IRTC-Business workshop summary

Identifying risks in industry supply chains

May 19, 2020

The IRTC-Business workshop on «Identifying risks in industry supply chains" took place via Zoom on May 19, 2020, from 11am to 3pm CET. Around 100 registered participants attended the workshop which in a first part introduced different perspectives on supply chain risks and how companies can address them. In a second part, a draft decision model for industries was presented and discussed in three working groups.

Peter Buchholz: How companies could improve their commodity risk management

Peter Buchholz is the head of the German Mineral Resource Agency (DERA) which is part of the German Geological Survey (BGR). The institute has conducted a variety of work on criticality assessments and monitoring raw material markets. Their two main objectives are to improve market transparency and advice companies about price and supply risks, and to support measures taken by companies and the German government to develop a sustainable and secure raw material supply.

To support market transparency and deliver advice for companies, DERA runs a basic database for raw materials information (ROSYS) and conducts systematic monitoring of raw materials by screening various parameters such as demand, price developments and global production. Once any critical risk arises, a more detailed analysis is conducted for the commodities in question. DERA monitors prices with various price monitoring mechanisms.

To assess demand trends, technologies are monitored and their effect on raw material markets is analyzed. DERA's last study from 2016 (next update to be published in 2021) summarizes the minor metals demand for 42 emerging technologies. The current focus of screening lies on technologies around e-mobility (Li, Ni, Co, graphite), renewable energy and digitalization (Cu, Ge, Ga, As, Ag, Au, Ta). Also Industry 4.0 (Cu, Ge, Ga, Ag, Au, Ta) forms a large topic with virtual reality glasses and next generation autonomous vehicles. Furthermore, 3D printing and light-weight construction (Al, Mg, Sc) are interesting topics, as well as – looking a little further ahead – quantum computers (graphene, Cu, Pd).

Via their monitoring activities, the effect of the current COVID-19 crisis on the mining industry could be evaluated. Although several mines stopped their production due to lockdowns, this resulted only

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in a change in supply of a few percentages. The main reason for the decreased production of critical raw materials was due to their decreased demand caused by the pandemic.

In order to support a stable and sustainable material supply base for the German government and industries, DERA evaluates mineral resources in 5-10 raw material rich countries and stimulates a diversified supply. The companies advised by DERA try to mitigate supply risks via various actions by purchasing departments as well as by technical processes such as substitution or recycling. Other, more costly mitigation strategies that increase supply security are vertical integration and long-term offtake agreements.

To overcome certain limits of supply risk management, big data systems are being tested by DERA. Supply risk software is commercially available, which uses consolidated data from various data suppliers. DERA tracks the current risk exposure for 12 metal markets in over 300 locations. For each metal market, 15 to 30 of the biggest mines and their headquarters are being tracked under real time conditions. The aim is to measure risk incidents for mineral markets in real time, including about 150 indicators. Information provided by DERA is publicly available on www.deutsche-rohstoffagentur.de.

Luisa Moreno: Criticality from a developing country's perspective

Luisa Moreno is a senior analyst and managing partner at Tahuti Global Inc., an independent consulting company that works with governments, mining and technology companies. They advise countries on investments in infrastructure to support mining activities and capacity building, help determining project viability and have expertise in strategic materials. Tahuti Global also supports policy-making in the mining sector in developing countries.

A material can be critical based on different aspects: its availability as a resource, its possible output dependencies – e.g. as a companion metal –, geographic factors (such as a high concentration on few supplying countries), geopolitical factors, as well as demand developments and strategic importance. Although materials that are critical can differ for each country, the list for developed countries shows in general an overlap and is different from raw materials that are typically deemed critical from the perspective of developed countries. Strategic materials for developed economies that are sourced in Africa, such as cobalt or tungsten, have a low demand in Africa itself. Based on the importance of raw materials for developing countries' economies, critical materials are iron and steel (which are mostly imported), glass, ceramics, aluminum, construction materials (e.g. limestone, sand, aggregates, cement, asphalt, etc.), agricultural materials (e.g. phosphate, potash), and energy materials (e.g. coal and uranium).

The role that African countries play in critical materials' supply chains often ends at the smelting and refining stage. However, upstream steps in the supply chain generate low added value compared to downstream stages that mostly take place in developed countries. Low added value minimizes the possibility to add taxation and to create other economic benefits, such as high-skilled jobs, within the country. The fact that many countries have import tariffs for processed materials makes the economic position of Africa even more difficult.

