IRTC-Business workshop summary

Building resilient economies - the role of policy

November 17 & December 11, 2020

The IRTC-Business workshop and Round Table on "Building resilient economies - the role of policy" took place via Zoom on November 17, 2020, from 2 am to 6 pm CET. Around 80 registered participants attended the workshop which comprised in a first part presentations from policy-making, industry and research on how more resilient economies can be built and supported. In a second part, the participants split in two groups, one with an industry and one with a policy focus on the topic. In both groups, an expert panel discussed questions surrounding the main topic from their respective views. Participants were able to contribute via a virtual whiteboard. In a follow-up event on December 11, the panelists and participants got the chance to discuss the preliminary results of the November workshop further. This report is a summary of the overall results of both events.

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1. Critical raw materials and the COVID-19 pandemic

1.1. Peter Handley: COVID-19 and Europe's raw materials management

Peter Handley is the Head of the Resource Efficiency and Raw Materials Unit at DG GROW at the European Commission.

The European Commission formulated the New Industrial Strategy early March 2020 (before the COVID-19 pandemic) to face the major challenges for the European economy to become climate neutral and digital by 2050, as formulated in the Green Deal. This transition requires the development of breakthrough technologies, which should be managed in a socially fair way, by at the same time ensuring global economic competitiveness. The EC strategy is called "open strategic autonomy", which is an approach towards a resilient EU economy.

The EU economy experienced supply disruptions due to COVID-19 in 2020, first due to measures taken in Wuhan, later also due to disrupted production and trade within Europe. Business confidence and investments were declining, which affected the raw materials sector and energy-intensive industries that are dependent on downstream demand. Keeping the businesses alive required a short-term strategy, whereas a long-term recovery plan was needed to mend the EU economy. The EC reached out to the industries, monitored the situation and tried to alleviate Europe-wide supply bottlenecks in March-May 2020. In response to the call of the European Council, a repair and recovery plan was established. The long-term recovery strategy should encompass the objectives of open strategic autonomy: hence, the disruption is used as an accelerator to move towards a more green, digital, and resilient economy. Member states are advised on how to put according the investments in place

In September 2020, a new critical raw materials list was communicated, addressing resilience, strategic autonomy, and lessons learned from COVID-19. A high concentration of supply from a single country, also within Europe, can pose a risk, e.g. when a company experiences financial problems or is targeted for a takeover from abroad. The list is published every three years and helps to inform trade policy, research and development policy, and industrial strategies. The list is rather stable, but includes since 2020 bauxite, lithium, titanium, and strontium.

A new concept that is put into the Industrial Strategy and the recovery plan is "industrial ecosystems", which brings together the interplay between products and services, large companies and SMEs, the contribution of research and innovation and investment communities to implement industry strategies. 14 industrial ecosystems are identified, including aerospace/defense, electronics, and renewable energy.

The European Commission now also conducted a forward-looking evaluation of CRMs in order to identify the raw material dependencies in 2030 and 2050 of climate-neutrality and digital policy strategies. Material consumption is forecasted to increase by a factor 12-50 for certain materials.

An action plan is formulated to ensure Europe's access to raw materials, containing 10 actions:

1) Establish and foster the European Raw Materials Alliance
2) Develop sustainable financing criteria for mining
3) Invest in research and innovation on waste processing, advanced materials and substitution
4) Map the potential supply of secondary CRMs from EU stocks and wastes

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5) Invest in mining projects that can be operational in 2025
6) Develop expertise and skills in mining
7) Deploy earth observation programmes for exploration, operation and post-closure environmental management
8) Develop research and innovation projects on exploitation and processing of CRMs
9) Develop strategic international partnerships to secure CRMs supply
10) Promote responsible mining practices for CRMs (including a legislative proposal on due diligence for batteries produced in Europe)

1.2. Sven Renner: Effects of the COVID-19 pandemic on extractive industries

Sven Renner is in charge of the Extractives Global Programmatic Support Trust Fund (EGPS) at the World Bank.

The COVID crisis affected both the supply and the demand of raw materials. Demand was affected by a tanking economy and a decrease in consumption. On the supply side, health protection measures were imposed to many large-scale mines worldwide. The World Bank evaluated the impact of COVID-19 on the mining of copper in Peru, covering industrial mines, but also artisanal and small-scale mines (ASM).

Copper demand can generally be expected to continuously increase due to its many applications. However, now, the global demand is estimated to fall back which will have a ripple effect over the next couple of years. Peru supplies mostly to the Asian market, and here mostly to China. Hence, the production is highly dependent on Chinese copper demand. Demand is expected to increase again due to the infrastructure-led economic recovery in China, China's announced carbon neutrality in 2060, and the US green energy and infrastructure plan presented by president-elect Joe Biden.

Global copper production has declined in 2020, even more strongly than during the Global Financial Crisis in 2008. This is not only due to a decreased demand, but also due to health protection measures. Peru's projected production in the coming years is lower than the pre-COVID forecasts due to delayed investments in the production sector. However, Peruvian copper production is relatively mildly affected due to Peru's strong position in the cost curve, which is further enhanced by a sharp decrease of fuel price (40% of OPEX).

Artisanal and small-scale mines are expected to be hit harder by the COVID crisis than industrial mines. Funded by the EGPS Trust Fund, the World Bank has assessed the viability of creating a specific financial facility to support ASM communities.

With the COVID crisis it is expected that poverty increases, related to migration back to rural areas[1] with an increasing spread of the disease, and pressure on food security and health services. Artisanal mining is an important source of livelihood in many regions, often poverty-driven, and associated with negative social impacts, e.g. related to human rights, illicit financial flows, forced migration, and

[1] A participant adds that recent migration in Peru and Brazil was also caused by the rising price of gold that is artisanally in the amazon area.

