing
7	Chemicals	Services and Utilities	Services and Utilities	Daily Instruments	Chemical Manufacturing	High-complexity Products	Weapons
8	Services and Utilities	Chemicals	Textile	Chemical Manufacturing	Weapons	Machinery and Construction	High-complexity Products
9	Textile	Textile	Chemical Manufacturing	Precious Stones	Clothing and Accessories	Clothing and Accessories	Clothing and Accessories
10	Chemical Manufacturing	Chemical Manufacturing	Precious Stones	Clothing and Accessories	Precious Stones	Precious Stones	Raw Manufacturing
11	Precious Stones	Precious Stones	Clothing and Accessories	Vegetables, Fruits and Plants	Raw Manufacturing	Raw Manufacturing	Precious Stones
12	Clothing and Accessories	Clothing and Accessories	Raw Manufacturing	Raw Manufacturing	Wood Products	Metals	Wood Products
13	Raw Manufacturing	Raw Manufacturing	Metals	Metals	Metals	Wood Products	Metals
14	Energy Drilling and Mining	Energy Drilling and Mining	Energy Drilling and Mining	Wood Products	Energy Drilling and Mining	Energy Drilling and Mining	Energy Drilling and Mining
15	Wood Products	Wood Products	Wood Products	Energy Drilling and Mining	Animals and By-products	Animals and By-products	Animals and By-products
16	Animals and By-products	Animals and By-products	Animals and By-products	Animals and By-products	Vegetables, Fruits and Plants	Food and Preparations	Food and Preparations
17	Food and Preparations	Food and Preparations	Food and Preparations	Food and Preparations	Food and Preparations	Vegetables, Fruits and Plants	Vegetables, Fruits and Plants
ECI	2.261503667	2.520234671	3.08896214	3.452901685	4.299466299	4.439916975	5.069638102

Table 9. Sample Incremental SDV Sensitivity for High-Complexity Products (2018)

Contingency Plan

The Contingency Plan aims to present a set of solutions with respect to upheavals in different industries. Instead of compensating for the declining production directly, the best strategy is to develop those incipiently profitable industries. In this manner, we can derive a contingency strategy for countries to deal with possible abrupt declines of crucial industries. In some cases, the SDV remains unchanged even when a zero-opportunity-gain industry declines to 20% in terms of export. We can then conclude the industry is not indispensable to the country. As a clarification, the three consecutive N/As mean that the country doesn't even need to respond to a collapse in the industry. Countries tend to have distinct solutions to the ups and downs of the same industry. To create the contingency strategy table, we decrease the

export level for each industry in the country's current production space by 60% respectively. The three highest-ranking industries in the new SDV are then returned.

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

Table 10. Sample Contingency Strategy (2018)

4.3 Sensitivity Analysis Results and Interpretation

We examine Chile's ECI Decremental and Incremental Sensitivity Charts for 2022. An increase in High-complexity Products will lead to the highest change in ECI, followed by Precious Stones. The low sensitivity effect of manipulating most industries contrasts previous years. Increases in Precious Stones will likely lead to increases in ECI, which is concurrent with our previous analysis. On the other hand, increasing High-complexity Products leads to a decrease in ECI, which can be interpreted as a warning to invest in moderate-complexity products first, such as Textiles or Precious Stones. For the negative shock cases, Energy, Drilling, and Mining and Chemicals become most impactful. This is interesting because both are relatively complex industries. In 2018, a negative shock to Energy, Drilling, and Mining lead to increases in ECI but in 2022, the same effect leads to decreases. This suggests that the industry has become more integral to the national economy.

