Brief History of Japanese Criticality Assessment

Shinsuke Murakami (PhD)

smurakam@sys.t.u-tokyo.ac.jp

Assoc. Prof., Sch. of Eng., The University of Tokyo

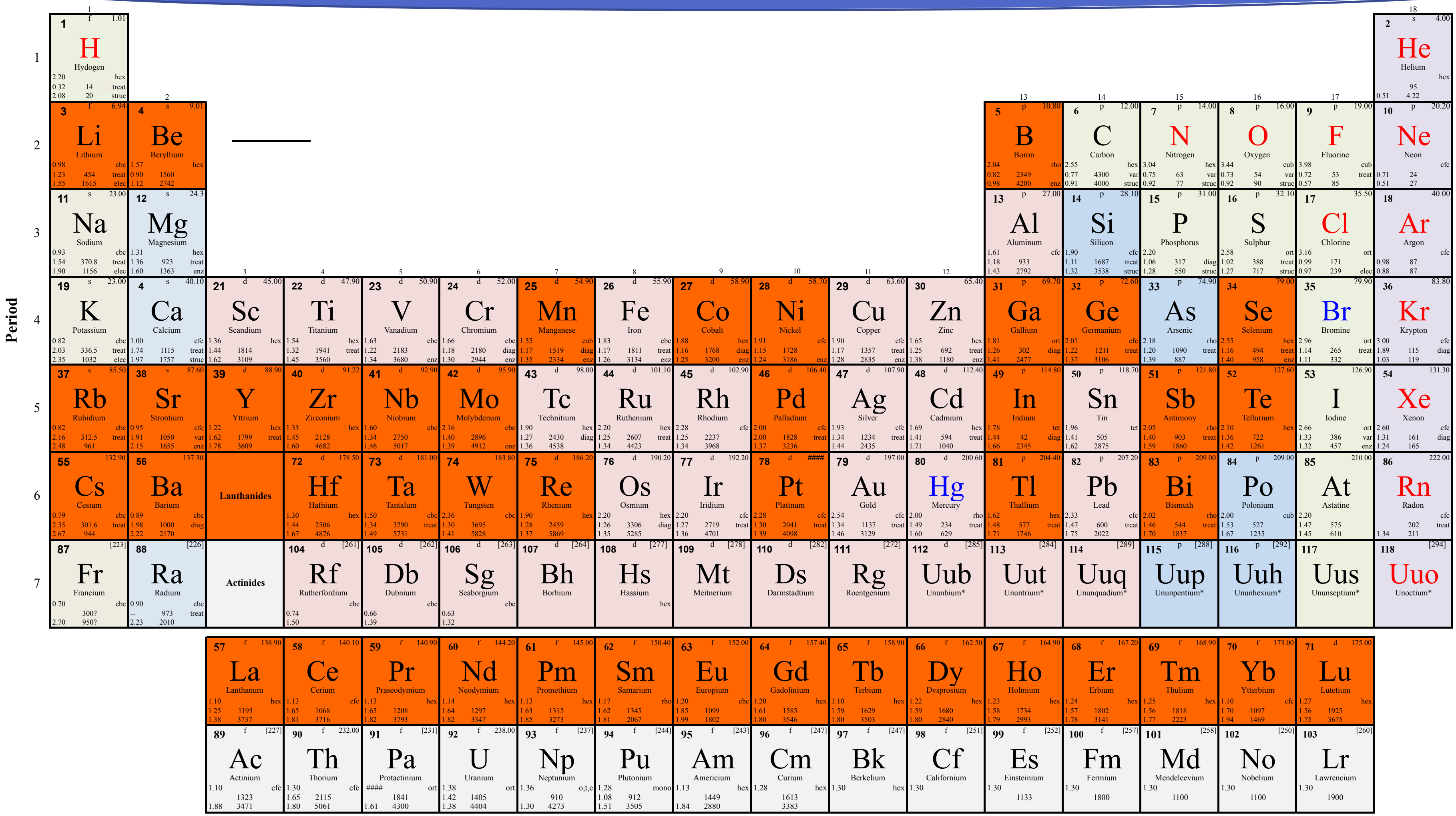
Chair, the Organizing Committee of EcoBalance 2018

