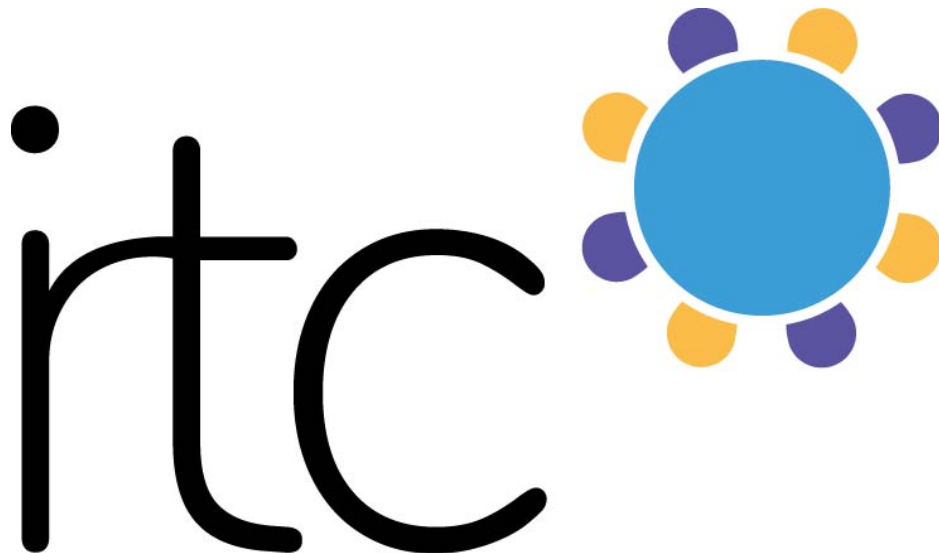# HOW METHODOLOGY DETERMINES WHAT IS CRITICAL
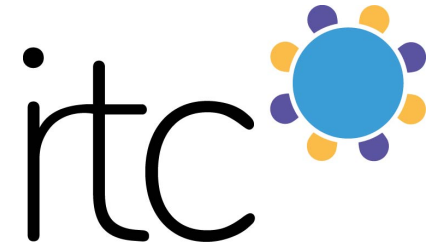
June 19, 2018