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financing of armed groups. Via questionnaires, data were collected among organisations that operate in areas with active ASM operations. In many African countries, South America, and Central Asia, the local population has suffered from negative impacts concerning health, food security, and access to markets. The following conclusions are drawn:

1. Human capital development will undergo shocks if ASM communities become infected. A substantial part of the population does not feel well informed about COVID-19 and the measures that have to be taken for health protection.
2. There is a sizeable gender gap when it comes to food security. 36% of male and 56% of female respondents state that food security has decreased since COVID-19 began, due to price increases and reductions in household income.
3. Surprisingly, personal security has not decreased due to COVID-19. On the contrary, improvements in security were observed in Indonesia, Mozambique, Nigeria, Sierra Leone, and Uganda. Increases in criminal activities were expected, e.g. due to the contained mobility, but this was so far not the case.
4. Miners intend to continue mining in spite of disrupted trade chains. Two major problems are a lack of formal access to financing and formal access to markets. The need for formalization has been an issue for a longer time, independent of the COVID crisis.

6 million USD have been mobilized by World Bank donors, especially from Switzerland, Belgium, the EU, and Germany, to develop activities that support the ASM communities in the affected areas that have been identified via the data collection. 22 grants are awarded to organizations working on the ground in 20 countries, and a next round of grants is coming up.

1.3. Peter Buchholz: Supply resilience of key metals in the COVID-19 context and outlook

Peter Buchholz is the Head of the German Mineral Resource Agency (DERA) which is part of the German Geological Survey (BGR). The institute is engaged in a variety of work on criticality, technology forecasting and monitoring of raw material markets.

According to the International Monetary Fund (IMF), the global GDP declined by 4,4% in 2020. Countries were hit differently by the COVID crisis, resulting in different growth rates. The only country with positive growth was China with +1,9%. In 2021, an overall growth of 5,2% is forecasted, with China and India leading. The World Economic Forum presented different “shapes” in which the economy could recover. It is unclear yet which shape will appear, and it could be different for each country. Based on a survey, most CEOs expect a gradual decline of the economy followed by a healthy rise (U-shape), whereas some predict a second drop in 2022 (W-shape) due to the end of governmental supporting systems.

Following the steel Purchasing Managers’ Index (PMI), steel demand in the manufacturing sector first declined in Asia, and subsequently in Europe and the US. Demand in Asia recovered quite quickly, and demand is currently restored in all regions. Similar trends are observable for aluminum and other commodities. Prices of base metals declined at the beginning of the COVID crisis, but increased again

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due to the economic growth in China.[2] Demand for precious metals, especially rhodium, dropped due to the crisis in the automotive industry, but this industry has also undergone a restorage. Prices of materials for batteries remained quite stable under COVID, because they were already relatively low due to an expected overcapacity.

Throughout the world, mines were shut down during the beginning of the pandemic. As they were recognized as "essential services", they resumed quickly in most countries, after necessary health measures were put in place. In this regard, the supply can be considered quite resilient. However, exploration budgets went down, also for copper for which demand is expected to increase in the long term. Therefore, it is expected that more investments in exploration can be observed after the pandemic.

The supply disruptions due to the lockdowns did not lead to major supply gaps, because demand was also low. Exceptions are manganese metal flakes, silicon metal, ferro-tungsten, and molybdenum, for which prices increased by 13-40% in February 2020 due to fears of supply disruption, as China is the main supplier. Prices came down when China resumed the production in April.

However, also next year, supply chains in the mineral market might be affected by regional outbreaks of COVID. Diversification could be the best way for industries to prepare for this: by looking for new or alternative suppliers in the market to fill possible supply gaps. A lesson can be learnt from the decreased supply of fluorspar from China to Germany and the Netherlands, which was due to increased environmental restrictions on mining in China. Germany successfully diversified their supply via imports from South Africa and Spain. However, diversification is becoming more and more difficult when political and economic power is becoming more concentrated, especially in some raw material markets. DERA established a graph showing how trade dominance of metallic resources shifted from Europe (around 2002) to China, especially in Asia, Africa, South America, and Australia. Europe and the US need to build better trade relations with resource-rich countries to make supply chains more resilient.

1.4. Scott Foster: COVID-19 and Sustainable Resource Management: Policies and actions to support resilience in the supply of critical raw materials

Scott Foster is the Director of the Sustainable Energy Division at UNECE.

The surge of the stock markets after the announcements about a vaccine against COVID-19 is a signal that society is heading back to where we were before the pandemic, which might not be the best path. If we want to build back better, there are 3 dimensions to consider that have not been included in 2019 forecasts:

- There is anecdotal evidence that the environment, especially the quality of air and water, benefited from the lockdown and the economic slowdown. However, 2020 was also the year

[2] A graph correlating the zinc price with the US dollar shows that the zinc price is higher when the dollar is weak.

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of forest fires and floods causing over 1 billion of animal deaths. The market did not respond to this.

- There is a strong focus on unemployment and quality of life. For example in the energy sector, there has been a strong decrease in demand and this might continue; the same is true for other sectors.
- Urbanization: pre-COVID forecasts predicted a global population of 9 billion people in 2050, with 70% living in cities. This would require building 255 additional cities with the size of Paris.

During the pandemic, resilience was expected from the individual to cope with stress, social isolation, job losses, and health issues, as well as from individual companies. A vision for the whole system, including the environment and other species, is needed. Sourcing basic raw materials in an environmentally, socially, and economically coherent way is key.

Governments are trying to improve the security of supply of raw materials. This does not necessarily imply supply independence, but rather redundancies in supply chains, and the ability to prepare for what can happen, to respond instantaneously, and to learning and retaining lessons from events. In order to build back better, there should be a common vision of shared outcomes, shared knowledge, integrated resource management, and a comprehensive toolbox.

