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*Resilience of the Global Electric
Vehicle Market under Cobalt
Supply Risk Shocks*

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Resilience of the Global Electric Vehicle Market under Cobalt Supply Risk Shocks

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- Electric Vehicle markets are seeing exponential growth.
- Global electric vehicle sales increased more than 500 times compared to 2010.
- At present, China's market share in the electric vehicle market is more than 60%.

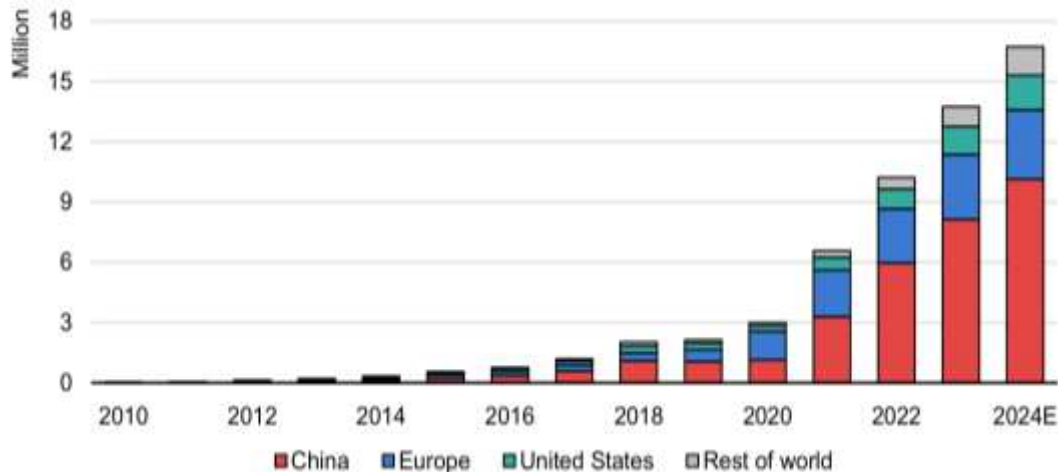


Fig1. Electric vehicle sales 2010-2024
(IEA, Global EV Outlook 2024)

- The market size of electric vehicles is expected to continue to expand in the future.
- According to the IEA, electric vehicle sales are expected to continue to grow over the next decade, with global electric vehicle sales accounting for more than 35% of new car sales by 2030.
- 2030: 3.2 Trillion USD



Fig2. Electric vehicle market share 2020 & 2030
(Data Source: IEA & Mordor Intelligence)

Cobalt: Demand Growth & Supply Risk



- **Demand Growth**

- The increase in demand for electric vehicles is driving demand for related critical minerals.
- According to Cobalt Institute, global cobalt demand will reach 187,000 tons in 2022, a year-on-year increase of 13%, mainly due to electric vehicles.

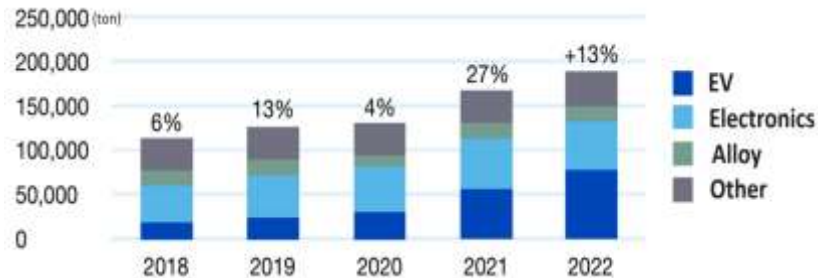


Fig3. Volatility of cobalt prices
(Cobalt Institute, Cobalt market report 2022)



Fig4. Growth in cobalt price (Data source:)