Resources for Future Generations Conference, Vancouver

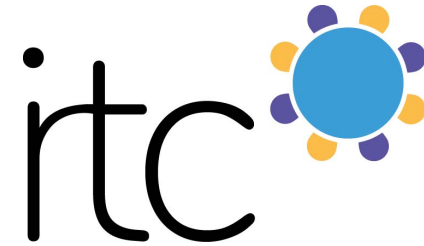# The methodological assessment of Korea for materials criticality
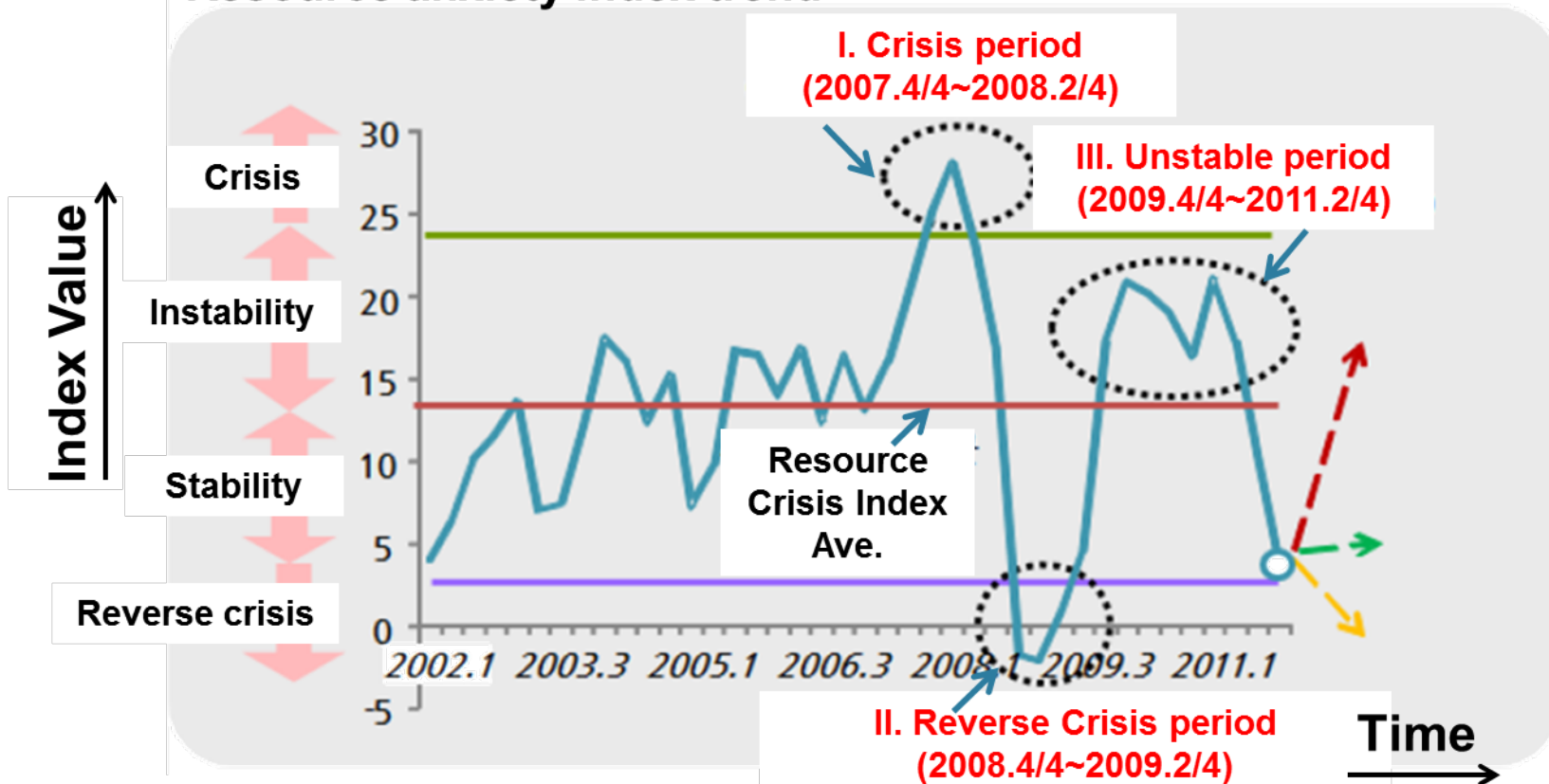
2018.06.19

Dr. Min-Ha Lee

KITECH (Korea Institute of Industrial Technology)

Goal and Scope

Demand-supply analysis of Critical Elements

Resource anxiety index trend

I. Crisis period
(2007.4/4~2008.2/4)

III. Unstable period
(2009.4/4~2011.2/4)

Crisis

Instability

Stability

Reverse crisis

Index Value

Resource Crisis Index Ave.

II. Reverse Crisis period
(2008.4/4~2009.2/4)

Time

2002.1 2003.3 2005.1 2006.3 2008.1 2009.3 2011.1

* Stability: I.V. (index value) is lower than average I.V.
Crisis: I.V. is higher than 'average + 1.5 × standard deviation'
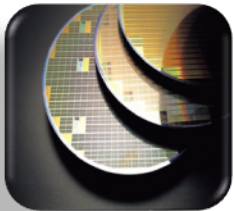Reverse Crisis: I.V. is lower than 'average − 1.5 × standard deviation'

