

52

## DERA Rohstoffinformationen



**Securing raw material supply:  
Benchmarking of measures of foreign manufacturing  
companies and recommendations for action**

*»Auftragsstudie«*

## Impressum

**Editors:** German Mineral Resources Agency (DERA) at the  
Federal Institute for Geosciences and Natural Resources (BGR)  
Wilhelmstr. 25–30  
13593 Berlin, Germany  
Phone: +49 30 36993 226  
dera@bgr.de  
www.dera.bund.de

**Authors:** Hannes Köster, Florian P. Neubert, Kai Dierksmeier, Lena Adelman,  
Heiko Lentge, Philipp Schmidt  
PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft  
Alsterufer 1  
20354 Hamburg

Contact DERA: Sven-Uwe Schulz | Sven-Uwe.Schulz@bgr.de

**Layout:** deckermedia GbR

**Date:** März 2022

**Cover images:** © monsitj/abstract background – stock.adobe.com  
© peshkov – iStock.com

**Reference:** KÖSTER, H., NEUBERT, F. P., DIERKSMEIER, K., ADELMANN, L.,  
LENTGE, H., SCHMIDT, P. (2022):  
Securing raw material supply:  
Benchmarking of measures of foreign manufacturing companies  
and recommendations for action. – DERA Rohstoffinformationen, 52:  
172 p., Berlin.

**ISBN:** 978-3-948532-59-8 (print version)

**ISBN:** 978-3-948532-60-4 (PDF)

**ISSN:** 2193-5319

Berlin, 2022



**Securing raw material supply:  
Benchmarking of measures of foreign manufacturing  
companies and recommendations for action**

*»Auftragsstudie«*

Im Auftrag der Deutschen Rohstoffagentur in der Bundesanstalt für  
Geowissenschaften und Rohstoffe, Berlin



## Preface

Raw materials are at the very beginning of the industrial value chain, and therefore have a major influence on downstream economic sectors. They are essential for the future viability of our society and for Germany to retain its position as a high-tech economy, especially in light of the major challenges created by the energy transition, digitalisation and increasing global competition. To remain innovative in the future, a reliable and sustainable supply of raw materials – metals and industrial minerals in particular – is essential.

The situation in the global raw materials markets has changed significantly in recent years. Competition for raw materials used in key technologies of today and tomorrow is increasing rapidly, and concerns about supply chain resilience are rising. The most visible sign of this uncertainty is the increase in price volatility of many raw materials. The supply shortfalls in the wake of the Covid-19 pandemic are also showing just how important a reliable supply of raw materials is for German manufacturers.

The update of the German Federal Government's raw materials strategy, which was endorsed on 15 January 2020, also involved a review of the general direction of German raw materials policy. Successful existing measures will be continued and developed further, and new measures in exchange with industry and society will be implemented as well. Under this framework the German government also backs measures taken by companies to secure raw materials and become more competitive.

This study was undertaken by PricewaterhouseCoopers GmbH on behalf of DERA. It examines strategies used by companies outside Germany to secure their supplies of raw materials, and hence enable more reliable planning. The aim of this study is to encourage German companies to pay more attention to the issue of securing raw materials, and to examine their supply chains for possible weak points. The study focuses on companies operating in market-oriented countries similar to Germany. Out of a large number of individual measures identified, the study examines a total of eleven strategies for securing raw materials, analysing them based on their degree of usage by non-German companies in seven different countries. The recommendations for German companies identified in this study provide valuable information on how procurement strategies can be improved or expanded. The study may also contribute to the discussion about possible new measures within the framework of the German Federal Government's raw materials strategy.

We would like to wish companies every success in maintaining a reliable supply of raw materials.

Dr Peter Buchholz

Head of the German Mineral Resources Agency (DERA) at the  
Federal Institute for Geosciences and Natural Resources (BGR)

## Vorwort

Rohstoffe stehen am Anfang der industriellen Wertschöpfung und haben damit einen großen Einfluss auf nachgelagerte Wirtschaftsbereiche. Sie sind für die Zukunftsfähigkeit unserer Gesellschaft und den Technologiestandort Deutschland, insbesondere mit Blick auf die großen Herausforderungen der Energiewende, der Digitalisierung und des zunehmenden globalen Wettbewerbs, essenziell. Um die Innovationsfähigkeit auch künftig zu gewährleisten, ist eine sichere und nachhaltige Versorgung insbesondere von Metallen und Industriemineralen eine wesentliche Voraussetzung.

Die Situation auf den Weltmärkten hat sich in den letzten Jahren bei den mineralischen Rohstoffen grundlegend verändert. Der Wettbewerb um Rohstoffe für Schlüssel- und Zukunftstechnologien nimmt stark zu und damit die Sorge um zuverlässige Lieferketten. Sichtbarstes Zeichen dieser Unsicherheit ist die Zunahme der Preisvolatilität vieler Rohstoffe. Aktuell wird auch an den Folgen der Covid-19-Pandemie offenbar, welche hohe Bedeutung die sichere Rohstoffversorgung für die produzierenden Unternehmen in Deutschland besitzt.

Mit der Fortschreibung der Rohstoffstrategie der Bundesregierung, die am 15. Januar 2020 vom Bundeskabinett beschlossen wurde, wurde auch der rohstoffpolitische Kompass überprüft. Erfolgreiche bestehende Maßnahmen werden fortgeführt und weiterentwickelt und neue im Austausch mit Wirtschaft und Gesellschaft umgesetzt. In diesem Rahmen flankiert die Bundesregierung auch Maßnahmen der Unternehmen zur Rohstoffversorgung, um deren Wettbewerbsfähigkeit zu verbessern.

Die vorliegende Studie der PricewaterhouseCoopers GmbH untersucht im Auftrag der DERA Instrumente und Strategien, mit denen ausländische Unternehmen ihre Rohstoffversorgung absichern und damit die Planungssicherheit erhöhen. Mit den Erkenntnissen aus dieser Untersuchung sollen deutsche Unternehmen ermutigt werden, ein größeres Augenmerk auf das Thema Rohstoffsicherung zu lenken und ihre Lieferketten auf mögliche Schwachpunkte hin zu untersuchen. Der Fokus der Studie liegt auf Aktivitäten von Unternehmen in Ländern, die ähnlich wie in Deutschland in einem marktwirtschaftlich orientierten Umfeld agieren. Insgesamt werden aus einer Vielzahl von identifizierten Einzelmaßnahmen elf Sicherungsstrategien untersucht und anhand ihrer Anwendung durch ausländische Unternehmen in sieben Ländern analysiert.

Mit der Ableitung von Handlungsempfehlungen für deutsche Unternehmen leistet die Studie einen wertvollen Beitrag dazu, wie Beschaffungsstrategien optimiert oder erweitert werden können. Sie kann ferner dazu beitragen, die Diskussion über mögliche neue Maßnahmen im Rahmen der Rohstoffstrategie der Bundesregierung zu fördern. In diesem Sinne wünschen wir den Unternehmen bei der Rohstoffsicherung weiterhin viel Erfolg.

Dr. Peter Buchholz

Leiter der Deutschen Rohstoffagentur (DERA) in der  
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)

## Table of contents

<b>List of tables</b>	<b>7</b>
<b>List of figures</b>	<b>8</b>
<b>List of abbreviations</b>	<b>9</b>
<b>Zusammenfassung</b>	<b>12</b>
<b>Summary</b>	<b>22</b>
<b>1 Introduction</b>	<b>31</b>
<b>2 Research and methodology</b>	<b>33</b>
2.1 Fundamental design	33
2.2 Development of hypotheses	34
2.3 Survey	36
2.4 Expert interviews	38
2.5 Critical success factors and recommendations for action	38
<b>3 General conditions in countries examined</b>	<b>40</b>
3.1 Japan	40
3.2 South Korea	41
3.3 Canada	43
3.4 United States	45
3.5 France	47
3.6 Italy	48
3.7 United Kingdom	50
<b>4 Investigation results</b>	<b>52</b>
4.1 Critical raw materials	52
4.2 Overview of strategies: extent of usage and effectiveness	54
4.3 Influence of market-specific and country-specific factors on raw material procurement	56
4.4 Examination of strategies	58
4.4.1 Commodity price hedging	59
4.4.2 Passing on increased raw material prices to customers	65
4.4.3 Stockpiling	71
4.4.4 Supplier diversification	76
4.4.5 Long-term contracts	84
4.4.6 Purchasing groups	91
4.4.7 Increased material efficiency	96
4.4.8 Recycling	103
4.4.9 Material substitution	108
4.4.10 Vertical integration	114
4.4.11 Business tools	122

<b>5</b>	<b>Strategy development and execution</b>	<b>129</b>
5.1	Status quo and goals	131
5.2	Creating a level playing field	134
5.3	Implementation and execution	140
5.4	Evaluation and adjustment	143
5.5	Corporate ecosystem	146
5.6	Macro trends	148
<b>6</b>	<b>Outlook</b>	<b>151</b>
<b>7</b>	<b>References</b>	<b>154</b>
	<b>Appendix</b>	<b>165</b>
	Online survey questionnaire	166
	Expert interview guideline questions	169
	Expert interviewees	170

## List of figures

Figure 1: Nutzung der Absicherungsstrategien in den untersuchten Unternehmen	13
Figure 2: Usage of strategies for securing raw material supplies in the companies surveyed	23
Figure 3: Methodology of the study	33
Figure 4: Development of hypotheses	34
Figure 5: Mind map of vertical integration (extract)	35
Figure 6: Overview of hypotheses	36
Figure 7: Target group sampling strategy	37
Figure 8: Overview of survey respondents	37
Figure 9: Location and affiliation of interviewees	39
Figure 10: Comparison of price risk and supply risk of specific raw materials	52
Figure 11: Usage of strategies in companies surveyed	55
Figure 12: Effectiveness of each strategy as assessed by the survey respondents	55
Figure 13: Market-specific factors and extent of influence on strategies for securing raw materials	56
Figure 14: Country-specific factors and extent of influence on strategies for securing raw materials	57
Figure 15: Usage of commodity price hedging	60
Figure 16: Effectiveness of commodity price hedging	60
Figure 17: Usage of price pass-through	66
Figure 18: Effectiveness of price pass-through	66
Figure 19: Usage of stockpiling	71
Figure 20: Effectiveness of stockpiling	71
Figure 21: Usage of supplier diversification	76
Figure 22: Effectiveness of supplier diversification	76
Figure 23: Selection criteria for the supplier qualification process	81
Figure 24: Sample scorecard	82
Figure 25: Usage of long-term contracts	85
Figure 26: Effectiveness of long-term contracts	85
Figure 27: Changes in contract duration	85
Figure 28: Simple combinations of prices and quantities for supply contracts	86
Figure 29: Usage of purchasing groups	91
Figure 30: Effectiveness of purchasing groups	91
Figure 31: Usage of increased material efficiency	96
Figure 32: Effectiveness of increased material efficiency	96
Figure 33: Usage and effectiveness of digital solutions for increasing material efficiency	97
Figure 34: Categories of measures to increase material efficiency	100
Figure 35: Usage of recycling	103
Figure 36: Effectiveness of recycling	103
Figure 37: Usage of material substitution	109
Figure 38: Effectiveness of material substitution	109
Figure 39: Vertical integration in the value chain (simplified example)	114
Figure 40: Usage of vertical integration	115
Figure 41: Effectiveness of vertical integration	115
Figure 42: Popularity of different investment targets for vertical integration	116

Figure 43: Usage of business tools	123
Figure 44: Effectiveness of business tools	123
Figure 45: Added value and complexity of implementing different methods of analysis	126
Figure 46: Strategy development and execution cycle	129
Figure 47: Supplier management cycle	138
Figure 48: Supplier involvement	142
Figure 49: Corporate ecosystem of a car manufacturer	147

### List of tables

Table 1: Summary of commodity price hedging	64
Table 2: Summary of passing on increased raw material prices to customers	70
Table 3: Summary of stockpiling	75
Table 4: Summary of supplier diversification	83
Table 5: Summary of long-term contracts	90
Table 6: Summary of purchasing groups	95
Table 7: Summary of increased material efficiency	102
Table 8: Summary of recycling	107
Table 9: Summary of material substitution	113
Table 10: Summary of vertical integration	121
Table 11: Summary of business tools	128
Table 12: Checklist for strategy development and execution	130
Table 13: Key takeaways: status quo and goals	133
Table 14: Comparison of risk mitigation and resources required for each strategy	135
Table 15: Key takeaways: creating a level playing field	139
Table 16: Key takeaways: implementation and execution	142
Table 17: Examples of KPIs for evaluating and adjusting raw material procurement strategies	144
Table 18: Key takeaways: evaluation and adjustment	145
Table 19: Key takeaways: corporate ecosystem	147
Table 20: Key takeaways: macro trends	150