If African countries aim to attract investment in downstream metal projects, the size of the market relative to required initial investment should be considered, among other factors. Some countries,

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especially landlocked ones, may need higher investments in infrastructure. A large resource and high market share are then required to make a project economically viable. Viability is furthermore supported by the ability to produce high-grade materials that require access to local expertise, constant supply of hazard reagents at competitive costs, and low-cost energy. Developing countries are sometimes held back by involvement of governments: for instance, some demand a high ownership share of mining projects although no investments are provided in return. In some countries there are export restrictions on unprocessed minerals, and mining companies are asked to develop downstream facilities that could support industrial development. During transient commodity price supercycles when prices are well above historical levels, some countries tend to increase royalties and mining taxes, bringing added uncertainty to the local mining business.

The global health crisis influenced all stages of metal supply chains. Junior mining companies struggled with raising money for exploration due to the market crash caused by the pandemic. Even though markets are currently recovering, this is not necessarily the case for critical materials. There have been delays in financing and traveling to sites was restricted, so exploration and mining have declined. Mining is still shut down in regions where it is not considered an essential operation. Regarding downstream processes, China produces a lot of electronic components that use critical materials and has shut down many of these facilities, which largely affected the demand. This negatively affected prices of critical materials in the beginning of the pandemic.

Jaebum Park, POSCO: Strategies of Korean companies preparing for the EV era

Jaebum Park researches battery value chains for electric vehicles and EV battery materials in the company POSCO. The automotive industry, being more than 100 years old, experienced no major changes in the last 20-30 years, but is now facing a crucial paradigm shift. This shift is also referred to by the acronym CASE (Connectivity, Autonomous, Shared & Service, Electrification). “Connectivity” means that cars can communicate with each other. “Autonomous” refers to self-driving cars, and “shared & service” relates to business models such as Uber. The largest and fastest impact on industry, however, will be electrification, as the other areas of change require social consensus and the implementation of new laws and systems, which is a slow process. In accordance with policy pushes, internal combustion engine (ICE) cars are slowly withdrawn from the market in Europe, China and India and replaced by electric vehicles, and automakers are under pressure to switch their production as fast as possible. Accordingly, companies such as Continental, GKN, Valeo, and Delphi are sharply increasing their share of products for electric vehicles.

According to the chasm theory published by Geoffrey A. Moore (1991), there are two major milestones to establish a new industry and replacing another one: moving from innovation to early adoption, and successively to an adaptation by the early majority. The current demand for EVs can be considered to be already beyond the first chasm between innovators and early adopters. EVs are about to become mainstream: the market share is expected to soon exceed 20%, and the second chasm between early adopters and the early majority will be overcome in foreseeable time. The markets for EVs, lithium ion batteries and secondary battery materials show a steep increase over the last two to three years, with a growth rate of 30-40%. This is an unusual case even compared to other very fast diffusing technologies, especially in the current period of global economic recession. All

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markets within the value chain of electric cars, including secondary battery production, are foreseen to grow rapidly over the next ten years, with an average annual growth rate of more than 20%.

Korean companies, such as LG, Samsung, and SK, are actively responding to the EV paradigm shift. However, the core business of certain companies is negatively affected by the transition: due to the demand for lighter cars, the demand for conventional materials such as steel is in decline. This could possibly be balanced by a certain extent by a potential use of steel in battery packs. In parallel, the demand for alternative materials, such as aluminum, magnesium, and carbon fiber reinforced plastic (CFRP) has increased.

Three fruitful business strategies to prepare for the EV era can be distinguished: economies of scope, economies of scale, and strategic alliances.

- Economies of scope refer to the strategy of building a diverse business portfolio while maximizing the efficiency between various materials. For example, many companies, among which is POSCO, are active in the industry of raw materials and parts for EVs, FCEVs, as well as still for ICEs - i.e. they prepare for the present and the future at the same time.
- To prepare for economies of scale, strategies of mass customization must be combined with efficient production, which requires smart factories. Through economies of scale, companies can increase their competitiveness by lowering costs and maximizing profits. It is expected that the battery and secondary battery industry will become as relevant as the semiconductor industry, which is the most important industry in Korea so far.
- In the future global economy, competition among companies will successively be replaced by competition among industrial ecosystems. Thus, in order to build strategic alliances, companies should strive to strengthen synergies with other companies that make up the industrial ecosystem in which they participate, thus minimizing investment risks and maximizing revenues.