Scope explanation

Critical Key Elements in Korea (2015)
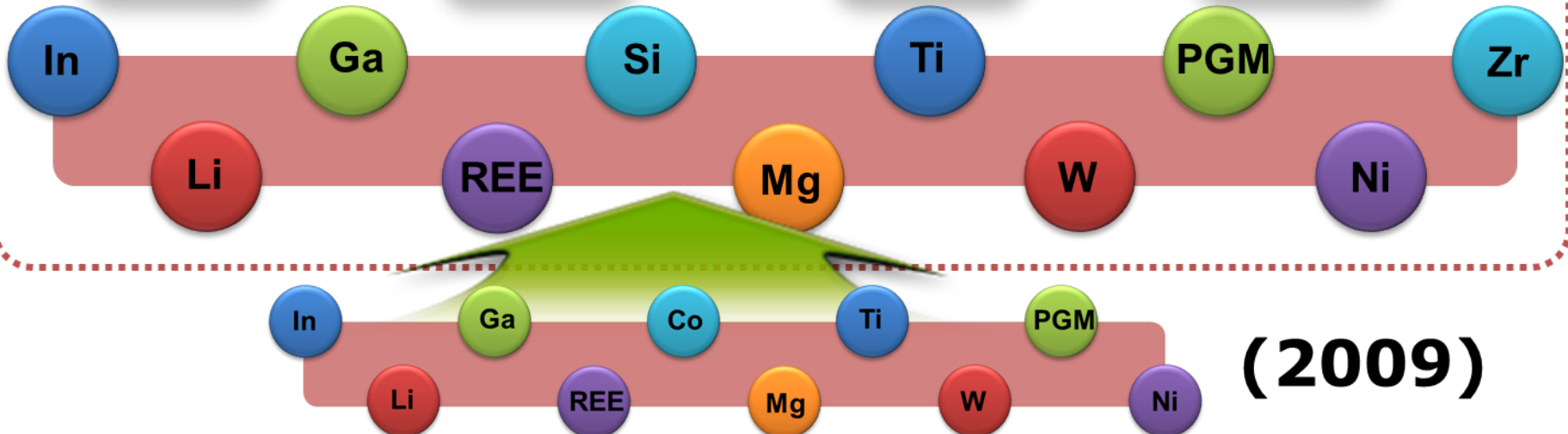
"11 Critical strategic elements"

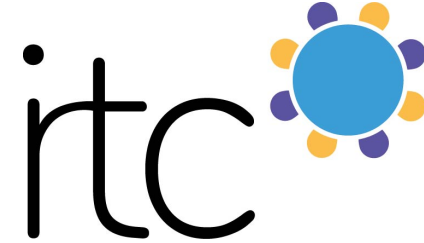Electric and Electronic · Car · Steel · Petrochemical

In · Ga · Si · Ti · PGM · Zr
Li · REE · Mg · W · Ni

In · Ga · Co · Ti · PGM
Li · REE · Mg · W · Ni

(2009)

Factor explanation

Demand of Critical Elements in main stream industry of Korea

Universal rule of criticality = (Rarity + Distribution) × (Demand + Rate of popularity)

● 수요 성장률**(MGR : Market Growth Rate)**

$$MGR = \frac{S_{T+1} - S_T}{S_T}$$

S_{T+1} : Total market sales (gross turnover) of T+1 period (current)
S_T : Total market sales (gross turnover) of T period (past-just before)

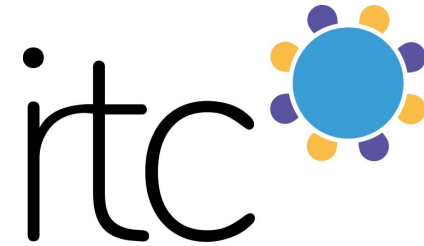● 시장 점유율**(RMS : Relative Market Share)**

$$RMS = \frac{MS_i}{MS_c}$$

MS_i : Market share of Korea (i)
MS_c : Market share of competitor (c)