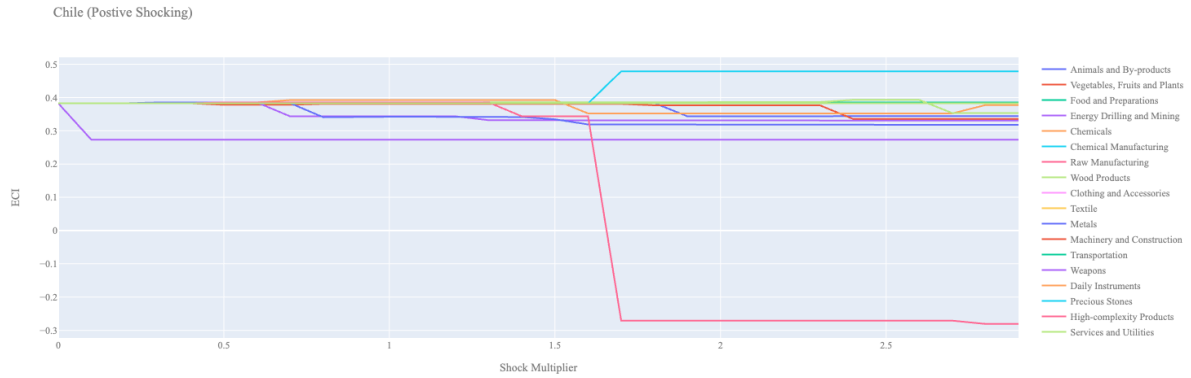


Figure 6a. Incremental ECI Sensitivity for Chile (2022)

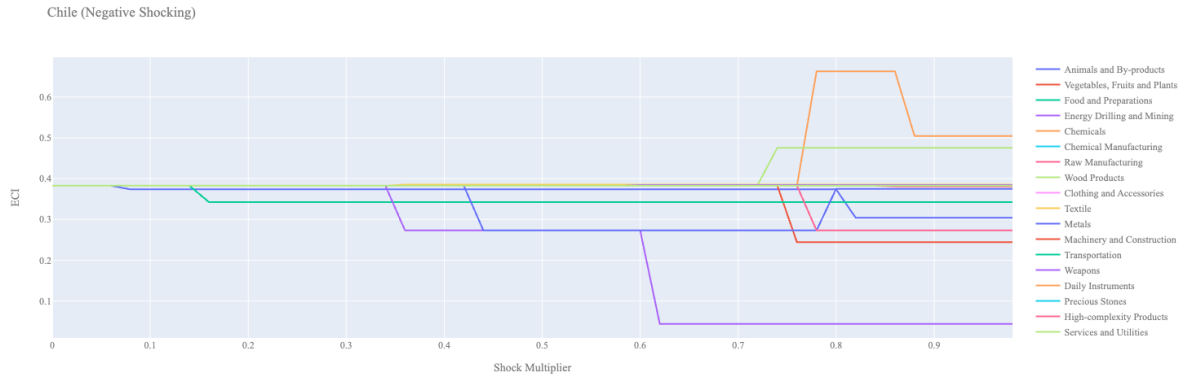


Figure 6b. Decremental ECI Sensitivity for Chile (2022)

Below is Chile's 2018 ECI Sensitivity Charts. Firstly in the positive chart, we notice immediately an increase in export in none of the industries lead to an increase in ECI score. We need to increase exports in a combination of industries in order to truly increase ECI score. Additionally an increase of export in many of the industries lead to slight decreases in ECI.

Next we consider Chile's 2018 Negative Shock chart. We see that Chile is especially sensitive to drawdown in Raw Manufacturing, Weapons, and Chemicals suggesting that these are key industries for the stability of the country's ECI score.