- **Supply Risk**

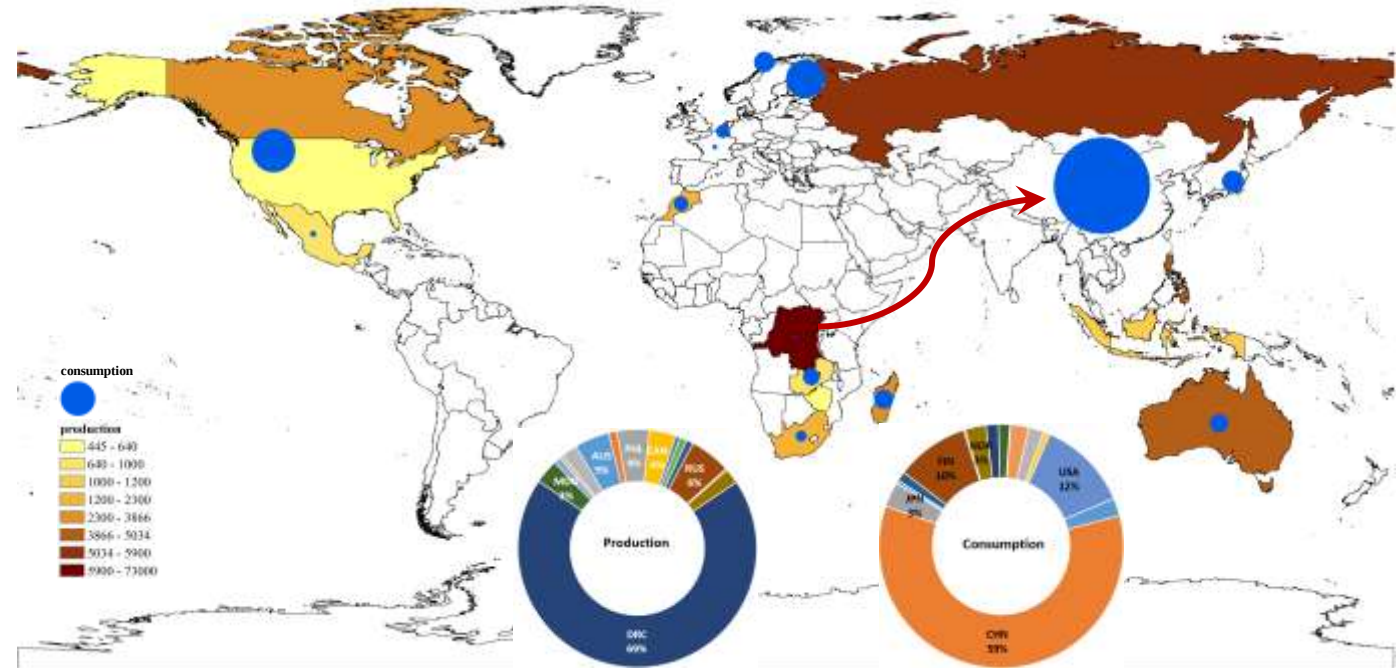


Fig5. Global Distribution of Cobalt Production and Consumption
(Data source: USGS)

- Countries involved in global cobalt production and consumption are geographically dispersed, primarily relying on imports.
- China's cobalt supply relies on imports from the DRC for more than 95%.
- The World Bank's overall risk rating for DRC is "high".

Government: Concerns & Positive Response

- In recent years, governments around the world have placed significant emphasis on the security of critical minerals.
- Governments frequently update the lists of critical minerals, with cobalt included in these lists.
- Many countries have enacted multiple policies.
- “Mineral Security Partnership”

