GLOBAL OUTLOOK ON ASSESSMENTS OF CRITICAL RAW MATERIALS

Focus on socio-economic, environmental and technical implications

RESOURCE MANAGEMENT WEEK 2023

ASSURING SUSTAINABILITY IN RESOURCE MANAGEMENT

UNECE

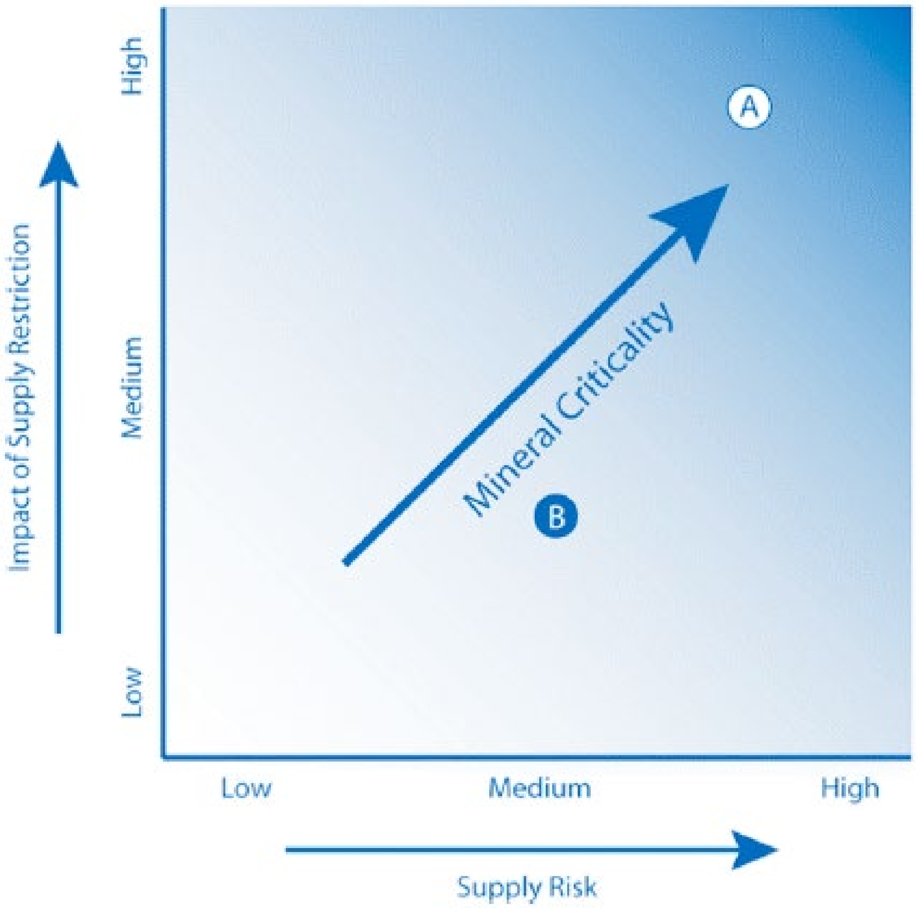
Criticality assessment <u>is</u>: ……….or was?

- A Call for Attention → **not panic**
- A Screening Exercise
- Prelude to Detailed Assessment

source: **Roderick Eggert**
Colorado School of Mines, US

International Criticality Study Groups

US NRC, 2008



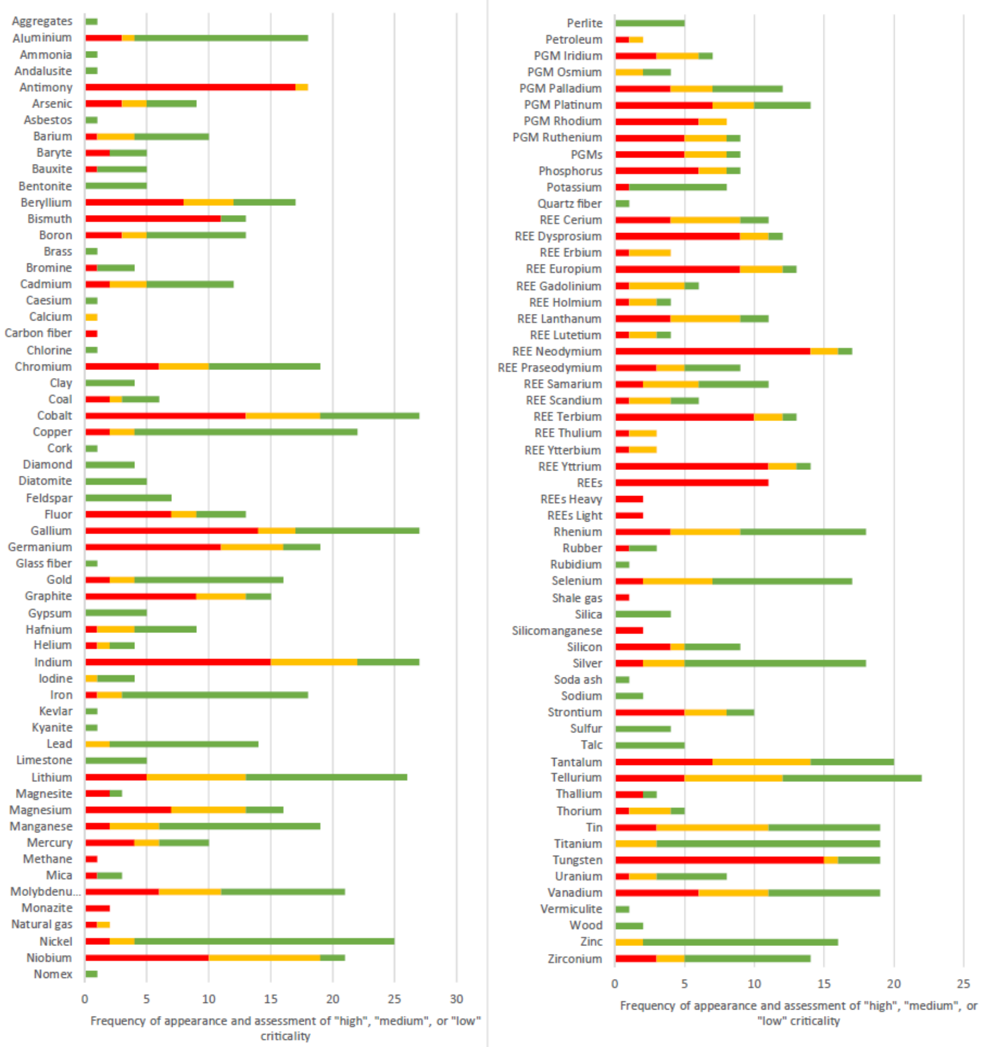
International Round Table on Materials Criticality – IRTC

- *Alessandra Hool, IRTC Coordinator, ESM Foundation, Switzerland*

    - Currently in third round:
        - 2018-2020 IRTC
        - 2020-2022 IRTC-Business
        - 2022-2025 IRTC-Training

Outlook on Criticality Assessments

IRTC



Resources, Conservation & Recycling 155 (2020) 104617

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

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A review of methods and data to determine raw material criticality

Dieuwertje Schrijvers[a,b], Alessandra Hool[c,*], Gian Andrea Blengini[d], Wei-Qiang Chen[e], Jo Dewulf[f], Roderick Eggert[g], Layla van Ellen[h], Roland Gauss[i], James Goddin[j], Komal Habib[k], Christian Hagelüken[l,c], Atsufumi Hirohata[m], Margarethe Hofmann-Amtenbrink[n], Jan Kosmol[o], Maïté Le Gleuher[p], Milan Grohol[q], Anthony Ku[r], Min-Ha Lee[s], Gang Liu[t], Keisuke Nansai[u], Philip Nuss[v], David Peck[h], Armin Reller[c,w], Guido Sonnemann[a,b], Luis Tercero[c,x], Andrea Thorenz[w], Patrick A. Wäger[c,y]

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Abbreviations: BGS, British Geological Survey; BRGM, Bureau de Recherches Géologiques et Minières; CRM, Critical Raw Materials; EC, European Commission; Empa, Swiss Federal Laboratories for Materials Science and Technology; EIT, European Institute of Innovation & Technology; EU, European Union; GE, General Electric; HDI, Human Development Index; HHI, Herfindahl-Hirschman-Index; ICIRCE, Instituto Universitario Investigación CIRCE Universidad Zaragoza; INSEAD, Institut Européen d'Administration des Affaires; IRTC, International Round Table on Materials Criticality; ISO, International Organization for Standardization; KIRAM/KITECH, Korea Institute for Rare Metals/Korea Institute of Industrial Technology; LCA, Life Cycle Assessment; NEDO, New Energy and Industrial Technology Development; NIES, National Institute for Environmental Studies; NRC, National Research Council; NSTC, National Science and Technology Council; OECD, Organisation for Economic Co-operation and Development; OH, Oakdene Hollins; PGM(s), Platinum Group Metal(s); PPI, Policy Perception Index; REE(s), Rare Earth Element(s); SDU, University of Southern Denmark; SI, Supplementary Information; UBA, Umweltbundesamt; UNDP, United Nations Development Programme; UNEP IRP, United Nations Environment Programme International Resource Panel; US DOE, United States Department of Energy; USGS, United States Geological Survey; VDI, Verein Deutscher Ingenieure; WGI, Worldwide Governance Indicators

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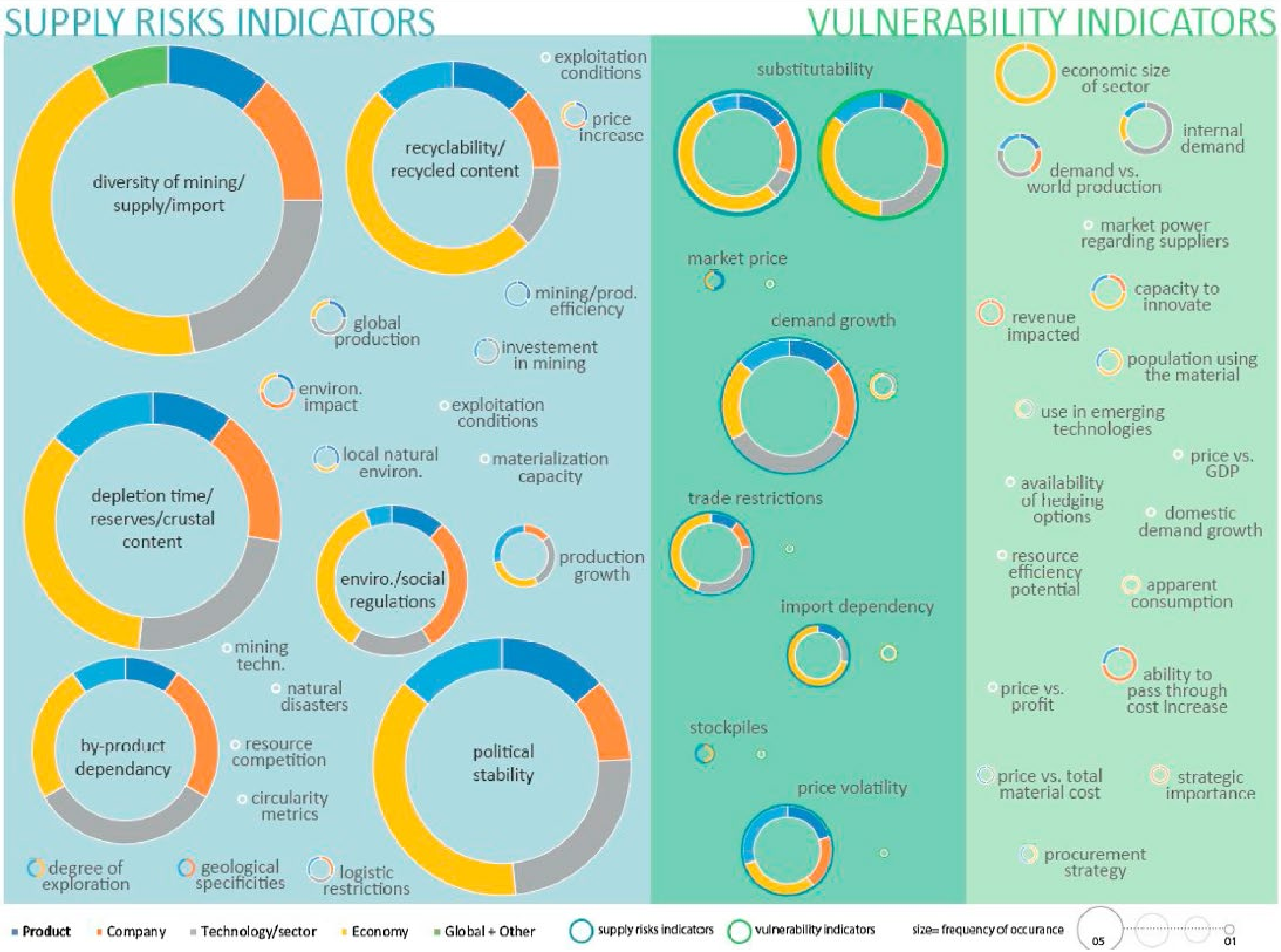
IRTC, 2020