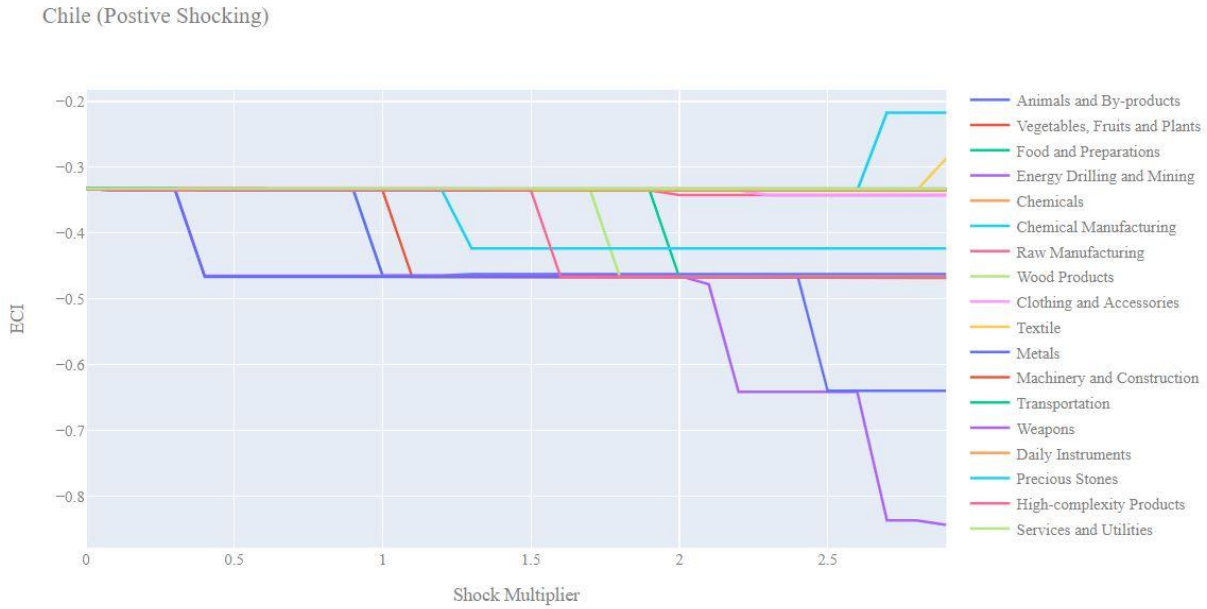


Figure 7a. Incremental ECI Sensitivity for Chile (2018)

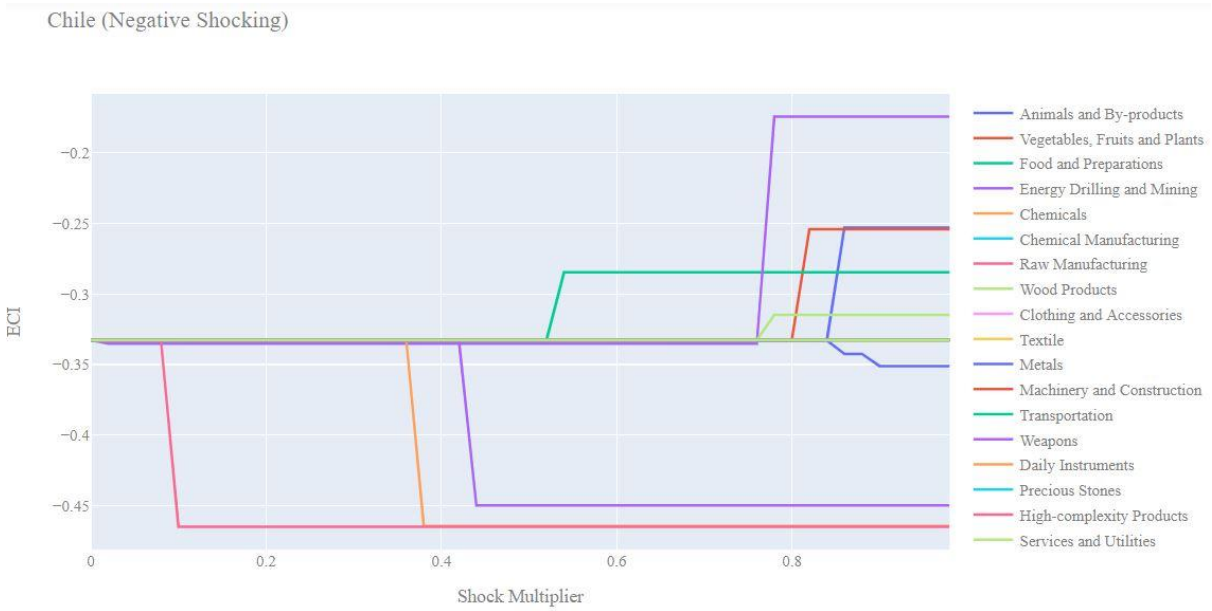


Figure 7b. Decremental ECI Sensitivity for Chile (2018)

Next we consider the 2013 ECI Sensitivity graphs. In the positive shocking case we see very similar behaviour as in 2018 although it is quite amplified. We see that increase in export for most industries actually decreases the ECI score.

In the negative shocking case we see again Chile is quite sensitive to decreases in Raw Manufacturing and Chemicals, even more so than we see in 2018. Large decreases in Energy, Drilling & Mining seem to increase the ECI score suggesting that this is a suboptimal industry for Chile to expand into.