## List of abbreviations

A			
<b>ADEME</b>	French Agency for Ecological Transition (Agence de la transition écologique)	<b>BMWK</b>	German Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz)
<b>AFD</b>	French Development Agency (Agence française de développement)	<b>bpb</b>	German Federal Agency for Civic Education (Bundeszentrale für politische Bildung)
<b>AI</b>	Artificial intelligence	<b>Bpifrance</b>	French Public Investment Bank (Banque publique d'investissement)
B			
<b>BAKS</b>	German Federal Academy for Security Policy (Bundesakademie für Sicherheitspolitik)	<b>BRGM</b>	French Geological Survey (Bureau de recherches géologiques et minières)
<b>BDE</b>	Federation of the German Waste, Water and Raw Materials Management Industry (Bundesverband der Deutschen Entsorgungs-, Wasser- und Rohstoffwirtschaft)	<b>B2B</b>	Business-to-business
<b>BDI</b>	Federation of German Industries (Bundesverband der Deutschen Industrie)	<b>B2C</b>	Business-to-customer
<b>BEIS</b>	British Department for Business, Energy & Industrial Strategy	C	
<b>BGR</b>	German Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe)	<b>CESE</b>	French Economic, Social and Environmental Council (Conseil économique social et environnemental)
<b>BGS</b>	British Geological Survey	<b>CGEJET</b>	French General Council for the Economy, Industry, Energy and Technology (Conseil général de l'économie, de l'industrie, de l'énergie et des technologies)
<b>BIS</b>	British Department for Business Innovation and Skills	<b>CMMP</b>	Canadian Minerals and Metals Plan
<b>BMBF</b>	German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung)	<b>CNI</b>	French National Council of Industry (Conseil national de l'industrie)
<b>BME</b>	German Association for Supply Chain Management, Procurement and Logistics (Bundesverband Materialwirtschaft, Einkauf und Logistik)	<b>COF</b>	Compound objective function
<b>BMLRT</b>	Austrian Federal Ministry of Agriculture, Regions and Tourism (Bundesministerium für Landwirtschaft, Regionen und Tourismus)	<b>COMES</b>	French Committee on Strategic Metals (Comité pour les métaux stratégiques)
<b>BMUV</b>	German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz)	<b>CRM</b>	Customer relationship management
<b>BMWi</b>	German Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)	<b>CRS</b>	U.S. Congressional Research Service
		<b>CSF</b>	French Strategic Committee of Industry (Comité stratégique de filière)
		D	
		<b>DEFRA</b>	British Department for Environment, Food & Rural Affairs
		<b>DEG</b>	German Investment Corporation (Deutsche Investitions- und Entwicklungsgesellschaft)
		<b>DERA</b>	German Mineral Resources Agency (Deutsche Rohstoffagentur) at the BGR
		<b>DLA</b>	U.S. Defense Logistics Agency
		<b>DOC</b>	U.S. Department of Commerce
		<b>DOD</b>	U.S. Department of Defense
		<b>DOE</b>	U.S. Department of Energy
		<b>DOI</b>	U.S. Department of the Interior

<b>DOL</b>	U.S. Department of Labor
<b>DRC</b>	Democratic Republic of the Congo
<b>E</b>	
<b>EMRD</b>	Energy and Mineral Resources Development Association of Korea
<b>ERP</b>	Enterprise resource planning
<b>ESG</b>	Environmental, social and governance
<b>ETL</b>	Extract, transform, load
<b>EUR</b>	Euro
<b>EXIM</b>	Export-Import Bank of the United States
<b>F</b>	
<b>Fraunhofer IPA</b>	Fraunhofer Institute for Manufacturing Engineering and Automation (Fraunhofer-Institut für Produktionstechnik und Automatisierung)
<b>G</b>	
<b>GAC</b>	Global Affairs Canada
<b>GDP</b>	Gross domestic product
<b>GICS</b>	Global Industry Classification Standard
<b>GSC</b>	Geological Survey of Canada
<b>I</b>	
<b>IEA</b>	International Energy Agency
<b>IoT</b>	Internet of things
<b>ISPRA</b>	Italian Institute for Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale)
<b>ITW</b>	Illinois Tool Works
<b>IW</b>	German Economic Institute (Institut der deutschen Wirtschaft)
<b>J</b>	
<b>JBIC</b>	Japan Bank for International Cooperation
<b>JOGMEC</b>	Japan Oil, Gas and Metals Corporation
<b>K</b>	
<b>KEPCO</b>	Korea Electric Power Corporation
<b>KEXIM</b>	Export-Import Bank of Korea
<b>KIGAM</b>	Korea Institute of Geoscience and Mineral Resources
<b>KNOC</b>	Korea National Oil Corporation
<b>KOGAS</b>	Korea Gas Corporation
<b>KOMIR</b>	Korea Mine Rehabilitation and Mineral Resources Corporation
<b>KORES</b>	Korea Resources Corporation

<b>KOTRA</b>	Korea Trade-Investment Promotion Agency
<b>KPI</b>	Key performance indicator
<b>KRW</b>	South Korean Won
<b>K-SURE</b>	Korea Trade Insurance Corporation
<b>L</b>	
<b>LAB-MP</b>	Italian Raw Materials Laboratory (Laboratorio Materie Prime)
<b>LME</b>	London Metal Exchange
<b>M</b>	
<b>METI</b>	Japanese Ministry of Economy, Trade and Industry
<b>MIRECO</b>	Korean Mine Reclamation Corporation
<b>MISE</b>	Italian Ministry of Economic Development (Ministero dello sviluppo economico)
<b>MIT</b>	Massachusetts Institute of Technology
<b>MOFA</b>	Ministry of Foreign Affairs of Japan
<b>MOTIE</b>	Korean Ministry of Trade, Industry and Energy
<b>MRI</b>	Magnetic resonance imaging
<b>N</b>	
<b>NEXI</b>	Nippon Export and Investment Insurance
<b>NRCan</b>	Natural Resources Canada
<b>O</b>	
<b>OEC</b>	Observatory of Economic Complexity
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>OEM</b>	Original equipment manufacturer
<b>P</b>	
<b>PESTEL</b>	Political, economic, social, technological, environmental and legal analysis
<b>POST</b>	UK Parliamentary Office of Science and Technology
<b>PPS</b>	Korean Public Procurement Service
<b>PwC</b>	PricewaterhouseCoopers Wirtschaftsprüfungsgesellschaft
<b>R</b>	
<b>R&amp;D</b>	Research and development
<b>RMO</b>	Raw Material Outlook
<b>ROI</b>	Return on investment
<b>S</b>	
<b>SaaS</b>	Software as a service
<b>S&amp;P</b>	Standard & Poor's

<b>SACE</b>	Italian Export Credit Agency (Servizi Assicurativi del Commercio Estero)
<b>SCREEN</b>	Solutions for Critical Raw Materials – a European Expert Network
<b>SMART</b>	Specific, measurable, achievable, realistic and time-bound
<b>SMEs</b>	Small and medium-sized enterprises
<b>SRL</b>	Substitution Readiness Level
<b>SRM</b>	Supplier relationship management
<b>SWP</b>	German Institute for International and Security Affairs (Stiftung Wissenschaft und Politik)

### U

<b>UK</b>	United Kingdom
<b>UKEF</b>	UK Export Finance
<b>UN</b>	United Nations
<b>US</b>	United States
<b>USD</b>	US Dollar
<b>USGS</b>	United States Geological Survey
<b>USTR</b>	Office of the U.S. Trade Representative

### V

<b>VCI</b>	German Chemical Industry Association (Verband der Chemischen Industrie)
<b>VDA</b>	German Association of the Automotive Industry (Verband der Automobilindustrie)
<b>VDI</b>	Association of German Engineers (Verein Deutscher Ingenieure)
<b>VDM</b>	Association of German Metal Traders (Verband Deutscher Metallhändler)
<b>VDMA</b>	German Mechanical Engineering Industry Association (Verband Deutscher Maschinen- und Anlagenbau)

### W

<b>WITS</b>	World Integrated Trade Solution
<b>WVM</b>	German Non-Ferrous Metals Association (Wirtschaftsvereinigung Metalle)

### Y

<b>YTD</b>	Year to date
------------	--------------

### Z

<b>ZVEI</b>	German Electrical Industry Association (Zentralverband Elektrotechnik- und Elektronikindustrie)
-------------	---

## Zusammenfassung

### Hintergrund und Zielsetzung der Studie

Getrieben vor allem durch das Bevölkerungs- und Wirtschaftswachstum, die Urbanisierung sowie den technologischen Fortschritt steigt der Bedarf nach Rohstoffen weltweit seit Jahrzehnten erheblich an (WELLMER et al., 2019; DERA, 2020). Die Energie- und Mobilitätswende sowie die zunehmende Digitalisierung sind weitere Faktoren, die den Bedarf nach Rohstoffen weltweit erhöhen (MARSCHIEDER-WEIDEMANN et al., 2021). So wird erwartet, dass sich beispielsweise der Bedarf nach Lithium als Folge der Elektrifizierung im Automobilssektor in den nächsten fünf Jahren vervierfachen und sich der Bedarf nach Kobalt verdoppeln könnte (BMWK, 2020a). Neben der strukturellen gestiegenen Nachfrage nach Rohstoffen haben in der Vergangenheit auch immer wieder globale Krisen und politische Ereignisse die zuverlässige Versorgung mit Rohstoffen erheblich beeinträchtigt. So führten beispielsweise die Covid-19-Pandemie oder auch Handelsstreitigkeiten zu Unterbrechungen in den Lieferketten und zu Spannungen an den Rohstoffmärkten. Das Risiko von Preisanstiegen und von Engpässen bei der Rohstoffversorgung wird durch die ungleiche geografische Verteilung von Lagerstätten in der Erdkruste und die damit einhergehende Konzentration einiger kritischer Rohstoffe in bestimmten Regionen noch weiter verschärft. Um sich den Zugang zu relevanten Rohstoffen zu sichern, konkurrieren Unternehmen weltweit – mit entsprechenden Folgen auf das Preisniveau (ACATECH et al., 2017). In der aktuellen Phase einer strukturell hohen Nachfrage und eines langsam reagierenden Angebots ist beispielsweise der durchschnittliche Jahrespreis für Lithiumkarbonat, das primär in Chile, Argentinien und Australien produziert wird, zwischen 2012 und 2021 um 306 % von USD 6.607 pro Tonne auf USD 20.228 pro Tonne gestiegen (BLOOMBERG, 2021). Gerade in Deutschland, wo wenige der strategisch wichtigen Rohstoffe aus heimischen Quellen stammen, ist die Abhängigkeit der Unternehmen von ausländischen Produzenten groß (BGR, 2020). Die zuverlässige Versorgung mit einer großen Bandbreite von Rohstoffen ist für Unternehmen entscheidend, um technologisch eine führende Rolle zu spielen und wettbewerbsfähige Produkte herzustellen (BMUB, 2016; BMWK, 2021a). Eine sichere Rohstoffversorgung rückt damit immer weiter in den Fokus vieler Unternehmen, sodass Strategien zur Reduzierung von Preis- und Verfügbarkeitsrisiken an Bedeutung gewinnen.

Ziel dieser Studie ist zu analysieren, wie ausländische Unternehmen ihre Versorgung mit Rohstoffen sichern, welche Strategien sie derzeit und zukünftig anwenden, mit welchen Chancen und Herausforderungen diese Strategien verbunden sind sowie welche Erfolgsfaktoren und Handlungsempfehlungen sich daraus für deutsche Unternehmen ergeben. Hierfür wurden eine Umfrage sowie Experteninterviews mit Unternehmensvertretern aus diesen sieben verschiedenen Industrienationen durchgeführt: Japan, Südkorea, Kanada, USA, Frankreich, Italien, Großbritannien. Der Fokus der Befragung und der Interviews lag dabei auf Unternehmen aus der Automobil-, Maschinen- und Anlagebau- sowie der Telekommunikationsindustrie. In Summe wurde die Umfrage von Supply-Chain-Experten und Führungskräften aus 59 Unternehmen beantwortet und es wurden Interviews mit 44 Experten geführt. Das primäre Ziel der Umfrage war es, Trends in der Nutzung von bestimmten im Ausland angewandten Absicherungsstrategien sowie die Strategiewahl beeinflussende Umweltfaktoren zu ermitteln. Die Gründe für die Nutzung von bestimmten Strategien, die Umsetzung, die Chancen und Herausforderungen sowie die genaueren Umstände und Faktoren für den erfolgreichen Einsatz wurden in den Interviews behandelt. Die Erkenntnisse aus der Umfrage und den Interviews wurden durch Ergebnisse aus einer Sekundärrecherche ergänzt. Darauf basierend wurden Handlungsempfehlungen für jede einzelne Strategie sowie für den gesamten Entwicklungs- und Implementierungsprozess identifiziert, entwickelt und dargestellt.

#### Absicherungsstrategien

- Commodity Price Hedging
- Weitergabe gestiegener Rohstoffpreise an den Kunden
- Erweiterung des Lagerbestandes
- Lieferantendiversifikation
- Langfristige Lieferverträge
- Einkaufsgemeinschaften
- Projekte zur Reduzierung des Materialeinsatzes
- Recyclingprojekte
- Substitutionsprojekte
- Vertikale Integration
- Business-Tools

### Untersuchte Strategien zur Sicherung der Rohstoffversorgung

Abbildung (figure) 1 zeigt das Ausmaß der aktuellen und zukünftig geplanten Anwendung der einzelnen Absicherungsstrategien bei den befragten Unternehmen. Die Strategien der Diversifizierung der Lieferantebasis und der Nutzung von langfristigen Lieferverträgen werden am meisten genutzt. Diese Strategien werden gemäß den Umfrageteilnehmenden auch als am effektivsten eingeschätzt, um die Rohstoffversorgung des Unternehmens zu sichern. Demgegenüber spielt die vertikale Integration (z. B. die Beteiligung an Bergbauprojekten) aufgrund des hohen Kapitaleinsatzes und der hohen Unsicherheit nur eine untergeordnete Rolle. Des Weiteren ist ein klarer Trend zu erkennen, dass die Strategien, die zur Steigerung der Nachhaltigkeit der Unternehmen beitragen (wie z. B. Projekte zur Reduzierung des Materialverbrauchs, Recyclingprojekte, Substitutionsprojekte), in den nächsten drei bis fünf Jahren deutlich stärker genutzt werden sollen. Ebenfalls auffällig ist die zukünftig verstärkte Nutzung von IT-gestützten Business-Tools im Bereich der Rohstoffbeschaffung. Angetrieben wird dies durch technologische Entwicklungen beispielsweise in den Bereichen Big Data Analytics, Artificial Intelligence, Cloud Computing, Blockchain und Predictive Analytics.