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EC Criticality Assessments

EC methodology

UNECE

- →2010 first release
- →2013 update
- →2015 revision (*JRC*)

European Commission

JRC TECHNICAL REPORTS

Assessment of the Methodology for Establishing the EU List of Critical Raw Materials

Background Report

Blengini, G.A., Blagoeva, D., Dewulf, J.,
Torres de Matos, C., Nita, V., Vidal-Legaz, B.,
Latunussa, C.E.L., Kayam, Y., T
Baranzelli, C., Manfredi, S., Mar
Nuss, P., Marmier, A., Alves-Dia
Pavel, C., Tzimas, E., Mathieux,
Pennington, D. and Ciupagea, C

2017

European Commission

METHODOLOGY FOR ESTABLISHING THE EU LIST OF CRITICAL RAW MATERIALS

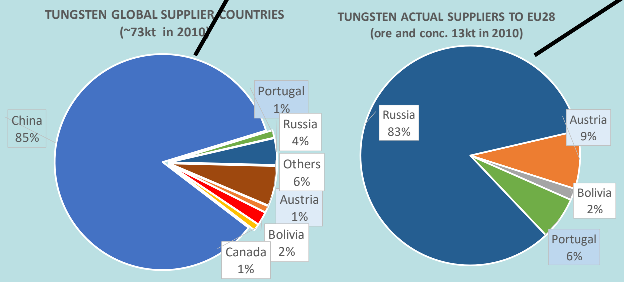
• Guidelines •

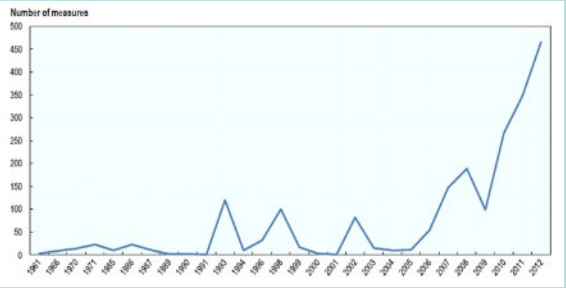
EC Criticality Assessments

2017 Guidelines – Supply risk

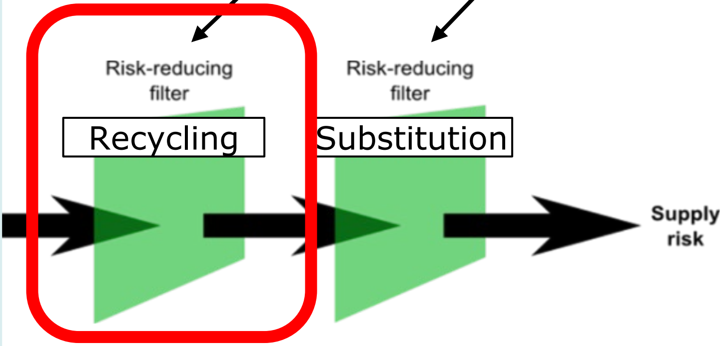
UNECE

$$SR = \left[(HHI_{WGI-t})_{GS} \cdot \frac{IR}{2} + (HHI_{WGI-t})_{EUsourcing}\left(1 - \frac{IR}{2}\right)\right] \boxed{(1 - EoL_{RIR})} \; SI_{SR}$$





- **Supply concentr. (HHI)**
- **Poor Governance (WGI)**
- **Global vs EU**
- **Import dependency**
- **Trade**
- **Supply chain**
- **Substitution**
- **Recycling**



- **Black → already in 2014**
- **Red → JRC introduced**
- **Blue → JRC improved**

Resources Policy 53 (2017) 12–19

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Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

ELSEVIER

EU methodology for critical raw materials assessment: Policy needs and proposed solutions for incremental improvements

Gian Andrea Blengini[a,e,*], Philip Nuss[a], Jo Dewulf[a,d], Viorel Nita[a], Laura Talens Peirò[a], Beatriz Vidal-Legaz[a], Cynthia Latunussa[a], Lucia Mancini[a], Darina Blagoeva[b], David Pennington[a], Mattia Pellegrini[c], Alexis Van Maercke[c], Slavko Solar[c], Milan Grohol[c], Constantin Ciupagea[a]

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ARTICLE INFO

Keywords:
Resource criticality assessment
Supply risk
Economic importance
Trade barriers
Import reliance
Recycling
Supply chain

ABSTRACT

Raw materials form the basis of Europe's economy to ensure jobs and competitiveness, and they are essential for maintaining and improving quality of life. Although all raw materials are important, some of them are of more concern than others, thus the list of critical raw materials (CRMs) for the EU, and the underlying European Commission (EC) criticality assessment methodology, are key instruments in the context of the EU raw materials policy.

For the next update of the CRMs list in 2017, the EC is considering to apply the overall methodology already used in 2011 and 2014, but with some modifications. Keeping the same methodological approach is a deliberate choice in order to prioritise the comparability with the previous two exercises, effectively monitor trends, and maintain the highest possible policy relevance. As the EC's in-house science service, the Directorate General Joint Research Centre (DG JRC) identified aspects of the EU criticality methodology that could be adapted to better address the needs and expectations of the resulting CRMs list to identify and monitor critical raw materials in the EU.

The goal of this paper is to discuss the specific elements of the EC criticality methodology that were adapted by DG JRC, highlight their novelty and/or potential outcomes, and discuss them in the context of criticality assessment methodologies available internationally.

1. Introduction

Raw materials form the basis of Europe's economy to ensure jobs and competitiveness, and they are essential for maintaining and improving our quality of life. Securing reliable, sustainable, and undistorted access of raw materials and their circular use in the economy is, therefore, of growing concern within the EU (EC, 2014, 2011; Vidal-Legaz et al., 2016) and globally (Coulomb et al., 2015). Recent years have seen a tremendous increase in the amount of materials extracted and used (Krausmann et al., 2009) together with a significant growth in the number of materials used in single products (product complexity) (Greenfield and Graedel, 2013). Global economic growth coupled with technological change (e.g., low-carbon energy and transportation systems, modern defence and communication systems) will increase the demand for many raw materials in the future (Blagoeva et al., 2016; Pavel and Tzimas, 2016).

"Criticality" combines a comparatively high economic importance with a comparatively high risk of supply disruption (Buijs et al., 2012). In 2008 the U.S. National Research Council proposed a framework for evaluating material "criticality" based on a metal's supply risk and the impact of a supply restriction (NRC, 2008). Since that time, a number of organizations worldwide have built upon that framework in various

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Abbreviations: CPA, Statistical classification of products by activity; CRM, Critical Raw Materials; EI, Economic Importance; EOL-RIR, End of Life Recycling Input Rate; GVA, Gross Added Value; HHI, Herfindahl Hirschman Index; IR, Import Reliance; JRC, Joint Research Centre; MSA, Material System Analysis; NACE, Statistical Classification of Economic Activities in the European Community; PPI, Policy Potential Index; RGI, Resource Governance Index; RM, Raw Material; RMI, Raw Materials Initiative; ROW, Rest of the World; SR, Supply Risk; WGI, World Governance Index; WTO, World Trade Organization

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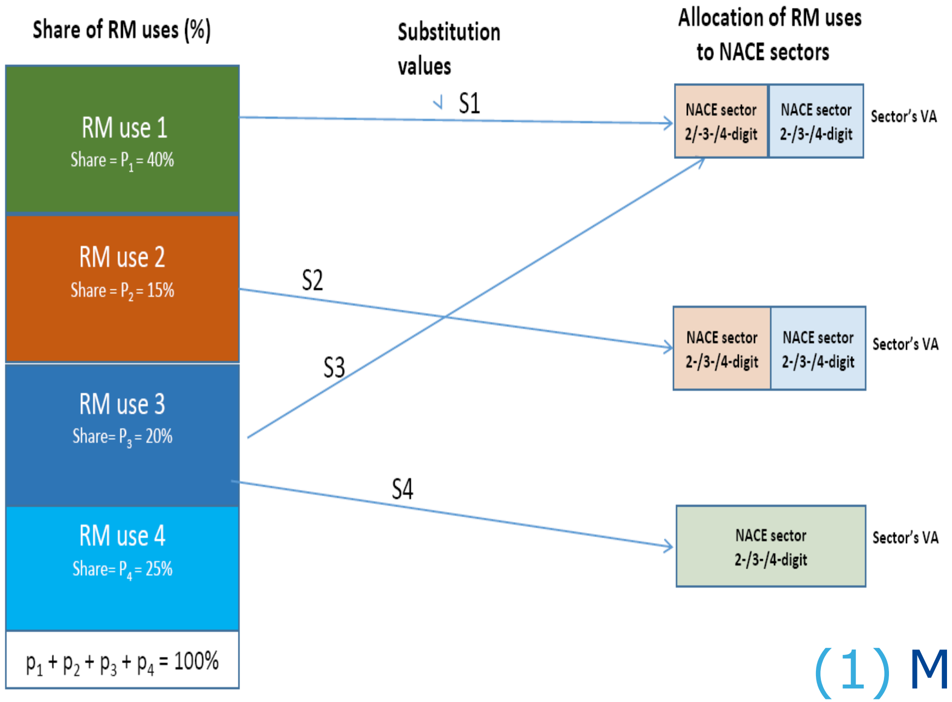
EC Criticality Assessments

2017 Guidelines – Economic importance



Share of RM uses (%)

RM use 1
Share = P_1 = 40%

RM use 2
Share = P_2 = 15%

RM use 3
Share= P_3 = 20%

RM use 4
Share= P_4 = 25%

$p_1 + p_2 + p_3 + p_4 = 100\%$

Substitution values

S1

S2

S3

S4

Allocation of RM uses
to NACE sectors

NACE sector 2/-3-/4-digit	NACE sector 2-/3-/4-digit	Sector's VA
NACE sector 2-/3-/4-digit	NACE sector 2-/3-/4-digit	Sector's VA
NACE sector 2-/3-/4-digit		Sector's VA

$$EI = \sum_{s} (A_s * Q_s) * SI$$

(1) MEGASECTORS → NACE-2

(2) allocation of RM uses (NACE-6)