Securing supply of CRMs can partially be achieved by diversification, partially by increased exploration and mining, and partially by increased sustainability of consumption and production. With current consumption patterns, we would need 7 earths to deliver the demanded resources, especially considering the increased development of low-income countries towards the standard of high-income countries, which is connected to a much larger material footprint. For sustainable production, engagement of local communities is needed to establish the social license to operate, which is currently impeded by the image of social and environmental problems associated with resource extraction.

To build back better, the resource management narrative should be rewritten:

- Align resource management to the 2030 Agenda: investments should flow into resource development for the technologies that deliver country commitments to sustainable development
- Improve financial resilience through business process innovation
- Derive good social, environmental, and economic outcomes
- Obtain social license to operate
- Integrated approach: mutually beneficial economic interdependence should be created
- Harmonization and common vocabularies, such that the same standards of sustainability are applied by all actors.

At the UN, the United Nations Framework Classification (UNFC) and United Nations Resource Management System (UNRMS) aid in identifying resources and manage them in order to meet a country's objectives. Transparent communication of these objectives furthermore increases trust, which contributes to the creation of mutual interdependencies. Investments made by MSMEs (Micro, Small and Medium Enterprises) across the whole value chain allow for diversification and resilience. These frameworks are being deployed throughout the world. UNFC covers renewables, uranium,

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thorium, petroleum, oil and gas, nuclear resources, and all critical raw materials. Implementing this system at a global scale is part of the creation of a shared vision which is critically important.

1.5. Akanksha Tyagi: Impact of the crisis on raw materials management of transitional countries

Akanksha Tyagi is representing the Council on Energy, Environment and Water (CEEW), a leading policy research institution based in New Delhi, India.

In India, the energy sector is already quite diversified. However, the notion of critical minerals is relatively new but increasingly important due to a growing demand for electronics, chemicals, food and beverages. In 2016, CEEW evaluated the criticality of 49 non-fuel minerals across 16 manufacturing sectors, including – among others – metals, food and beverages, textiles and apparels, refining, and electronics, over the period of 2011-2030.

With the applied methodology, the economic importance of the minerals is based on i) the consumption pattern (the fraction of the mineral consumption in a sector), and ii) the industrial structure (the contribution of that sector to the national GDP). The supply risk is evaluated by i) national resource endowment (via import dependence and domestic reserves), ii) geopolitical risk (via the Worldwide Governance Indicators), iii) substitution risk (substitutability) and iv) recyclability risk (recycling potential). Based on this, minerals that will be critical in 2030 are mostly metals due to the specific consumption of sectors that will contribute to the expected development of India. Critical minerals are heavy and light rare earth elements (increased demand for clean energy technology and electronics), Ta, Sr, Be, graphite, Si (difficult to refine in a transitional country due to high energy requirements for processing), Ge (low recycling rate in India), Cr, Re, Zr, V, PGM, limestone, Bi Nb, and potash.

India committed to various international and domestic development objectives, such as an emission reduction of 30-35% by 2030 compared to the emissions of 2005 within the Paris agreement. India is on track to meet this target due to the energy conservation program that aims for increased energy efficiency, e.g. via use of LEDs and efficient building codes. Other targets are 175 GW of renewable energy in 2022 and potentially 450 GW by 2030, EV sales of 30% by 2030, and this year the implementation of the BS VI/ Euro VI standards for vehicles to decrease air pollution. India strives for an increased digitalization via 600 million broadband connections by 2022. These objectives all require the use of metals, making these metals critical.

COVID-19 reinforced the sentiment that India needs to assess its use of CRMs. The government tries to rebuild the economy in a clean and sustainable manner, but there is a renewed focus on domestic value creation and self-reliance via i) industrial expansion and integration with global value chains, ii) adopting a low-carbon approach, and iii) supporting indigenization of low-carbon solutions. There is increased support for MSMEs, via improved access to finance, as it is not strategic to rely on a few major companies. 10 critical sectors are supported via a “Production Linked Incentive Scheme”. To strengthen the domestic PV manufacturing industry, a custom duty is imposed on modules procured abroad. Most tenders deployed in India require a domestic engagement.

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Emerging policy considerations are resource availability, recycling, and substitution. To create resilient supply chains for strategic and critical minerals, KABIL was created, which is a conglomerate of three public enterprises that generate a consistent supply of aluminum and copper, and conduct mineral exploration. Regional cooperation between India, US, Japan and Australia allows for improved exchange between business and academia, and continuous exchange of information and technologies, which could lead to enhanced domestic exploration and improved recycling. India has a large recycling sector. However, this sector is mostly informal; hence, value creation is marginal and minerals are not always directed towards the sector in which they are most needed. Unlike for solar modules for which there was no clear waste management plan, the government set waste management rules for batteries alongside the scaling up of battery production, as manufacturing and waste management should go hand in hand. Finally, the government promotes R&D and technology transfer between industry and academy to increase substitutability. The government applies a technology-agnostic approach, meaning that any technology that enables achieving India's objectives is welcome to be upscaled – leading to increased diversity and use of more domestically abundant minerals.

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2. How policy can support sustainable supply for industries

2.1. Yasushi Harada: Hitachi's experience with increasing circularity of REEs

Yasushi Harada is Senior Chief Researcher at the Center for Technology Innovation at Hitachi, Ltd. He is presenting Hitachi's experience with increasing circularity of REEs in collaboration with Takeshi Nemoto from Hitachi's Water & Environment Business Unit.