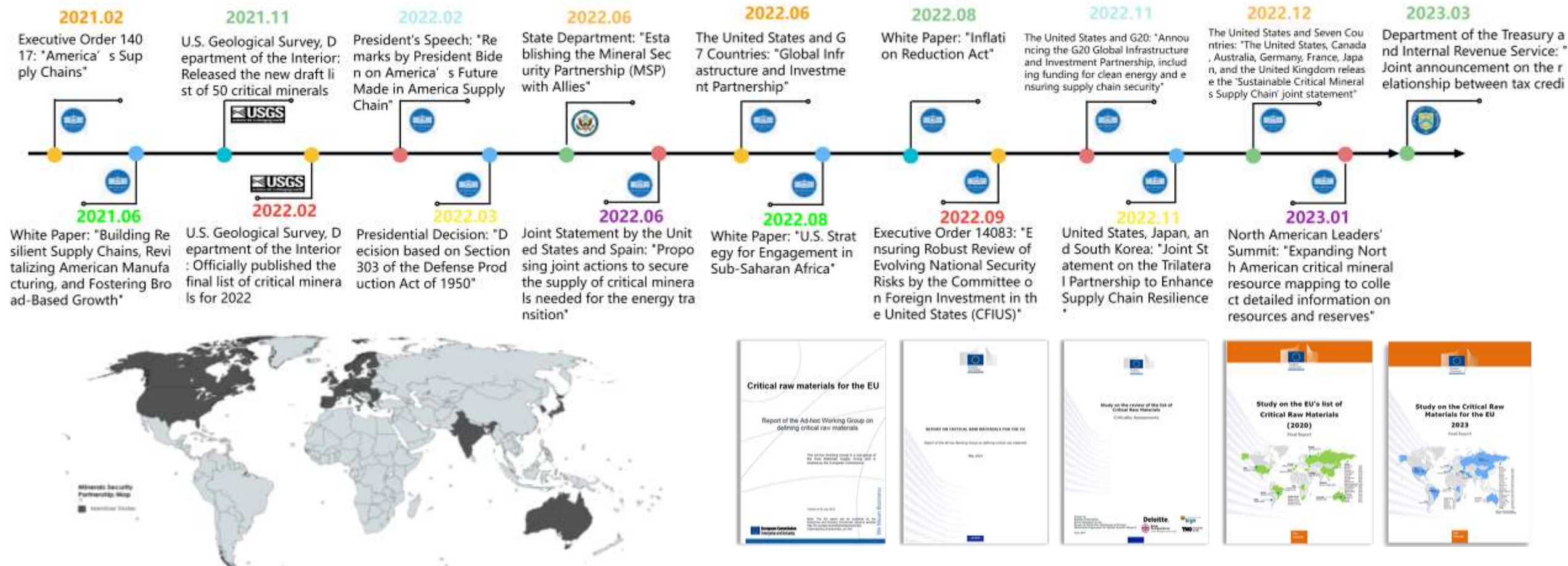
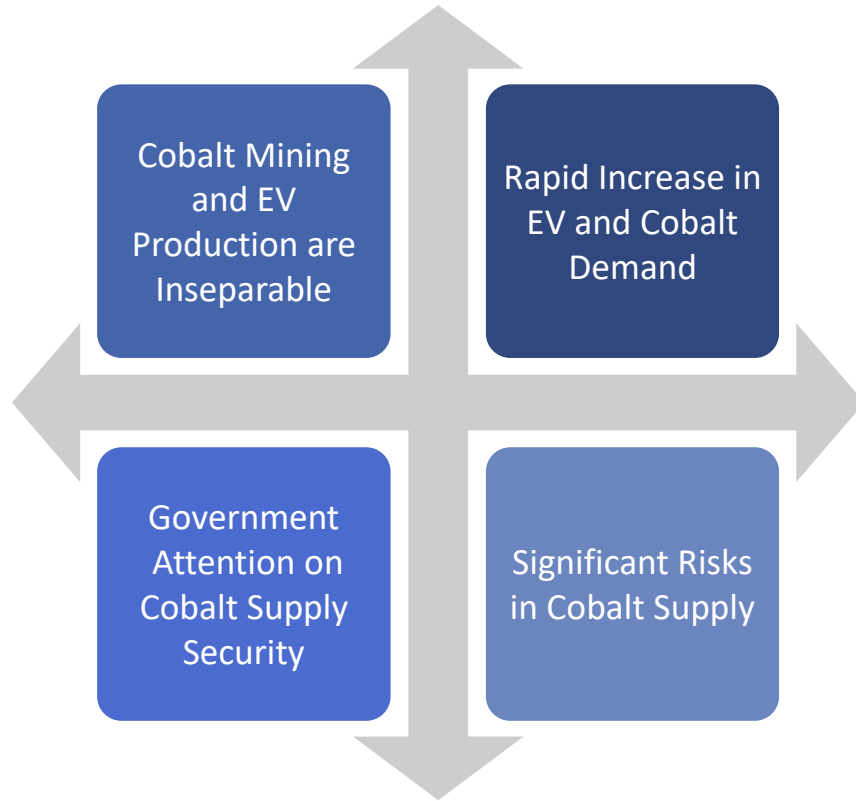


Fig6. Mineral Security Partnership (Bourenane Chahine.,2023)