(3) RM-specific substitution index

EC Criticality Assessments

2023 List of Critical Raw Materials

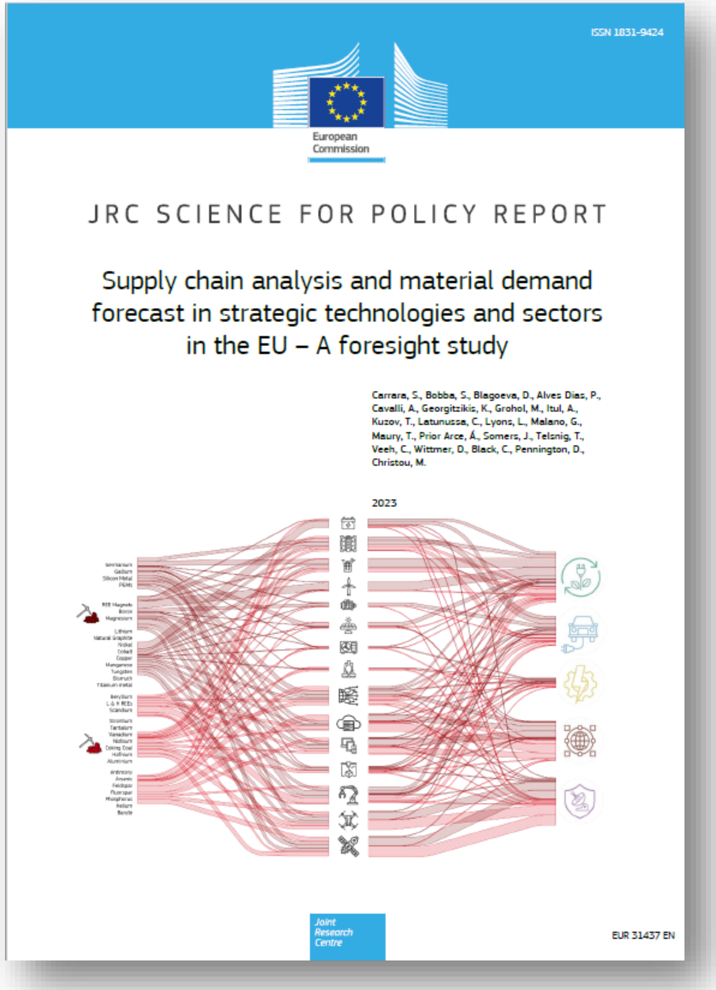
2023 CRMs vs. 2020 CRMs

aluminium/bauxite
antimony
baryte
beryllium
bismuth
borate
cobalt
coking coal
fluorspar
gallium
germanium
hafnium
HREE
lithium
LREE
magnesium
natural graphite
niobium
phosphate rock
phosphorus
PGM
scandium
silicon metal
strontium
tantalum
titanium metal
tungsten
vanadium
arsenic
feldspar
helium
manganese
copper
nickel
~~indium~~
~~natural rubber~~

Legend:
Black: CRMs in 2023 and 2020
Red: CRMs in 2023, non-CRMs in 2020
~~Strike:~~ Non-CRMs in 2023 that were critical in 2020

EC Criticality Assessments

2023 Foresight Report & Strategic raw materials



ISSN 1831-9424

European Commission

JRC SCIENCE FOR POLICY REPORT

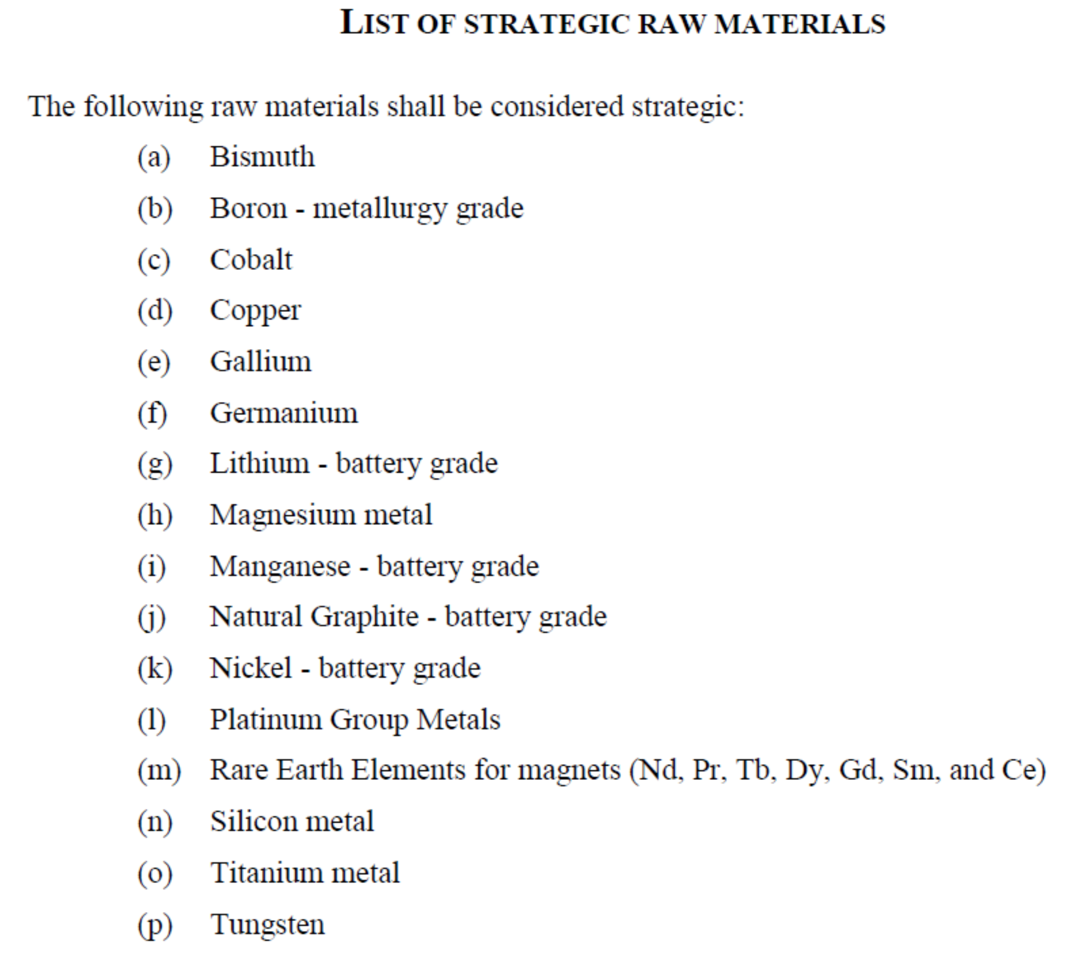
Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study

Carrara, S., Bobba, S., Blagoeva, D., Alves Dias, P., Cavalli, A., Georgitzikis, K., Grohol, M., Itul, A., Kuzov, T., Latunussa, C., Lyons, L., Malano, G., Maury, T., Prior Arce, Á., Somers, J., Telsnig, T., Veeh, C., Wittmer, D., Black, C., Pennington, D., Christou, M.

2023

Joint Research Centre

EUR 31437 EN



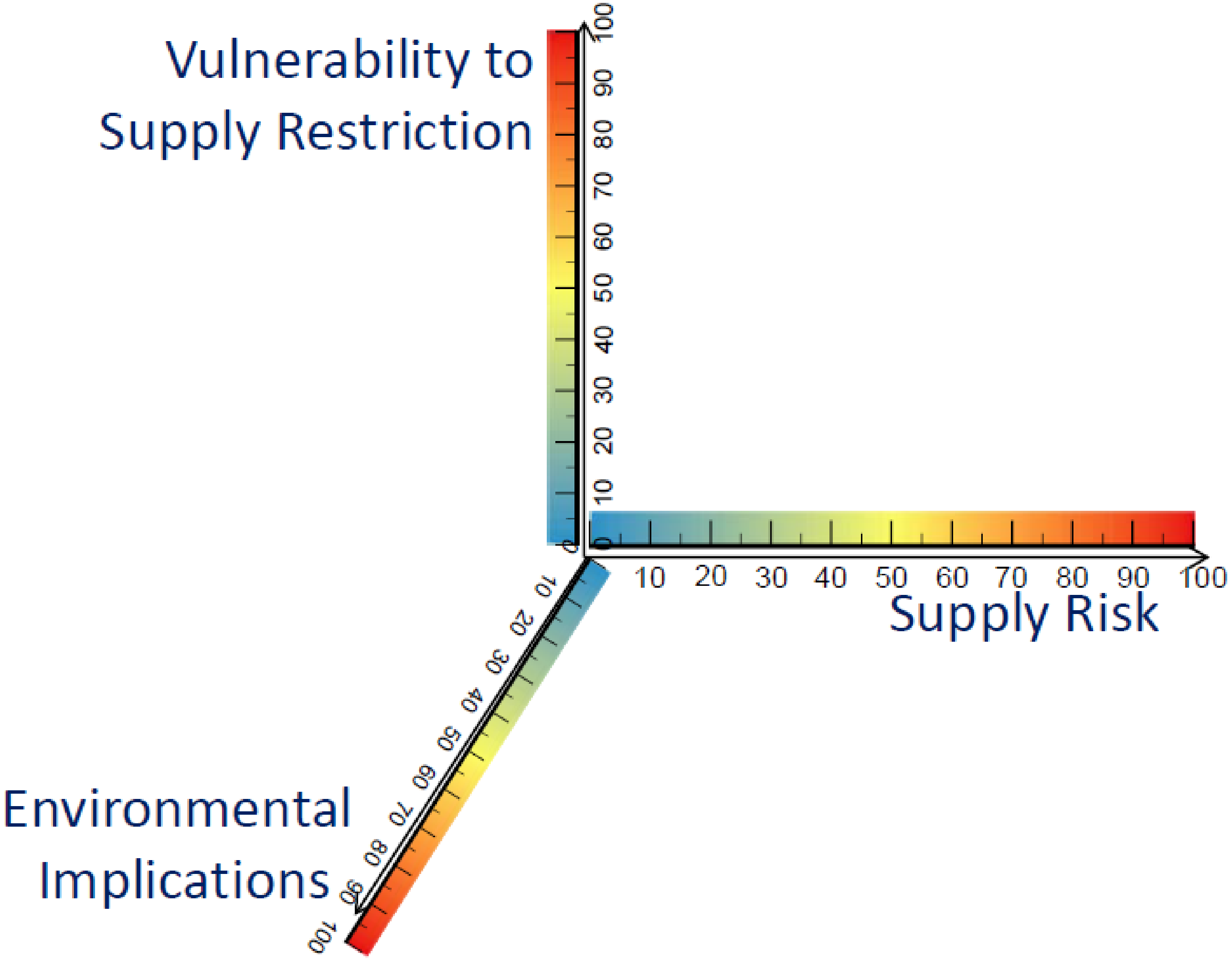
LIST OF STRATEGIC RAW MATERIALS

The following raw materials shall be considered strategic:

(a) Bismuth
(b) Boron - metallurgy grade
(c) Cobalt
(d) Copper
(e) Gallium
(f) Germanium
(g) Lithium - battery grade
(h) Magnesium metal
(i) Manganese - battery grade
(j) Natural Graphite - battery grade
(k) Nickel - battery grade
(l) Platinum Group Metals
(m) Rare Earth Elements for magnets (Nd, Pr, Tb, Dy, Gd, Sm, and Ce)
(n) Silicon metal
(o) Titanium metal
(p) Tungsten

International Criticality Study Groups

Yale University, 2012




Environmental Science & Technology
Article
pubs.acs.org/est

Methodology of Metal Criticality Determination

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Center for Industrial Ecology, School of Forestry and Environmental Studies, Yale University, 195 Prospect Street, New Haven, Connecticut 06511, United States

Ⓢ *Supporting Information*

ABSTRACT: A comprehensive methodology has been created to quantify the degree of criticality of the metals of the periodic table. In this paper, we present and discuss the methodology, which is comprised of three dimensions: supply risk, environmental implications, and vulnerability to supply restriction. Supply risk differs with the time scale (medium or long), and at its more complex involves several components, themselves composed of a number of distinct indicators drawn from readily available peer-reviewed indexes and public information. Vulnerability to supply restriction differs with the organizational level (i.e., global, national, and corporate). The criticality methodology, an enhancement of a United States National Research Council template, is designed to help corporate, national, and global stakeholders conduct risk evaluation and to inform resource utilization and strategic decision-making. Although we believe our methodological choices lead to the most robust results, the framework has been constructed to permit flexibility by the user. Specific indicators can be deleted or added as desired and weighted as the user deems appropriate. The value of each indicator will evolve over time, and our future research will focus on this evolution. The methodology has proven to be sufficiently robust as to make it applicable across the entire spectrum of metals and organizational levels and provides a structural approach that reflects the multifaceted factors influencing the availability of metals in the 21st century.