In Summe ist zu erkennen, dass bei allen Absicherungsstrategien die geplante Nutzung in den nächsten drei bis fünf Jahren höher ist als ihre momentane Nutzung. Dies verdeutlicht, dass in den untersuchten ausländischen Unternehmen das Thema der sicheren Rohstoffbeschaffung an Relevanz zugenommen hat und dass die Unternehmen vermehrt Strategien anwenden und intensivieren wollen, um ihre Rohstoffversorgung zu sichern und das Risiko von Preisanstiegen sowie Lieferengpässen zu reduzieren. Im Folgenden werden die einzelnen Absicherungsstrategien im Detail erläutert. Dabei werden die Kernergebnisse bezüglich der Gründe für die Nutzung, die Chancen und Herausforderungen sowie die Erfolgsfaktoren und Haupthandlungsempfehlungen für jede Strategie dargestellt.

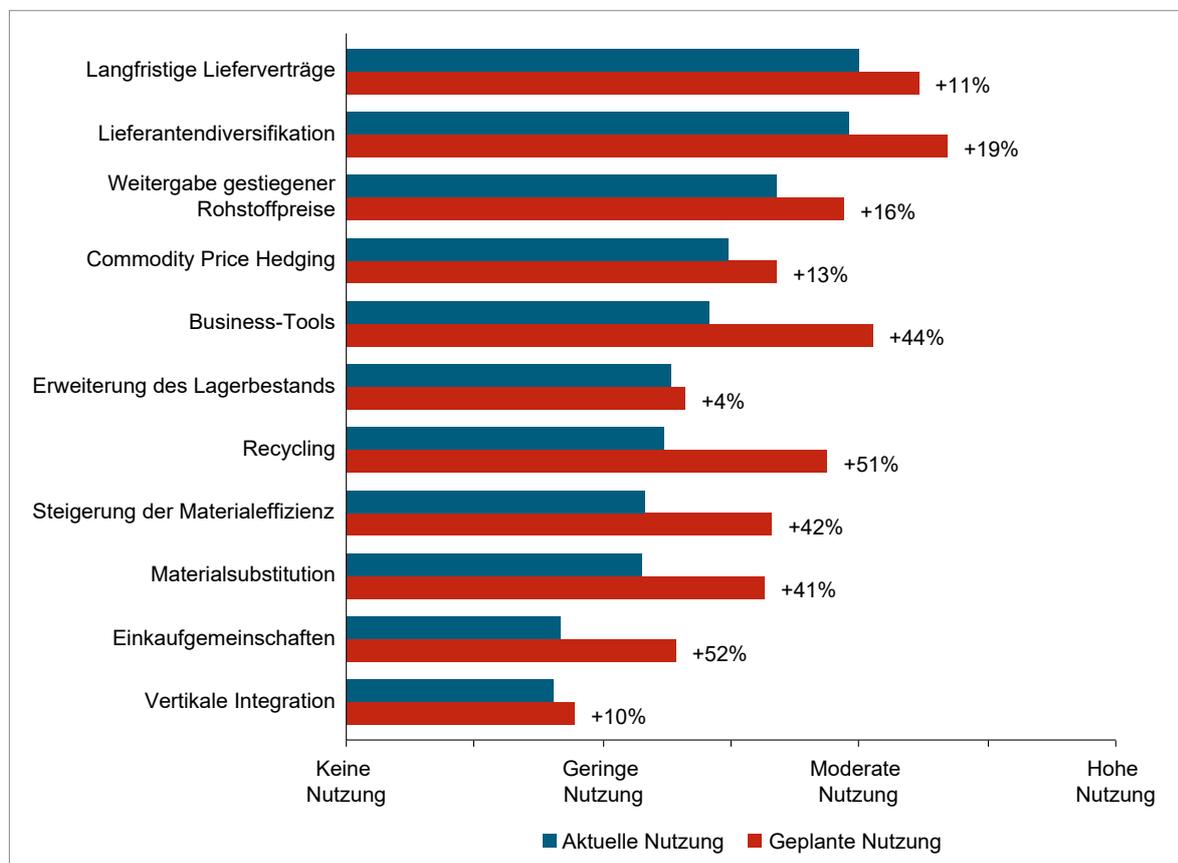


Figure 1: Nutzung der Absicherungsstrategien in den untersuchten Unternehmen

### Commodity Price Hedging

Mittels verschiedenster Hedginginstrumente wie Futures, Forwards, Optionen und Swaps können Unternehmen Rohstoffpreissrisiken effektiv absichern. Die vergleichsweise flexible Einsetzbarkeit ermöglicht eine agile Absicherung von Preisrisiken und damit eine höhere Planungssicherheit im Unternehmen. Während Hedging bereits zu einer der meisteingesetzten Strategien in den befragten Unternehmen gehört, wird die Nutzung in den kommenden drei bis fünf Jahren weiter zunehmen. Gründe für die steigende Relevanz sind gemäß der befragten Experten die Erwartung steigender Preisvolatilitäten an den Rohstoffmärkten und der generelle Ausbau des Risikomanagements in vielen Unternehmen. Hindernisse für die erfolgreiche Nutzung sind vor allem fehlende Expertise in den Unternehmen und das Fehlen von passenden Hedgingprodukten für alle Rohstoffe. Neben der Erlangung des nötigen Know-hows sind für die erfolgreiche Implementierung eine gute interne Organisation und Kooperation nötig. Hedging sollte auf der Gesamtunternehmensebene geplant und für den gesamten Einkauf gebündelt werden. Es empfiehlt sich daher der Einsatz eines multidisziplinären Kompetenzteams aus Experten verschiedener Abteilungen zur Ermittlung optimaler Hedgingpositionen. Des Weiteren empfiehlt sich die Durchführung umfassender Marktanalysen und der Einsatz von Business-Analytics-Tools für Preisprognosen und für die Bestimmung des zukünftigen Rohstoffbedarfs im Unternehmen.

**Das zunehmende Angebot an Hedgingprodukten am Markt ermöglicht, das Preisrisiko einer Vielzahl von Rohstoffen abzusichern.**

### Weitergabe gestiegener Rohstoffpreise an den Kunden

Mit der Weitergabe gestiegener Rohstoffpreise an den Kunden, können Unternehmen kurzfristig Preisrisiken absichern. Da die Implementationszeit sehr gering ist, kann die Weitergabe von Preisen schnell und flexibel eingesetzt werden und damit die Gewinnmargen des Unternehmens absichern oder vor Verlusten schützen. Diese Strategie zählt nach Auskunft der befragten Unternehmen zu einer der derzeit meistgenutzten Strategien. Ebenso planen die befragten Führungskräfte diese Strategie in den nächsten drei bis fünf Jahren aufgrund ihrer Flexibilität und der Erwartung weiter steigender Rohstoffpreise verstärkt zu nutzen. Hindernisse für die erfolgreiche Nutzung sind vor allem eine hohe Konkurrenz an den Absatzmärkten und der daraus resultierende Preisdruck. Die erfolgreiche Weitergabe von höheren Preisen setzt eine detaillierte Analyse des Absatzmarktes sowie eine offene Kommunikation dem Kunden gegenüber voraus. Es empfiehlt sich daher, beispielsweise unter Nutzung von Analytics-Tools, die Preisentwicklungen und Sensibilitäten am Markt zu beobachten und zu prognostizieren, sodass die Reaktionen der Konkurrenz und der Kunden auf Preissteigerungen besser abgeschätzt werden können. Für den Fall, dass gestiegene Preise an den Kunden weitergegeben werden sollen, empfiehlt es sich, die Gründe und die Notwendigkeit für die gestiegenen Verkaufspreise dem Kunden transparent, z. B. per Kundeninformation, offenzulegen und klar zu kommunizieren, um die Akzeptanz beim Kunden zu erhöhen. Grundsätzlich sollten jedoch Preis erhöhungen zur Vermeidung von Wettbewerbsverlusten nicht übereilt, sondern bedacht vorgenommen werden.

**Bei der Weitergabe von gestiegenen Preisen müssen die Gründe dafür klar an den Kunden kommuniziert werden, um die Akzeptanz zu erhöhen.**

### Erweiterung des Lagerbestands

Mittels der Erhöhung der Lagerbestände, können Unternehmen Lieferengpässe kurz- bis mittelfristig überbrücken und Marktturbulenzen besser abfedern. Durch erhöhte Lagerbestände ist das Unternehmen weniger dem Risiko von Ausfällen bei den Lieferanten oder dem Mangel an Rohstoffen auf dem Markt ausgesetzt. Somit kann die Produktion auch bei unvorhergesehenen adversen Marktentwicklungen aufrecht erhalten werden. Zudem ermöglicht ein erhöhter Lagerbestand schneller auf Kundenanfragen reagieren zu können und somit den Order-to-Cash-Zyklus zu optimieren. Die Strategie der Erweiterung des Lagerbestandes wird jedoch von den befragten Unternehmen nur mäßig angewandt. In naher Zukunft planen die befragten Unternehmen auch keine erheblich verstärkte Nutzung dieser Strategie. Dies wird mit den damit verbundenen erhöhten Lagerhaltungskosten, dem gebundenem Kapital sowie der Gefahr begründet, dass die Unternehmen auf den Rohstoffen sitzen bleiben, wenn sich die Nachfrage nach dem eigenen Produkt verändert. Neben der Identifizierung der kritischen Rohstoffe, die von Ausfällen oder Engpässen betroffen sein könnten, sollte ein Unternehmen seine Rohstoffbedarfe zuverlässig planen können, um diese Strategie erfolgreich anwenden zu können. Es empfiehlt sich daher, die Kundenstruktur, die Nachfrage nach den eigenen Produkten und den Rohstoffbedarf umfangreich zu analysieren. Daher sollte ein fortgeschrittenes Enterprise-Resource-Planning-System (inkl. Business-Analytics-Tools) im Unternehmen eingesetzt werden, um zuverlässige Nachfragevorhersagen zu treffen und Leistungskennzahlen überwachen zu können. Anstelle der Lagerung von bereits verarbeiteten Gütern im Unternehmen, könnte auch die Möglichkeit der verstärkten Lagerung unverarbeiteter Rohstoffe beim Lieferanten geprüft werden. Dies würde die Flexibilität erhöhen, auf Bedarfsänderungen bzw. sich ändernde Spezifikationswünsche der Kunden reagieren zu können.

**Die Erweiterung des Lagerbestandes stellt in erster Linie eine gute Möglichkeit dar, kurz- und mittelfristige Versorgungsunterbrechungen zu überbrücken.**

### Lieferantendiversifikation

Durch die Diversifizierung der Lieferantenbasis können Unternehmen die Abhängigkeit von einzelnen Lieferanten verringern und die Gefahr von Lieferengpässen und -unterbrechungen reduzieren. Eine international diversifizierte Lieferantenbasis ermöglicht zudem, dass flexibel z. B. auf politische Ereignisse wie Exportrestriktionen einzelner Länder reagiert werden kann. Der Einsatz der Strategie trägt zur Erhöhung der Wettbewerbsfähigkeit bei, da durch ein größeres globales Lieferantennetzwerk die Konkurrenz unter den Lieferanten – mit positiven Folgen auf den Preis und die Qualität der Produkte – erhöht werden kann. Zudem führt der Austausch mit vielen Lieferanten zu einer deutlich verbesserten Markttransparenz, Marktvergleichbarkeit und Marktverständnis. Gemäß der Auswertung der Umfrageergebnisse wird diese Strategie bereits sehr stark in den Unternehmen angewandt. Für die nächsten drei bis fünf Jahre planen die Unternehmen die Diversifikation der Lieferantenbasis noch weiter auszubauen. Erlebte Transportengpässe und Marktturbulenzen infolge der Covid-19-Pandemie oder aufgrund politischer Spannungen sind primäre Gründe für die zunehmende Relevanz dieser Strategie in den befragten Unternehmen. Hindernisse für die erfolgreiche Nutzung dieser Strategie sind vor allem die Identifizierung passender Lieferanten und der erhöhte Aufwand für die Kontrolle und Abstimmung mit einer größeren Anzahl an Lieferanten. Für die erfolgreiche Implementierung sind eine detaillierte Kosten-Nutzen-Analyse und ein Qualifizierungsprozess bei der Aufnahme von neuen Lieferanten von zentraler Bedeutung. Bei der Auswahl von Lieferanten ist es ratsam, umfassende Scorecards zu verwenden, die nicht nur ökonomische, sondern auch soziale und ökologische Aspekte mit einbeziehen. Des Weiteren empfiehlt es sich, IT-Schnittstellen mit den Lieferanten einzurichten, um den automatisierten Austausch von Informationen in Echtzeit zu ermöglichen sowie den Koordinations- und Überwachungsaufwand zu reduzieren.