Summary of the IRTC-Business draft decision model

Dieuwertje Schrijvers (University of Bordeaux) drafted a first version of a decision model which forms the basis of the discussion during the working group sessions (Figure 1). The decision model considers three types of risks, which are discussed in the respective working groups. Working group 1 will discuss the risk of a severe problem with the physical accessibility of a material, working group 2 will take an economic perspective and discuss the risk of price fluctuations, and working group 3 will consider the CSR perspective by exploring potential reputational risks due to the use of a material.

The general outline of the decision model starts with the already challenging determination of which materials and products are used by the company. Awareness and transparency of all components that are required to produce the final product is a prerequisite for a company to become aware about its vulnerability and to motivate action.

The probability that the used materials are affected by the three risk types is evaluated via a set of indicators, such as by-product dependency, supplier concentration, and demand growth. If the probability of a risky situation is high, a company can subsequently evaluate and potentially decrease their vulnerability via mitigation actions including substitution, stockpiling, and internal recycling.

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The point is raised that it is difficult to evaluate the three identified types of risks separately. If there is a physical supply disruption, such as the limited distribution of goods during the COVID-19 pandemic, this often influences its price. Physical disruptions could be more relevant in the short term, whereas price effects might have a delay. Physical disruptions are also more relevant in specific contexts where only a few suppliers are available, which have limited capacity and might prioritize certain buyers. Price risks are generally considered to be relevant (with the exception of national security), especially when they affect material that is comparatively expensive for a company or when prices become too low to continue supplying operations. Reputation damage due to environmental, health, or social issues is also perceived as being increasingly relevant, both in terms of consumer demand as well as access to skilled labor. Market shifts towards more responsible supply chains can cause supply bottlenecks and affect prices as well. Furthermore, reputation damage can negatively affect the company's market value.

It is noted that the decision tree does currently not evaluate the potential damage that a risky situation could cause, and that multiple mitigation measures might be needed before criticality is successfully mitigated. Mitigation measures could be layered based on their effective time frame: a stockpile to mitigate short-term disruptions and price volatility, multiple suppliers for intermediate term uncertainty, and activities that require R&D for the long-term. Furthermore, there is no single correct prioritization of mitigation measures. The magnitude of effectiveness can be strongly dependent on the context, e.g. whether the targeted material is produced in low or high volume, or as a main or by-product. For the concrete implementation of mitigation measures, it can be useful to split mitigation strategies between commercial and technical solutions. Depending on where in the supply chain the company in question is placed and also similarly within a company, different departments with different functions have different ownerships and responsibilities, such as engineering functions or sourcing functions. It is an open question whether the decision model should assign departments to certain questions, or whether every company should do that on its own.

Companies might already have mitigation measures in place, such as stockpiling. The decision model could reflect whether their current efforts are sufficient or need to be revised. Furthermore, mitigation measures could provide – besides decreasing risks – also opportunities in terms of new processes, new patents, new products, or new sustainable business models. Such opportunities are currently underrepresented in the discussion and communication on criticality.

There might be a relevant difference between large companies that have the capacity to analyze their supply chain in detail and smaller companies that have less ability to identify potential risks due to a lower availability of data and capacity to put mitigation measures in place. Therefore, the tool developed in IRTC Business might help especially SMEs to increase awareness aware of their risks and opportunities.

After the introduction and the possibility to comment and interact on the virtual board provided, the participants split in the three working groups.