* CEs consumption amounts decided by material flow of each industry group
* Stockpile amount of each CE decided by stockpile period (days) of element × MGR of industry group
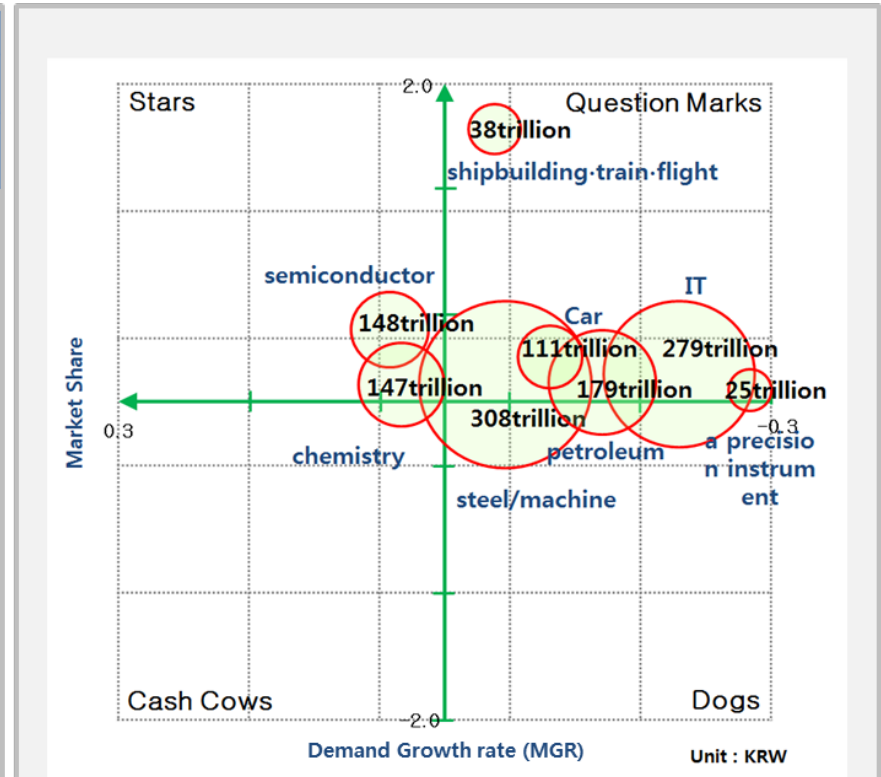
Aggregation

BCG matrix (Boston Consulting Group Matrix)

Index	Content
MGR (X axis)	(Current sales − Past sales)/Past sales
RMS (Y axis)	Market share of Korea/Market share of competitor

**High** — Market Share (RMS) — **Low**

Star (Expand)
High Market Share
&
High Market Growth
Doing well, Great Opportunities

Question Mark (Expand or withdraw)
Low Market Share
&
High Market Growth
Don't know what to do with opportunities: Decide whether to increase investment

Cash Cow (Maintain)
High Market Share
&
Low Market Growth
Doing well in no growth Market with limited Opportunities

Dog (Withdraw)
Low Market Share
&
Low Market Growth
Weak in market, Difficult to make profit

Market Growth (MGR) — **High** / **Low**

Stars — Question Marks
38trillion
shipbuilding·train·flight
semiconductor
IT
148trillion
Car
111trillion
279trillion
147trillion
179trillion
25trillion
308trillion
chemistry
petroleum
a precision instrument
steel/machine
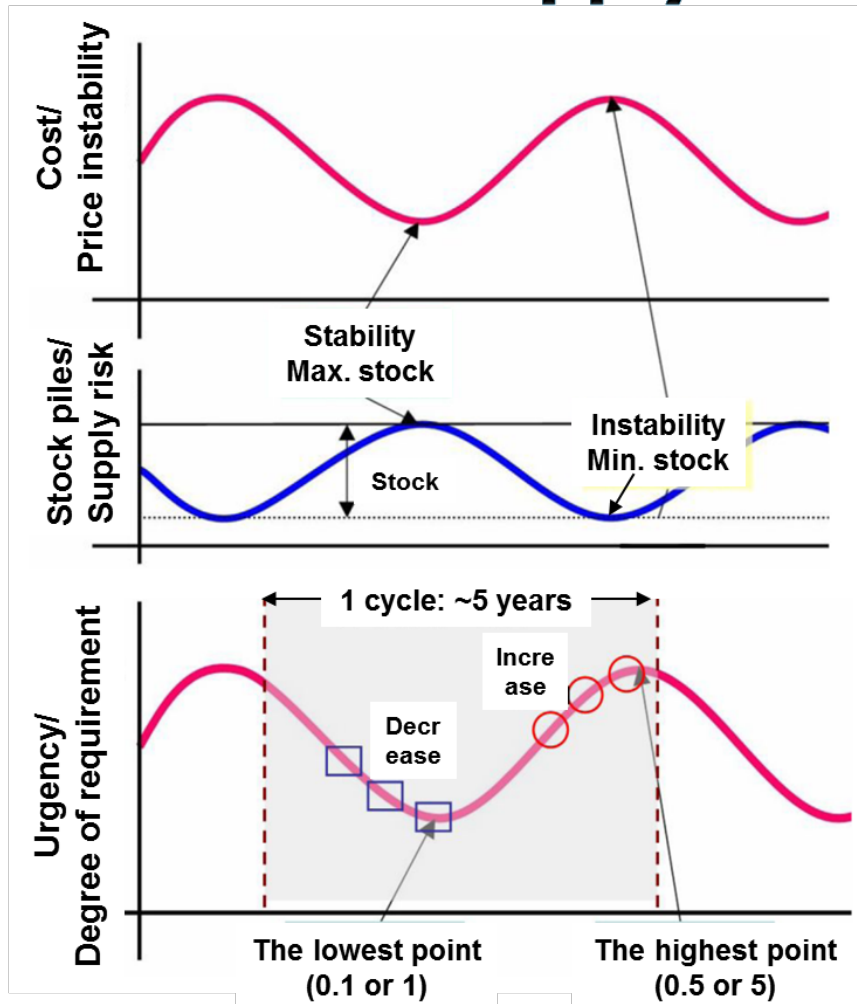Market Share
Cash Cows — Dogs
0.3 / −0.3
2.0 / −2.0
Demand Growth rate (MGR)
Unit : KRW