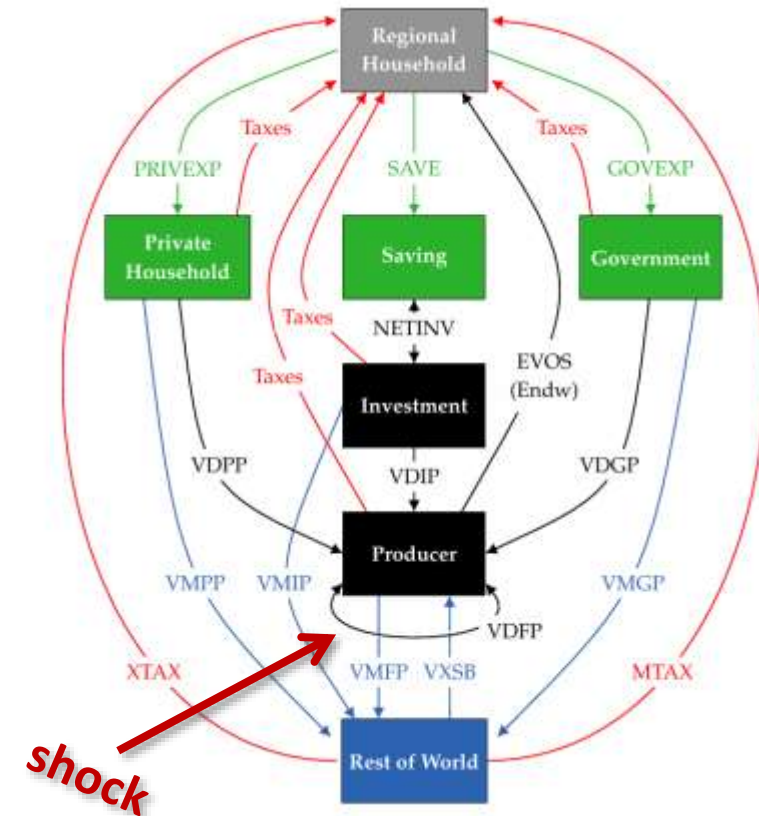
Fig7.EU's critical minerals lists (European Commission, 2011;2014;2017;2020;2023)

Problem: Statement & Solution



- **What is the impact of cobalt supply risks on the EV market?**

- Compared with traditional econometric models, CGE models have outstanding advantages when facing unexpected risks.
- The CGE model is more suitable for assessing the systemic impact caused by policies and emergencies.



shock

Fig8. Circular flows in a regional economy (Corong et al., 2017)

Data: Split Input-Output Table

- Aggregate the GTAP database into 12 regions and 13 sectors.
- Non-Competitive Input-Output Table from the GTAP 11 Database.
- Input-Output Table Including Cobalt (Cobalt Concentrate, Refined Cobalt, EV).

Tabal 1. Steps for splitting the Input-Output Table

	Item	Data Source
1	Total Output	Cobalt Concentrate, Refined Cobalt Quantity: USGS Price: USGS
2	Export	Trademap、UN Comtrade (Divide the country)
3	Final Demand	Estimated based on the proportion of mining and nonferrous metals sectors
4	Intermediate Use	Total Output - Export - Final Demand as the control number Cobalt Concentrate: Mainly directed towards refining cobalt Refined Cobalt: Allocated based on the proportion of material flow analysis(MFA)
5	Total Input	Total Input
6	Value Added	Estimated based on the proportion of mining and nonferrous metals sectors
7	Intermediate Input	Import as the control number (Trademap), Total Input - Value Added - Import as domestic intermediate input control number Cobalt Concentrate: Determine the proportion of mining sector's major input, then allocate the remaining proportion to the mining sector's intermediate input Refined Cobalt: Determine the proportion of refined cobalt's input, then allocate the remaining proportion to the nonferrous metals sector's intermediate input

Tabal 2. Structure of the splitted Input-Output Table by sector

	Sector1	Sector2	...	Cobalt concentrate	Other mining	...	Refined cobalt	Other metals	EV	Final demand	Export (Divide country)	Total output
Domestic products	Sector1											
	Sector2											
	...											
	Cobalt concentrate											
	Other mining											
	...											
Imported products	Refined cobalt											
	Other metals											
	EV											
	Sector1											
	Sector2											
	...											
Value added	Cobalt concentrate											
	Other mining											
	...											
	Refined cobalt											
	Other metals											
	EV											
Total input												