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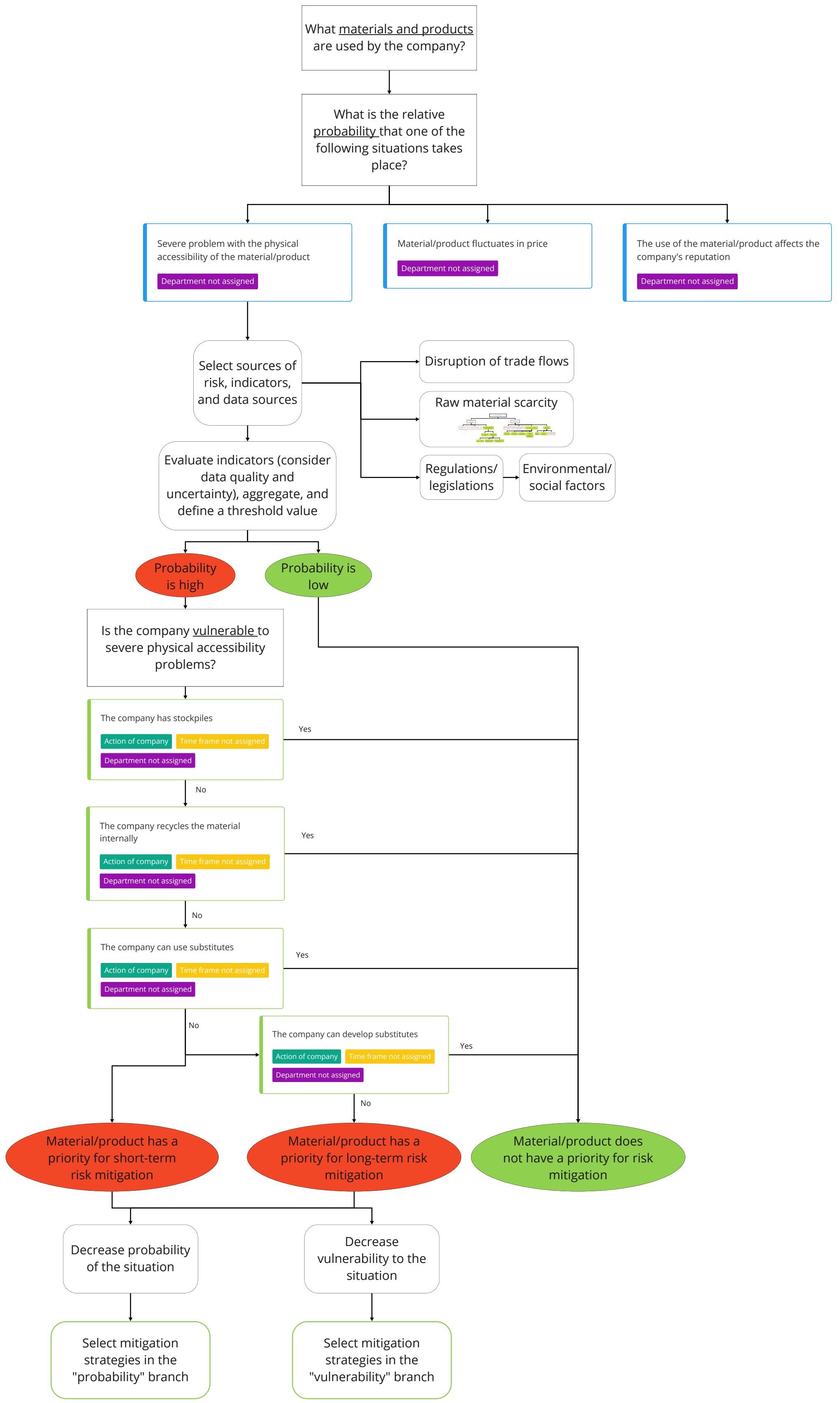

Figure 1: Overview of the draft decision model.

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Working group 1: Supply risks perspective

The workshop chairs **Anthony Ku** (China Energy) and **Kotaro Shimizu** (Mitsubishi Research) kicked off the session on physical supply risks using the example of rhenium supply shortages from the late 2000's-early 2010s. The majority of global rhenium use is in aerospace applications, where its addition to superalloys is used to improve turbine blade mechanical properties at very high temperatures. There are two major aspects that contribute to its criticality. First, overall rhenium production is not very large. In terms of physical supply, the USGS published numbers on the quantities of rhenium produced in the years between 2007 and 2011, being between 44'000 and 50'000 tons per year. Today, the production is a bit higher. Second, rhenium is a by-product of molybdenum mining, which itself is a by-product of copper mining. Even though rhenium has a high value and price itself, its low concentration in copper ores prevents it from meaningfully impacting the profitability of a copper mine. Thus, the quantity of rhenium that is supplied to the market depends on the demand for primary copper.