Japanese Resource Policy and Rare-Metals

- Japan has really limited domestic supply of metal ores.
  - only one small gold mine is now currently operating.
- Japanese economy's high dependency on manufacturing industries, especially electronics, machineries, therefore securing stable supply of materials for the industries has been essential for Japan.
- *Rare-metals*?: 31 elements defined officially by Japanese government (See the periodic table in the next slide)
  - Selection criteria: {"Geologically rare" or "technically economically difficult to recover"} & "strong demand in industry for now and future"

Japanese Policy

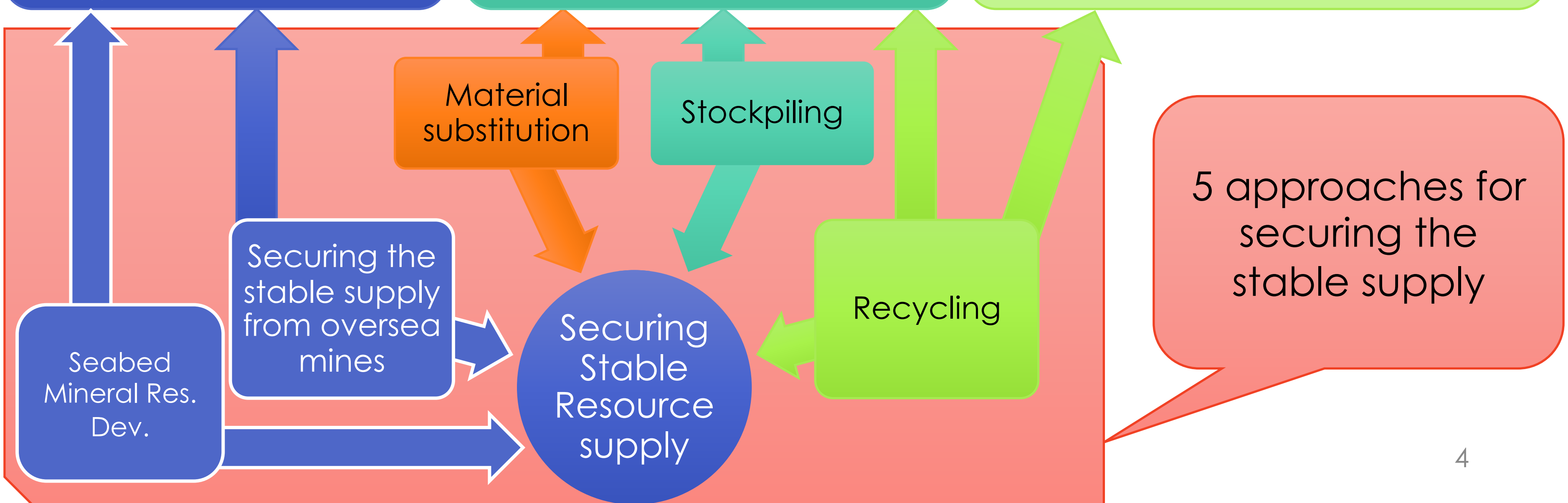
Rare-metals (Orange colored) 30 + Rare Earth Elements



Japanese Policy

5 core policy measures in Japanese mineral resource policy

Exploration – Development – Production (Mining)	Materials Production and Use	EOL management (recycling)
<Oversea Mines> • Financial aid for oversea exploration • Loans for private mining companies... • Diplomatic efforts <Seabed> • Reserve estimation, tech. R&D	• Funding R&D for material *substitution*, *reducing* the rare-metal use, *new scrap recycling* and other smelting refining technologies • *Stockpiling*	• Funding R&D projects for EOL recycling • Social Systems for more comprehensive EOL management?