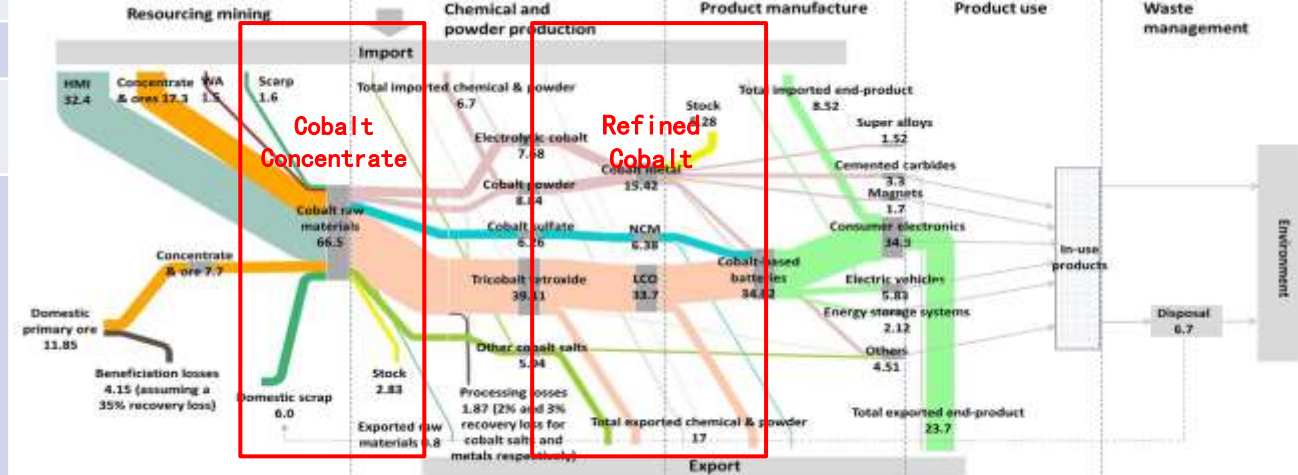


Fig 9. Cobalt Material Flow Analysis (Chen et al.,2020)

- Splitcom: Input-Output Table → GTAP



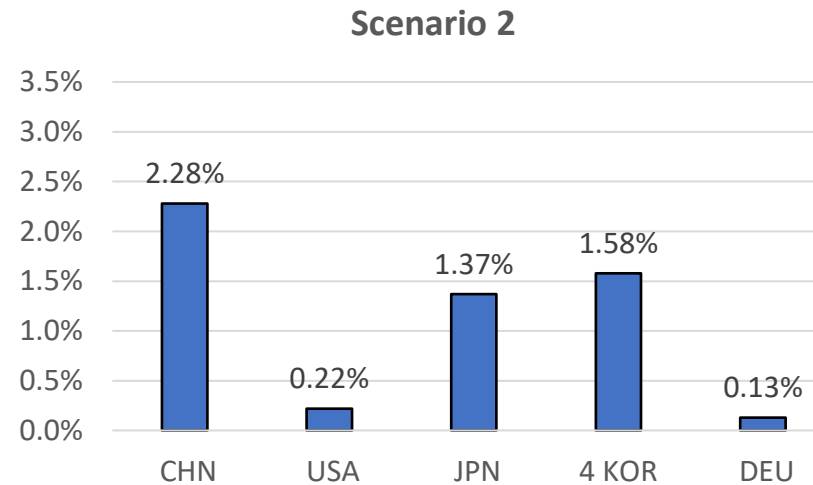
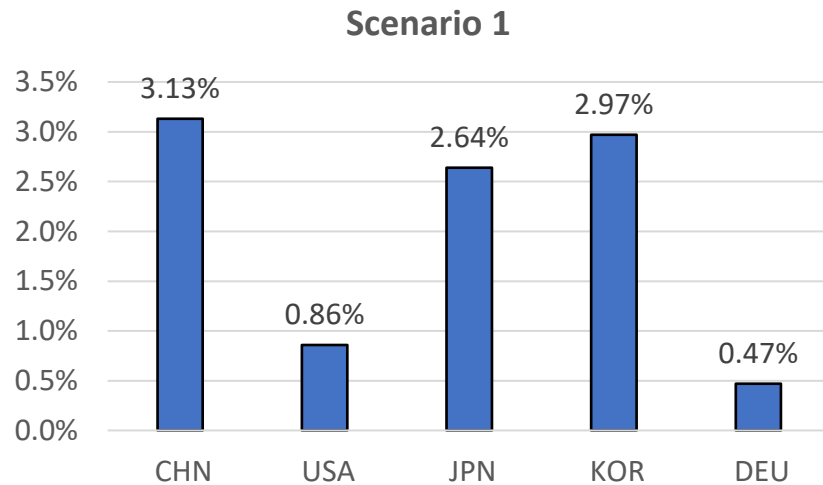
- Model: GTAP V6
- Make the cobalt concentrate output (q_o) exogenous
- Shock to the Democratic Republic of the Congo's exports (q_{xs})
- Shock to the cobalt concentrate tariffs (t_{ms})