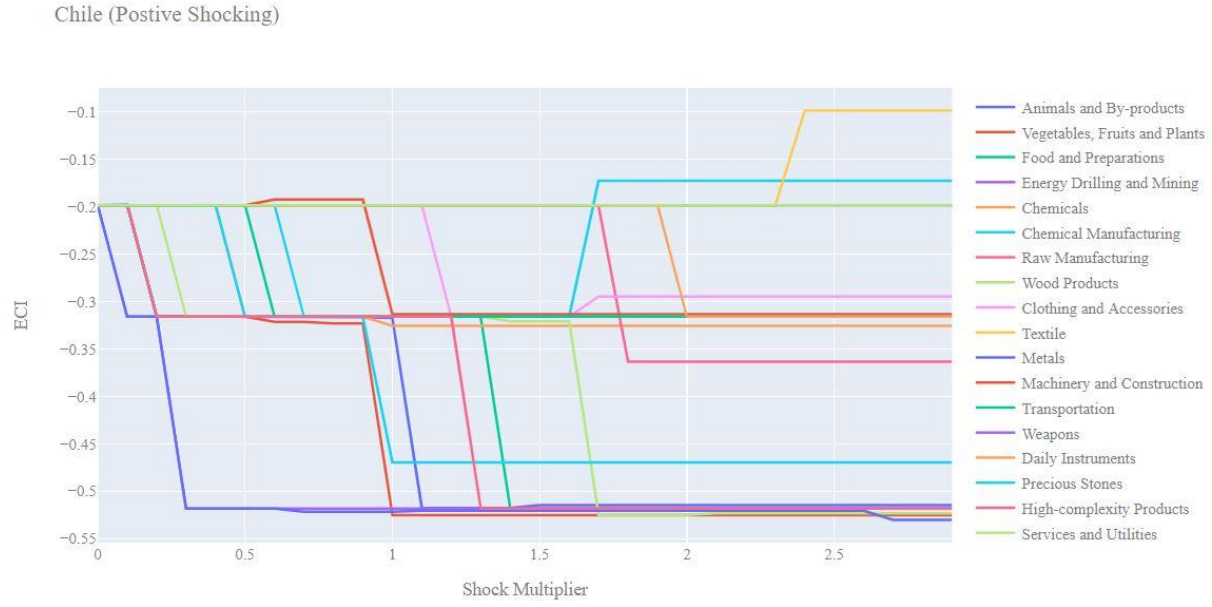


Figure 8a. Incremental ECI Sensitivity for Chile (2013)

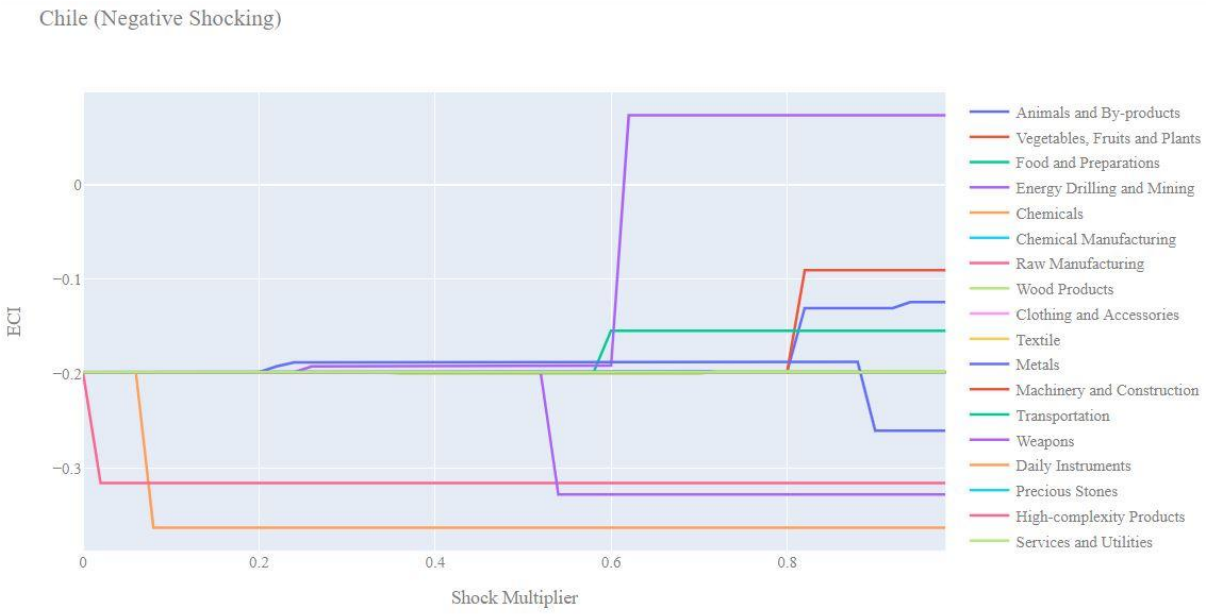


Figure 8b. Decremental ECI Sensitivity for Chile (2013)