Companies have mitigated rhenium's criticality by several strategies which were used in different time frames, at different costs, and with different degrees of success: stockpiling, increasing material efficiency during the manufacturing process (e.g, by recovering metal shavings), and through recycling (i.e., taking blades back at the end of life and recovering the rhenium). Efforts to engineer superalloys with less rhenium have had with mixed success. The group was asked to consider how the example of rhenium may or may not be generalized to other materials criticality challenges faced by industry.

The COVID-19 pandemic has broadly disrupted supply chains around the world; the discussion started with some general comments on how government responses to the current crisis might affect the way that criticality should be evaluated and mitigated. The pandemic demonstrated that a supply disruption does not necessarily take place at the mining or factory level, but it can be anywhere in the supply chain, including distribution. Physical supply could be at risk due to disrupted trade flows, regulations, but also due to price risks. It is difficult to isolate supply disruptions from economic risks. For example, by-products are not only critical due to potential shortages or price volatility at the mining stage. Further down in the supply chain, refiners serving multiple industries may be subject to vulnerabilities. If a refiner supplies two industries and one of them experiences an economic decline, this can cause the refiner to shut down, leading to shortages in the second industry. In the case of rhenium, bilateral contracts are negotiated between a limited number of market participants making price discovery difficult. In such small markets, incentives to start new production – which would enable downstream companies to diversify their supply – are limited, and fraught with uncertainty. This is for example highlighted in the case of tellurium: companies, especially in Latin America, do not invest in extracting and processing more tellurium, which is a by-product of copper, given the small size of its market. In such cases, market forces to balance supply and demand fail, interventions are necessary to support supply via subsidies or other (policy) instruments.

However, by-production does not necessarily pose a problem for material supply. Although this factor usually increases the criticality scoring in country-level criticality studies, it might also provide opportunities. Frequently there are certain capacities that are not extracted, which allows suppliers to react fast if demand is increasing, since the large-scale mining and processing infrastructure are already in place. An example of this is gallium, which is present in unrefined tailings held as a

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byproduct of bauxite and zinc ore processing. An increase in demand (due to increased use as III/V bandgap semiconductors in LED lighting) could be met by processing of these tailings rather than opening of new mining operations, due to the more favorable economics.

This dynamic might also be relevant for companion metals, where the host metal is extracted at a large scale and the by-product is only partially exploited. However, there is a large uncertainty regarding the amount of byproduct metals left in tailings due to limited public data. Furthermore, is difficult to match the timeframe needed to increase the extraction of these by-products to the timeframe a company should protect by own stockpiles.

There is no single recipe for criticality mitigation that can be applied for all cases. Locating alternative suppliers, also locally, and including secondary sourcing as well as stockpiling are all important mitigation measures. If stockpiling is considered, additional costs, material shelf-life, and increases in working capital should be considered. Using of substitutes might not always be an option, as substitutes could be equally critical or could lead to differences in performance and price of products. Recycling of CRMs is not always a viable mitigation measure either, or needs technological advancement first, as CMRs are often used in small quantities and the materials are dispersed, making recycling technically challenging. Furthermore, there is a time lag between the production of the product and the availability of the CRMs at end of life, since the raw materials are bound in stock during the product lifetime. Internal recycling could be an incremental solution but does usually not cover the full demand of the company.

Successful mitigation measures can be dependent on the degree of a supply disruption, the awareness and knowledge about the mechanisms in place, the size of the company, its position in the supply chain, the basket of materials that is used, and importantly: on appropriate timing. Sectors with different timeframes of their product cycles might be competing for the same materials and might have different capabilities to absorb shocks. Consumer electronics can have product life cycles that change on the order of years, or faster, which makes them relatively flexible to respond to supply changes. On the other hand, certain companies, such as in the aerospace sector, can have a very long-term roadmap for their general development and technology which can range from 10 to 30 years. The time horizon of technology outlooks and the management of raw material supply go hand in hand. Another aspect that affects a company's flexibility is the possibility to absorb price fluctuations. Whereas in energy markets the main incentive is to cut costs per kWh, with very small marginal revenues per unit, short-cycle and more flexible markets - such as the computer or the home entertainment industry - create substantial additional value per item. Overall, competition for raw materials could be detrimental for important societal and technological changes such as the energy transition. Prioritization of sectors, such as the health sector during the pandemic, could safeguard societal urgencies, while putting other sectors at risk. Growing demand in competing sectors should therefore be carefully monitored.