According to its environmental vision and long-term environmental targets, Hitachi strives towards a low-carbon, resource-efficient society that is harmonized with nature. These targets include an 80% reduction in CO2 emissions throughout the company's value chain in 2050 (compared with 2010), a 50% improvement in the efficiency of the use of water and other resources in 2050, and a minimization of Hitachi's impact on natural capital. Furthermore, Japanese manufacturers, like Hitachi, are heavily impacted by the stagnating imports of raw materials such as plastic, base metals like iron and copper. As Japan does not have a large amount of domestic natural resources, recycling is an important strategy against price increases related to increased resource consumption.

16 affiliates of Hitachi, forming a nationwide collection and recycling network, contribute to a circular use of resources from 100 different product types via product recycling service centers that collect end-of-life products from customers. The standardized method of Hitachi, which includes regulations regarding the security management and recycling procedures, is certified by the National Permit System for industrial waste by the Ministry of Environment of Japan. The used products, such as IT servers, computers, disk drives, and automated teller machines (ATMs), are disassembled into parts; frequently by manual labor. They are being recycled into materials like waste plastics, steel, copper, aluminum, glass, and magnets. A total of about 500 metric tons of products have been handled in 5 years from 2014 to 2018, with hard disk drives accounting for about 10 metric tons, an equivalent of 20'000 drives.

Every year, several thousands of ATMs are collected and recycled. Since 2007, the ATM manufacturer (Hitachi-Omron Terminal Solutions) and the disassembler (Hitachi Industrial Equipment Nakajo Engineering) have been working closely together and share information. Nakajo Engineering has the advantage of having been an ATM manufacturer in the past. They retained their in-house engineers who are knowledgeable in the physical structure of ATMs. ATMs are disassembled manually, to break the equipment down as much as possible into single materials which can then be recycled efficiently into resources, or which can be reused after refurbishment. Approximately 20 different types and a total of 7'000 parts have been effectively reused to date, mostly as parts for maintenance. The service life of an ATM is limited to 10 years due to upgrades of equipment and change in design. However, many parts are often still usable for the new product. Such Design for Environment (DfE) needs to be more widespread to increase refurbishment and reuse.

ATMs are comprising metals, circuit boards, cables, hard disk drives, rechargeable batteries, waste plastics and glass. Only the glass materials used in the panel is classified as waste. Metals make up about 90% of the overall material. The metal that is most effectively recycled is steel. Recycling of steel does not only decrease the need to import iron ore from other countries, but also decreases the

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energy consumption of the steelmaking process. Recovery of heat from plastics, or the use of burnt ashes in aggregates is strictly speaking also recycling, although it still reflects the linear economy. In the future, more awareness about the circular economy is needed.

Hard disk drives (HDDs) contain an aluminum casing, a disk, a motor, a magnetic head, a circuit board, screws, and a voice coil motor (VCM) which contain rare earth elements. HDDs were also disassembled by hand. However the speed of disassembly was limited by 10-12 drivers per worker per hour. An automated disassembler was developed that increased this rate to 140 drives per worker per hour. This disassembler is designed to avoid the VCMs from being damaged, which could lead to spontaneous combustion or the infiltration of contaminants in the magnet refurbishing process. The Hitachi disassembler has processed 26 tons of magnets from HDDs over 6 years since 2013. In 2018, MRI scanners were also targeted for rare earth recycling. In that year alone, the total volume of magnets collected soared up to 25 tons.

The recycling of rare earths allows to supply 10% of the total RE demand of Hitachi. Furthermore, the collection and recycling of rare earth magnets by Tokyo Eco Recycle Co., Ltd (one of the three recycling companies of Hitachi) reduces CO_2 emissions to less than 10% of the emissions that would have taken place if the same weight of magnets would have been manufactured from primary resources. By making the rare earth magnet value chain more circular, Hitachi reduces the disposal of magnets, and provides means of added value in the value chain, via reuse of parts and materials and recycling into raw materials. The circular flow prolongs product lifetimes and saves resources, improving the co-existence of humans and nature. Initially this was motivated by environmental impact reduction, and the implementation of regulations from the Japanese government supported by governmental subsidies. However, in the end, the collection of used parts and automatization of equipment also lead to cost reductions. In order to help achieving the SDGs "Responsible consumption and production" and "Partnerships for the goals", Hitachi will continue practicing efficient resource recycling through both supply chain coordination within Hitachi and partnerships outside the group.

2.2. Dieuwertje Schrijvers: Identified gaps between industry capacity and policy needs in a raw materials risk framework

Dieuwertje Schrijvers is a postdoctoral researcher at the ISM-Cyvi group at University of Bordeaux. In the IRTC-Business project, she is responsible for research and publication.

One of the goals of IRTC-Business is to prepare a decision-making tool that supports the management of critical raw materials for companies. A decision-making model was drafted and discussed during the IRTC workshop that was organized in May 2020.

This model was based on the classic structure of criticality assessments in which materials are critical when the probability for a supply disruption is high and when the company is vulnerable to this disruption. The model represented three types of risks: i) the severe problem with the physical accessibility of a material, ii) material price fluctuations, and iii) the reputational risks due to the use of a material. Workshop participants could provide feedback via the online platform Miro. Overall, there was agreement on the relevance of the three risk types. However, they should not be assessed

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separately, as the risks might be related; i.e., accessibility problems could lead to fluctuating prices. Furthermore, the model did not consider that multiple risk mitigation measures might need to be applied in parallel, before criticality is successfully mitigated. The potential damage caused by the use of CRMs was also not reflected by the model. Via parallel discussion sessions, an overview of mitigation measures, as well as practical limitations regarding their implementation, was generated for each type of risk. For example, some measures might only be effective in the short or long term, or the required investments are only feasible for larger companies. Successful mitigation also seems to be dependent on the company's commitment to criticality mitigation, because collaboration is needed between different company departments, such as marketing, purchasing, legal, and environment, health and safety. The full report of the workshop of May 2020 can be accessed here.