- Scenario 1: Due to labor issues, political instability, or natural disasters, cobalt exports from the Democratic Republic of the Congo(DRC) are reduced by 50%.
- Scenario 2: In the event of an extreme situation, such as a full-scale civil war in the DRC or an international trade embargo, cobalt supply is completely interrupted, resulting in a 100% reduction in exports.
- Scenario 3: With the rise of global resource nationalism, cobalt-producing countries increase tariffs on cobalt to protect their domestic resources by 30%.
- Scenario 4: Amidst global trade tensions and protectionist sentiments, cobalt-producing countries impose higher export tariffs on cobalt, increasing them by 60%.

Table 3. Description of cobalt supply risks scenarios

Scenario	Description
Scenario 1	Cobalt exports from the DRC decrease by 50%
Scenario 2	Cobalt exports from the DRC decrease by 100%
Scenario 3	Cobalt export tariffs increase by 30%.
Scenario 4	Cobalt export tariffs increase by 60%

Results of EVs Price Changes in Major EV Producing Countries



	Scenario 3	Scenario 4
CHN	0.01%	0.01%
USA	0	0
JPN	0	0
DEU	0	0

- A shortage in cobalt supply or an increase in tariffs will **drive up the production costs** of downstream products EVs.
 - Scenario Analysis: In both Scenario 1 and Scenario 2, the production costs of EVs rise across major producing countries.
- Due to differences in production structures, the extent of **cost increases varies** among countries.
 - **Minimal Impact on the US and Germany.**
 - **Significant Impact on China.**
- Given that cobalt constitutes a small portion of the overall EVs price, its impact on production costs is limited. Only in China do EV prices experience a noticeable, albeit small, increase.

Results: Output Levels



- There is **significant heterogeneity** in Evs output changes.
- Due to the impact of costs, China's Evs output shows the most significant decline across all four scenarios, with Scenario 2 resulting in a loss of \$7.746 billion in revenue.
- Conversely, **Evs output in the United States and Germany increases, compensating for the decline in China.** Notably, Germany's output rises by 2.51%, 4.04%, 0.01%, and 0.01% in the respective scenarios.

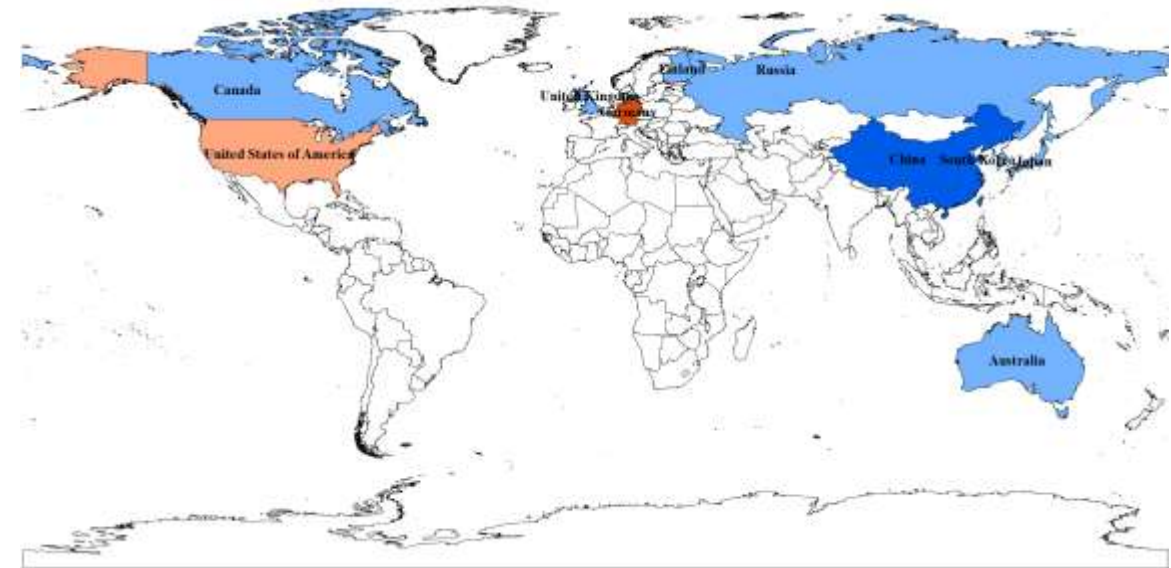


Fig 10. Changes in EVs Output

(Note: Blue indicates decrease, red indicates increase.)