Japanese Policy

Previous Assessments for Governmental Stockpile

<Early Assessment>

- After experiencing two oil crisis, not only crude oil but also minerals stockpiling scheme was established in 1983.
    - Demands for 60 days stockpiled. (42 by government, while 18 days by private.)
- 7 rare-metals were chosen to be stockpiled.
    - Co, W, V, Mo, Ni, Cr, Mn: 1st choice. (1984)

<Later…>

- In, Ga: already added to stockpile? (2009)
    - Pt, REE, Nb, Ta, Sr: should be carefully monitored

Assessment for Recycling

Around 2011, when the recycling law for Small-size home appliance was prepared, the governmental council discussed which minor elements should be targeted in the EOL recycling.

- Nd, Dy, Co, W, Ta was chosen.
  - Firstly, 14 elements was chosen as candidates.
  - From the 14 elements, 3 metals, which are already well recycled from new scraps (In, Ga, Ce,) and 6 metals, which seems technically impossible to recycle now (Li, La, Y, Eu, Tb, Sm) are excluded.
- The recycling of the chosen 5 elements had no economic feasibility at that time therefore council advised to support R&D projects and also implement needed social systems.

Ongoing Assessment

Even though, I'm chairing the Chair of the policy review committee on resource criticality, this is my own individual presentation.

(Simply, the PJ has not yet completed therefore nothing concrete available.)

Criticality Assessment PJ

- METI (precisely, its branch of Agency for Natural Resource and Energy) carried out the assessment PJ. However, the results were only disclosed as a part of huge reports for mineral resource policy. And it initiated new criticality assessment project in 2015.

- This assessment has the following characteristics:
  - Not only for rare metals, but common metals are target,
  - Explicit consideration of economic importance (vulnerability.)
  - Try to develop the system, which can be semi-automatically updated with statistical data.
  - Hopefully, the assessment should be useful information to specify the policy target, but also to assess the effectiveness of the introduced policies.

Methodology & Data

- No intention to develop the whole new methodology. Instead, it should be comparable with other assessment in EU, US and others.
- Simply, list the factors we‘ve cared, organize them into two groups of the factors affecting supply risk and economic importance.
    - Supply Risk: TERP framework in Dewurf et al. (2016)
- Data will be obtained various sources. For now, the assessment only with public data might be disclosed public. In addition, we may try to put all data available no matter whether they’re confidential or not.