INTRODUCTION

Metals are vital to modern society. Indeed, it is difficult to think of a facet of human society that does not incorporate metals in one form or another. Human reliance on metals is not a new phenomenon, of course. What is new is the rate at which humans are extracting, processing, and using metals. The growth of materials use during the 20th century is such that overall global metal mobilization increased nearly 19-fold from 1900 to 2005, with aluminum increasing over 1000-fold.[1] Not only has the quantity of metals utilized by human societies increased, but so too have the number and variety of metals. In the 1980s, for example, computer chip manufacturing required the use of 12 elements. Today that number has increased to around 60—a sizable fraction of the naturally occurring elements.[2]

The exponential increase of metal utilization witnessed over the past century has led to a marked shift of metal stocks. Historically, all available stocks have been in Earth's crust. Now a significant portion resides above ground in the anthroposphere. This shift, coupled with ever-decreasing ore grades,[3] raises important questions such as whether we should be concerned about the long-term availability of metals and whether it is possible to recycle our way to sustainability.

In 2006, the United States National Research Council (NRC) undertook a study to address the lack of understanding and of data on nonfuel minerals important to the American economy. The report, titled *Minerals, Critical Minerals, and the U.S. Economy*,[2] defined the criticality of minerals as a function of two variables, importance of uses and availability, effectively communicated by a graphical representation referred to hereafter as the criticality matrix in which the vertical axis reflects importance in use and the horizontal axis is a measure of availability (for more details, see the Supporting Information).

The NRC committee carried out preliminary criticality analyses for several metals. Of those surveyed, a number fell within the region of danger—rhodium, platinum, manganese, niobium, indium, and the rare earths. Copper was considered not critical, not because of a lack of importance of use (termed "impact of supply restriction" by the committee) but because supply risk was judged to be low. A number of other elements were located between these extremes. The evaluations were regarded as very preliminary, but served to point out the potentially great differences in criticality among a number of the metals.

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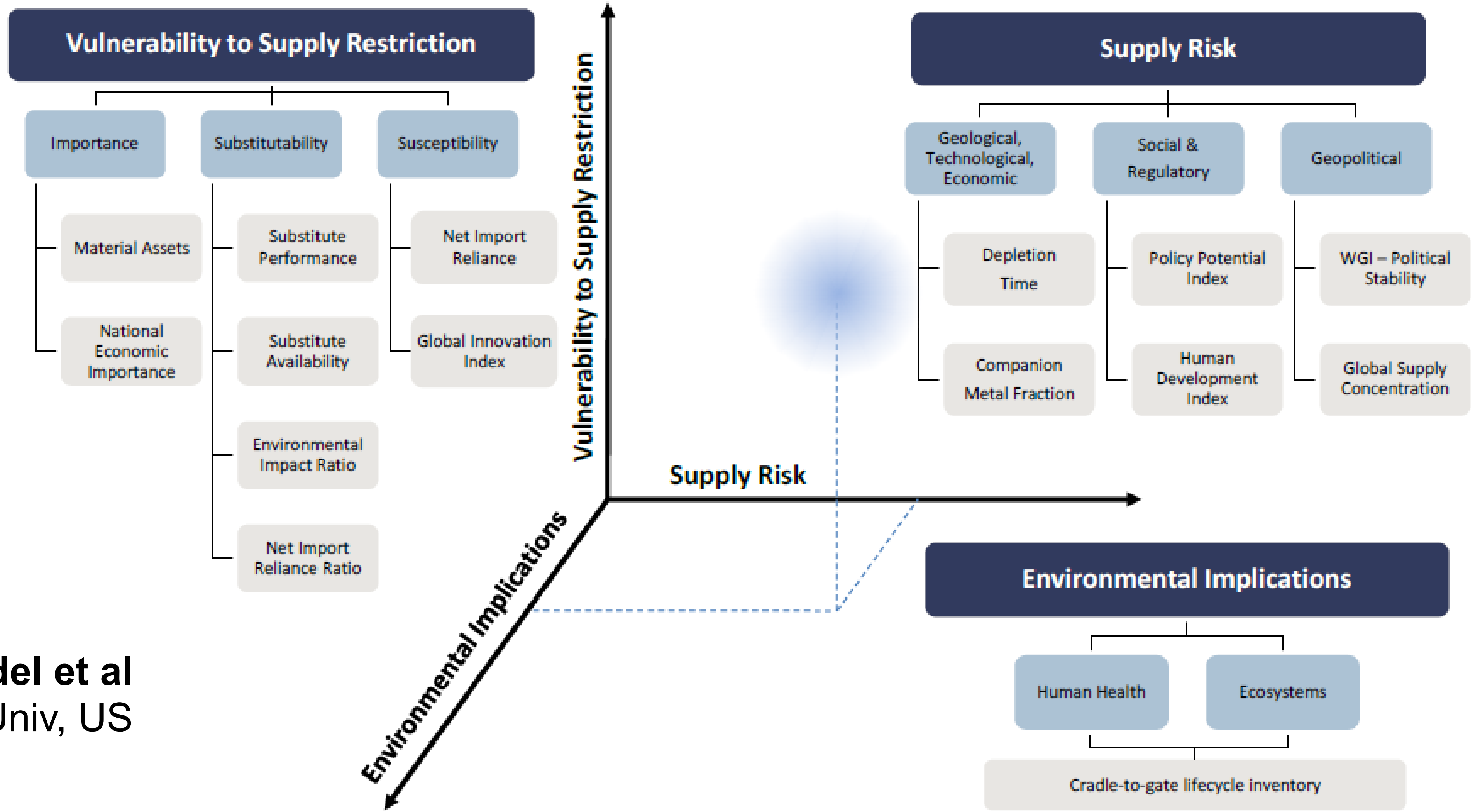
ACS Publications