Table 4. Changes EVs Output Volume and Percentage under Different Scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1 CHN	-4356	-7746	-11	-10	-2.12%	-3.77%	-0.01%	0
2 USA	476	683	1	1	0.43%	0.62%	0	0
3 JPN	-312	-511	-1	-2	-0.48%	-0.79%	0	0
4 KOR	-120	-137	-1	-1	-0.50%	-0.57%	0	0
5 DEU	2334	3754	7	6	2.51%	4.04%	0.01%	0.01%
6 GBR	-144	-380	0	0	-1.33%	-3.49%	0	0
7 FIN	-76	-137	0	0	-21.87%	-39.19%	-0.06%	-0.06%
8 AUS	-106	-251	0	0	-3.46%	-8.15%	0	0
9 RUS	-31	-60	0	0	-0.54%	-1.02%	0	0
10 CAN	-25	-44	0	0	-0.34%	-0.60%	0	0
11 DRC	-91	-185	0	0	-115.90%	-234.14%	0.01%	0.01%
12 ROW	1286	1974	3	3	0.72%	1.11%	0	0

Where did the increased or decreased production go?

Results: Trade Structure

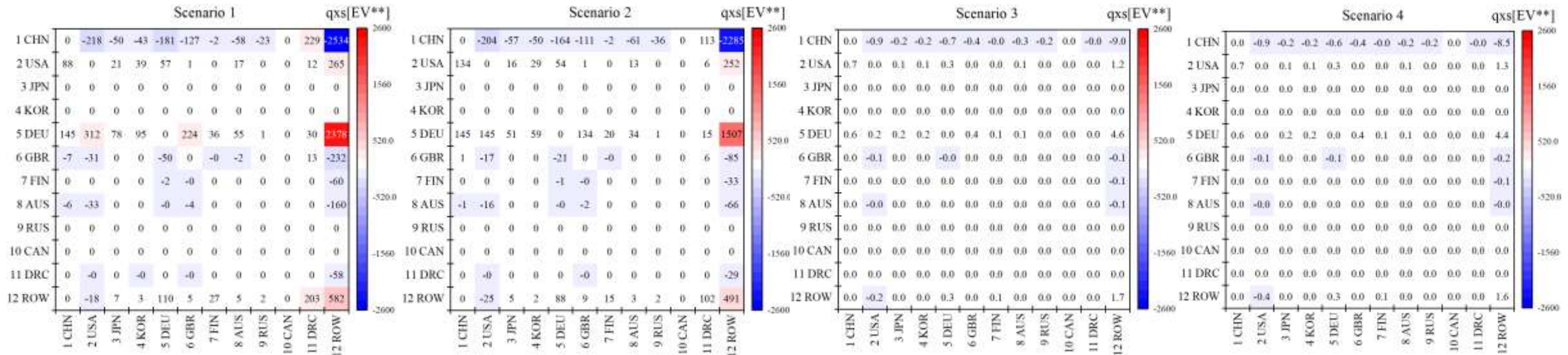


Fig 11. Changes Evs' exports and imports under Different Scenarios

- Due to the relatively larger rise in Chinese EVs price, **China has lost its competitive edge** in the international market, resulting in a significant export substitution effect.
 - Germany's EV exports primarily increase to the United States and the United Kingdom.
 - The United States sees a substantial increase in EV exports to China.
 - Consequently, China's EV exports to the United States, Germany, and the United Kingdom decrease.
- In Scenarios 3 and 4, the major changes also occur in China, with a noticeable decline in EV exports to all countries.

- **Database Construction:** Further refine the input structure by incorporating micro-level data from enterprises.
- **Model Structure:** Develop a model that better reflects the characteristics of mineral resources, considers technological advancements, and introduces dynamic elements.
- **Research Direction:**
 - Investigate the long-term impact of cobalt supply risks on the electric vehicle industry.
 - Comparative Analysis: Compare the economic and social impacts of cobalt supply risks across different countries.
 - Cobalt Recycling: Assess the impact of cobalt recycling on the electric vehicle industry.



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Thank you for your attention!