Most of major rare metal related industries are requested to jump from questionable area to highly spotted area

* KITECH-KORES report (2012)

Aggregation
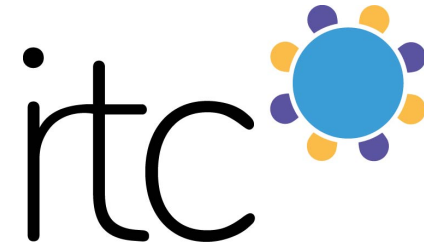
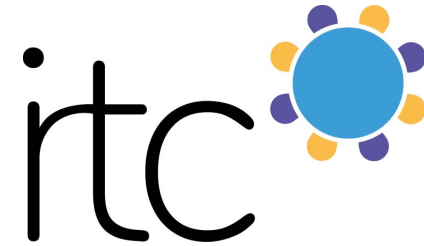## Demand-supply analysis of Criticality

Stability and instability model

- Analyze cycle frequency
- Estimate impact of cycle on the economy

Generalization of Benjamin Graham theory

- Degradation is driving force to rise up desire
- Rising up is driving force to degrade desire

Unique features

Parameters of Criticality of Elements
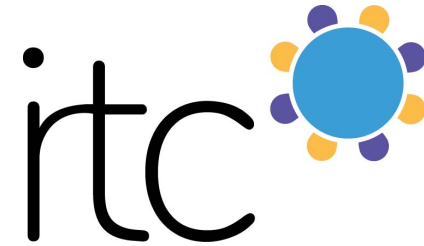
Parameters set up by GE/McKinsey model

Industrial demand (Y axis)	Weight value (A)- urgency [0.1~0.5]	Degree of requirement (B) [1-5]
Market volume (RMS)	0.1	3
Demand growth rate (MGR)	0.3	5
Price inflation (Price instability)	0.4	4
Capital intensity	0.1	2
Resources bias intensity	0.1	2