dx.doi.org/10.1021/es203534z | Environ. Sci. Technol. 2012, 46, 1063−1070

International Criticality Study Groups

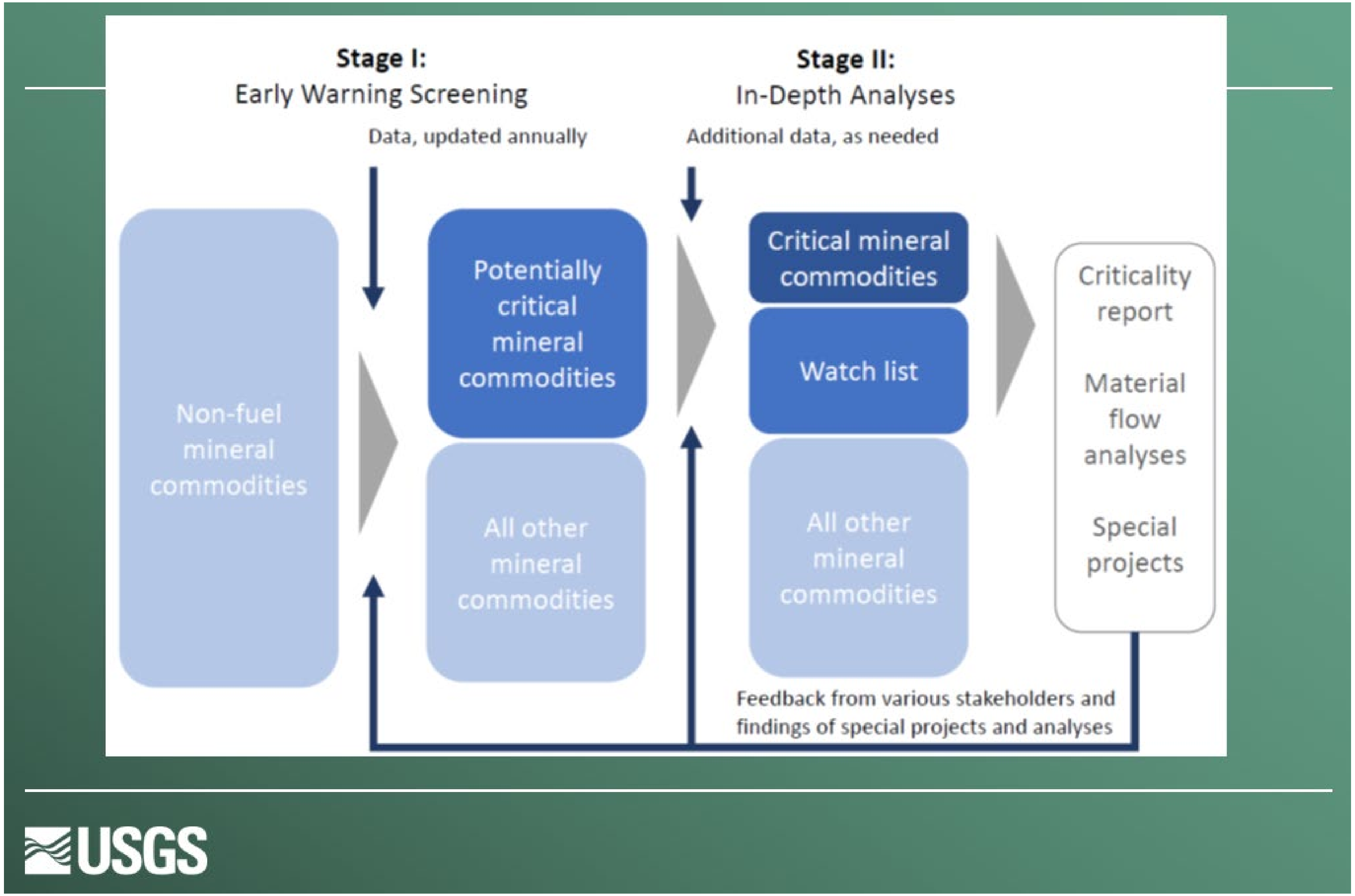
Yale University, 2012



source: **Tom Graedel et al**
Yale Univ, US

International Criticality Study Groups

USGS

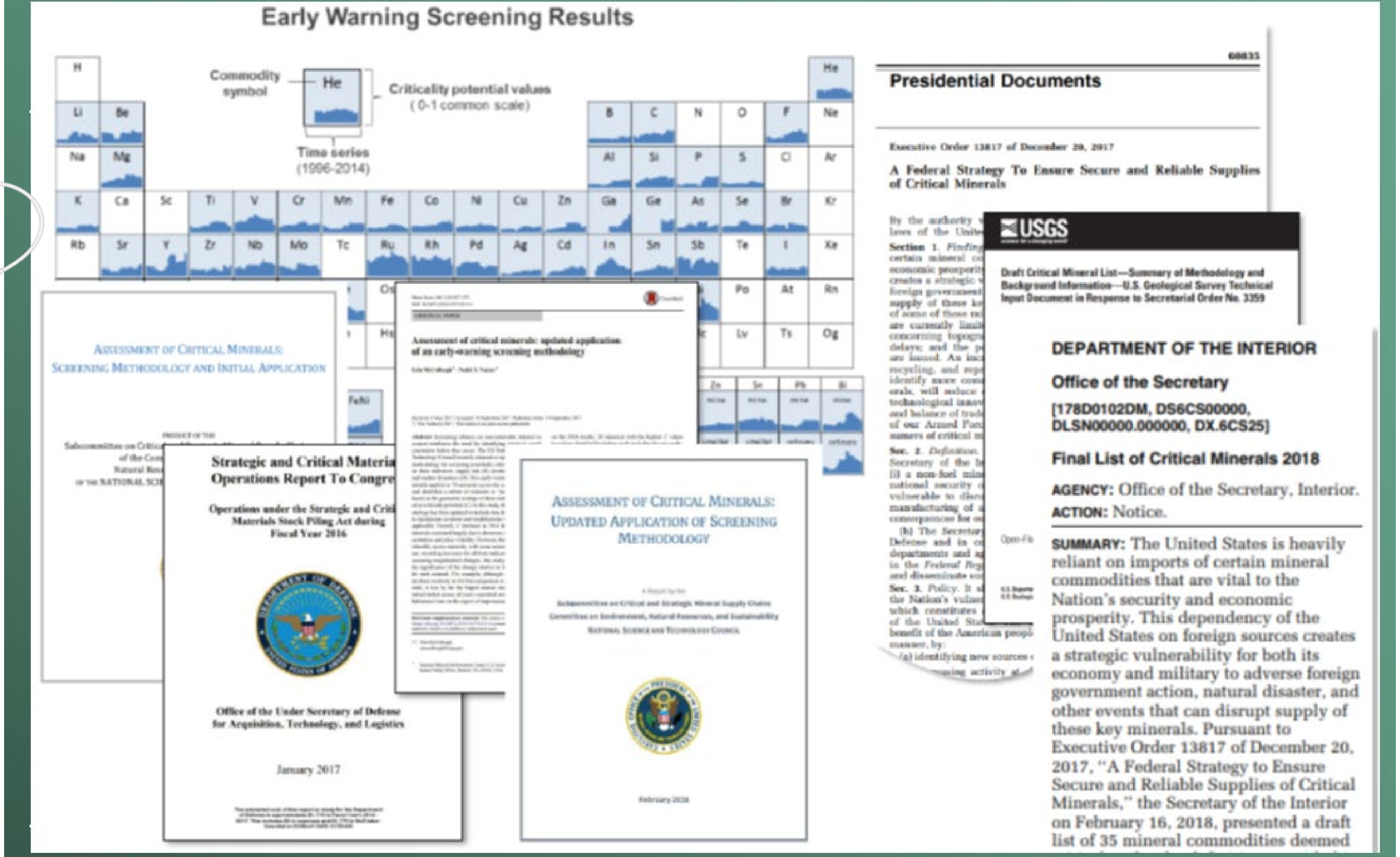


Stage I:
Early Warning Screening

Stage II:
In-Depth Analyses

source: **Nedal Nassar**
USGS, US

US list of CRMs – 2018



Presidential Documents

Executive Order 13817 of December 20, 2017

A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals

USGS

Draft Critical Mineral List—Summary of Methodology and Background Information—U.S. Geological Survey Technical Input Document in Response to Secretarial Order No. 3359

DEPARTMENT OF THE INTERIOR

Office of the Secretary

[178D0102DM, DS6CS00000, DLSN00000.000000, DX.6CS25]

Final List of Critical Minerals 2018

AGENCY: Office of the Secretary, Interior.

ACTION: Notice.

SUMMARY: The United States is heavily reliant on imports of certain mineral commodities that are vital to the Nation's security and economic prosperity. This dependency of the United States on foreign sources creates a strategic vulnerability for both its economy and military to adverse foreign government action, natural disaster, and other events that can disrupt supply of these key minerals. Pursuant to Executive Order 13817 of December 20, 2017, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," the Secretary of the Interior on February 16, 2018, presented a draft list of 35 mineral commodities deemed

ASSESSMENT OF CRITICAL MINERALS: SCREENING METHODOLOGY AND INITIAL APPLICATION

Assessment of critical minerals: updated application of an early-warning screening methodology

Strategic and Critical Materials Operations Report To Congress

Operations under the Strategic and Critical Materials Stock Piling Act during Fiscal Year 2016

Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics

January 2017

ASSESSMENT OF CRITICAL MINERALS: UPDATED APPLICATION OF SCREENING METHODOLOGY

A Report by the

Subcommittee on Critical and Strategic Mineral Supply Chains

Committee on Environment, Natural Resources, and Sustainability

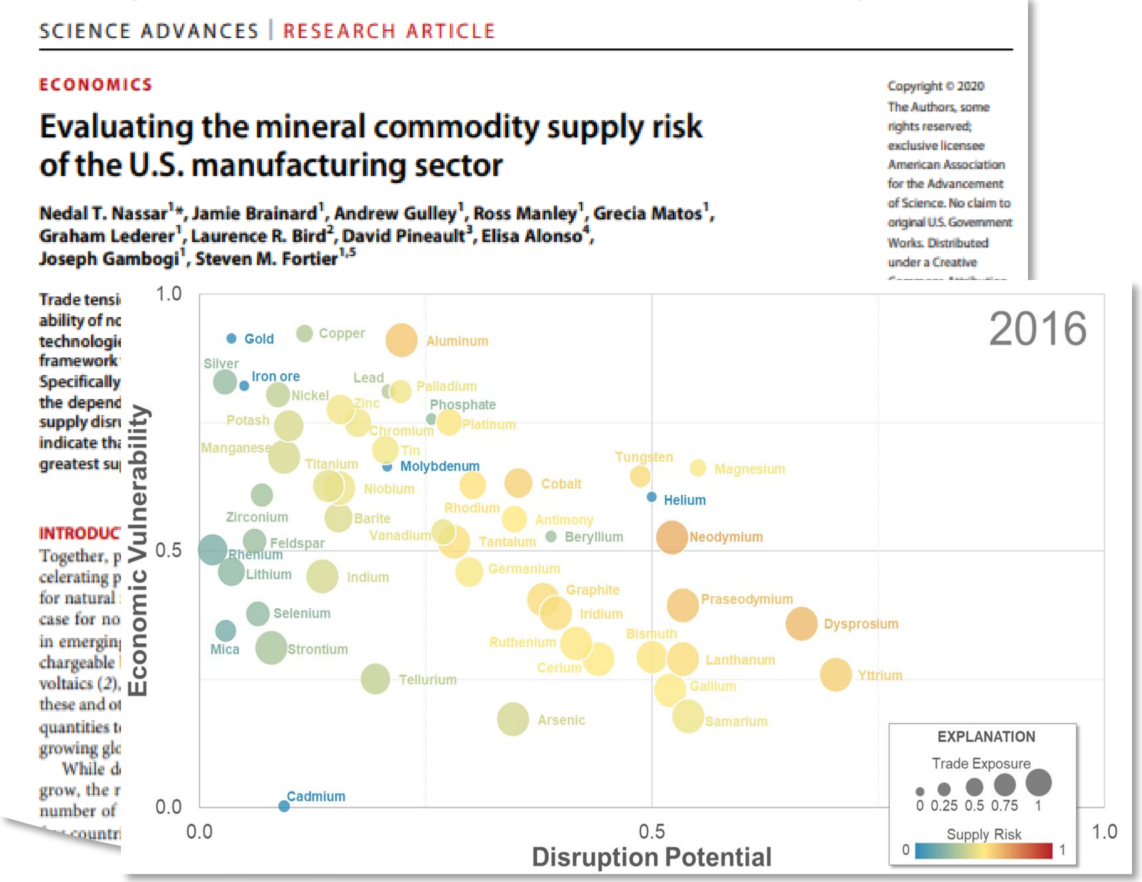
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

February 2016

USGS

Result: 35 CRMs → ***50 in 2022***

A risk modeling framework is used to assessing mineral commodities supply chains that pose the greatest risk to the U.S. economy.



SCIENCE ADVANCES | RESEARCH ARTICLE

ECONOMICS

Evaluating the mineral commodity supply risk of the U.S. manufacturing sector

Nedal T. Nassar[1]*, Jamie Brainard[1], Andrew Gulley[1], Ross Manley[1], Grecia Matos[1], Graham Lederer[1], Laurence R. Bird[2], David Pineault[3], Elisa Alonso[4], Joseph Gambogi[1], Steven M. Fortier[1,5]

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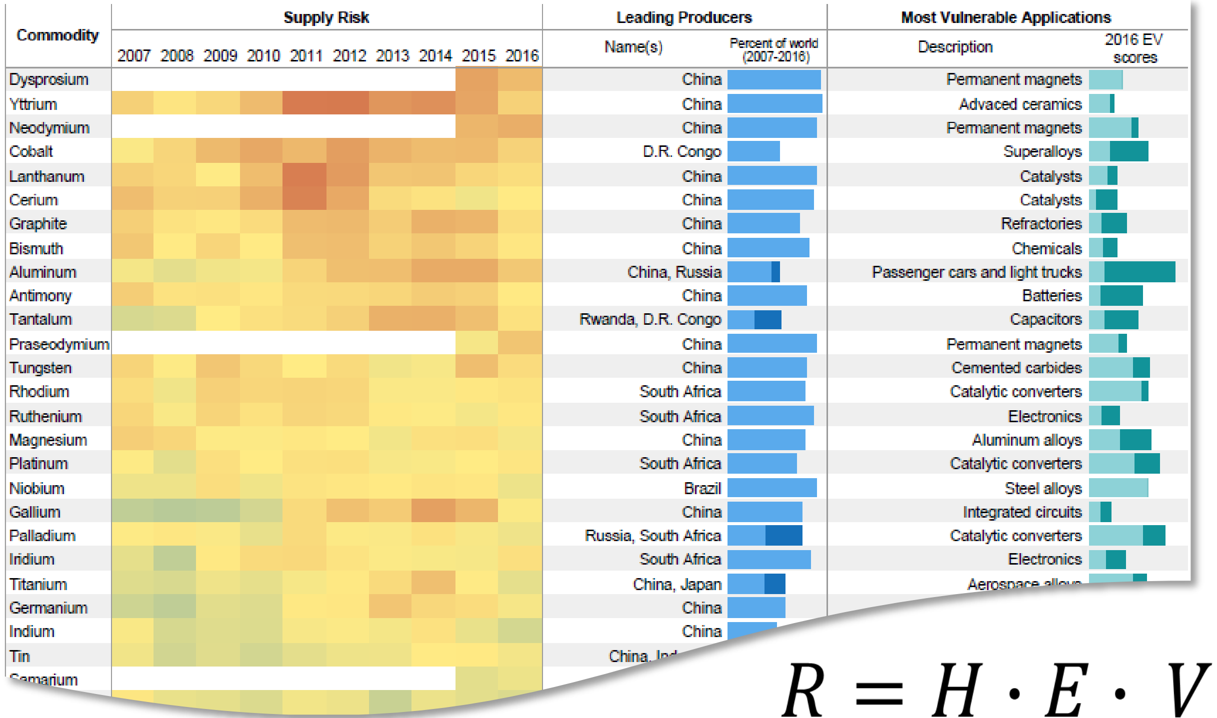
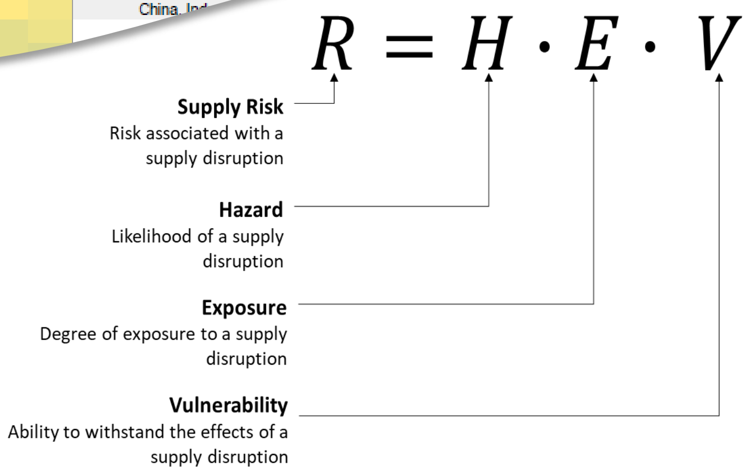