**Die Diversifikation der Lieferantenbasis ist gemäß den befragten Unternehmen die effektivste Strategie, um die Rohstoffversorgung sicherzustellen.**

### Langfristige Lieferverträge

Mittels einer gezielten Ausgestaltung von Laufzeitklauseln in Lieferverträgen kann eine langfristige Versorgung mit Rohstoffen gesichert werden. Neben der mengenmäßigen Absicherung können auch die Preise über verschiedene Preisregime, wie beispielsweise mithilfe von Preisunter- und -obergrenzen, indexierten Preisen, Festpreisen oder komplexeren Preisanpassungsformeln, abgesichert werden. Langfristige Lieferverträge stellen nicht nur ein geeignetes Instrument zur langfristigen Absicherung der Versorgung und Preise dar, sondern sind in ihrer Ausgestaltung sehr flexibel und können den Bedürfnissen des Unternehmens angepasst werden. Der Abschluss von langfristigen Verträgen ist ein viel genutztes und bewährtes Mittel zur Sicherung der Rohstoffversorgung, das gemäß den befragten Unternehmen auch in Zukunft intensiv genutzt werden wird. Grund für die steigende Relevanz dieser Strategie ist nach den Ausführungen der befragten Unternehmensvertreter die steigende Versorgungsunsicherheit auf den Rohstoffmärkten. Grundsätzlich sind Verträge mit längerer Laufzeit vorteilhaft, um eine dauerhafte Versorgung sicherzustellen; sie gehen aber mit einem Verlust an Flexibilität einher. Die Möglichkeiten der Reaktion auf kurzfristige Marktentwicklungen sind eingeschränkt. Langfristige Verträge verpflichten grundsätzlich zur Abnahme der vereinbarten Rohstoffmengen, auch wenn diese Rohstoffe, beispielsweise aufgrund einer veränderten Nachfrage nach dem Endprodukt des Unternehmens, in geringerem Umfang benötigt werden. Eine zuverlässige Vorhersage des Rohstoffbedarfs sowie eine ausgeprägte Verhandlungskompetenz im Unternehmen sind daher von hoher Bedeutung für eine erfolgreiche Nutzung der Strategie. Dementsprechend empfiehlt sich der Einsatz von Business-Tools, um den zukünftigen Rohstoffbedarf zuverlässig zu ermitteln und eine fundierte Grundlage zur Bestimmung optimaler Vertragslaufzeiten, Abnahmemengen und Preisregime zu schaffen. Generell empfiehlt sich das Verhältnis zwischen langfristigen und kurzfristigen sowie fixen und variablen Verträgen auszubalancieren, um eine gewisse Flexibilität beizubehalten. Des Weiteren kann es sinnvoll sein, externe Unterstützung mit dem Schwerpunkt Verhandlungsführung und Vertragsgestaltung in Anspruch zu nehmen, um die Verhandlungskompetenz auszubauen.

**Langfristige Verträge werden als Strategie zur Absicherung der Rohstoffversorgung aktuell am stärksten von den untersuchten Unternehmen eingesetzt.**

### Einkaufsgemeinschaften

Die Bildung von Einkaufsgemeinschaften ist eine Möglichkeit, die eigene Position durch die gemeinsame Rohstoffbeschaffung mit anderen Unternehmen zu stärken. Dank der Bündelung wächst das Einkaufsvolumen und damit verbessert sich die Verhandlungsposition gegenüber dem Lieferanten, wodurch Preise wie auch die Versorgung vorteilhafter ausgehandelt werden können. Die befragten Unternehmen bilden Einkaufsgemeinschaften derzeit nur in einem geringen Umfang. Allerdings planen mehrere der befragten Unternehmen diese Strategie in den kommenden Jahren stärker zu nutzen. Grund für die steigende Relevanz ist nach Auskunft der Experten die zunehmende Verhandlungsmacht der Rohstoffproduzenten aufgrund der steigenden Knappheit von bestimmten Rohstoffen sowie der steigenden Angebotskonzentration. Durch die Bildung von Einkaufsgemeinschaften soll der zunehmenden Verhandlungsmacht der Rohstoffproduzenten entgegengewirkt werden. Hindernisse für die erfolgreiche Nutzung dieser Strategie sind primär unterschiedliche Interessen zwischen den Partnern sowie die ungewollte Offenlegung von Informationen und Handelspraktiken mit einem Wettbewerber. Für eine erfolgreiche Implementierung von Einkaufsgemeinschaften als Strategie zur Absicherung von Preis- und Versorgungsrisiken ist daher eine partnerschaftliche Sicht auf die Zusammenarbeit mit anderen Unternehmen nötig. Um eine gute und langfristige Zusammenarbeit mit anderen Unternehmen zu gewährleisten, sollten die Motive aller Partner vor Beginn genau analysiert und aufeinander abgestimmt werden. Entsprechend der befragten Unternehmen empfiehlt es sich auch zu prüfen, ob Partnerschaften

**Zur Bildung von Einkaufsgemeinschaften empfiehlt es sich, die Zusammenarbeit mit Unternehmen sowohl innerhalb als auch außerhalb der Branche zu sondieren.**

mit Unternehmen anderer Branchen mit ähnlichen Rohstoffbedarfen eingegangen werden können, um eine ungewollte Transparenz gegenüber den Wettbewerbern zu vermeiden. Nach der Gründung einer Einkaufsgemeinschaft ist eine transparente und offene Kommunikation zwischen allen Beteiligten empfehlenswert, die durch zu Beginn festgelegte Kodizes, Ziele und Prozesse gefördert wird. Des Weiteren empfiehlt sich, zu prüfen, ob die Zusammenarbeit auch in anderen Bereichen ausgebaut werden kann (z. B. gemeinschaftliche Recyclinganlage), um weitere Vorteile erschließen zu können. Dabei sind die Regeln des Wettbewerbsrechts zu beachten.

### Projekte zur Reduzierung des Materialeinsatzes

Die Reduzierung des Materialeinsatzes zielt auf eine Verbesserung des Output-Input-Verhältnisses durch Materialeffizienzsteigerung ab. Die Reduktion ist die Folge einer Anpassung des Produktdesigns, technischer Innovationen oder der schrittweisen Verbesserung der Herstellungsverfahren. Der geringere Bedarf wirkt sich dabei positiv auf das zu beschaffende Rohstoffvolumen und somit auf das Beschaffungs- und Preisrisiko aus. Während Projekte zur Erhöhung der Materialeffizienz derzeit in den befragten ausländischen Unternehmen nur in einem geringen Ausmaß durchgeführt werden, planen die Unternehmen entsprechende Projekte in den nächsten drei bis fünf Jahren erheblich auszuweiten. Ein Grund für die steigende Relevanz ist nach Aussage der befragten Unternehmen das Bestreben nachhaltiger zu wirtschaften. Der Trend zu mehr Nachhaltigkeit verändert Gesellschaft und Wirtschaft grundlegend und ist in den Zielen vieler befragter Unternehmen verankert. Hindernisse für die erfolgreiche Nutzung dieser Strategie sind vor allem die Kosten und der Zeitaufwand, die mit der Änderung von Produktionsverfahren, mit der Beschaffung von neuen Maschinen und mit der Entwicklung von Innovationen verbunden sind. Für den erfolgreichen Einsatz dieser Strategie ist generell eine Offenheit gegenüber Innovationen und eine Kultur der permanenten Verbesserung im Unternehmen von großer Bedeutung. Dementsprechend empfiehlt es sich, Bemühungen von Mitarbeitenden, die zur Erhöhung der Materialeffizienz beitragen, zu fördern und z. B. finanziell zu belohnen. Des Weiteren sollten Taskforces gebildet und digitale Lösungen unterstützend eingesetzt werden, um Fehlerquellen und Ineffizienzen zu erkennen und Optimierungen vornehmen zu können. Daneben ist es ratsam, sich über Beratungs- und Förderinitiativen zu informieren, die von staatlichen Institutionen (u. a. auch vom BMWK in Deutschland) bereitgestellt werden.

**Bemühungen von Mitarbeitenden, die zur Erhöhung der Materialeffizienz beitragen, sollten gefördert und bspw. finanziell belohnt werden.**

### Recyclingprojekte

Recycling beschreibt den Prozess der Wiederverwertung von Materialien aus Produktionsabfällen und aus Produkten, die ihr Lebensende erreicht haben. Das Recyceln von Materialien führt zu einer Abnahme der Nachfrage nach dem Primärrohstoff und verringert somit die Abhängigkeit von dessen Verfügbarkeit sowie von den entsprechenden Lieferanten und Lieferketten. Zudem verbessern Projekte dieser Art oft die Reputation des Unternehmens. Der Recyclingprozess kann intern wie auch von spezialisierten Unternehmen ausgeführt werden. Während Recycling aktuell im Vergleich zu den anderen untersuchten Strategien wenig zum Einsatz kommt, planen die befragten Unternehmen in den nächsten drei bis fünf Jahren die Nutzung dieser Strategie stärker auszubauen. Gründe für die steigende Relevanz sind nach Meinung der befragten Unternehmensvertreter auch der gesellschaftliche und politische Druck zum Wandel zu einem nachhaltigeren Wirtschaften. Barrieren für die erfolgreiche Nutzung dieser Strategie sind vor allem niedrige Rückführungsquoten, Qualitätsverluste bei recycelten Materialien sowie wirtschaftliche und technologische Grenzen. Um Recycling erfolgreich einsetzen zu können, muss eine geeignete Infrastruk-

**Um Recyclingprojekte erfolgreich umzusetzen, sollten Allianzen mit anderen Unternehmen geprüft werden.**

tur für die Rückführung von Produkten vorhanden sein. Des Weiteren ist entscheidend, dass die Qualität des recycelten Materials dem des Ursprungsmaterials möglichst nahekommt und für die Entwicklung entsprechender Recyclingtechnologien und -prozesse ausreichend fachliche und finanzielle Kapazitäten vorhanden sind. Grundsätzlich empfiehlt es sich bei der Produktentwicklung bereits auf die spätere Recycelbarkeit zu achten. Vor dem Hintergrund der hohen Investitionsaufwendungen, kann es zudem ratsam sein, Allianzen mit anderen Unternehmen oder Zulieferern einzugehen, um Netzwerke für die Sammlung von Altprodukten aufzubauen oder gemeinsam Recyclinganlagen zu errichten. Des Weiteren sollten die internen Prozesse zur Sammlung, Aufbereitung und Wiederverwertung von Produktionsabfällen laufend unter Berücksichtigung von Best-Practice-Konzepten und verbesserten Technologien optimiert werden.

### Substitutionsprojekte

Substitutionsprojekte beziehen sich auf den Austausch von kritischen Rohstoffen durch andere Rohstoffe mit dem Ziel, die Abhängigkeit vom ursprünglich eingesetzten Rohstoff dauerhaft zu verringern und somit Preis- und Versorgungsrisiken zu minimieren. Durch die Substitution von Rohstoffen können auch die Abhängigkeit von bestimmten Lieferanten reduziert und Nachhaltigkeitsziele realisiert werden. Zudem können sich neue Marktpotenziale durch die Innovation, die eventuell mit der Substitution einhergeht, ergeben. Während derzeit vergleichsweise wenige der befragten Unternehmen versuchen, kritische Rohstoffe zu substituieren, planen viele Unternehmen in den nächsten drei bis fünf Jahren die Strategie verstärkt zu nutzen. Nach Auskunft der befragten Unternehmensvertreter nimmt die Relevanz dieser Strategie durch die wachsenden Schwierigkeiten bei der Beschaffung bestimmter kritischer Rohstoffe und durch die zunehmende Aufmerksamkeit für Fragen der Nachhaltigkeit in der Gesellschaft zu. Dementsprechend versuchen Unternehmen auch, Substitute zu entwickeln, die umweltfreundlicher und nachhaltiger hergestellt werden können. Hindernisse für die erfolgreiche Nutzung sind vor allem die technische Umsetzbarkeit bzw. die Gleichwertigkeit des neuen Produktes und die hohen Entwicklungskosten. Die Substitution von Rohstoffen ist zudem oftmals ein umfangreiches Unterfangen, das beispielsweise auch die Umstellung von Produktions-, Beschaffungs- und Logistikprozessen umfasst. Für die erfolgreiche Umsetzung dieser Strategie sind daher die volle Unterstützung des Managements und die Bereitstellung von ausreichend Ressourcen und Zeit notwendig. Entsprechend sollte im Vorfeld ausgiebig untersucht werden, welche Substitute bereits am Markt verwendet werden und wie weit der Stand der Forschung bzw. der industriellen Umsetzung bei möglichen neuen Substituten ist. Zudem sind weitere Faktoren (technische Eigenschaften, Kosten, Leistungsfähigkeit, Kundenbedürfnisse, Verfügbarkeit des Substituts, Nachhaltigkeitsaspekte etc.) in der Analyse zu berücksichtigen. Zur Reduzierung des Kapitalaufwandes sollte geprüft werden, ob staatliche Zuschüsse in Anspruch genommen werden können. Entsprechende Förderprogramme werden in Deutschland unter anderem vom Bundesministerium für Bildung und Forschung (BMBF) und vom Bundesministerium für Wirtschaft und Klimaschutz (BMWK) bereitgestellt. Des Weiteren empfehlen sich die Prüfung der Zusammenarbeit mit staatlichen Forschungsinstituten und Hochschulen oder die Bildung von Forschungsallianzen mit anderen Unternehmen. Kooperationen mit staatlichen Forschungsinstituten und Hochschulen wurden von den befragten Unternehmen als besonders vorteilhaft bewertet.