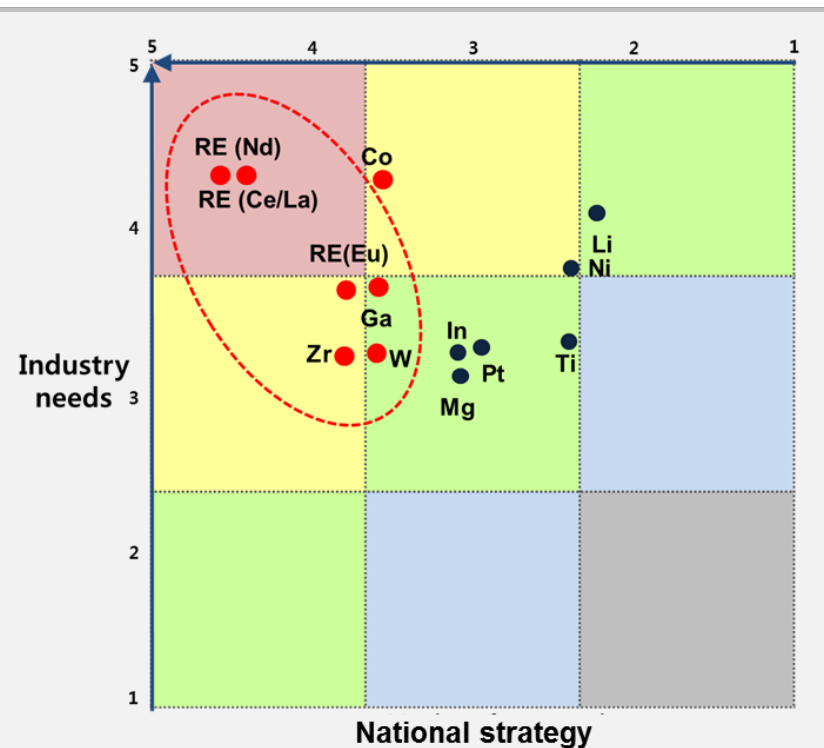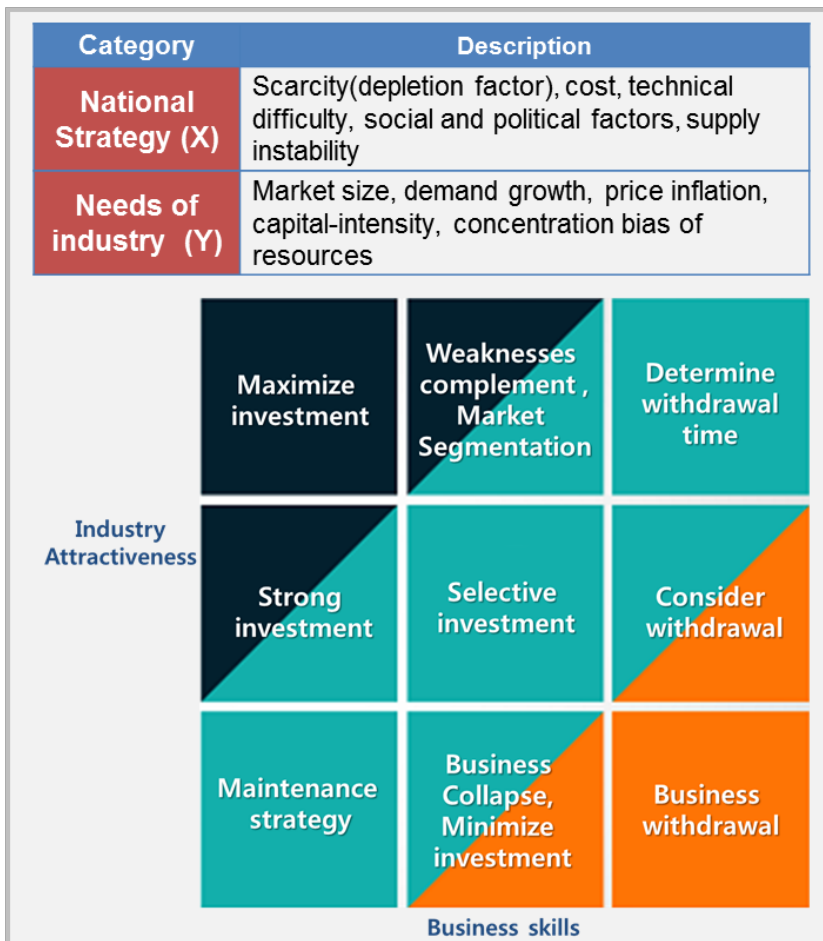| National strategy (X axis)	Weight value (A)- urgency [0.1~0.5]	Degree of strategy (C) [1-5]
Rarity (depletion factor)	0.2	3
Cost	0.1	3
Technical difficulty	0.3	4
Social and political factors	0.1	2
Supply risk	0.3	5

* Criticality of each CEs : $X = \sum (A \times B)$, $Y = \sum (A \times C)$

Results and implications

Attractiveness of Industry – Business Capability Matrix

Category	Description
National Strategy (X)	Scarcity(depletion factor), cost, technical difficulty, social and political factors, supply instability
Needs of industry (Y)	Market size, demand growth, price inflation, capital-intensity, concentration bias of resources