The next step in the improvement of the decision-making model is to classify mitigation measures, which allows to effectively combine them in the management of criticality. For this purpose, a cause-and-effect diagram was developed (Figure 1). Such cause-and-effect diagrams are also used in Life Cycle Assessment (LCA) to evaluate environmental risks. In LCA, the impact of the use of a resource or an emission on the ecosphere is modeled via an impact pathway that models the fate of the emission, the exposure, the effect, and finally the damage on the ecosphere. Similarly, in the cause-and-effect diagram of Figure 1, the damage of the use of a raw material on a company can be modeled. A company can be exposed to the three types of risks mentioned earlier (physical accessibility problems, price fluctuations, or reputation damage). The effects of these risks cause a damage: the company will have unstable operations. The origins of the risk types could be considered the "fate" of the raw materials, e.g. the supply of the material can be disrupted, or there could be a mismatch between supply and demand.

Different mitigation measures have a mitigation potential at different points in the cause-and-effect diagram. For example, the ability to pass on costs to costumers does not avoid costs increases, but it can avoid that the increased costs cause damage to the company. Having stockpiles does not avoid that the company is exposed to accessibility problems or fluctuating prices, but it can avoid that the company will experience the effects of these problems. The position of the mitigation measures can already give an idea about the timescale. Measures on the right-hand side of Figure 1 can be implemented relatively quickly, but might only be effective on the short term. Measures on the left-hand side might need more time to be implemented, but can also have a long-term protection against risks.

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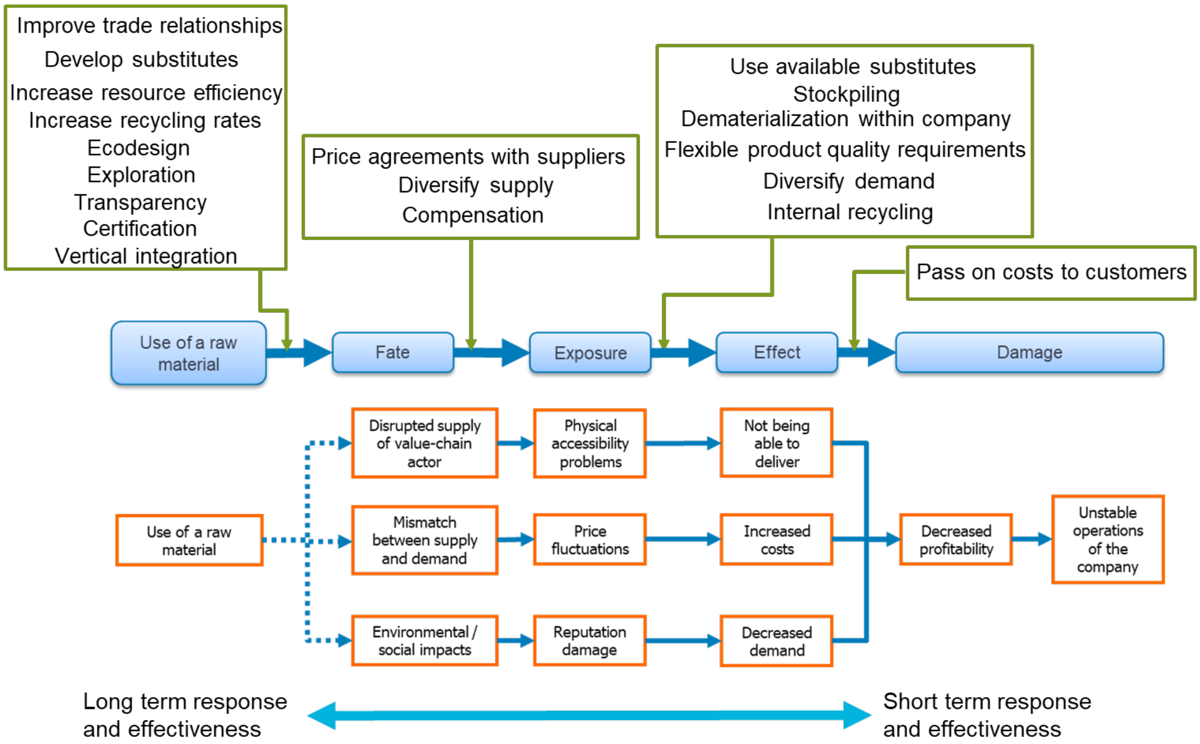

Figure 1 Classification of mitigation measures according to their mitigation potential in the cause-and-effect chain that links the use of critical raw materials to potential company damage.

The diagram of Figure 1 can also provide some insights regarding who is responsible for mitigating criticality. First, it appears that only companies will experience the damage of using critical raw materials, but this damage can also be felt by society, via the unstable provision of jobs, goods, or taxes to sustain education and health care. This justifies the help of policymakers in mitigating company risks, as was also visible during the COVID crisis. Raw material risks also might be caused by the political landscape in which the company operates, e.g. due to regulations or trade relationsthat make a material more or less critical.

Many mitigation measures can be implemented on the scale of the company, especially measures that reduce damage or exposure to risks. Mitigation measures that reduce the sources of risks might require more often the support of policymakers, such as investments in recycling or exploration, which might not be profitable in certain market conditions. Furthermore, these mitigation measures have the potential to affect a large range of companies, making the mitigation effort more structural.

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3. Summary of the Round Table Discussion

The Round Table Discussion took place in two parallel virtual panels during the workshop of November 17. Panel 1 was moderated by Alessandra Hool (ESM Foundation) and applied a focus on the industry perspective on building resilient supply chains. Panel 2, moderated by Dieuwertje Schrijvers (University of Bordeaux), had a policy focus. Both panels addressed the following overarching topics:

- The influence of policies
- COVID-19 impact
- Sustainability
- Cooperation

The panelists were asked questions on the above-mentioned topics. In parallel, participants of each panel were invited to contribute with their opinions and ideas by providing comments on a virtual whiteboard via the platform Miro.