**Aus der Kooperation mit Hochschulen und Forschungseinrichtungen bei der Entwicklung von Substituten erwachsen Vorteile für alle Beteiligten.**

### Vertikale Integration

Die vertikale Integration beschreibt die Erweiterung der Geschäftsaktivitäten innerhalb des eigenen Wertschöpfungsnetzwerkes. Es wird generell zwischen dem Umfang der Ausweitung (bspw. Mehrheitsbeteiligung), der Art und Weise der Ausweitung (Gründung oder Zukauf von Unternehmen) und der Richtung der Ausweitung (vorgelagert oder nachgelagert) unterschieden. Mit der Beteiligung an vorgelagerten Unternehmen können Versorgungs- und Preisrisiken durch den direkten Zugang zu den entsprechenden Materialien und Produkten langfristig abgesichert werden. Insbesondere sind dabei Beteiligungen an Zulieferern, Materialverarbeitungsunternehmen, Bergbaubetreibern und Recyclingunternehmen von Relevanz. Die Beteiligung an Bergbauentwicklungs- sowie Explorationsprojekten stellen weitere Möglichkeiten dar, um sich den Zugang zu kritischen Ressourcen frühzeitig zu sichern. Gemäß der Auswertung der Umfrageergebnisse wird die vertikale Integration von den befragten ausländischen Unternehmen kaum genutzt. Sie stellt die am wenigsten genutzte Strategie dar. Auch in der zukünftigen Planung der befragten ausländischen Unternehmen spielt sie keine bzw. nur eine untergeordnete Rolle. Die geringe Nutzung der Strategie ist vor allem in dem hohen Kapitalaufwand, dem Verlust an Flexibilität sowie der hohen Komplexität in der Übernahme und Integration von Unternehmen begründet. Die Umfrageergebnisse zeigen auch, dass Unternehmen besonders zurückhaltend sind, wenn es um die Beteiligung an Bergwerken und Bergbauprojekten geht. Neben dem hohen Kapitalaufwand wird dies von den befragten Unternehmen unter anderem dadurch begründet, dass ihr Hauptgeschäftsmodell zu weit vom Geschäftsmodell eines Bergbaubetriebes entfernt ist und die entsprechenden Kompetenzen fehlen. Zudem werden die wirtschaftlichen Risiken und die Gefahr von Reputationsschäden bei der Beteiligung an Bergwerken als besonders hoch eingestuft. Ausreichend finanzielle Ressourcen, umfassendes Fachwissen und eine anpassungsfähige Organisationsstruktur sind ausschlaggebend für eine erfolgreiche Implementierung der Strategie. Aus Sicht der befragten Unternehmen empfiehlt es sich, umfangreiche Make-or-Buy-Analysen durchzuführen, um damit die Umsetzbarkeit der Strategie und den optimalen Umfang wie auch die Art und Weise der Integration bestimmen zu können. Bei der Analyse sollten interne Faktoren, wie der Rohstoffbedarf des Unternehmens, die Kosten, die Expertise und die Integrationsfähigkeit aber auch externe Faktoren wie der Effekt auf die Reputation des Unternehmens und die Qualität der Rohstoffe berücksichtigt werden. Des Weiteren müssen die infrage kommenden Unternehmen, deren wirtschaftliche Lage und die zu erwartenden Cashflows sowie das Marktumfeld ausgiebig analysiert werden. Die dafür nötigen Fachkenntnisse sollten z. B. durch Trainings und gezielte Neueinstellungen aufgebaut und durch den Einbezug von externen Quellen (u. a. spezialisierte Beratungs- sowie Rechtsanwaltsgesellschaften) ergänzt werden. Insbesondere bei Beteiligungen an Bergbauprojekten empfiehlt es sich für die Finanzierung und Abdeckung von wirtschaftlichen und politischen Risiken, sich über Förderungen von staatlichen Institutionen, staatlichen Kreditinstituten sowie Kredit- und Investitionsversicherungsagenturen zu informieren. In den untersuchten Ländern werden entsprechende Vorhaben vonseiten des Staates oftmals gefördert. Auch in Deutschland gibt es entsprechende Unterstützungen, wie z. B. die staatlichen Garantien für Ungebundenen Finanzkredite (UFK-Garantien), welche Kredite für Rohstoffvorhaben gegen wirtschaftliche und politische Ausfallrisiken im Gegenzug zum Abschluss von Lieferverträgen absichern. Des Weiteren können auch deutsche Direktinvestitionen in Entwicklungs- und Schwellenländern gegen politische Risiken mittels der Investitionsgarantien des Bundes abgesichert werden. Ein weiteres Beispiel ist die anteilige Kostenübernahme von Machbarkeitsstudien durch die Deutsche Investitions- und Entwicklungsgesellschaft (DEG).

**Bei der Beteiligung an Bergbauprojekten und ähnlichen Vorhaben der direkten Absicherung sollte geprüft werden, ob staatliche Fördermaßnahmen genutzt werden können.**

## Business-Tools

Business-Tools sind alle IT-Applikationen die zur Verbesserung der Entscheidungsfindung für Managementprozesse wie beispielsweise in der Planung, Messung, Bewertung, Prognose und Überwachung genutzt werden können. Im Einkauf können mittels dieser Tools verschiedenste KPIs wie der Rohstoffbedarf, die Verfügbarkeit von Rohstoffen, die Lieferzuverlässigkeit, Preise und andere Faktoren berechnet, überwacht und prognostiziert werden. Zudem können die Lieferanten über entsprechende Tools und eine gemeinsame IT-Schnittstelle integriert werden, was wiederum einen direkten automatisierten Informationsaustausch und die Überwachung des Materialflusses ermöglicht. Business-Tools bieten damit die Möglichkeit zur Überwachung und Steuerung des Einkaufs in Echtzeit. Sie können sowohl als Frühwarnsystem wie auch zur Optimierung des langfristigen Einkaufs verwendet werden und somit sowohl Preis- wie auch Versorgungsrisiken minimieren. Während Business-Tools zurzeit mit moderater Häufigkeit und Intensität genutzt werden, wird deren Nutzung in den kommenden drei bis fünf Jahren bei den befragten Unternehmen stark steigen. Die Auswahl an nützlichen Tools ist aufgrund von Fortschritten in der Informationstechnologie (z. B. in den Bereichen Big Data Analytics, Automatisierung, Cloud Computing und Predictive Analytics) in den letzten Jahren enorm gestiegen. Getrieben durch diesen Fortschritt sowie aufgrund der größeren Verfügbarkeit an Daten nimmt die Relevanz dieser Strategie in den befragten Unternehmen stark zu. Hürden für die erfolgreiche Nutzung der Business-Tools sind die Wahl der richtigen Softwarelösungen sowie die Integration in die bestehende IT-Infrastruktur. Für eine erfolgreiche Nutzung ist es daher wichtig zu verstehen, wie relevante Daten generiert werden können, wie die vorhandenen Daten verarbeitet werden können und welche Bedürfnisse durch die Nutzung des Business-Tools erfüllt werden sollten. Um dies zu erreichen, sollten in einem ersten Schritt Status-quo- und Anforderungsanalysen ausgeführt werden, welche sich mit dem Ziel der Applikation und mit den Anforderungen befassen sowie die Datenverfügbarkeit in quantitativer und qualitativer Hinsicht und die derzeitige IT-Infrastruktur berücksichtigen. Des Weiteren sind bei der Beschaffung von Softwarelösungen Faktoren wie die Skalierbarkeit, Anpassbarkeit, Kompatibilität, Implementierungsaufwand, Support, Wartung und Sicherheit zu prüfen. Je nach Umfang und Komplexität kann es nach Auskunft der befragten Unternehmen ratsam sein, externe Unterstützung für den Auswahl- und Implementierungsprozess zu engagieren. Für die Implementierung sowie effektive Nutzung der Business-Tools ist eine abteilungsübergreifende Zusammenarbeit zwischen den IT-Abteilungen und den Beschaffungsabteilungen nötig, die z. B. durch Workshops oder auch strukturell durch die Implementierung von IT-Businesspartnern gefördert werden kann.

**Getrieben durch die zunehmende Verfügbarkeit von Daten und das Angebot an fortschrittlichen IT-Tools am Markt werden Business-Tools verstärkt unterstützend bei der Sicherung der Rohstoffversorgung eingesetzt.**

## Strategieentwicklung und -umsetzung

Für die Implementierung bzw. Optimierung der im Unternehmen verwendeten Absicherungsstrategien empfiehlt es sich, einen ganzheitlichen iterativen Prozess im Unternehmen zu implementieren. Dieser geht von der Definition der Ziele über die Auswahl des passenden Strategiemixes und der richtigen Implementierung bis zur Überwachung und Anpassung der Strategien. Dabei sollten auch das Unternehmensökosystem sowie generelle äußere Einflüsse wie z. B. politische, soziale, technologische oder ökologische Trends berücksichtigt werden. Bei der Definition von Zielen sollten der Status quo (intern sowie extern) umfangreich analysiert werden sowie die Versorgungs- und Preisrisiken für die jeweiligen Rohstoffe bestimmt werden. Die Analyse des Status quo umfasst u. a. die Bestimmung des eigenen Rohstoffbedarfs, der damit verbundenen Kosten, der unternehmensinternen Anforderungen sowie die Untersuchung der Wettbewerber, der Kundenanforderungen, der Lieferanten und der generellen Marktentwicklungen. Hier emp-

**Ein ganzheitlicher iterativer Prozess zur fortlaufenden Prüfung und Anpassung der genutzten Absicherungsstrategien sollte eingeführt werden.**

fehlt sich auch der Einsatz von entsprechenden Business-Intelligence- und Analytics-Tools. Die Ziele sollten möglichst klar, spezifisch, messbar, realistisch und zeitlich abgesteckt definiert werden. Basierend auf den Zielen, den organisatorischen Gegebenheiten und dem zeitlichen Horizont erfolgt die Bestimmung des passenden Strategiemixes. Bei der Auswahl der Strategien sind die einzelnen Chancen und Herausforderungen der jeweiligen Strategien zu berücksichtigen. Generell empfiehlt es sich, verschiedene Strategien miteinander zu kombinieren, um kurz- und langfristige Preis- und Versorgungsrisiken absichern zu können. Für die Umsetzung der Strategien sollten die Verantwortlichkeiten im Unternehmen geregelt sein und die benötigten Ressourcen bereitgestellt werden. Während der Implementierungsphase ist vor allem eine offene und klare Kommunikation vom Topmanagement, zwischen den einzelnen Abteilungen und zu den externen Partnern nötig. Dazu sollten abteilungsübergreifende Teams und Schnittstellen für die Implementierung einzelner Strategien gebildet werden. Ein enger und kooperativer Austausch mit den Lieferanten sollte zudem gefördert werden. Bei der Überwachung und Anpassung der Strategien sollte mittels quantitativer und qualitativer KPIs die Erreichung der definierten Ziele bewertet und bei Bedarf die Nutzung der ausgewählten Strategien angepasst werden. Des Weiteren empfiehlt es sich, bei der Ausgestaltung und Umsetzung bestimmter Strategien nicht nur entlang der eigenen Wertschöpfungskette zu schauen, sondern auch das gesamte Unternehmensökosystem zu betrachten und z. B. Forschungs- und Entwicklungsallianzen mit Unternehmen aus anderen Branchen, mit staatlichen Institutionen oder NGOs einzugehen. Zudem sollten externe Trends in die Strategiebestimmung und -ausführung miteinbezogen werden. Beispielsweise empfehlen sich die Entwicklung einer unternehmensweiten „Environmental, Social and Governance (ESG)“-Agenda und ihre Anwendung auf die gesamte Lieferkette.

### **Ausblick und Trends**

Die Untersuchung der Rohstoffsicherungsstrategien zeigt, dass einige bereits erkennbare Trends die Rohstoffbeschaffung in den nächsten Jahren beeinflussen werden. Es wird vermutet, dass die Komplexität der Rohstoffmärkte aufgrund voranschreitender Globalisierung bei gleichzeitig zunehmender (Re-)Nationalisierung steigen wird. Dies könnte darin begründet sein, dass die Märkte in Zukunft vernetzter werden, während der Protektionismus einzelner Staaten zunimmt. Aufgrund der Kritikalität gewisser Rohstoffe, ist davon auszugehen, dass das Bestreben lokale Rohstoffquellen abzuschirmen in Zukunft zunehmen wird. Dieser Protektionismus führt möglicherweise zu veränderten Wettbewerbsbedingungen und Verfügbarkeiten in der Rohstoffbeschaffung. Des Weiteren könnte die erwartete Vernetzung der Marktteilnehmer zu einer verstärkten Interdependenz zwischen Abnehmern, Lieferanten und weiteren Stakeholdern führen. Die globale Verflechtung könnte somit die Sensibilität des Marktes gegenüber unvorhersehbaren Ereignissen erhöhen. Ein Exempel bot sich jüngst, als die Ever Given 2021 den Suezkanal für sieben Tage blockierte. Dies lies weitere 150 Schiffe verspätet ihre Frachten ausliefern, was wiederum zu Verzögerungen bei den adressierten Abnehmern führte. Darüber hinaus besteht die Vermutung, dass Preisvolatilität und eingeschränkte Rohstoffverfügbarkeiten die Märkte beeinflussen werden. Aufgrund globaler Entwicklungen wie dem Bevölkerungswachstum, der Urbanisierung, dem technologischen Fortschritt oder der Energiewende ist es denkbar, dass die Nachfrage gewisser Rohstoffe deren Angebot kurzfristig übersteigt. Die Transparenz über die Rohstoffverfügbarkeiten und deren Preise wird durch die Vernetzung, Digitalisierung und Automatisierung steigen, jedoch präzise Vorhersagen aufgrund der Preisvolatilität vermutlich erschweren. Außerdem wächst der Druck zur Einhaltung von Nachhaltigkeitsstandards im Wertschöpfungsnetzwerk bereits heute. Die ESG-Agenda der Unternehmen dient als Performance Indikator und Bewertungsmaßstab für potenzielle Geschäftsbeziehungen. Umfangreiche unternehmerische Maßnahmen werden notwendig, um die eigene unternehmenseigene ESG-Agenda auszubauen. Massive Investitionen in die Reduktion des CO<sub>2</sub>-Fußabdruckes entlang der Wertschöpfungskette sowie der Ausbau interner und externer Recycling-Verfahren und Anlagen könnten zukünftig im Fokus stehen. Aufgrund der starken Dynamiken im Rohstoffmarkt müssen sich Unternehmen flexibler und agiler aufstellen. Zur Sicherung von Rohstoffbedarfen und -preisen gewinnen eine adaptive Wertschöpfungskette sowie ein resilientes Instrumentenportfolio an Bedeutung.