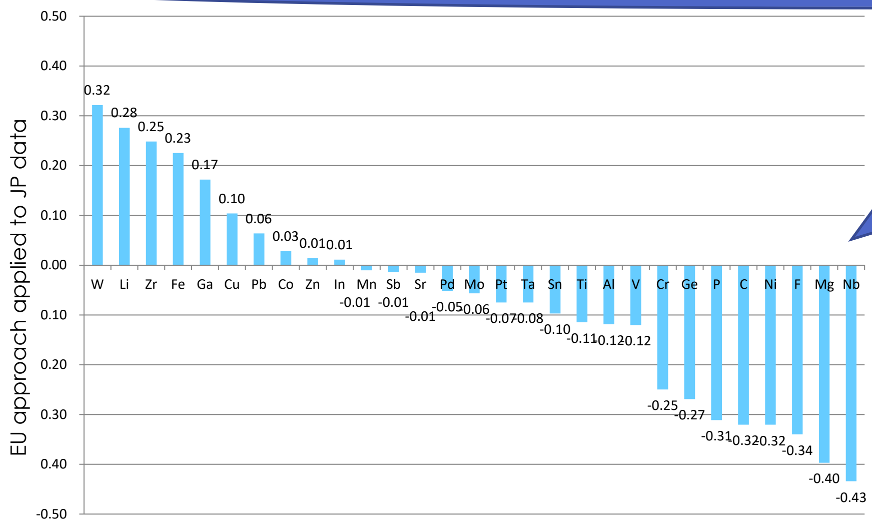
Ongoing Assessment

Supply Risk Indicators

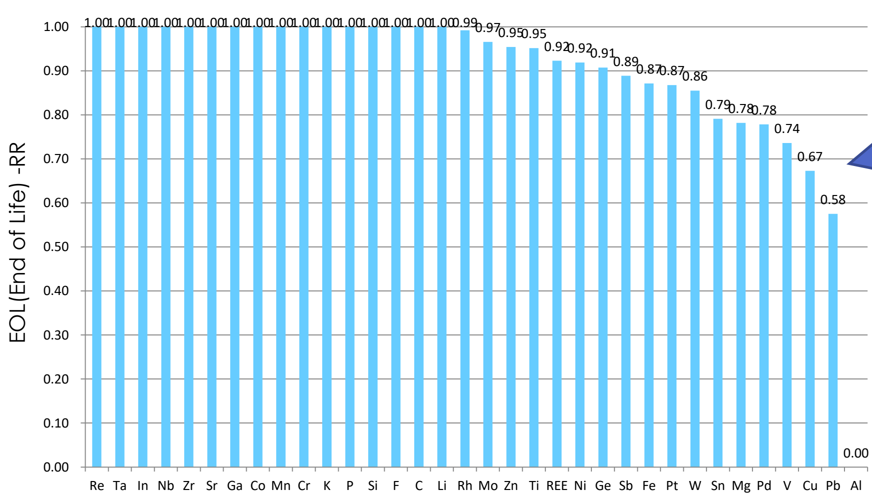
based on TERP concept proposed in the work of Dewulf et al. (2016)

Items should be considered.			Candidate Indices
Supply Risk	T	Depletion/Degradation/Accident	①Trend of grades / # of Accidents
	E	Market Oligopolization	②HHI of Production by countries / ③Mines
			④HHI of Reserves by countries / ⑤Mines.
		Concentration of trade partners	⑥HHI of imports by country
		Price Volatility	⑦Historical Volatility of Price
		Stability of supply side	⑧Change of R/P
		Self sufficiency	⑨Attributable primary production to JP companies / total primary inputs
	R	EOL recycling	⑩EOL scraps share in total inputs for material production
	P	Governance of Trade Partners	WGI_HHI