During the follow-up workshop of 11 December, an overall summary was presented of the four overarching topics. The participants of the workshop were invited to further reflect on the outcome of the parallel sessions, both by a live discussion and via the commenting function on the virtual whiteboard.

This section presents the final summary of the input gathered during the two virtual workshops.

3.1. The influence of policies

The workshop participants discussed to what extent companies or policymakers are responsible to build resilient supply chains, and which policy tools could be deployed.

Companies were found to be responsible to manage their risks. This means that companies need to identify what raw materials they use, and what potential risks are related to these materials. As this is a resource-intensive task, a screening step that evaluates resource use by order-of-magnitude mass balances might be a good starting point (following the Pareto principle). Risks could be related to an unstable access to the materials, fluctuating prices, or the company's image. The identification of risks is especially important for technologies for the future, e.g. hydrogen technologies, fuel cells, or new types of smart phones. Once risks are identified, the company should mitigate these risks. Mitigation strategies include establishing reliable supply contracts, diversifying supply, start with recycling of internal scraps or, via new business models, with recycling of end-of-life products taken back from downstream customers, investing in R&D to increase circularity and substitutability of raw materials, or price hedging. Risk mitigation is increasingly becoming common practice, although it is more challenging for small companies with a lower capacity to make large investments.

Profit optimization is a main driver, but should not be the only driver for risk mitigation; responsible sourcing is important as well. A strong policy framework is needed to hold companies accountable for unsustainable operations, either via regulations (e.g. such as the Dodd-Frank act, or recent initiatives requiring due diligence in the EU, Switzerland, and Germany) or via positive incentives, such as tax benefits. Consumers also have a role here, although they generally do not have an overview of which

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regulations or standards apply to a certain company. Furthermore, consumers also prioritize costs over sustainability. It is possible to be profitable while implementing sustainable strategies at the same time. However, if there are no incentives, sustainability does not naturally happen. If there are too many regulations, companies could move to countries with lower requirements. Hence, (long-term) profitability and sustainability incentives must be balanced.

There are different viewpoints on the extent that policymakers are responsible for building resilient supply chains – depending on the dominant political vision. On one side of the political spectrum, it could be argued that policymakers are responsible for supporting the free market. This could be facilitated by improving access to information – e.g. via data sharing platforms – while at the same time safeguarding proprietary information, e.g. on prices, volumes, and supplier terms and conditions. Supporting the free market also requires creating a level playing field. This involves removing barriers to free trade, such as import and export restrictions – although these might also support sustainable circularity, e.g. by linking restrictions to clear standards of sustainable management of exports for reuse, refurbishment, or recycling. Integrating environmental and social externalities into the market can also enable a level playing field. The latter could be achieved by developing, implementing, or supporting certification schemes.[3] However, the playing field should also stay stable – at least regarding the direction in which it is going, contrary to the policy swings that we now see in the USA. Consistent policies over a period of 10-20 years are necessary for companies to make capital investments, make strategic alignments, and hire training. Supply chains can take a fair amount of time and capital to set up and to adapt.

On the other side of the political spectrum, the support of specific companies or sectors could be justified. SMEs and technologies that use CRMs but which have low profit margins, such as renewable energy technologies, could benefit from governmental aid. For example, tax credits could be provided to companies that need to reconfigure their critical supply chains. The Japanese REE example presented by Hitachi today just showed how efficient State-industry cooperation with an intensive contribution of public funding via loans and a high-priority research effort across the whole supply chain can help to overcome the REE challenge. However, close collaboration with companies, such as via public-private partnerships, could be disadvantageous for other companies within the same market. Policymakers could furthermore fill the gap between research and upscaling of new technologies, and they can accelerate profitability by stimulating economies of scale. In the middle of the political spectrum, policymakers could be attributed the responsibility to raise awareness on supply chain criticality, for example by publishing a list of CRMs, and communicating with industry experts. Finally, policymakers could create a supportive framework to companies by providing access to finance, state aid, and beneficial fiscal conditions, and by protecting innovations.

Various examples of policy tools that could aid in building resilient supply chains were discussed. Policymakers could implement new regulations, but already-existing regulations could also be applied to manage CRMs. For example, in the USA, the situation around CRM was called an emergency, which gave companies and governments access to the defense production act via an executive order, allowing to secure the supply of CRMs. Another policy tool is to create standards and requirements, in line with policy goals, which are compulsory for companies to access the stock market. Examples of

[3] See, for example, https://hcss.nl/report/standards-critical-materials

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this are the Global Reporting Initiative – which is voluntary and reports consolidated data at a corporate level – and the Canadian NI 43-101 reporting instrument, the latter contributing to increased transparency and accountability of mining projects. Stock exchanges are private entities, but they are regulated and they in turn regulate the participating companies. The London Metal Exchange has announced that they will require listed brands (producers of steel, aluminum, zinc, etc.) to declare the responsibility and traceability standards behind their products. Such information is necessary for investors to make informed decisions. These initiatives should be intensified and extrapolated to other stock markets. Other examples of policy requirements are requirements regarding the recycled content or design for disassembly/recycling for new renewable energy projects.