Commodity	Supply Risk										Leading Producers		Most Vulnerable Applications	
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Name(s)	Percent of world (2007-2016)	Description	2016 EV scores
Dysprosium											China		Permanent magnets	
Yttrium											China		Advaced ceramics	
Neodymium											China		Permanent magnets	
Cobalt											D.R. Congo		Superalloys	
Lanthanum											China		Catalysts	
Cerium											China		Catalysts	
Graphite											China		Refractories	
Bismuth											China		Chemicals	
Aluminum											China, Russia		Passenger cars and light trucks	
Antimony											China		Batteries	
Tantalum											Rwanda, D.R. Congo		Capacitors	
Praseodymium											China		Permanent magnets	
Tungsten											China		Cemented carbides	
Rhodium											South Africa		Catalytic converters	
Ruthenium											South Africa		Electronics	
Magnesium											China		Aluminum alloys	
Platinum											South Africa		Catalytic converters	
Niobium											Brazil		Steel alloys	
Gallium											China		Integrated circuits	
Palladium											Russia, South Africa		Catalytic converters	
Iridium											South Africa		Electronics	
Titanium											China, Japan		Aerospace alloys	
Germanium											China			
Indium											China			
Tin											China, Ind			
Samarium														

All components are necessary; each alone is an insufficient condition for risk



$$R = H \cdot E \cdot V$$

Supply Risk
Risk associated with a supply disruption

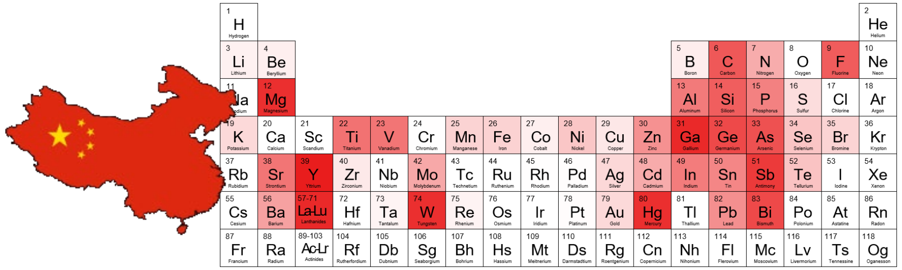
Hazard
Likelihood of a supply disruption

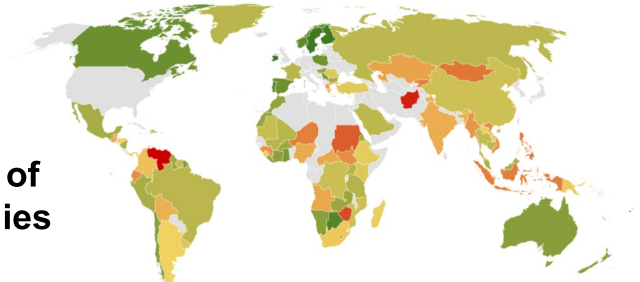
Exposure
Degree of exposure to a supply disruption

Vulnerability
Ability to withstand the effects of a supply disruption

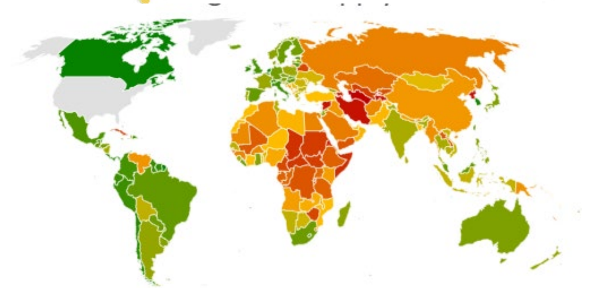
Nassar, N. T., Brainard, J., Gulley, A., Manley, R., Matos, G., Lederer, G., Bird, L. R., Pineault, D., Alonso, E., Gambogi, J., & Fortier, S. M. (2020). Evaluating the mineral commodity supply risk of the U.S. manufacturing sector. *Science Advances*, *6*(8), eaay8647.

	Disruption Potential	Trade Exposure	Economic Vulnerability
Issue	Likelihood of a foreign supply disruption	Degree of exposure to a supply disruption	Ability to withstand the effects of a supply disruption
Indicator	Concentration of production in countries that may become unable or unwilling to supply the United States	Net import reliance as a percentage of apparent consumption	Annual expenditure on the mineral commodity by each industry relative to each industry's profitability

