

Methodology Main Model

The main goal of the model is to provide the effect the Co increasing industry as average historical and forecast.

- Value Added
- Labour Income
- Employees
- Tax Contribution
- Output

Before starting the explanation of the model, in the next image we find the settings of the model. We will use it as a reference guide in some parts of the explanation

Select Region / Country: **China** 1

Cobalt value used: **Base product value + value addition** 2

For end manufacturing: **Include value addition at first use** 3

First use mode: **Average** 4

Include end sectors: **Yes** 5

Include income effects: **Yes** 6

From period: **2022** 7

Until period: **2023** 7

From period UNIDO: **2010** 8

Until period UNIDO: **2021** 8

Use MINSTAT REV 4 for UNIDO **Yes**

Smelting and Refining Products **All Products**

RUN PROCESS

The explanation is divided into the next sections and it is sorted regarding the current flow of processing:

- 1) Calculating the OECD's multipliers: see sheet "Methodology Main Model-OECD"
- 2) Calculating the Unido averaged indicators: see sheet "Methodology Main Model-UNIDO"
- 3) Getting the Prices and Co data: see sheet "Methodology Main Model-Co Data"
- 4) Putting all together and getting final results
- 5) Global region vs individual region
- 6) Summary sheet results

4) Putting all together and getting final results

Inside the sheets "Roskill IO Model PIVOT" all the information processed in steps 1) to 3) is mixed for output the final model results. We can divide this sheet as is showed in the next images:

[illegible]

- (1) This is the header of the sheet. Basically, it contains the description of each application for MSR, First Use, End Use and Recycling applications. The descriptions are used to get the values from OECD (see point 7 below). In case of a description has two OECD's codes, the values are averaged to get the final value from OECD.
NACE's codes are not currently used
- (2) Sectorial Analysis information: The process gets the final indicators from Unido (see the section "c) Calculating the final averaged indicators for each application:" inside sheet "Methodology Main Model-UNIDO") in each row in here for each application.
- (3) Company Analysis: The process gets the final indicators from Co Data (see the section "c) Calculating the final averaged indicators for MSR:" inside sheet "Methodology Main Model-Co Data") in each row in here for "Mining" and "Smelting and Refining" applications. Because the "Representative Companies Analysis" just have data about MSR, for the First Use, End Use and Recycling applications the value is equal to the value from Sectorial Analysis. This way, the MSR applications are the only ones that have both point of view. For the rest, the value to take in care is the Sectorial Analysis
- (4) This section consolidates the information from "Sectorial" and "Representative Companies" Analysis, depending of what option is currently setting in the initial configuration "First Use Mode" (item 4 of filter image) Basically, the next rule or formula is applied:
- If the value of the filter is "ISC Sectorial analysis", then the process takes the value of point (2). Also, the R&D will be 0 for MSR and First Use applications
 - If the value of the filter is "Representative Companies", then the process takes the value of point (3)
 - If the value of the filter is "Average", then the process takes the average between the value of point (2) and the value of point (3). The R&D is equal to the value of point (3)
- (5) Cobalt Value: Represents the average per year of cobalt's production value, considering the years filtered from "FROM PERIOD" to "TO PERIOD" (item 7 of filter image). One important observation is that this value is the same for historical data, so, basically, if we limit the "FROM PERIOD" and "TO PERIOD" to historical years, we will the same result for each scenario. This way, we can emulate the result of the original model without taking into account any forecasting component
- (6) The "Direct Effect" result. Basically, each row is the result of multiplier the Cobalt Value (point (5)) with each of the indicators in point (4). Conceptually, each of the indicators in point (4) represents the relation between Labour Cost, Value Added, Employees, Taxes and R&D with the Total production value. So, multiplying each of this with the Cobalt Production Value (point (5)), the process calculates which is the effect of Cobalt Production in Labour Cost, Value Added, Employees, Taxes and R&D. In a few words, it calculates what is the portion of each indicator that could be explained only by Cobalt Production
- (7) IO coefficients: This is taken from OECD final results (see sheet "Methodology Main Model-OECD"). Basically, ..., TBD
- (8) This, together with (6), are the final output of the model. The results are calculated multiplying the IO Coefficients (point (7)) and the Cobalt Value Production (point (5)).

5) Global region vs individual region

If we select a particular region that is not "Global", then, the calculations performed are the described above. This final results are pasted into the sheet "Roskill_IOModel", that is where anyone can find the final output. For the case of Global Region, what is saved in this sheet is the sum of each of the calculations performed for each of the individual regions. It is important to observe that the result of the calculations above over the processed data for Global Region is not equal to the result of the sum. Because of this, the process has to do the calculations per each region, and not do the calculations just filter the Global region.