## Summary

### Background and objectives

Primarily driven by increasing population, economic growth, urbanisation and technological development, global demand for raw materials has been increasing for decades (WELLMER et al., 2019; DERA, 2020). The energy transition, the growth of e-mobility and the ongoing process of digitalisation are also driving up demand for raw materials (MARSCHIEDER-WEIDEMANN et al., 2021). For example, it is predicted that electrification in the automotive industry will cause demand for lithium to quadruple and demand for cobalt to double by 2026 (BMWK, 2020a). Alongside structural increases in demand for raw materials, repeated global crises and political events have had a significant impact on reliability of raw material supplies. For example, the Covid-19 pandemic and international trade disputes have triggered widespread disruption in supply chains and created tensions in commodity markets. The risk of price increases and of raw material shortages is further exacerbated by the uneven distribution of raw material deposits around the world, which means that reserves and production of some critical raw materials are concentrated in certain regions. To secure access to raw materials, companies compete globally – with corresponding effects on prices (ACATECH et al., 2017). For example, lithium carbonate is primarily mined in Chile, Argentina and Australia. Because supply has been increasing much more slowly than demand, the average annual price of this material increased by 306% between 2012 and 2021, from USD 6,607 per tonne to USD 20,228 per tonne (BLOOMBERG, 2021). German companies are particularly dependent on foreign producers, as very few key raw materials are available from domestic sources (BGR, 2020). A reliable supply of a wide range of raw materials is crucial if companies are to manufacture competitive products and remain at the cutting edge of technological development (BMUB, 2016; BMWK, 2021a). Securing supplies of raw materials is thus becoming an increasing focus for many companies, and strategies to reduce price risk and supply risk are becoming ever more important.

The aim of this study is to analyse how companies outside Germany secure their supplies of raw materials, which strategies they are currently using and plan to use in the future, and which opportunities and challenges are associated with these strategies. Based on this analysis, the study then identifies success factors and recommendations for action for German companies. To obtain the necessary primary data, a survey and expert interviews were conducted with representatives of companies from seven different industrialised nations: Japan, South Korea, Canada, the US, France, Italy, and the UK. The survey and the interviews were focused on companies from the manufacturing, automotive and telecommunications industries. In total, supply chain experts and executives from 59 companies responded to the survey, and 44 experts were interviewed. The primary objective of the survey was to identify trends in usage of specific raw material strategies, and factors influencing the choices of strategies which companies make. The interviews looked into the reasons for using certain strategies, implementation of the strategies, the opportunities and challenges inherent in the strategies, and details of the circumstances and factors required for successful use of the strategies. Secondary research was also undertaken to augment the findings of the survey and the interviews. Based on this, the study identifies and presents recommendations for action for each individual strategy and for the overall strategy development and implementation process.

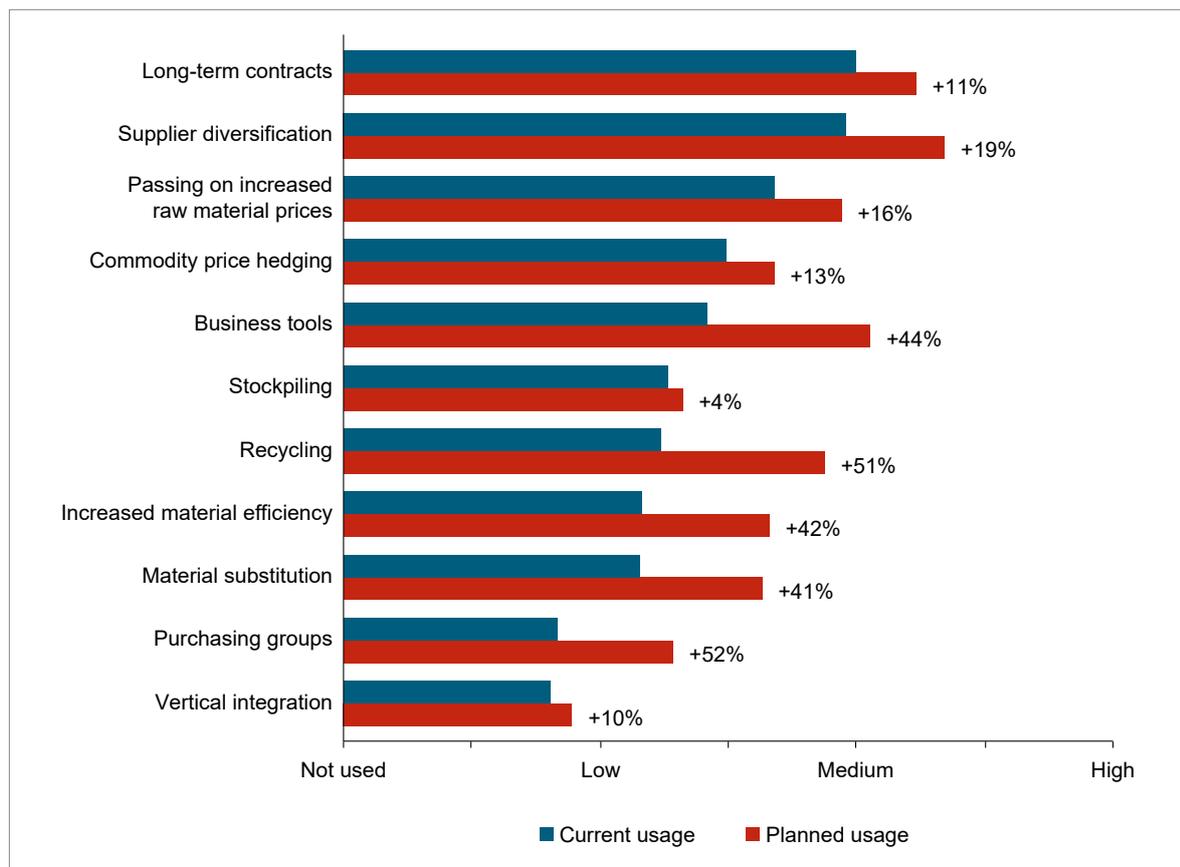
#### Raw material strategies

- Commodity price hedging
- Passing on increased raw material prices to the customer
- Stockpiling
- Supplier diversification
- Long-term contracts
- Purchasing groups
- Increased material efficiency
- Recycling
- Material substitution
- Vertical integration
- Business tools

**Raw material strategies examined**

Figure 2 shows the extent to which the individual raw material strategies are currently used among the companies surveyed, and the extent to which these companies are planning to use the strategies over the next three to five years. Supplier diversification and long-term contracts are the most widely used strategies. The survey respondents also considered these strategies to be the most effective in securing their company’s supply of raw materials. In contrast, vertical integration only plays a minor role due to the high capital investments required and the high uncertainty involved. Looking at future usage, a clear trend can be seen towards strategies that contribute to sustainability (such as increasing material efficiency, recycling and material substitution). Another noticeable upward trend is in the use of IT-powered business tools in raw material procurement. This is being driven by technological developments, such as big data analytics, artificial intelligence (AI), cloud computing, blockchain and predictive analytics.

Overall, the companies surveyed are planning to increase their usage of all eleven strategies over the next three to five years. The issue of reliable raw material procurement has become more relevant in the companies surveyed, and they are planning to increase their focus on raw material strategies to ensure a reliable supply of materials and mitigate price risk. Detailed explanations of each raw material strategy can be found below, including reasons for using the strategy, opportunities and challenges, success factors, and key recommendations for action.



**Figure 2: Usage of strategies for securing raw material supplies in the companies surveyed**

### Commodity price hedging

Companies can hedge commodity price risk using a wide range of hedging instruments, such as futures, forwards, options and swaps. Application of this strategy can be relatively flexible, enabling flexible hedging of price risk and thus allowing more dependable planning in the company. Hedging is already one of the most widely used strategies in the companies surveyed, and its use is expected to further increase in the next three to five years. According to the experts interviewed, hedging is becoming an increasingly important strategy because price volatility in the commodity markets is expected to rise further and because of the general trend towards risk management in many companies. The main challenges for successful use of commodity price hedging are lack of expertise and perceived lack of suitable hedging products for some commodities. For successful implementation, companies need to acquire the necessary know-how, establish an effective internal organisation and ensure cooperation between departments; the strategy should be planned at the company level and pooled for all purchases. Use of a multidisciplinary skills team of experts from various departments to determine the best hedging positions is therefore recommended. It is also advisable to carry out comprehensive market research and to use business analytics tools for price forecasting and to determine the company's future raw material needs.

**The increasing variety of hedging products on the market makes it possible to hedge price risk for many commodities.**

### Passing on increased raw material prices to the customer

Passing on increased commodity prices to customers (also known as price pass-through) enables companies to mitigate price risk in the short term. Because it can be implemented quickly, price pass-through is a flexible strategy for protecting company profit margins and preventing losses. Price pass-through is currently one of the most widely used strategies among the companies surveyed, and they are planning to increase use of this strategy over the next three to five years; this is due to the flexibility of the strategy and because further price increases are expected. High levels of competition in the sales markets and the price pressure that this creates are the main challenges when passing on prices. Successful price pass-through requires a detailed analysis of the sales market and transparent communication with customers. It is therefore advisable to use analytical business tools to observe and forecast price developments and price sensitivity on the market to enable better prediction of how competitors and customers will react to price increases. If increased prices are to be passed on to the customer, it is advisable to clearly communicate the reasons behind the increased selling prices to the customer. This should increase acceptance among customers. In general, hasty price increases should be avoided in order to prevent losing market share to competitors.

**When passing on increased prices, the reasons for doing so must be clearly communicated to customers to ensure acceptance.**

### Stockpiling

Stockpiling enables companies to cope with short- to medium-term bottlenecks in the supply chain and better manage market turbulence or shortages of raw materials on the market. This enables production to continue, even if unforeseen adverse developments occur in the raw materials market. Increased stocks of raw materials also enable faster response to customer requests, accelerating the order-to-cash cycle. However, the companies surveyed only make moderate

**Stockpiling is primarily a good way to bridge short- and medium-term supply chain disruption.**

use of stockpiling, and they do not plan to significantly increase their use of this strategy in the future: this is due to the increased storage costs and tied-up capital associated with stockpiling, and the risk of being left sitting on large quantities of raw materials. To successfully apply this strategy, companies need to be in a position to reliably plan their raw material needs, so it is advisable for companies to thoroughly analyse their customers, the demand for their products, and the raw materials required. An advanced enterprise resource planning (ERP) system (including business analytics tools) should therefore be used to produce reliable demand forecasts and monitor key performance indicators (KPIs). Another possible option is to increase storage of unprocessed raw materials on the supplier's premises, rather than storing processed materials on company premises: this would increase flexibility to respond to changes in demand or changing customer needs.

### Supplier diversification

Diversifying suppliers enables companies to reduce their dependence on individual suppliers and reduce the risk posed by shortages or supply chain disruption. If companies have a range of suppliers across multiple countries, this strategy also makes it possible for companies to react flexibly to unforeseen events. These include political developments such as export restrictions imposed by individual countries. Supplier diversification can help increase competitiveness, as a larger global supplier network can increase competition among suppliers – with positive effects on both the price and the quality of the raw materials. Interaction with a large number of suppliers also makes markets significantly more transparent, comparable and understandable for companies. The companies surveyed already make heavy use of supplier diversification, and they are planning to further increase their use of the strategy over the next three to five years. This is primarily due to previous experience of transport disruption, market turbulence due to the Covid-19 pandemic, or political tensions. The main challenges when using this strategy are identifying suitable suppliers and dealing with the increased complexity involved in monitoring and coordinating a larger number of suppliers. Companies should undertake cost-benefit analyses and carefully evaluate new suppliers to ensure success of this strategy. When selecting suppliers, it is advisable to use comprehensive scorecards, including social and environmental considerations in addition to purely economic aspects. Companies are also advised to set up IT interfaces with their suppliers to enable automated exchange of information in real time and to reduce the effort involved in coordination and monitoring.