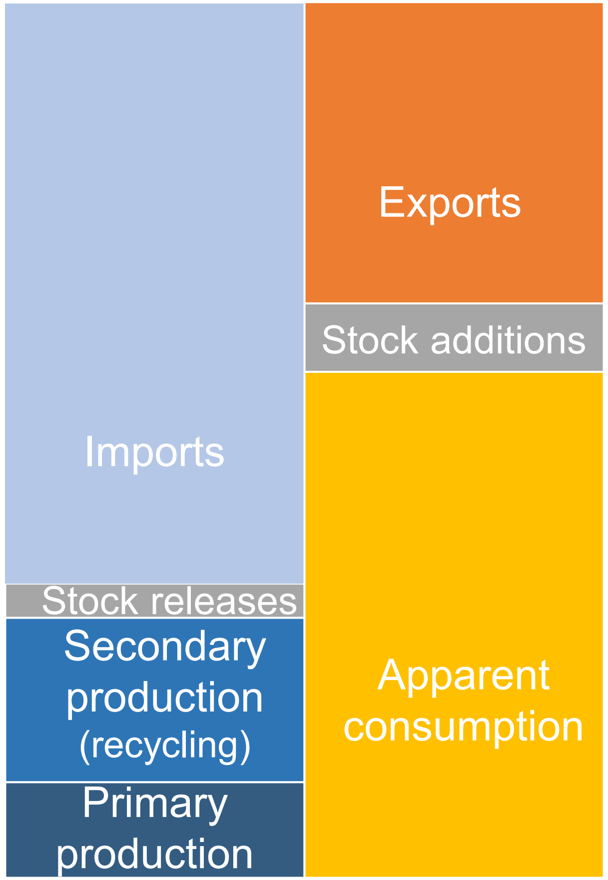


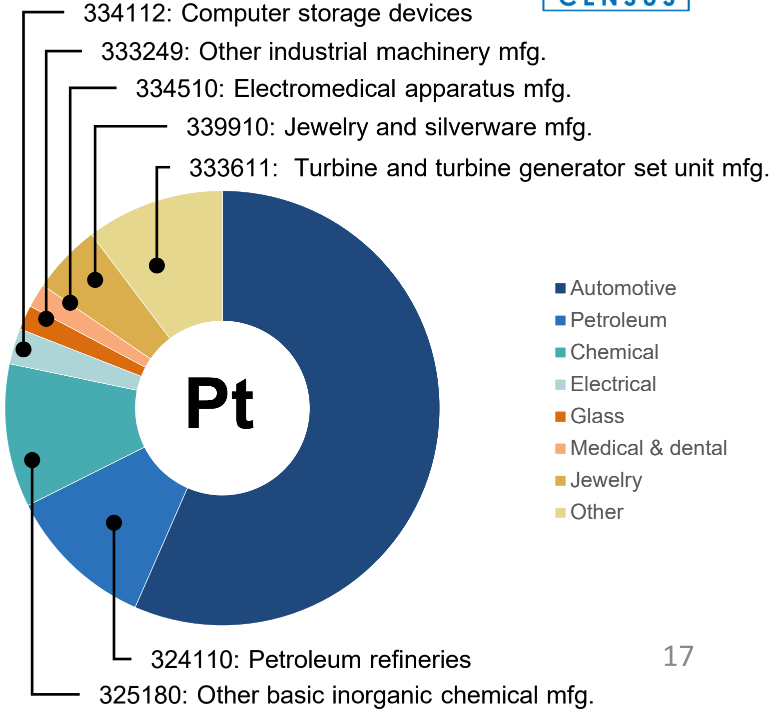


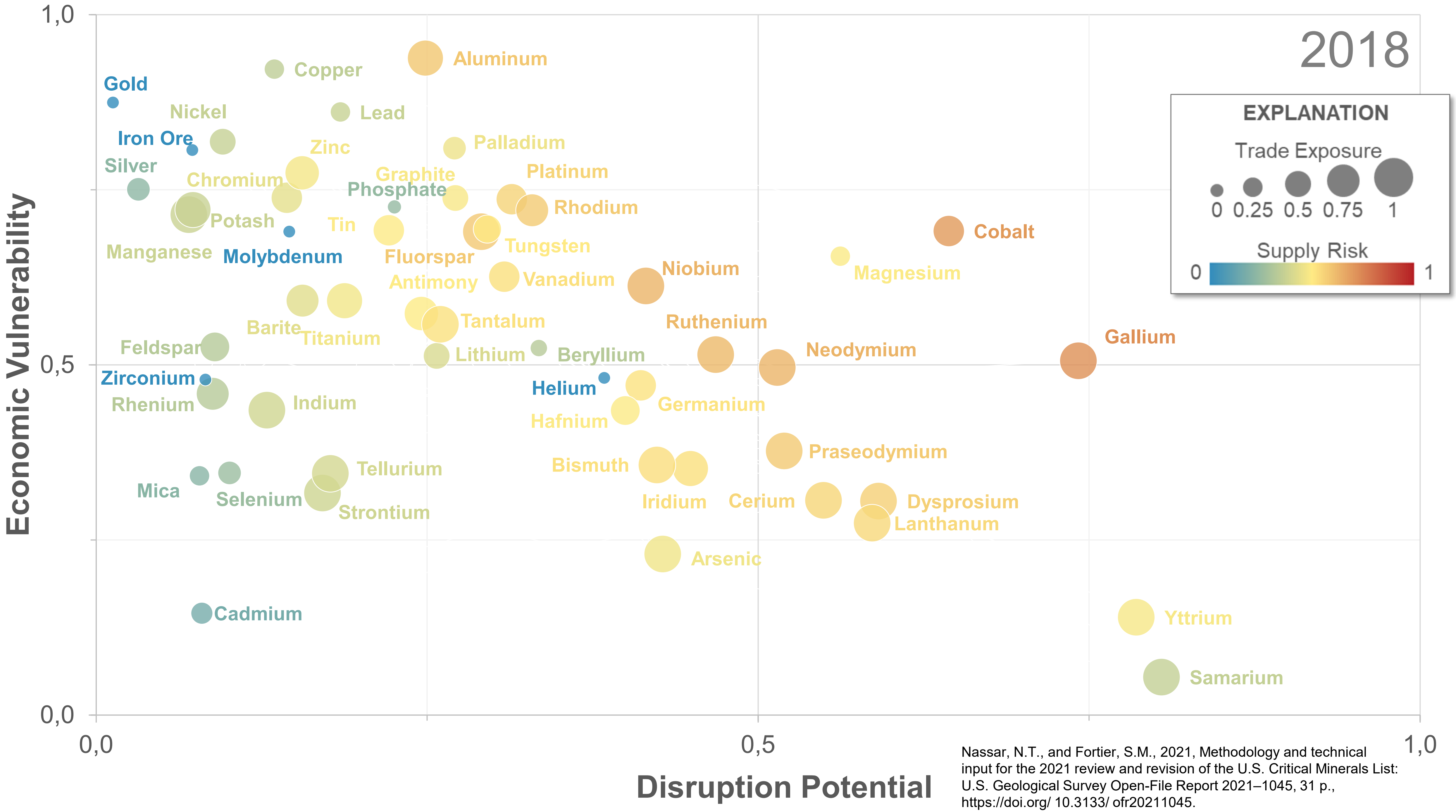
Annual Survey of Mining Companies



Willingness to Supply Index





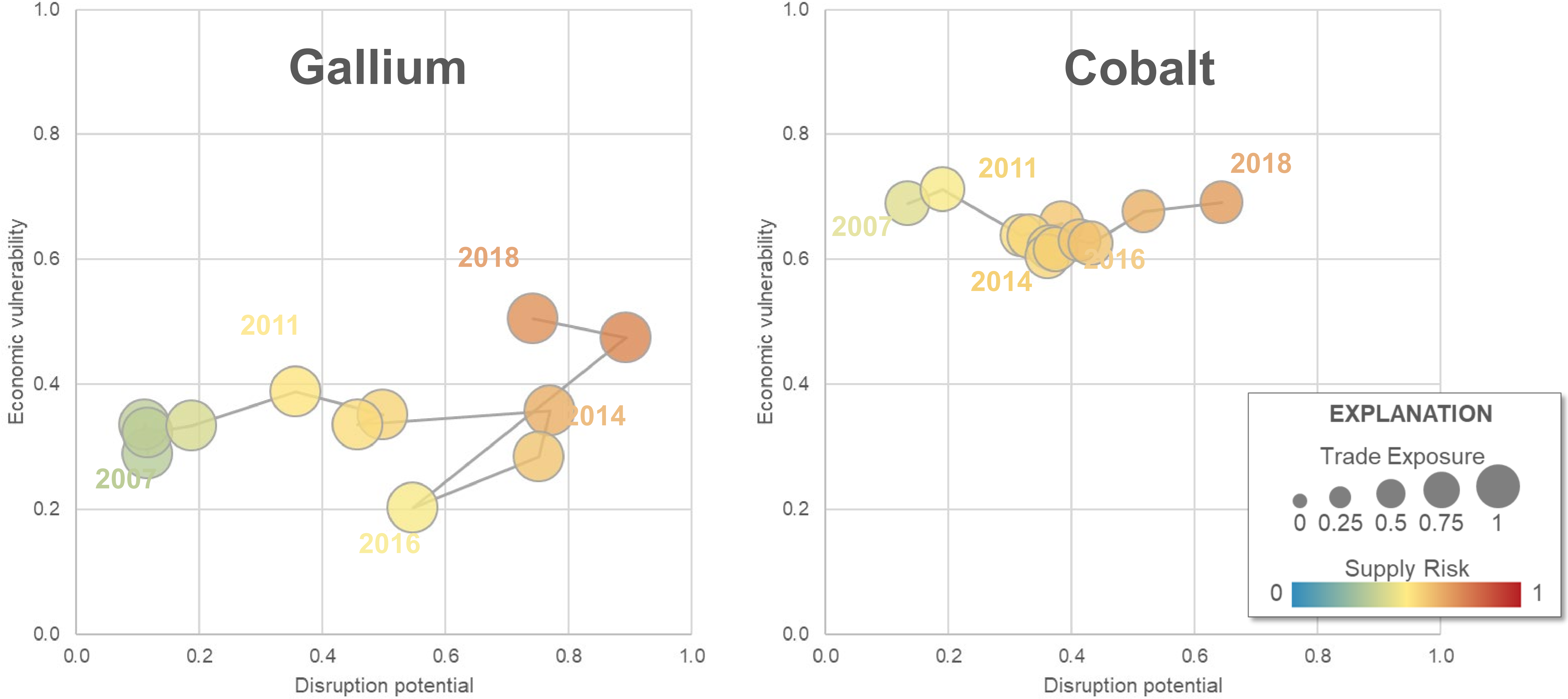


Nassar, N.T., and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. Critical Minerals List: U.S. Geological Survey Open-File Report 2021–1045, 31 p., https://doi.org/ 10.3133/ ofr20211045.

International Criticality Study Groups

USGS

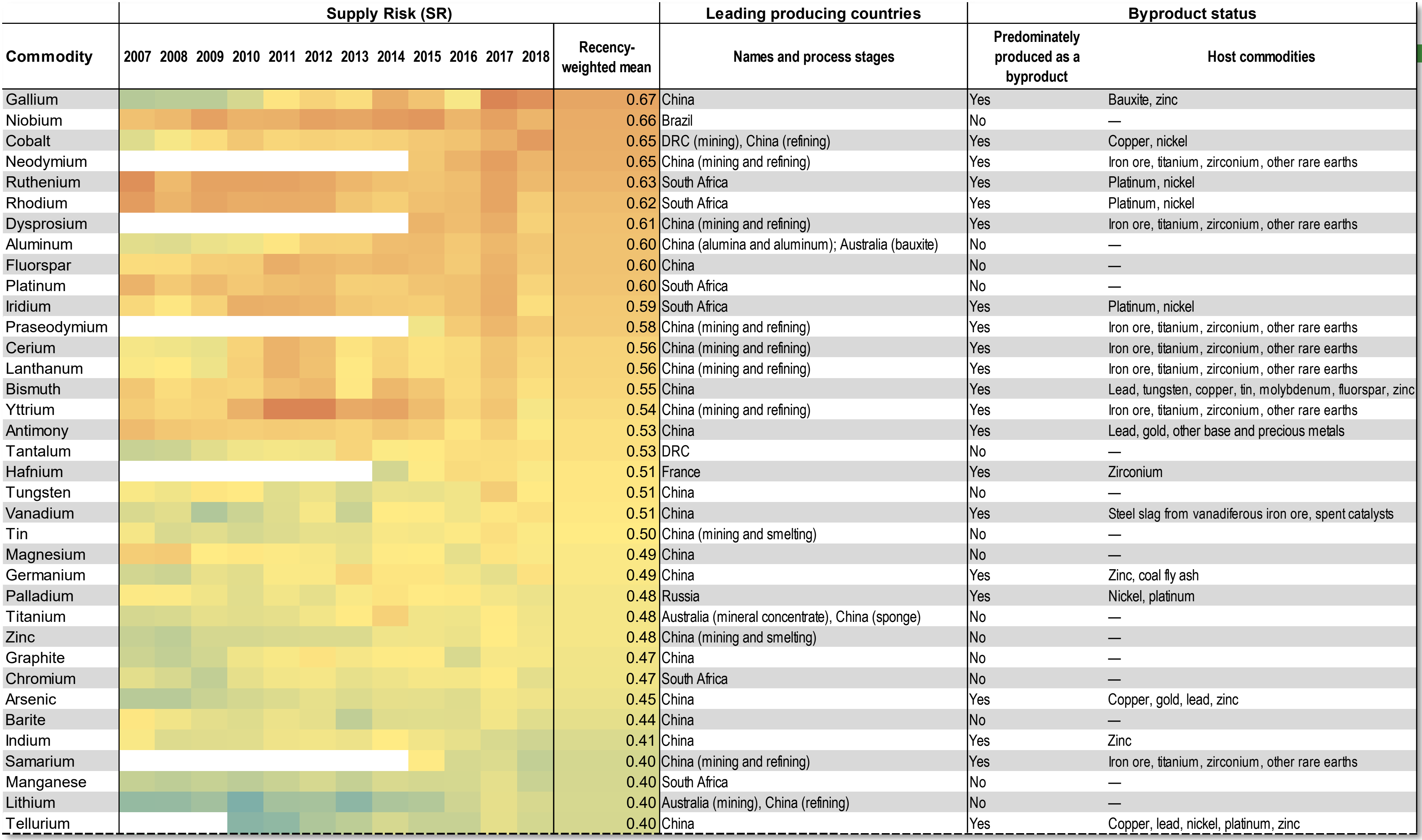
For some mineral commodities, the supply risk to the United States has increased notably over the past decade.



Based on Nassar, N.T., and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. Critical Minerals List: U.S. Geological Survey Open-File Report 2021–1045, 31 p., https://doi.org/ 10.3133/ ofr20211045.

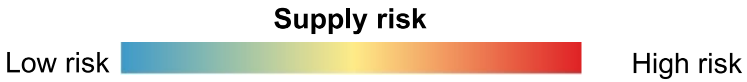
International Criticality Study Groups

USGS



	Supply Risk (SR)													Leading producing countries	Byproduct status	
Commodity	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Recency-weighted mean	Names and process stages	Predominately produced as a byproduct	Host commodities
Gallium													0.67	China	Yes	Bauxite, zinc
Niobium													0.66	Brazil	No	—
Cobalt													0.65	DRC (mining), China (refining)	Yes	Copper, nickel
Neodymium													0.65	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Ruthenium													0.63	South Africa	Yes	Platinum, nickel
Rhodium													0.62	South Africa	Yes	Platinum, nickel
Dysprosium													0.61	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Aluminum													0.60	China (alumina and aluminum); Australia (bauxite)	No	—
Fluorspar													0.60	China	No	—
Platinum													0.60	South Africa	No	—
Iridium													0.59	South Africa	Yes	Platinum, nickel
Praseodymium													0.58	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Cerium													0.56	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Lanthanum													0.56	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Bismuth													0.55	China	Yes	Lead, tungsten, copper, tin, molybdenum, fluorspar, zinc
Yttrium													0.54	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Antimony													0.53	China	Yes	Lead, gold, other base and precious metals
Tantalum													0.53	DRC	No	—
Hafnium													0.51	France	Yes	Zirconium
Tungsten													0.51	China	No	—
Vanadium													0.51	China	Yes	Steel slag from vanadiferous iron ore, spent catalysts
Tin													0.50	China (mining and smelting)	No	—
Magnesium													0.49	China	No	—
Germanium													0.49	China	Yes	Zinc, coal fly ash
Palladium													0.48	Russia	Yes	Nickel, platinum
Titanium													0.48	Australia (mineral concentrate), China (sponge)	No	—
Zinc													0.48	China (mining and smelting)	No	—
Graphite													0.47	China	No	—
Chromium													0.47	South Africa	No	—
Arsenic													0.45	China	Yes	Copper, gold, lead, zinc
Barite													0.44	China	No	—
Indium													0.41	China	Yes	Zinc
Samarium													0.40	China (mining and refining)	Yes	Iron ore, titanium, zirconium, other rare earths
Manganese													0.40	South Africa	No	—
Lithium													0.40	Australia (mining), China (refining)	No	—
Tellurium													0.40	China	Yes	Copper, lead, nickel, platinum, zinc

A subset of mineral commodities pose the greatest supply risk for the U.S. manufacturing sector.