4.4 Contingency Strategy

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

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

Table 13. Chile's Contingency Strategy (2018)

5. Macro-level Predictions

5.1 Structural Optimality Index

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

After obtaining this measure for all countries in our database, we further regress countries' five-year economic growth, which is defined as the percent increase in GDP (USD), over their SOI. Figure 9 illustrates the regression output, which shows a strong positive correlation between countries' SOI and their five-year GDP growth, significant at the [Percentage]% level and achieving an adjusted R^2 of [Percentage]%. 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 Chile and Its Implications

During the first examined period, Chile, for instance, has an average level of structural optimality as compared with its developed peers. As the regression in Figure 10a suggests (the red curve represents export increase and the blue curve stands for opportunity gain of the corresponding industry), Chile demonstrates an average level of correlation with the suggested developmental path, having an adjusted R-square of around 3.34%

Chile ranks in the second quartile among all countries in terms of SOI and has made a average rate of economic progress among its emerging peers from 2013 to 2018 with a 5-year GDP growth rate of 19.8%, which is consistent with the regression result in Figure 4b. This is in direct contrast to emerging economies such as Turkey, where there is a high SOI of around 21.8% and corresponding GDP growth of 37.7% from 2013 to 2018, making it one of the fastest developing economies during the period.

Specifically, Chile's moderate 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, Chile invested heavily in the Services and Utilities industry, while it should have focused more on moderately complex industry groups such as Precious Stones industry.

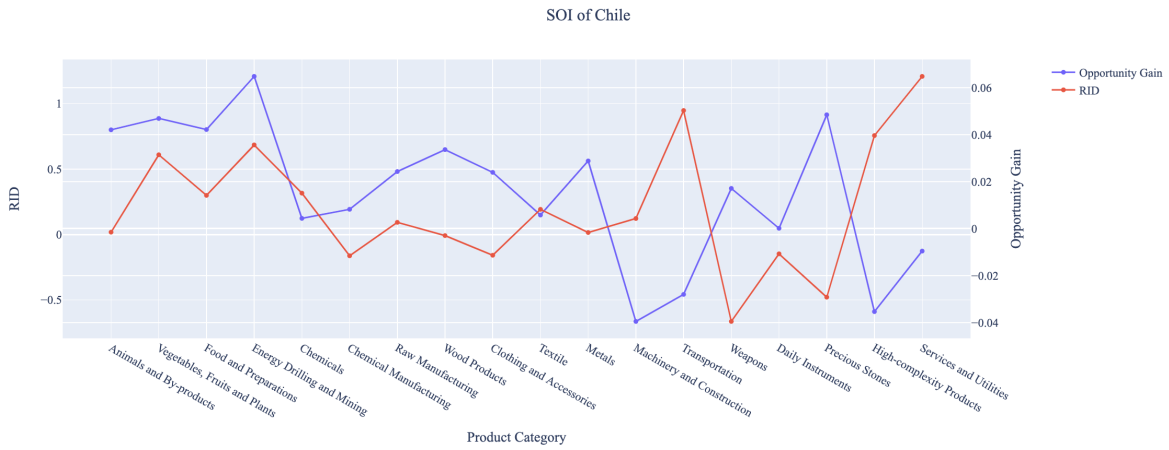


Figure 10a. SOI of Chile (2013-2018)

For the 2019-2022 years, Chile had a strong presence in the Precious Stones and Machinery and Construction industries, which is partially aligned with our previously recommended development strategy. We attribute Chile’s small GDP growth and significant ECI growth to this alignment. In the future, Chile should continue to invest in Machinery and Construction because it demonstrates high opportunity gain. It should take a more conservative approach to Precious Stones; while it has previously been a rewarding industry, it now has lower opportunity gain. Additionally, in the budget allocation section of this report, we also saw that Precious Stones played a progressively smaller role with each increase in export growth. Chile should also consider other moderately complex industries with high opportunity gains, such as Daily Instruments, to improve its growth.

Higher than before, its adjusted R-squared value of 11.28% now indicates a high correlation between the GDP growth and the implemented development path. Progress is slow on a global scale during this period, but Chile demonstrates a greater ability to adjust to negative economic shocks by improving SOI and increasing GDP growth than it did between 2013 and 2018.