Industry Attractiveness

| Maximize investment	Weaknesses complement, Market Segmentation	Determine withdrawal time
Strong investment	Selective investment	Consider withdrawal
Maintenance strategy	Business Collapse, Minimize investment	Business withdrawal

Business skills

Selecting six kinds of critical elements by national & industrial common demand =
(Market share x Demand growth rate) + (Industrials demand x National strategy)
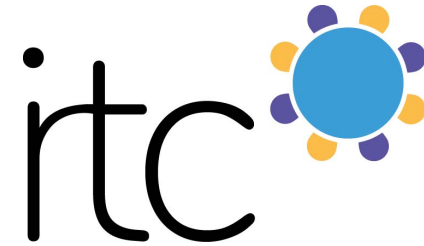
Results and implications
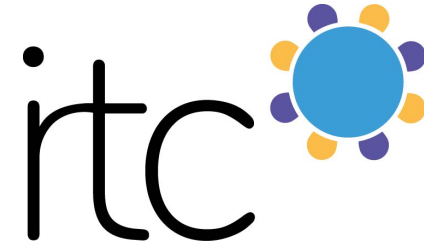
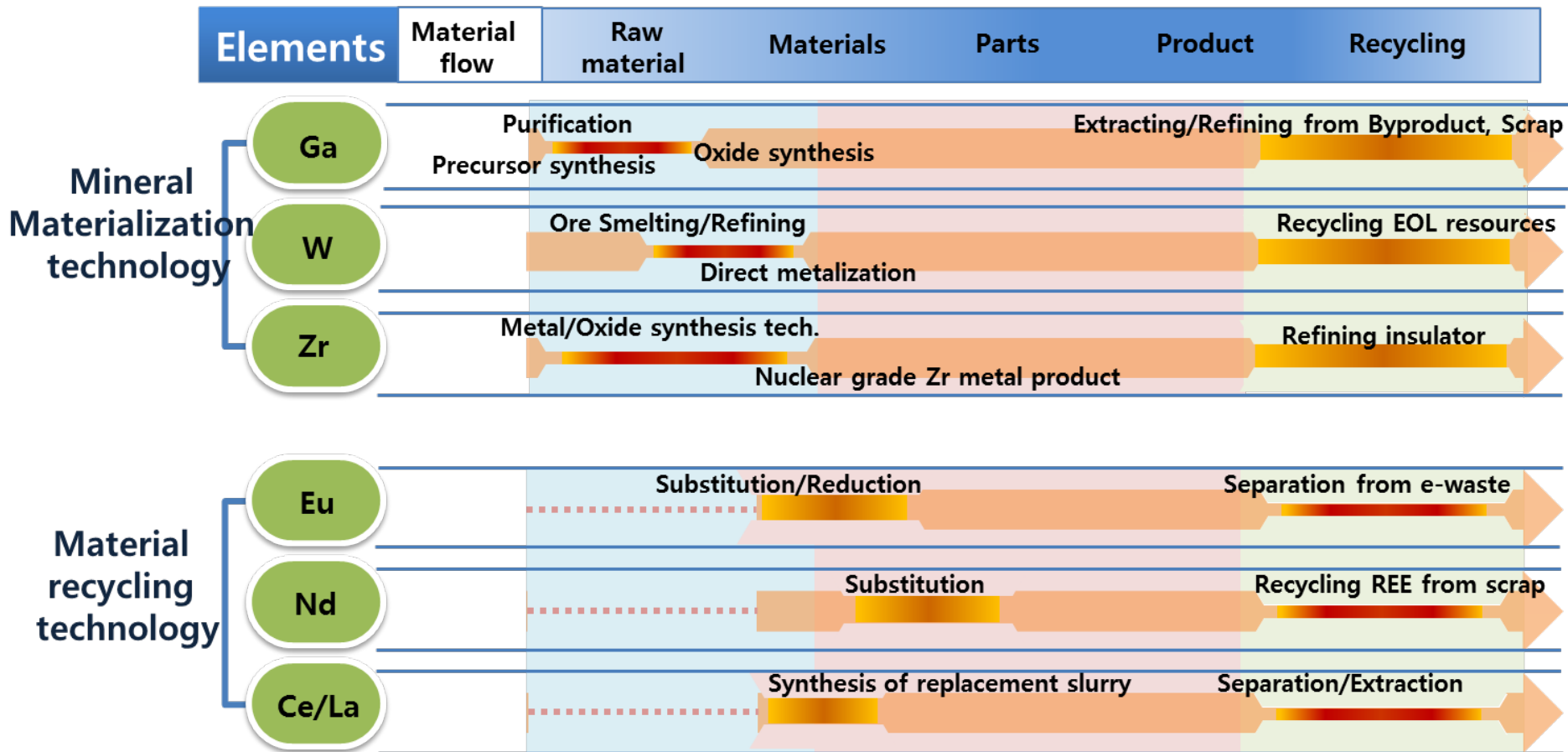## Stockpile of Critical Elements
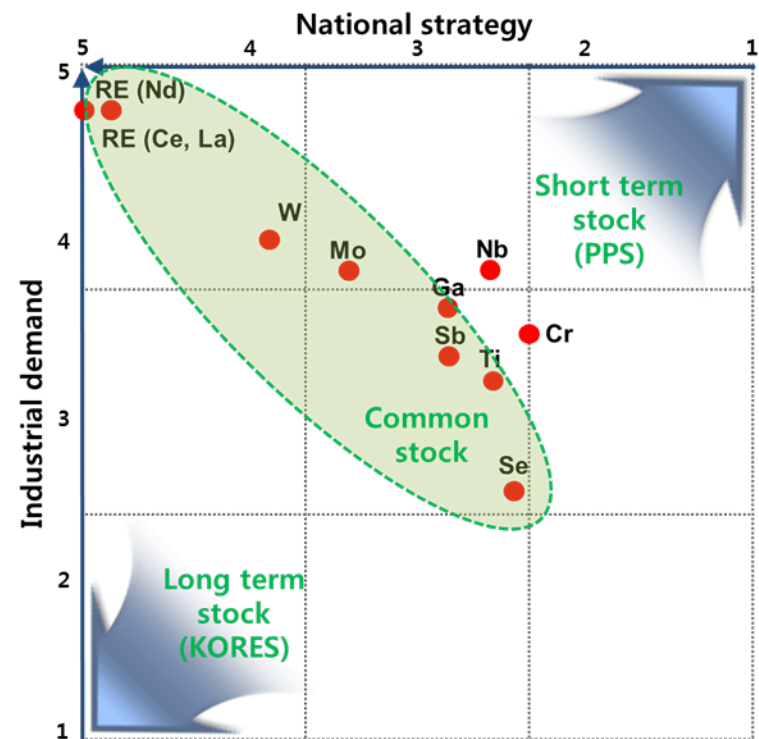
* Stockpile period (SPP) of each CEs :