**According to the companies surveyed, supplier diversification is the most effective strategy for securing their supply of raw materials.**

### Long-term contracts

Longer-term supply contracts are a strategy which aims to ensure continuous supply of raw materials. As well as guaranteeing supply of the required quantity of raw materials, various mechanisms to secure prices can also be used in long-term contracts, such as price floors, price caps, indexed prices, fixed prices or more complex price adjustment mechanisms. The structures of long-term contracts are very flexible and can be adapted to company needs. They are widely used and are a tried-and-tested means of securing raw materials. The companies surveyed are planning to further increase their use of this strategy in the future, due to growing supply risk on the raw material markets. In general, contracts with longer terms increase reliability of supply; however, they go hand in hand with a loss of flexibility. Potential to react to short-term market developments is limited, and long-term contracts generally oblige the company to purchase the agreed quantities of raw materials, even if a change in demand for the company's end product means that the full quantity is no longer needed. Reli-

**Long-term contracts are currently the most used strategy among the companies surveyed.**

able forecasting of raw material needs and good negotiating skills within the company are therefore key to the success of this strategy. Accordingly, companies are recommended to make use of business tools to reliably determine future raw material needs and to create a foundation for identifying optimal contract periods, quantities and price regimes. In general, it is advisable to balance usage of long-term, short-term, fixed and variable contracts to maintain a degree of flexibility. External support with a focus on negotiation and contract design may also be helpful for developing negotiating skills.

### **Purchasing groups**

Purchasing groups are alliances of multiple companies in which the companies' raw material needs are pooled and jointly procured. They provide a way for individual companies to strengthen their positions in negotiations with suppliers: purchasing groups procure larger quantities of raw materials than any one of their members would, giving extra bargaining power to obtain better prices and other conditions. The companies surveyed currently only use this strategy to a small extent, but several companies are planning to increase their usage of this strategy in the coming years. According to the experts interviewed for this study, purchasing groups are becoming a more popular strategy due to the increasing bargaining power held by raw material suppliers, which in turn is due to the increasing scarcity of certain raw materials and the increasing concentration of supply among a small number of producers. Purchasing groups are intended to counteract these trends. The main challenges of this strategy are the complexity of the preparation process, differing goals among group members, and the risk of unwanted disclosure of information and trading practices to competitors. Therefore, a collaborative spirit is necessary for successful implementation of this strategy. To ensure productive and sustainable collaboration, the intentions of all partners should be analysed in detail and coordinated before joining or establishing a purchasing group. The interviewees recommended working with companies from other sectors to avoid sensitive information being disclosed to competitors. Once a purchasing group is established, transparent and open communication between all members is very important; this can be promoted by codes of conduct, goals and processes established at an early stage. It is also sensible to examine whether collaboration can be expanded to cover other areas (e.g. joint recycling plants), as this has the potential to create further synergies. Of course purchasing groups have to act within the framework of the valid competition law.

**When forming purchasing groups, it is advisable for companies to consider partners both inside and outside their own industry.**

### **Increased material efficiency**

Material efficiency describes how much material is used and wasted to make a product, with high material efficiency indicating low levels of waste and overall material usage. Increased material efficiency leads to lower consumption of raw materials per product: this means that smaller quantities of raw materials need to be procured, thus reducing the company's exposure to supply risk and price risk. Material efficiency can be increased by technical innovation, modifying product designs, or gradual improvement of manufacturing processes. Although the companies surveyed are not currently using this strategy to a very great extent, they are planning to increase their level of usage considerably in the next three to five years. According to these companies, the desire to improve sustainability is a key reason for the increasing relevance of material efficiency. The trend towards sustainability is fundamentally changing both society and the economy, and is now widely found in corporate goals. The main challenges involved in material efficiency projects are the costs and time required to innovate, change production processes and buy new machinery. For this strategy to succeed, it is very important for

**Efforts by employees to increase material efficiency should be encouraged and (financially) rewarded.**

companies to be open to innovation and to have a culture of continuous improvement. Accordingly, it is advisable to encourage and reward efforts by employees to increase material efficiency; rewards may be financial or non-financial. Internal task forces should be established to identify potential for improvement, which can be achieved using business tools to help reveal sources of error and inefficiency. It is also advisable to check whether advice and support is available from state institutions, such as the German Federal Ministry for Economic Affairs and Climate Action (BMWK).

### Recycling

Recycling describes the process of reusing waste generated in the production process and material from products that have reached the end of their lives. Recycling reduces the quantity of primary (non-recycled) raw materials that a company needs, thus making the company less dependent on suppliers, supply chains and availability of these materials. In addition, recycling projects often improve the company's reputation. Recycling can be carried out internally or by external specialists. Although this strategy is currently not very heavily used, the companies surveyed are planning to significantly increase their usage of this strategy over the next three to five years. According to the company representatives interviewed, this is mainly due to social and political pressure to move towards a more sustainable economy. The main challenges involved in recycling are low recycling rates, lower quality of recycled materials, and economic and technological feasibility. For successful recycling, companies need to develop suitable infrastructure for customers to return end-of-life products. It is also crucial that the quality of recycled materials is as close as possible to that of the original materials, and sufficient technical and financial capacity must be available for developing recycling technologies and processes. Recyclability should be considered early, ideally at the product development stage. Recycling requires heavy investment, so it may be advisable to enter alliances with other companies or suppliers to establish networks for collecting end-of-life products, or to set up joint recycling plants. Companies also need to continuously improve internal processes for collecting, treating and recycling waste, considering best practices and improved technologies.

**For successful recycling, companies should consider alliances with other companies.**

### Material substitution

Material substitution refers to the replacement of critical raw materials with alternatives, with the aim of making the company less dependent on the raw material originally used and thus minimising price risk and supply risk. Substituting raw materials can also make the company less dependent on individual suppliers and help achieve sustainability goals, and the innovation involved may create new market potential. Although comparatively few of the companies surveyed are currently trying to develop substitutes for critical raw materials, many are planning to make greater use of the strategy in the next three to five years. According to the company representatives interviewed, this strategy is becoming more important due to the growing difficulties in procuring certain critical raw materials and the growing focus on sustainability issues in society. Accordingly, companies are also trying to develop substitutes that can be produced more sustainably and with less environmental impact. The main challenges involved in substituting materials are technical feasibility, avoiding loss of quality or essential properties, and high development costs. In addition, material substitution is often a wide-ranging undertaking that also requires changes to production, procurement and logistics processes. Successful implementation of this strategy therefore requires sufficient resources and time, and full support from senior management. Before embarking on a substitution project, compa-

**Cooperation with universities and research institutions in developing substitutes is beneficial for all parties involved.**

nies should therefore extensively investigate which substitutes are already being used on the market, and find out which stage of research or implementation any possible new substitutes have reached. Other factors such as technical properties, costs, performance, customer needs, availability of the substitute and sustainability should also be considered in this analysis. To reduce capital expenditure, companies should investigate whether any government subsidies are available. In Germany, funding for research of this nature is provided by players such as the Federal Ministry of Education and Research (BMBF) or the Federal Ministry of Economic Affairs and Climate Action (BMWK). It is also advisable to consider collaboration with public research institutes or forming research alliances with other companies; the study participants considered collaboration with public research institutes to be particularly beneficial.

### Vertical integration

Vertical integration refers to the expansion of business activities within a company's own supply chain. Vertical integration projects vary by scope of expansion (majority or minority shareholding), means of expansion (founding or acquisition) and direction of expansion (upstream or downstream). Acquiring a stake in upstream companies provides direct access to raw materials or products, enabling long-term mitigation of both supply risk and price risk. Suppliers, material processing companies, mining companies and recycling companies are particularly relevant targets for vertical integration. Involvement in mining development and exploration projects presents further opportunities to secure access to critical resources at an early stage. However, the survey results show that vertical integration is the least used strategy among the companies surveyed, and it is not expected to play any major role in the near future. This is mainly due to the large capital investments, loss of flexibility and considerable complexity inherent in the strategy. The survey results also show that companies are particularly reluctant to invest in mines and mining projects. Alongside the large capital investments involved, one of the reasons for this is that companies often lack the necessary expertise, and have business models too far removed from the business models of mining companies. Mines are also considered to pose particularly high economic risks and risks of reputational damage. Sufficient financial resources, wide-ranging expertise and a flexible organisational structure are crucial for successful implementation of this strategy. Experts advise conducting comprehensive make-or-buy analyses to determine the feasibility of the strategy, along with the ideal scope and means of integration. This analysis should consider internal factors such as the company's raw material requirements, costs, expertise and integration capabilities, as well as external factors such as the effect of vertical integration on the company's reputation and on the quality of the raw materials. The economic situation, expected cash flows and the market environment of potential target companies must also be extensively analysed. Training and targeted recruiting should be undertaken to develop the necessary expertise within the company, supplemented by help from external sources such as specialist consultants and law firms. For mining projects, it is particularly advisable to investigate whether finance or risk coverage is available from government-owned investment banks, development banks, credit insurance agencies or investment insurance agencies. State support is often provided for these projects in the countries examined in this study. In Germany, too, support of this nature is available, such as state guarantees for untied financial loans: these secure loans for mining projects against economic and political default risk. Investment guarantees against political risks are also available from the German Government for German direct investment in developing and emerging countries. The German Investment Corporation (DEG) is another example of a state institution which offers support for mining projects, such as partial funding for feasibility studies.

**Companies looking to get involved in mining and similar projects should examine whether government support is available.**

### Business tools

Business tools are IT applications designed to improve decision-making in management processes such as planning, recording, evaluating, forecasting and monitoring. In procurement, these tools can be used to calculate, monitor and forecast a wide range of KPIs, such as quantity of raw materials needed, availability of raw materials, reliability of supply, and prices. Some tools provide a common IT interface to integrate suppliers, which enables direct, automated exchange of information and monitoring of material flows. Business tools thus enable real-time monitoring and control in procurement. They can be used both as an early warning system and to improve long-term planning, thus helping to minimise both price risk and supply risk. While the companies surveyed currently only make a moderate level of use of business tools, this is set to increase sharply over the next three to five years. This is due to the ever-increasing availability of data and the significant increase in the range of useful tools available in recent years, driven by technological advances in areas such as big data analytics, automation, cloud computing and predictive analytics. Key challenges include choosing the right software solutions and integrating them into existing IT infrastructure. To successfully use business tools, it is therefore important for companies to have an understanding of what they want their solution to achieve, and how to obtain and process the relevant data. To reach this understanding, companies should start by analysing their status quo and their requirements. This will highlight the aim behind using the application and what the company wants from the application, along with the current availability of both qualitative and quantitative data and the current state of the company's IT infrastructure. When procuring a software solution, companies also need to consider factors such as scalability, compatibility, scope for customisation, complexity of implementation, support, maintenance and security. For complex projects, it may be advisable to obtain external support for the selection and implementation process. As well as IT infrastructure, business tools also need appropriate organisational infrastructure to realise their potential: cross-departmental cooperation between the IT department and the procurement department is very important, and should be promoted by means such as workshops or designated IT business partners.

**Driven by the increasing availability of data and the growing variety of advanced IT solutions on the market, business tools are increasingly being used to help secure raw material supplies.**

### Strategy development and execution

To implement or improve their strategies for securing raw materials, companies should implement a comprehensive, iterative process. This spans setting procurement goals, selecting an appropriate mix of strategies and implementing these strategies, right up to monitoring and adjusting the strategies. Companies should consider both the corporate ecosystem and general external factors and trends in this process. When setting procurement goals, companies should comprehensively analyse the status quo (internal and external) and determine the supply risk and price risk for the raw materials in question. Status quo analysis includes determining the company's own raw material needs, the costs involved, and the company's general internal requirements, as well as examining competitors, customer requirements, suppliers and general market developments. Companies are strongly recommended to use appropriate business intelligence systems and analytics tools. As far as possible, procurement goals should meet the SMART criteria: specific, measurable, achievable, realistic and time-bound. The next step is to determine an appropriate mix of strategies, based on the company's procurement goals, its internal circumstances and the timescale in question. It is important to consider the individual opportunities and challenges of each strategy during the selection process. In general, companies are advised to combine different strategies to mitigate both short-term and long-term price risk and supply risk. To implement the strategies, clear responsibilities in the company are important, and the necessary resources must be made available.

**Companies should implement a comprehensive, iterative process to continuously review and improve their raw material strategies.**

During the implementation phase, clear and open communication from senior management, between individual departments and with external partners is particularly important. To achieve this, cross-departmental teams and interfaces should be set up to implement individual strategies. Companies should also promote close and cooperative communication with suppliers. When monitoring and adjusting strategies, both quantitative and qualitative KPIs should be used to assess whether the company's procurement goals have been achieved; if necessary, companies should then alter their selected strategies and how they are used. For some strategies, companies should look beyond their own supply chains to consider their entire corporate ecosystem. This may reveal opportunities such as research and development (R&D) alliances with companies from other sectors, government institutions or non-governmental organisations. External trends should also be factored into the strategy development and execution process. For example, increasing focus on environmental, social and governance (ESG) issues means that it is advisable to develop a company-wide ESG agenda and apply it to the entire supply chain.