Example

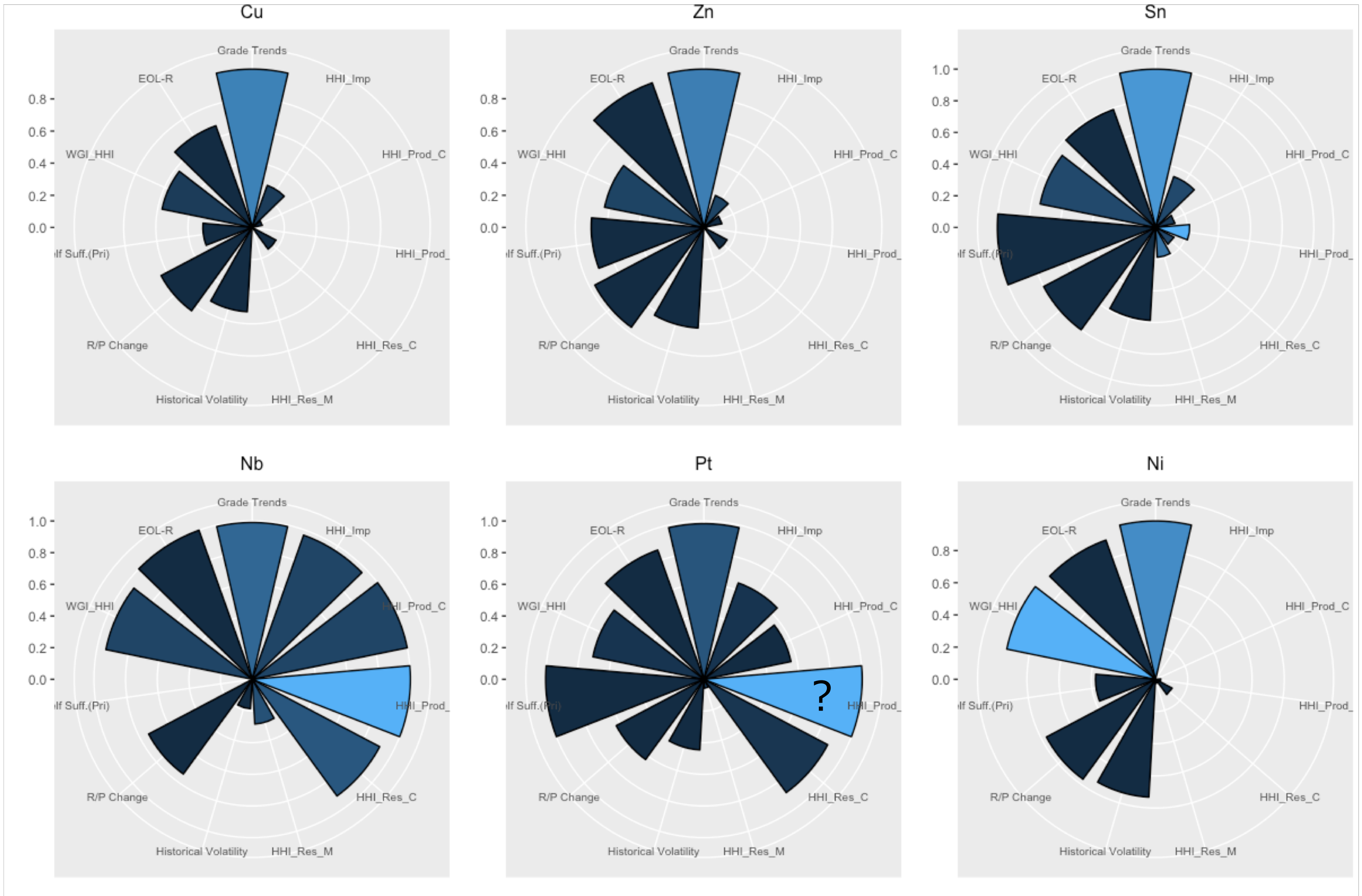


Before starting our own assessment, we applied EU SR approach to our own data. (However, we do not have substitutes information for now.)



Just as an example, EOL-RR dataset is shown here. Biggest issue is the denominator, the demand. We used the demand of the inputs to material production. Of course, data quality for some elements is problem.

Not integrated, but…



Conclusion

- Japan has really long history of supply risk assessment as unfortunately resource-poor economy depending manufacturing industry.
  - Mainly to support policy making such as, stockpiling, funding for R&D works, even recycling scheme development.
- However, its methodology was not necessarily systematic nor quantitative.
- Right now, it seriously considers to develop more stable/sustainable assessment system.
- Vulnerability part is a huge task left untouched. Also, we need to find out some method to quantify the followings;
  - # of accidents: Text mining of news/SNS? (*Space for international collaboration?*)
  - substitutability: If Japanese material industry/academia is really good, why not asking them?

Supplement

使用指標と評価方法（フェーズII）

①平均鉱石品位の低下

$$R_{grade} = \frac{1}{n}\sum_{i=1}^{n}(\frac{g_{i,t-10} - g_{i,t}}{g_{i,t-10}})$$

R_{grade}: 平均鉱石品位の低下　※R<0の場合はR=0とした

$g_{i,t}$ ：t年における鉱山iの鉱石品位（当該資源）※Millhead精鉱品位の場合と埋蔵品位の場合あり

n　：当該資源を産出する鉱山の数　※品位情報がNAとなっている鉱山を除く

②③寡占度（生産量HHI)

$$R_{pro.,HHI} = \sum_{i=1}^{n} {s_{pro.,i}}^{2}$$

$R_{pro.,HHI}$: 生産量をベースとした寡占度

$s_{pro.,i}$ ：鉱山i（国ベースの寡占度評価にあってはi国）の当該資源生産シェア　(0<s<1)

n　：当該資源を産出する鉱山（国）の数　※品位情報がNAとなっている鉱山（国）を除く

使用指標と評価方法(フェーズII)