$$SPP = Ave.\left(\frac{x \times period}{\# \, parameters} + \frac{y \times period}{\# \, parameters}\right)$$

Limitations

Analysis of technical bottleneck of Critical Elements

Elements	Material flow	Raw material	Materials	Parts	Product	Recycling

Mineral Materialization technology

- **Ga**: Purification / Precursor synthesis / Oxide synthesis — Extracting/Refining from Byproduct, Scrap
- **W**: Ore Smelting/Refining / Direct metalization — Recycling EOL resources
- **Zr**: Metal/Oxide synthesis tech. / Nuclear grade Zr metal product — Refining insulator

Material recycling technology

- **Eu**: Substitution/Reduction — Separation from e-waste
- **Nd**: Substitution — Recycling REE from scrap
- **Ce/La**: Synthesis of replacement slurry — Separation/Extraction

*Technical analysis for finding out the bottleneck technology of 6 critical rare industrial metals

Outlook
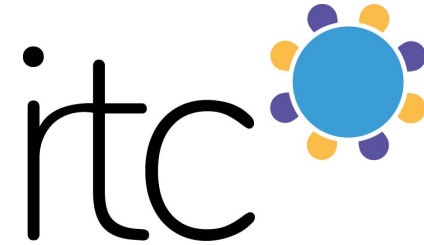
- Development of universal criteria or methodology to include Criticality, Industrial demand and Technological difficulty.

- Adjusting or introducing effectiveness of parameters by worlwide trend: Environment, Responsibility, Consumer product type etc.