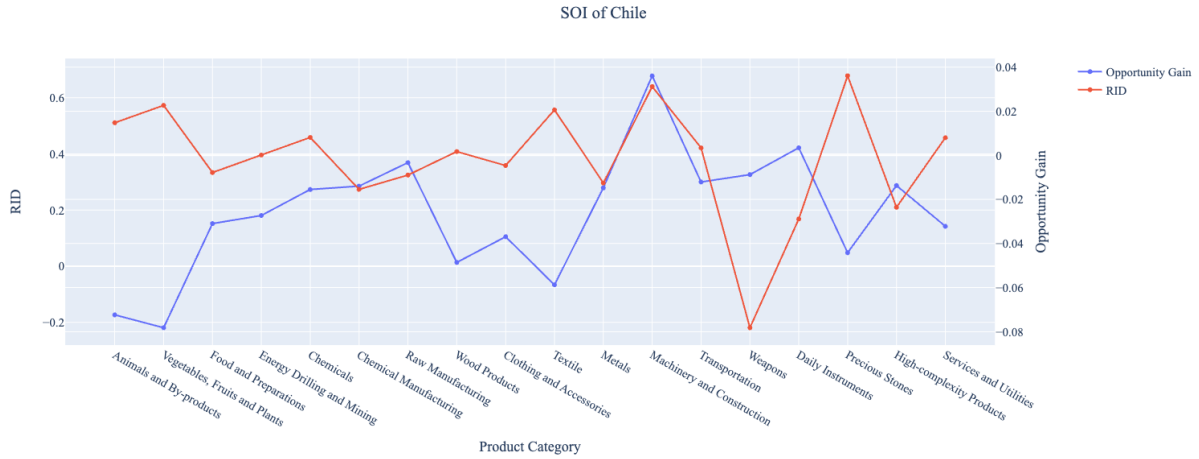


Figure 10b. SOI of Chile (2019-2022)

6. Concluding Remarks

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

The mixed progress during the first period, we believe, can be partially explained through the analysis of the economic and product complexity structure of Chile 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 Chile consistently relied on developing the Services and Utilities and Transportation industries in 2013 to 2018, 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, Chile can further its gains by prioritizing a combination of sectors, most notably Services and Utilities and Chemical Manufacturing and Precious Stones. We further note that Chile has a slightly mismatched development strategy that indicates an average (compared to other emerging economies) level of structural optimality on the complexity level, having an adjusted R-square of around 3.34%. Since a significant positive correlation exists between five-year GDP growth and the structural optimality index of an economy as we define and calculate, Chile 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, Chile performed stronger than before and compared to other countries, particularly Bolivia and Peru. We infer that during the COVID-19 period, Chile focused on developing a mix of moderately complex industries with its fiscal stimulus package. We also note that Chile has increased its investment in the sectors identified earlier, leading to a strong boost from Precious Stones, but still leaving some room for additional strategic improvement. The opportunity gain in the SOI suggests that greater growth could have been achieved through Machinery and Construction, while the budget allocation suggests that slow or moderate growth can be maximized by continued investments in Precious Stones. The surprising growth also increased the adjusted R-squared value to 11.28% in 2021 from 3.34% in 2018, demonstrating the pursued strategies contributed to the GDP. With the revised focus, Chile has further potential to advance its economic growth to maintain its position among other countries to continue its ongoing economic expansion.

References

Hausmann, R., Hidalgo, C., Bustos, S., Coscia, M., Chung, S., Jimenez, J., Simoes, A. and Yıldırım, M. (2007). *The Atlas of Economic Complexity*. [online] Atlas.cid.harvard.edu. Available at: http://atlas.cid.harvard.edu/.

Balassa, B., "The Purchasing Power Parity Doctrine - A Reapprais- al," *Journal of Political Economy* **72**, 584-596 (1964).

Feenstra, R.; Lipsey, R.; Deng, H.; Ma, A. & Mo, H. "World Trade Flows: 1962-2000" NBER working paper 11040. National Bureau of Economic Research, Cambridge MA (2005).

United Nations Commodity Trade Statistics Database (http://comtrade.un.org/db/), accessed in August 2019.

The World Economic Forum, "The global competitiveness report," (various years).

Barro, R. & Lee, J-W. "A New Data Set of Educational Attainment in the World, 1950-2010," NBER Working Paper No. 1590 (2010).

Kaufmann, D. & Kraay, A. "Governance Indicators: Where Are We, Where Should We Be Going?" Policy Research Working Paper 4370. Washington, DC: World Bank (2008).

Hanushek, E.A. & Woessmann, L. "The Role of Cognitive Skills in Economic Development," Journal of Economic Literature 46(3), 607- 668 (2008).