The first step to mitigate criticality is obtaining information about material use and an understanding of the supply chain beyond the first tier. This is frequently impeded by lacking data availability and transparency. Data on intermediate alloys and electronic parts can be difficult to collect and thus analysis of stocks and flows, and subsequently assessment of criticality, can be hampered. Besides the question on which raw materials are used, forecasting their demand – for example based on a technology roadmapping – can be challenging as well. Managing criticality is a company-wide

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undertaking involving research and development, production, marketing and business strategy, purchasing, legal, as well as HES departments. This broad involvement of different entities requires good coordination on the company level. Furthermore, while a lot of companies face critical raw material issues, companies are not always willing to talk about their exposure to criticality since they fear to put themselves in a position of disadvantage. Having a forum to share actual cases of disruptions, best practices or coordinated action without risking confidentiality may be an interesting way for companies to mitigate risks, and could generate new opportunities in the field of raw materials management.

Working Group 2: Economic risks

Working group 2 was chaired by **Henrik Ørskov Pedersen** (Grundfos) and **Christian Hagelüken** (Umicore). The economic perspective to raw material use is introduced by Henrik Ørskov Pedersen via the use of rare earth elements (REEs) in pumps. Grundfos has set up a cross-functional team, including purchase, operations and development departments, to investigate criticality and provide recommendations. The company invests in the development of robust supply chains with long-term partnerships and evaluates the environmental impacts of their products. Furthermore, the analyses of price curves and price risks play an important role. The price of neodymium and praseodymium peaked in 2011, which influenced design choices within the company. Recently, steps are taken towards a more circular use of materials, via internal recycling of scraps, take-back programs of end-of-life motors, and reuse.

The working group participants agreed that the starting point to assess economic risks are usually fluctuating prices of metals. Other issues could be CO_2 pricing (in the longer term), speculation, supplier default, trade wars, import/export tariffs, fluctuating exchange rates, competing uses of a material, and fluctuating demand. The prices of metals that are traded on the London Metal Exchange are publicly accessible, and price fluctuations are generally mitigated via hedging (example Tesla and lithium). This is not the case for minor metals that are subject to lower price transparency. Economic risks are relevant when the material is not substitutable and the strategic relevance or the value-impact of a material is very high; the physical quantity that is used is of minor importance. It must be noted that not only materials that end up in the final product, but also ancillary materials (e.g. helium) and equipment could be exposed to economic risks. The relative financial impact on the end-product is of relevance. Companies that can pass on cost increases to their customers (e.g. when the company is the only supplier of a strategic product) or that can receive subsidies might be less concerned by economic risks. It is unlikely that geological scarcity results in economic risks, maybe even on the contrary – higher prices could motivate exploration and increased valorization of by-products. However, mining activities do not directly respond to short-term price fluctuations, as their response time is much slower. Increased demand, for example of renewable energy technologies and batteries, could create temporary shortages in the market, resulting in fluctuating prices. Short-term price fluctuations are therefore of higher concern than the long-term availability of the material.

Stockpiling of materials could be a mitigation action against price increases. However, there is a risk that the stockpile loses its value when prices decrease. Other mitigation strategies are establishing price agreements with suppliers (on the short term), and taking back end-of-life products – which is easier to implement in B2B than in B2C relationships. For the latter, circular business models should

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be implemented, such as leasing, sharing, or a deposit system. Internal recycling of production scrap usually has limited effects due to the small quantities that are available but there are cases of high purity products – such as germanium wavers or indium-tin oxide sputter targets - with relatively large volumes of production scrap where effective recycling can substantially contribute to supply. In general, increased resource efficiency could mitigate economic risks by decreasing costs overall. Substitution can be challenging, as changes in the product's composition require additional time-consuming certification processes with downstream consumers. Economic risks could be furthermore mitigated by vertical integration (holding shares of their suppliers, buying upstream operations, or having longer term strategic alliances with suppliers). Changing the location of a company might reduce some risks related to tax or import duties or trade restrictions. Multiple mitigation measures must probably be implemented in parallel to effectively decrease criticality. Some mitigation measures are more commercial in nature, and others more technical, which makes it useful to group them for the classification of the relevant departments within the company.