④⑤寡占度（埋蔵量HHI）

$$R_{res.,HHI} = \sum_{i=1}^{n} {s_{res.,i}}^2$$

$R_{res.,HHI}$: 埋蔵量をベースとした寡占度

$s_{res.,i}$: 鉱山i(国ベースの寡占度評価にあってはi国)の当該資源埋蔵シェア （0<s<1） ※可採ベース

n : 当該資源を埋蔵する鉱山(国)の数 ※品位情報がNAとなっている鉱山（国）を除く

⑥価格ヒストリカルボラティリティ

$$R_{price.vol.} = \sqrt{\frac{250}{n}\sum_{i=1}^{n}(c_i - \bar{c})^2} \quad c_i = log_e(\frac{p_i}{p_{i-1}}) \quad \bar{c} = \frac{1}{n}\sum_{i=1}^{n} c_i$$

$R_{price.vol.}$: 相場のヒストリカルボラティリティ(日相場)

c_i : 第i日目における前日からの相場変化率 ※対数表示

p_i : 第i日目における相場（終値）

$\bar{c}$: 評価対象期間中におけるc_iの算術平均

n : 評価対象日数(1日あたり1データとしてそのデータ個数)

使用指標と評価方法（フェーズII）

⑦輸入寡占度

$$R_{import,HHI} = \sum_{i=1}^{n} {s_{import.,i}}^2$$

$R_{import.,HHI}$: 輸入量をベースとした寡占度

$s_{import.,i}$ ：鉱山i（国ベースの寡占度評価にあってはi国）の当該資源輸入（日本から見た場合）シェア（0<s<1）

n ：当該資源を輸入する相手の鉱山（国）の数　※品位情報がNAとなっている鉱山（国）を除く

⑧可採年数変化率

$$R_{minable} = \frac{r_t}{p_t} / \frac{r_{t-10}}{p_{t-10}}$$

$R_{minable}$: 可採年数変化率

r_t ：t年における当該資源の可採埋蔵量（純分換算）

p_t ：t年における当該資源の採掘量（生産量：純分換算）

使用指標と評価方法(フェーズII)

⑨海外自山鉱調達

$$R_{jp.proc.} = \frac{p_{jp}}{d_{domestic}}$$

$R_{jp.proc.}$: 海外自山鉱調達率 (0<R<1) ※R>1の場合はR=1とした

p_{jp} : 日系権益分の生産量(2015年度ベース) ※実際の輸入分ではなく、日系企業による権益分

$d_{domestic}$: 当該資源の日本国内需要量(2015年度当該資源の中間原料等生産量:純分ベース)

※輸出分を除く

⑩二次原料調達

$$R_{recycle} = \frac{sr_{jp}}{d_{domestic}}$$

$R_{recycle}$: 二次原料調達率

sr_{jp} : 日本国内で消費されるスクラップ等二次原料の調達量(2015年度当該資源純分ベース)

※あくまで市中くず等スクラップや再生地金の回収量であり、工程くず等スクラップや製錬残渣等は除く。

$d_{domestic}$: 当該資源の日本国内需要量 (2015年度当該資源の中間原料等生産量 : 純分ベース)

※輸出分を除く

使用指標と評価方法（フェーズII）

⑪輸入相手国ガバナンス

$$R_{WGI.HHI} = \sum_{i=1}^{n} WGI_i \cdot {s_{exp.,i}}^2$$

$R_{WGI.HHI}$: 輸入相手国ガバナンス指標

WGI_i : i国におけるガバナンス指標（PV.EST：2016年ベース）

※PV.EST：Political Stability and Absence of Violence/Terrorism: Estimate

$s_{exp.,i}$: 我が国におけるi国からの当該資源輸入シェア（2015年度当該資源純分ベース）