Policymakers can furthermore establish sustainable partnerships and trade agreements. In Europe, the European Commission works on the creation of common goals and trade agreements, with free movement of goods among all EU member states. Another example is the German-Mongolian Resource Partnership. Finally, policymakers could identify raw material production capacities, either domestically or internationally. One drawback of too much policy intervention is that too many regulations could block an efficient use of raw materials. Besides, new regulations could lead to unintended responses of companies. Not only direct suppliers might be affected by regulations, but also other actors in the value chains. The whole complex system of industrial actors should be taken into consideration. Furthermore, regulations should be assessed regarding their costs and complexity of implementation and enforcement, and the suitable timing of implementation. New rules should be forward-looking to follow the rapid changes in the market.

3.2. COVID-19 impact

COVID-19 has led to a very sudden and global disruption, affecting both supply and demand, perhaps even symmetrically. Whereas metals at the extraction stage often dominate the discourse on criticality, all commodities, including food and energy materials, and all value chain stages – including the distribution of final goods – were affected by the pandemic. Extracting countries might however be more vulnerable for the consequences of the pandemic, because their economy is more dependent on the export of raw materials. Also, less developed health system in poorer countries might affect the ability to produce and amplify inequalities. Due to the generic and global nature of the disruption, lessons might be taken from risk assessments in the financial market.

Shortages of products were caused by the lockdown of production facilities, but also by new societal needs. Demand increased for medical equipment, but also for information technology equipment due to global changes in people's behavior: people worked more from home.

From the COVID crisis it became clear that not all disruptions can be prevented – even if they can be anticipated. In order to absorb potential shocks, we should move to more resilient supply chains. The disruption caused by the pandemic was fast and had a high impact. This asked for very strong policy responses. Governments demonstrated the scope and the scale of their willingness to seek resilience and protect their economies. However, supply chains also should remain efficient. Companies need to be cost efficient, and resource efficiency is necessary for climate mitigation. Mitigation of supply-chain risks, or risk management in general, might ask for investments in the short term, but long-term profitability can still be safeguarded – which is presumably the objective of companies.

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Now, we have the opportunity to redesign the value chains and “build back better”. Increased resilience could be achieved by increased adaptability, for example via increased substitution, increased stockpiling, increased diversification (including locally and from secondary resources), and, perhaps most importantly, enhanced collaboration among industries, as companies cannot manage all risks alone. This was also demonstrated in the beginning of the pandemic, where German companies jointly set out a strategy to respond to the spread of the virus. SMEs might be more disadvantaged by the COVID crisis, as they have less reserves. However, as discussed during the presentations, SMEs play an important role in the creation of more resilient supply chains as they contribute to increased value chain diversity.

Companies should become more agile. Via R&D, they can invest in enlarging their options to react, and increase their ability to change their activity when the supply or demand of materials and products is disrupted. This might require a shift in the company’s strategy from “producing a product” to “responding to a societal need”. Criticality risk mitigation, but also investments for circularity and sustainability have both operational, day-to-day, and longer-term strategic aspects that should be considered. The COVID crisis can teach companies to what extent they have the capacity to anticipate and respond to supply risks.

Even if supply chains are still vulnerable to large disruptions, much improvement has been made, especially behind the scenes. For example, regarding REEs, in the past decade a wealth of additional information and knowledge has been gained about resources, also outside current producing countries. Significant progress has been achieved at laboratory scale on the improvement of processes for primary production, recycling, and reuse. These innovations are not commercialized yet, but this can be expected in the next decade. Commercialization is important to effectively contribute to increased resilience. It depends on one’s policy perspective whether it is deemed appropriate that government funding is used to bridge the gap between the lab and commercial upscaling, as stated before.

Furthermore, materials that were critical 10 years ago, such as europium and terbium, have changed status due to rapid technological development (e.g. the fast uptake of LED lamps replacing fluorescent lamps). Technological shifts in jet engines or batteries might lead to similar changes in determinations of critical raw materials. Various signals hint towards a decreasing role of Nd and Dy for high performance magnetic materials in the future, which may become significantly substituted by more common raw materials. Foresight studies that point out expected innovations and identify future CRMs are very useful in this regard.

3.3. Sustainability

Sustainability is a broad topic covering the environment, society, and the economy. It is stated that there is no long-term economic sustainability without environmental sustainability and social acceptance.

We are still much relying on the primary extraction of raw materials, because the demand for raw materials is increasing and stocks are still being built up. Therefore, it is important that primary extraction is conducted in a sustainable manner. Increased circularity can improve the sustainability of the use of raw materials and make the sector more resilient, by also accounting for environmental

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and social performance of secondary production. For a comprehensive view, considering social aspects, energy consumption, water use, resource efficiency, and pollution, strong evaluation methodologies are needed. Whereas policymakers can debate circularity and sustainability in conceptual terms, scientist, engineers, and companies need to develop quantified terms that measure the extent to which activities, technologies, and investments are indeed sustainable. This helps in formulating clear Environmental, Social, and Governance (ESG) objectives and commitments by companies, contributing to their credibility.

Primary extraction is still mostly taking place in emerging economies. In order to escape the "resource curse" (the paradox that countries with more natural resources have lower economic growth), these countries need to develop their own sustainability, resilience, and competitiveness goals. Adding value along the resources' value chain is more challenging in emerging economies, as they do not always have access to affordable power, reagents, or qualified labor. Institutions such as the World Bank could provide assistance where needed.

In order to create environmentally and socially sustainable primary extraction and recycling practices, investments are needed. However, in both sectors, many workers have an informal status, i.e. artisanal and small-scale miners (ASM) and informal recyclers, for example in India. Formal recognition of their work is a requirement before investments will be made. The workers need rights, e.g. access to land and security of tenure, and education in the value of the products and the dangers of their activities. If the right incentives are set, developing and transitional economies might be able to meet low emission policies and simultaneously address inequality and social impacts.