6) Summary sheet results

In the summary sheet we will see two main tables (see images below):

- 1) For "Production of cobalt", the process sum the applications of MSR
- 2) For "Direct applications", the process sum the First Use applications
- 3) For "End Manufacturing", the process sum the End Use applications
- 4) For "Recycling", the process takes the final output for Recycling application
- 5) In "Total", the process sum the results for all the applications in the upper points

Value added	LOW SECTOR					BASE CASE					HIGH CASE				
	Production of cobalt	Direct applications	Manufacturing	Recycling	Total	Production of cobalt	Direct applications	Manufacturing	Recycling	Total	Production of cobalt	Direct applications	Manufacturing	Recycling	Total
	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added	Value added
Direct effect	3,651	1,231	623	150	5,556	4,564	1,539	779	188	7,070	5,677	1,847	935	225	8,684
Indirect effect	1,132	589	669	162	2,552	1,132	589	669	162	2,552	1,132	589	669	162	2,552
Indirect input effect	2,779	1,061	1,135	162	4,667	2,889	1,126	1,145	202	5,833	9,419	1,591	1,747	243	13,000
Indirect output effect	28	14	2	2	46	28	14	2	2	46	28	14	2	2	46
Total effect	7,091	2,895	2,450	416	12,872	8,863	3,169	3,086	520	15,630	10,656	4,343	3,705	624	19,308
Labour income															
Direct effect	180	179	145	183	687	225	224	181	229	859	270	269	218	276	1,033
Indirect effect	437	254	297	43	1,031	572	318	374	44	1,314	686	381	445	65	1,577
Indirect input effect	973	467	518	73	2,031	1,217	583	648	93	2,548	1,460	700	777	109	3,046
Indirect output effect	14	7	1	1	23	14	7	1	1	23	14	7	1	1	23
Total effect	1,624	907	961	308	3,798	2,030	1,148	1,209	375	4,738	2,436	1,360	1,450	189	5,697
Employees															
Direct effect	14,096	23,699	15,659	1,597	55,051	17,620	29,824	19,571	6,307	69,488	21,544	35,549	23,488	2,998	82,577
Indirect effect	48,064	28,818	11,361	4,966	93,209	60,022	40,043	15,914	7,209	122,988	85,226	48,882	17,448	7,176	171,266
Indirect input effect	120,788	59,344	34,405	9,651	255,804	150,997	74,180	42,513	12,064	319,754	181,397	99,016	99,015	14,477	385,885
Indirect output effect	1,924	951	155	137	3,957	4,045	2,085	1,427	173	8,686	3,885	1,427	1,427	205	6,935
Total effect	284,864	112,812	64,975	16,551	429,003	231,080	141,105	82,719	20,449	519,255	279,296	181,716	17,463	24,527	645,704
Tax contribution															
Direct effect	818	286	558	63	1,724	1,001	357	607	97	2,065	78	1,155	1,237	493	2,586
Indirect effect	956	596	286	57	1,922	956	596	286	57	1,922	956	596	286	57	1,922
Indirect input effect	1,104	507	555	75	2,242	1,381	634	694	242	2,803	1,657	767	833	113	3,363
Indirect output effect	11	6	1	1	19	11	6	1	1	19	11	6	1	1	19
Total effect	2,889	1,084	1,445	186	5,240	3,355	1,551	1,555	1,806	5,205	3,744	1,626	2,167	279	7,808

- b. The summary table and charts of Cobalt focused information

The table is split into "Value of Cobalt" and "Volumes of Cobalt"

- 1) For "Value of Cobalt", the process takes the values from point (5) of 4) Putting all together and getting final results", for each scenario,
- 2) For "Volumes of Cobalt", the process takes the information directly from Co Data (sheets "Co_MSR", "Co_First_Use", "Co_End_Use" and "Co_Recycling". Basically, these values are the sum of Cobalt Production volumes for each of the applications (depending of the column it could be Mining, Smelting and Refining, First Use, End Use or Recycling) averaged by the "PERIOD FROM"-"PERIOD TO" filters



	Mine production	Refined production	Direct applications	End manufacturing	Recycling
LOW – Value of cobalt	46	6,128	3,246	3,681	515
BASE – Value of cobalt	57	7,660	4,057	4,602	644
HIGH – Value of cobalt	68	9,193	4,869	5,522	773
Volume of cobalt	3,186	95,328	29,404	45,779	12,151