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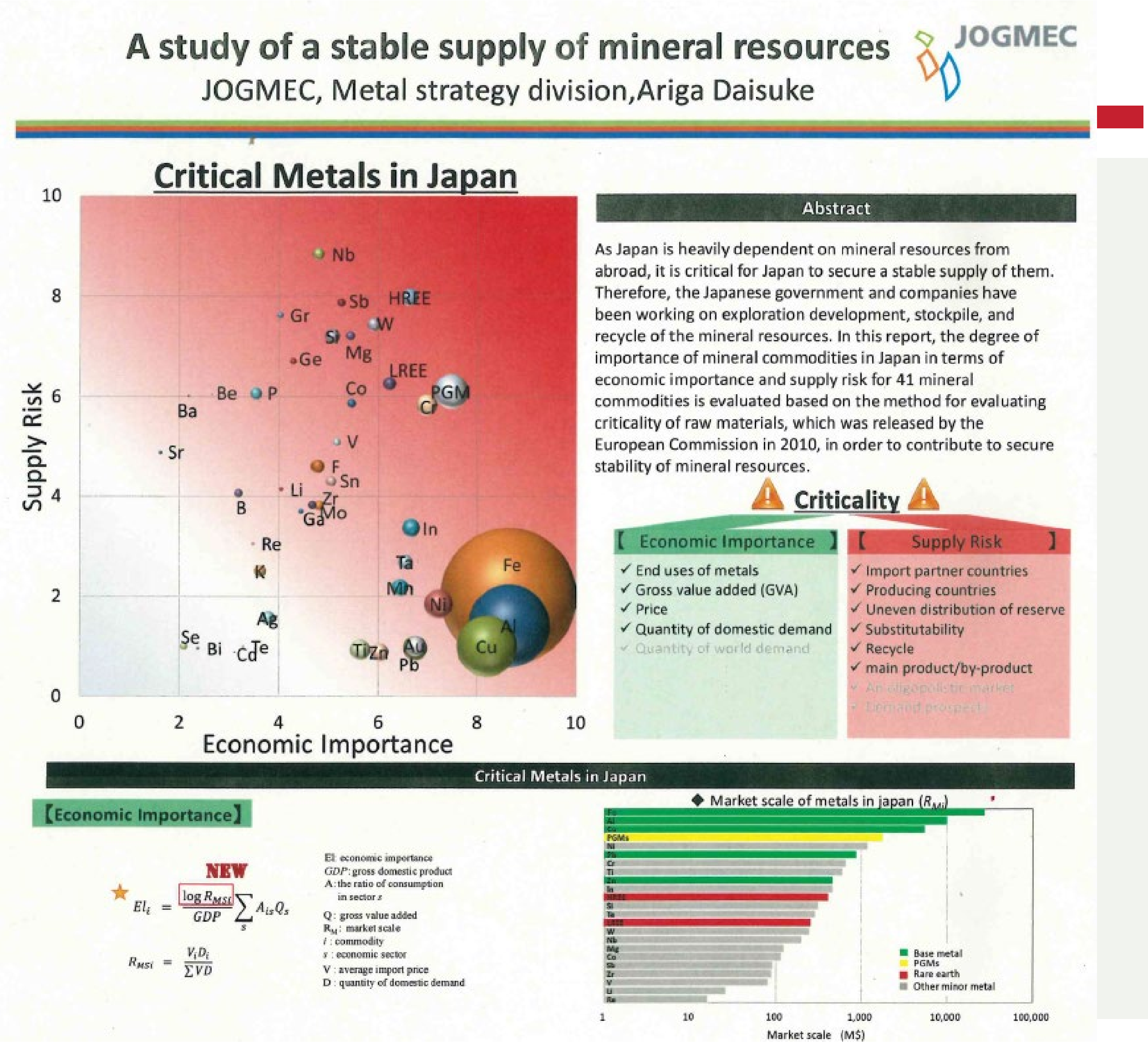
International Criticality Study Groups

JAPAN

UNECE



A study of a stable supply of mineral resources

JOGMEC, Metal strategy division,Ariga Daisuke

JOGMEC

Critical Metals in Japan

Abstract

As Japan is heavily dependent on mineral resources from abroad, it is critical for Japan to secure a stable supply of them. Therefore, the Japanese government and companies have been working on exploration development, stockpile, and recycle of the mineral resources. In this report, the degree of importance of mineral commodities in Japan in terms of economic importance and supply risk for 41 mineral commodities is evaluated based on the method for evaluating criticality of raw materials, which was released by the European Commission in 2010, in order to contribute to secure stability of mineral resources.

Criticality

【 Economic Importance 】
- ✓ End uses of metals
- ✓ Gross value added (GVA)
- ✓ Price
- ✓ Quantity of domestic demand
- ✓ Quantity of world demand

【 Supply Risk 】
- ✓ Import partner countries
- ✓ Producing countries
- ✓ Uneven distribution of reserve
- ✓ Substitutability
- ✓ Recycle
- ✓ main product/by-product
- ✓ An oligopolistic market
- ✓ Demand prospects

Critical Metals in Japan

【Economic Importance】

NEW

$$\star\ EI_i = \frac{\boxed{\log R_{MSi}}}{GDP}\sum_s A_{is}Q_s$$

$$R_{MSi} = \frac{V_i D_i}{\sum VD}$$

EI: economic importance
GDP: gross domestic product
A: the ratio of consumption in sector s
Q: gross value added
R_M: market scale
i: commodity
s: economic sector
V: average import price
D: quantity of domestic demand

◆ Market scale of metals in japan (R_{Mi})

- 🟩 Base metal
- 🟨 PGMs
- 🟥 Rare earth
- ⬜ Other minor metal

Reported Supply Disruptions

SR are **major breakdowns** in the mineral market equilibrium

«Healthy system» → «disease»

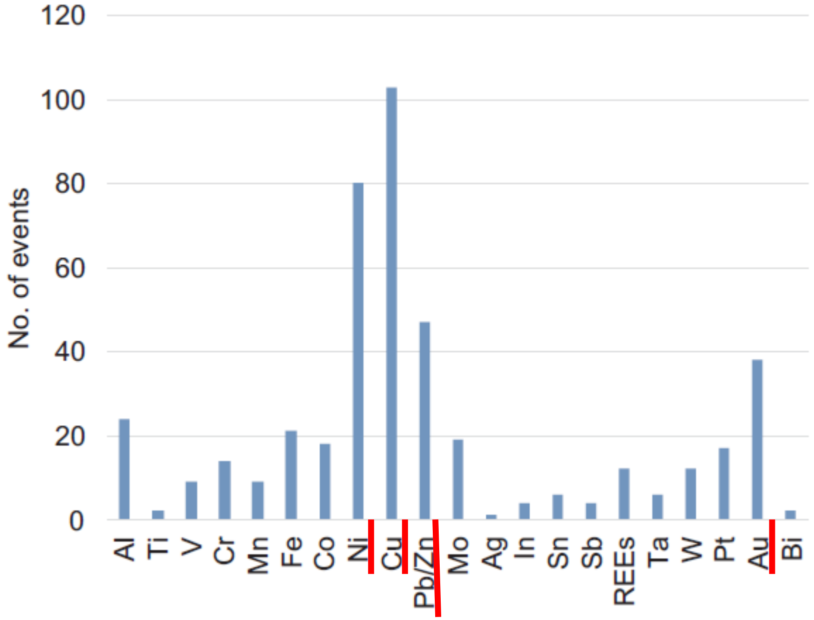
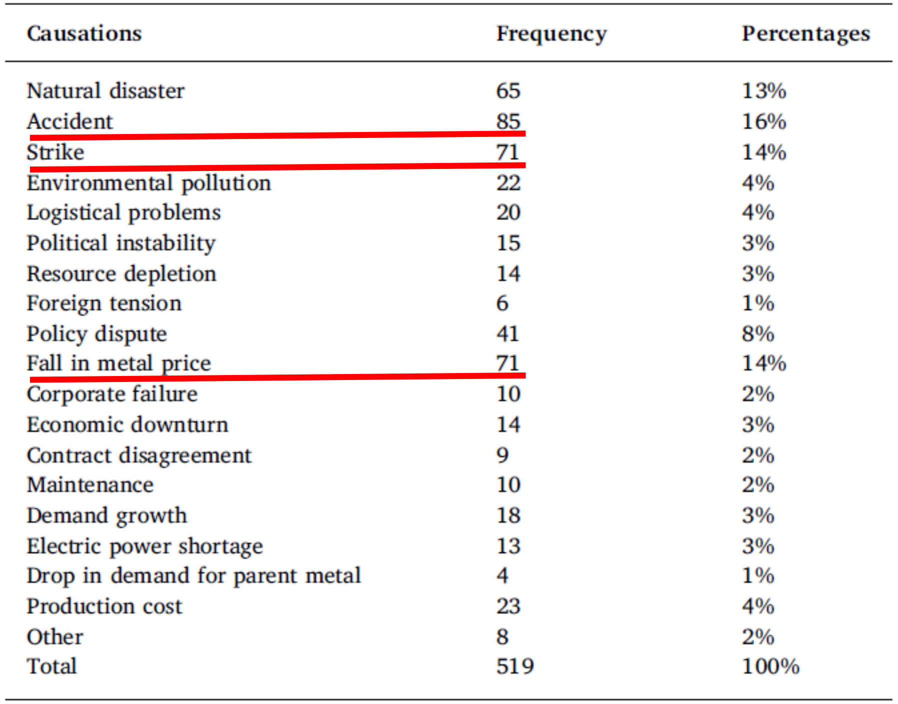


Fig. 3. Number of disruption events by metal.

Table 2
Breakdown of causations extracted from investigated events.



Causations	Frequency	Percentages
Natural disaster	65	13%
Accident	85	16%
Strike	71	14%
Environmental pollution	22	4%
Logistical problems	20	4%
Political instability	15	3%
Resource depletion	14	3%
Foreign tension	6	1%
Policy dispute	41	8%
Fall in metal price	71	14%
Corporate failure	10	2%
Economic downturn	14	3%
Contract disagreement	9	2%
Maintenance	10	2%
Demand growth	18	3%
Electric power shortage	13	3%
Drop in demand for parent metal	4	1%
Production cost	23	4%
Other	8	2%
Total	519	100%

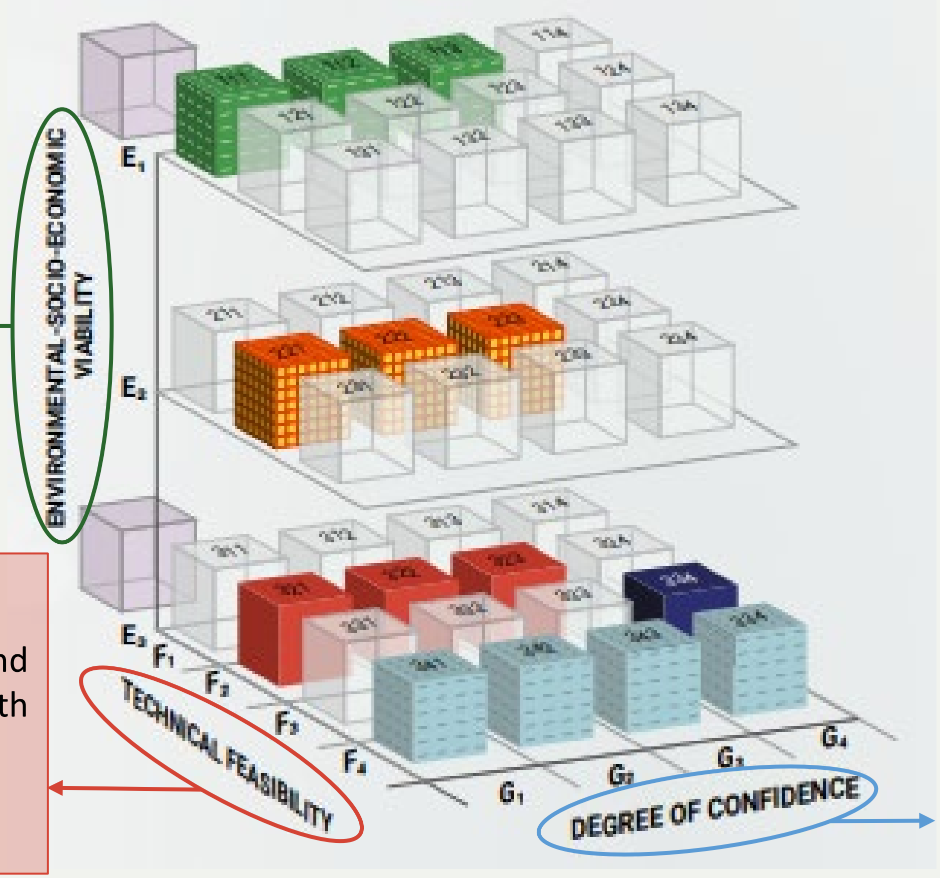
Hatayama H., Tahara K. 2018, Adopting an objective approach to criticality assessment: Learning from the past, Resources Policy, Volume 55, 96-102

Links between Criticality parameters and UNFC axes - discussion

E axis

E axis assesses the sustainability of mineral development in terms of environmental and socio-economic factors

- Backbone in most criticality assessments
- (…)



F axis

F axis assesses the ability to extract and process a mineral economically and with available technology.

- Technological aspects
- (…)

G axis

G axis estimates the level of understanding of a mineral resource's quantity and quality.

- Minor aspects in criticality?
- (…)

Thank you!

Gian Andrea Blengini
Associate Professor
Politecnico di Torino
Date 25 I 04 I 2023, Geneva

RESOURCE MANAGEMENT WEEK 2023

ASSURING SUSTAINABILITY IN RESOURCE MANAGEMENT

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