Circularity could be enhanced by formulating circularity targets, or recycling targets, that are raw material specific. Recycling targets of certain percentages or tons of waste are not sufficient to improve the circularity of CRMs, because they are used in such small quantities that they are not well represented by mass-based targets. This is also discussed in the IRTC perspective paper.[4] Circularity is also impeded by sensitive information about flows. Moving towards more circularity requires investments in viable recycling technologies and infrastructure. Increased automatization and digitalization could overcome current limitations, although related technologies might require, in turn, more CRMs. However, technology is not the only limiting factor, especially in industrialized countries. If it is not evident that recyclable products will be collected and will enter state-of-the art processes, and companies are reluctant to make large investments into this. The legislative framework could incentivize the collection of end-of-life products and the implementation of circular business models such as leasing systems or deposit systems.

It remains a question of debate how the "willingness to pay for sustainability" can be increased, and which mechanisms governments or voluntary standard initiatives can provide to increase it, such as price premiums, ecolabels, or boarder tax adjustments. Carbon taxes might improve the business case for recycled raw materials. If the true (environmental and social) costs of materials would be accounted for, stewardship over those materials would become a more natural solution to

[4] Tercero Espinoza, Luis et al. 2020. "Greater Circularity Leads to Lower Criticality, and Other Links between Criticality and the Circular Economy." *Resources, Conservation and Recycling* 159: 104718. https://doi.org/10.1016/j.resconrec.2020.104718.

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maintaining affordability, and design for revocery would be incenivized, as well as product-service systems which are more resilient against price volatilities. If take-back is incentiviced – for example via deposits or leasing schemes – standardization would help to facilitate recycling. However, standardized product compositions are hard to achieve in innovative sectors where products undergo quick developments.

Challenges and strategies towards increased sustainability are specific to each economy but might also be raw-material specific. For example, different strategies might be relevant for low-margin commodities that are used in large quantities, such as iron and copper, and specialty metals, such as rare earth elements. Investing in sustainability and circularity requires a mid-to-long term perspective. Hence, companies need a mandate to justify such investments, as shareholders often demand short-term profits. In any case, companies with a long-term vision tend to perform better, also economically. Investments might also be needed in education, in order to introduce the concepts of sustainability and circularity in engineering and business curricula to ensure that the next generation of workers has proficiency with the concepts and tools to address these issues widely. In Europe, the European Commission already pushes towards increased circularity and resource efficiency, which could provide the mandate to make such investments.

3.4. Cooperation

Collaboration between companies is very important to achieve responsible sourcing, because OEMs do not always have an overview of their supply chains beyond their first-tier suppliers. However, there is already some improvement regarding the transparency of supply chains, for example in the field of batteries and consumer electronics. Companies also need to collaborate to achieve a circular economy – for example between manufacturers and recyclers: recyclers need to understand what materials are present in products, whereas manufacturers refrain to disclose this to protect propriety information. Also, local collaboration might become more important, for example to achieve industrial symbiosis. Collaboration is hindered by IP rights, know-how, antitrust laws, and domestic policy, which instead results in a concentrated supply of technology materials. Sharing information could be facilitated if recyclers become an integral part of the company group. Distributed ledger technologies, such as blockchain, could support the sharing of information while protecting confidentiality.

At the moment, every actor aims to optimize their own performance. There is a need for a system perspective: there should be an alignment of interests of actors within the value chain, and trade-offs need to be addressed. It is important to recognize that sustainability and circularity do not always lead to win-win solutions. Furthermore, the dual role of actors in CE business models should be taken into consideration, which could create competitive tensions: manufacturers supply primary products and components, and perform remanufacturing and refurbishing activities, while consumers act as suppliers of products and components. This requires a revision of the established and traditional relations.

International collaboration and increased multilateralism are needed to overcome global as well as local sustainability challenges, and pandemics. Currently, there are many initiatives towards increased sustainability, but none of these take a real comprehensive and global perspective. There is a need for an international framework that establishes common goals and redefines "competitiveness", as currently different actors around the world can play according to different rules. The UN Sustainable

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Development Goals are internationally agreed upon, so they can provide the basis for such a framework. This should be organized and hosted by a neutral global institution, for example by the WTO or via the creation of an "International Mineral Resources Authority", following the model of the International Energy Agency. International finance institutions such as the World Bank, the Asian Development Fund, and national initiatives such as China's Belt and Road Initiative (BRI) supply funding and financing for development projects for resource extraction and development. Alignment with these institutions could contribute to including appropriate sustainability metrics into investment and decision-making processes, which reduces the chance of lock-in of unsustainable technologies within large projects – which will operate during the following decades.

Collaboration is also crucial to create more diverse supply chains. Developed economies need to collaborate with emerging economies when they do not have domestic ores. More collaboration however means more complexity. This increased complexity could mean that a local problem can easily become a global problem, as we saw during the pandemic. Complexity is difficult to avoid and not necessarily a bad thing, as diverse supply is more complex, but also more resilient. However, certification programs and sustainability goals are more difficult to implement in diverse and complex supply chains. Focusing on domestic solutions could lead to increased resource nationalism and distort international (trade) relations. Diversification thus contradicts the current tendency to become increasingly self-reliant.

This summary was written by Dieuwertje Schrijvers, Sophia Ganzeboom and Alessandra Hool.

About the project

The International Round Table on Materials Criticality in Business Practice (IRTC-Business), supported by EIT RawMaterials, is a continuation of the IRTC project with the aim to support the advancement of the evaluation and mitigation of criticality by establishing a dialogue between international experts from industry, academia, and governments. The project consists of over more than 40 researchers from Europe, US, Canada, Australia, Japan, Korea and China; 15 of them industry representatives which form the advisory group of the project. IRTC-Business publishes joint scientific papers on current topics in criticality; its final outcome will be a web-tool for company decision-making on raw material risks. More information is available on https://irtc.info.

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