The implementation of mitigation measures could require the collaboration of multiple company departments. This often includes business development, purchasing, the legal department, and a CSR / sustainability department (e.g. for take-back programs). A strategic foresight unit would be relevant, although this is sometimes integrated into the marketing or strategic development department. In practice, different company units often work independently from each other. Increased collaboration and a top management overarching mitigation strategy could enable cost reduction. For example, using fewer different materials in different product lines could lead to more flexible stockpiling. Criticality evaluations could be the responsibility of risk departments – which however frequently put low priority on material risk. At some companies, a strategic market analysis department is responsible for such cross-functional issues. Otherwise, when multiple departments are involved, the general management or the CEO could be in charge of the implementation of mitigation measures – especially when risks could result in increased costs for customers, stopping a product line, or the need to invest in R&D. Some mitigation actions only concern a single department, such as price clauses and agreements (purchasing), although ideally procurements would not only rely on price information, but also on sustainability considerations (CSR).

The fastest response to economic risks would be price clauses in contracts, and, in case of a dramatic price increase, a first containment action in which product lines are internally prioritized for the allocation of materials. Such coordination is especially important in big companies in which different business units operate independently, while using the same raw materials. Stockpiling could provide a solution for a short-term duration, as stockpiles for longer than 10 years are very costly and might entail legal issues. Stockpiling of raw materials is more interesting than stockpiling of finished goods, as the latter might become superfluous due to technological development. An alternative to stockpiling is to work with dedicated suppliers that prioritize your company in situation of crisis. Similarly, customers that have the highest priority for the company should be identified as well, in consultation with the sales department. The development of substitutes can take years and does not always have a positive outcome.

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Working group 3: CSR risks

The chairs **James Goddin** (Hoskins Circular) and **Andrew Clifton** (Rolls Royce) introduce the company CSR perspective via the example element cobalt. Lithium cobalt oxide is a prime ingredient in mobile batteries, including electric vehicles and other mobile devices, and in various super alloys. The supply of cobalt is dominated by the Democratic Republic of Congo (DRC), where around 100.000 artisanal miners provide 10-25% of the production. Especially for these miners there are concerns about child labor and a lack of safety standards. This has led some companies to look for alternative suppliers. The fact that cobalt is a potential carcinogenic is an additional source of concern. Recycling rates are rather low (~35% in the EU). Moving to a circular economy is challenging as batteries are not standardized (compositions, geometries) or designed for reuse or recycling.

Although the use of cobalt can make products more sustainable by decreasing the emissions of particulates or CO_2, cobalt is often considered a high risk material and is increasingly associated with other materials of high risk, such as the conflict minerals tin, tantalum, tungsten, and gold, which are subject to regulations including the Dodd-Frank act and EU regulations from next year onwards. Customers of applications in which cobalt is used, such as in the aerospace sector, are often interested in a responsible sourcing of this material. Several companies have responded to the regulations and the increasing public awareness by moving their supply to more stable regions.

The participants of the working group agree that potential reputation damages can make a material critical, although different terminologies are used within companies, such as "reputation risk assessment". Besides social problems in a product's value chain, environmental impacts upstream (e.g. gold) or downstream (e.g. plastics, fossil fuels), and the use of toxic materials (cadmium, lead, antimony) could contribute to reputational risk. There are two ways in which reputation damage can affect a company. Firstly, the public opinion can influence shareholders, investors, public funding, and access to stock markets, which directly affects the company's operations. This is mostly relevant for business-to-customers relationships, as these downstream companies have a higher visibility vis-à-vis the public at large. Secondly, a shift of companies to less problematic suppliers could create supply bottlenecks. This consequence is also relevant for companies that have mostly business-to-business relationships, as such shifts within the market could lead to higher prices or increased supply risks related to a lower number of eligible suppliers.

Certification is often used as strategy to mitigate reputation damage, although it poses the risk to create "premium" market segments with responsible supply chains, where other market segments do not improve. Another effective strategy is direct engagement, such as industry development partnerships. However, such an engagement is very resource intensive and can therefore usually only be done for a few materials. Effective communication (marketing) to the stakeholders is key to take advantage of these investments. Other mitigation strategies, such as ecodesign, substitution, and resource efficiency require engagement of the R&D department. Furthermore, the legal department and the EHS department can be involved in conducting CSR projects.

Companies with opaque supply chains seem generally less concerned about reputation damage. Besides, it is very costly to increase the traceability of materials and the transparency of supply. A collaborative approach between companies and regulators is needed to drive both the sustainability objectives and the desired behaviors of supply chain actors. It must be understood who has

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responsibility in the supply chain and how responsibilities shift between actors. To facilitate this, guidance or standards that define responsible mining, production, and recycling are necessary, as well as guidance on how to achieve this. Policy actions in those matters would create a level playing field and could support the investment in responsible supply chains since they would provide a competitive advantage. Possibilities provided by the digital age, such as blockchain technologies, should be further explored to facilitate material traceability.

Concluding statements

After the outcomes of the working groups have been presented by the chairs, the final discussion and statements led to some concluding outcomes of the workshop:

Although it is viable to separate different types of risks in a decision model, there are practical challenges in isolating the topics of physical supply risks, economic risks and reputational risks, which have to be further considered in the development process. The different branches are interconnected and depending on the individual case, similar situations might pose different risks, require different mitigation options, and involve different approaches and responsible departments.

Raw material risks should not only be discussed in view of negative impacts that have to be avoided, but active raw materials risk management can be a competitive advantage for companies, not least in view of sustainability. However, the increased costs of implementing more sustainable raw material solutions and supply chains can be considerable especially for small and medium-sized companies. Governmental support and international agreements will be needed to bear the additional costs of implementing good practices. To ensure a level playing field in responsible sourcing, international standards are required. Those are likely to be widely adapted once a critical mass of relevant companies follows them.

Government intervention is also needed to regulate the economic dysfunctions in minor metals markets, especially in value chains that are easily disrupted. In the developing world, it is furthermore important that government interventions actually support companies economically and in their capacity-building. Government programs to cover interest rates and distribute loans for stockpiles – as it is done in China - could also be an option for Europe to support industries and help SMEs to survive during supply or demand shocks.

Governments are dependent on data sharing by companies as a basis for research and analysis of raw materials reserves, stocks and flows. A traceability or data sharing system will be beneficial to bridge the information gap between stakeholders. Confidentiality will be a major hurdle in this regard. Strategic alliances might be considered in the context of reducing vulnerability of companies or improving access to raw materials. Here, consortia for buying materials might offer interesting options, but will be subject to regulatory rules. However, if companies share their viewpoints actively, mitigation ideas can be fertilized and spread, which might provide a head start for firms engaging in these discussions.

Resources shared by the participants

https://docs.google.com/spreadsheets/d/12BIdpRYLgfzJuCPCKMhdPeKJ4crtFd2W0iRTmwwnuVM

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Next IRTC-Business event: November 17, 2020 – save the date!

The next IRTC-Business event will be a virtual workshop and Round Table on "**Building resilient economies - the role of policy**". It will take place in the framework of the European Commission's Raw Materials Week.

Mitigation actions for raw materials supply risks range from those that are effective on company level to those that necessitate coordinated government action. The COVID-19 pandemic has shown that companies' ranges of action can be limited when it comes to large-scale disruptions on a global scale. Firms can hardly protect their supply chains from events of global magnitudes.

The probability of supply disruptions is difficult to predict due to its dynamic nature and the wide range of potentially relevant supply risk factors. However, the study of supply risk factors can help to identify vulnerabilities of current global economic systems. In order to mitigate potential risks, it can be helpful to focus on the development of more resilient supply chains that have a lower vulnerability to large-scale disruptions and distortions. There is a role of both companies and policymakers to anticipate possible bottlenecks and find solutions to mitigate supply disruptions in mid or long-term time frames to limit economic and social damage.

In times of crises, governments take a more decisive role, and their actions can have an essential impact on industry operations. How can the possibility of such global crises be anticipated in risk management, and how can these risks be effectively mitigated for vulnerable industries, while also balancing economic competitiveness requirements? How can favorable circumstances for risk mitigation be put in place in order to facilitate industry initiatives? The workshop and Round Table will investigate the role of policy-making for raw material risk mitigation and possible ways forward.

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.

Coordinator contact

Alessandra Hool
ESM Foundation, Junkerngasse 56, 3011 Bern, Switzerland
alessandra.hool@esmfoundation.org

This summary was written by Dieuwertje Schrijvers, Alessandra Hool, Sophia Ganzeboom and Marcus Berr in collaboration with the speakers and working group chairs.

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