### **Outlook and trends**

The examination of raw material strategies undertaken for this study has shown that some trends which are already visible will have a significant influence on raw material procurement in the coming years. Increasing globalisation and a simultaneous increase in focus on domestic raw materials is expected to increase the complexity of raw material markets. Markets might become more interconnected in the future, but individual states may also increase their efforts to protect local sources of raw materials. Protectionism such as this will change the nature of competition on the raw material markets, and may affect the availability of raw materials. Increasing interconnection in raw material markets is also expected to make buyers, suppliers and other stakeholders increasingly dependent on one another. Global interconnection of this nature can increase market sensitivity to unforeseen events. A recent example was the Suez Canal becoming blocked for seven days in 2021 when a cargo vessel, the *Ever Given*, ran aground. This caused another 150 ships to deliver their cargoes late, creating additional delays for huge numbers of customers. Price volatility and limited availability of raw materials are also expected to influence markets. Global trends such as population growth, urbanisation, technological development and the energy transition may lead to demand for some critical raw materials exceeding supply in the short term. Interconnection, digitalisation and automation are likely to increase transparency regarding current availability and prices of raw materials. High price volatility, however, means that these factors are unlikely to become any more predictable. Companies are also under growing pressure to ensure compliance with sustainability standards throughout their supply chains. ESG is already being used as an indicator of performance and as a benchmark to evaluate potential business relationships. Taking ESG seriously requires decisive action from management. The focus in the future will be on the huge investments necessary to reduce carbon footprints from supply chains and to develop internal and external recycling processes and facilities. Finally, the very dynamic nature of the raw material markets means that companies need to become more agile. A flexible supply chain and a resilient portfolio of strategies will be essential to secure a reasonably priced supply of raw materials.

## 1 Introduction

Global demand for raw materials has undergone a sustained increase in recent decades. Consumption of raw materials more than tripled between 1970 and 2017, rising from 27bn tonnes per year to 89bn tonnes per year. By 2060, this figure is forecasted to increase to 167bn tonnes per year (OECD, 2019)<sup>1</sup>. This growth in demand is being fuelled by global population growth, economic growth in emerging markets, and urbanisation. Technological developments and the energy transition are also driving up demand for certain raw materials. Huge quantities of critical raw materials are needed for many key technologies, such as for renewable energy, e-mobility, digitalisation, AI and robotics (UMBACH, 2019). Electrification and digitalisation in almost all areas of life are turning many raw materials into valuable commodities – this applies just as much to industrial metals such as copper, iron and aluminium as it does to other raw materials such as lithium, rare earths, gallium and indium (ACATECH et al., 2017). With demand rising much faster than supply, many raw materials have become significantly more expensive (Hume & Terazono, 2021). The annual average price of lithium carbonate, for example, rose from USD 6,607 per tonne in 2012 to USD 20,228 per tonne in 2021 – an increase of approximately 306% (BLOOMBERG, 2021). The imbalance between supply and demand also means that seemingly minor developments can have a significant impact on prices, resulting in consistently high levels of price volatility.

Alongside ever-increasing demand, political decisions can also have significant effects on the availability and prices of raw materials. State intervention can lead to price increases and shortages of raw materials, such as happened in the rare earths market in 2010. This occurred when China decided to tighten control over domestic production and exports of rare earths, stating that it wanted to reduce rare earth exports by 70% in the second half of 2010 compared to the previous year. This resulted in a sharp rise in prices on the global rare earth markets: the average price of rare earths from China rose from USD 5,589 per tonne in January 2010 to USD 158,389 per tonne

in September 2011, reaching unsustainable levels for industry (MORRISON, W. M. & TANG, R., 2012).

Global crises such as oil crises, financial crises or the Covid-19 pandemic have also highlighted the vulnerability of the commodity markets to external events. The Covid-19 pandemic has had a drastic impact on raw material supply (KUHANATHAN, 2021). Disruption – both in raw material production and logistics – has resulted in shortages, affecting production, sales and financial stability in many companies (SWANSON & SUZUKI, 2020). This shows that industry is heavily dependent on a reliable supply of raw materials throughout the value chain.

The risks of price increases or shortages of raw materials are exacerbated by the concentration of some critical raw materials in a small number of regions. For example, Australia, Chile and China accounted for 87% of global lithium production in 2020 (DERA, 2021). Lithium is a key material for the production of batteries, and is vital for the expansion of e-mobility. Similarly, China alone was responsible for 69% of global production of rare earth minerals in 2018 (DERA, 2021). Rare earths, such as neodymium or praseodymium, are essential for the production of permanent magnets, which are needed in electric motors for hybrid or electric vehicles, and in generators for wind turbines. China also dominates the germanium and tungsten markets, accounting for 84% and 79% of global production, respectively (DERA, 2021). Germanium is needed for fibre-optic cables, while tungsten is used to harden steel and other alloys; the tungsten market has long been characterised by price turbulence, owing to Chinese export restrictions and environmental reforms which particularly impacted tungsten mines and smelters (ROSKILL, 2021a). Cobalt offers yet another example of uneven geographic distribution of critical materials. Like lithium, cobalt is needed for the production of batteries; 72% of the world's cobalt is mined in the Democratic Republic of the Congo (DRC) (DERA, 2021). Mining operations in some countries (such as the DRC) have raised questions around social, environmental, human rights and governance standards.

<sup>1</sup> Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels.

As a leading industrial nation, Germany is heavily dependent on a variety of raw materials, such as copper, iron, aluminium, rare earths, tungsten and cobalt. While many raw materials needed in Germany – such as gravel, sand and lime – can be obtained from domestic sources, Germany has to import most of its metals and industrial minerals (BGR, 2020). The importance of raw material imports for Germany will continue to increase in the future. A reliable supply of a wide range of raw materials is crucial if companies are to produce competitive products and remain at the cutting edge of technological development. Availability of raw materials is also critically important for government initiatives aimed at achieving net zero carbon emissions by 2050, expanding e-mobility and promoting digital transformation (BMUB, 2016; BMWK, 2021a).

A reliable supply of raw materials is therefore essential to keep the German economy competitive. To secure supplies of raw materials, companies worldwide have developed a wide variety of different strategies. Examples include supplier diversification, long-term contracts, stockpiling, recycling, and vertical integration. As outlined above, today's raw material markets are extremely dynamic, making it particularly important for companies to implement effective strategies to anticipate and counteract adverse developments in these markets.

The goal of this study was to analyse how companies outside Germany secure their supplies of raw materials, and to identify recommendations for action for German companies based on this analysis. The study examines which strategies are currently used by the companies surveyed, the extent of current usage, and the extent to which the companies are planning to use these strategies in the future. The study also analyses the effectiveness of the strategies, the opportunities and challenges associated with each strategy, and the critical success factors for each strategy. Based on this analysis, the study provides recommendations for action for each individual strategy and for the overall strategy development and implementation process.

The study is based on a survey, interviews with experts from seven industrial nations, and secondary research. The nations covered in this study are France, Italy, the UK, the US, Canada,

Japan and South Korea. These countries have industries similar to those in Germany, including the manufacturing, automotive and telecommunications industries. As a result, the approaches used by the companies examined in this study are likely to be suitable for German companies as well. The study focuses on these key industries, and covers base metals, minor metals, iron and steel alloys, precious metals, lightweight metals, battery metals, rare earth elements and industrial minerals. Raw materials which provide energy, such as coal and oil, do not fall within the scope of this study.

The methodology and the structure of the study are further described in Chapter 2. Chapter 3 provides information on the general conditions in the countries examined. Chapter 4 analyses the individual strategies, presents the results of both the quantitative and the qualitative analysis, outlines the critical success factors and provides recommendations for action for each strategy. Chapter 5 introduces the iterative process of developing and implementing a portfolio of strategies, while Chapter 6 concludes the study and provides an outlook.

#### Main strategies identified

- Commodity price hedging
- Passing on increased raw material prices to the customer
- Stockpiling
- Supplier diversification
- Long-term contracts
- Purchasing groups
- Increased material efficiency
- Recycling
- Material substitution
- Vertical integration
- Business tools

## 2 Research and methodology

### 2.1 Fundamental design

The following chapter describes the methodology of this study. As stated in Chapter 1, the goal of the study was to determine the leading strategies for securing raw materials employed in industrial nations, to identify key success factors for effective use of these strategies, and to develop recommendations for action based on this analysis. A number of hypotheses were developed to structure research into the strategies. The overall methodology was structured into four steps, which are outlined in Figure 3.

The **first step** was to define the scope of the study. This involved carrying out a literature review, developing mind maps, identifying examples from real-life companies, and drawing up hypotheses to structure the study and identify relevant topics. A workshop was also held with representatives of German industry associations to discuss and further refine the hypotheses and the scope of the study.

The **second step** involved developing and carrying out a **survey** to gain quantitative information on strategies used by foreign companies to secure their supplies of raw materials, and on factors related to these strategies. The survey was

primarily intended to identify general trends and developments in companies' activities to secure raw materials; it was not designed to obtain statistically significant results. The survey and its results were used as the basis for **expert interviews**, which collected detailed qualitative information on the individual strategies. Implementation of the strategies, opportunities and challenges, critical success factors and recommendations for action were discussed in detail with the experts. The primary research undertaken for this study was complemented by **secondary research**, which drew on scientific publications, business news articles, and studies from academic institutions, companies and other sources.

In **step three**, the insights gained in steps one and two were used to identify trends in the use of the various strategies, reasons for their use, and the opportunities and challenges associated with each strategy. The hypotheses were also evaluated against the evidence obtained in step two. Based on these findings, the conditions and success factors for successful use of the strategies were identified.

In **step four**, recommendations for action were developed for industry based on the results of steps two and three. Recommendations for action were developed for each individual strategy, as well as for the overall strategy development and implementation process.

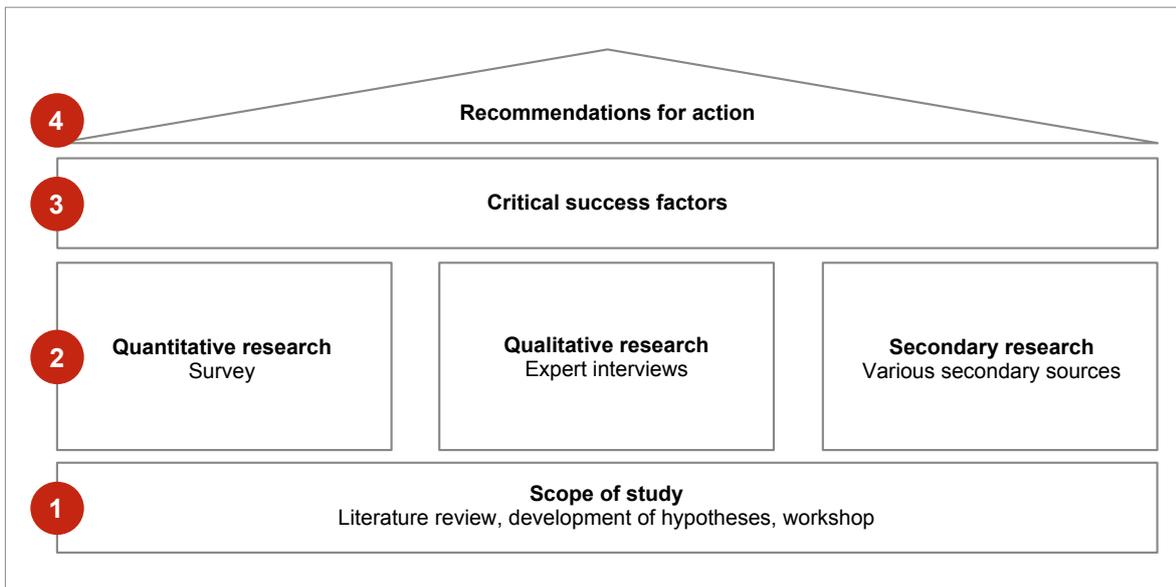


Figure 3: Methodology of the study

## 2.2 Development of hypotheses

The starting point of this study was a series of hypotheses regarding the usage of various strategies for securing raw materials. The process used to develop these hypotheses is outlined in Figure 4.

First, a comprehensive **literature review** was carried out to assemble an underlying body of knowledge. This covered research into resource scarcity, supply chain management and shortage mitigation strategies, strategy execution across different countries and key factors affecting these strategies. The literature review also examined **practical examples** of the various strategies in the selected industries. Sources used in this review included scientific articles, studies performed by research institutes, strategy reports, annual statements, papers from government entities and industry associations, and information published by individual companies.

Next, **mind maps** were drawn up for each strategy to structure and visualise the results of the literature review. Each mind map helped develop a broader understanding of each strategy and elaborate relevant topics and subtopics. The mind map for vertical integration is shown as an example in Figure 5. Based on these mind maps, hypotheses were formulated to serve as a basis for in-depth research into each specific strategy and factors affecting its usage.

Step three involved discussing and refining the hypotheses during a **workshop** with the German Mineral Resources Agency (DERA)/the Federal Institute for Geosciences and Natural Resources (BGR). Experts from selected industry associations were also involved in this workshop, including the Federation of German Industries (BDI), the German Association of the Automotive Industry (VDA), the German Chemical Industry Association (VCI), the Association of German Metal Traders (VDM), the German Electrical Industry Association (ZVEI), the German Mechanical Engineering Industry Association (VDMA) and the German Non-Ferrous Metals Association (WVM). As well as discussing the various hypotheses, the workshop attendees were asked for their assessment of the relevance of the individual raw material strategies for German industry. Potential opportunities and challenges for each strategy were compiled, and the specific areas of focus for the survey were discussed in the workshop.

The final step was to incorporate the feedback received in the workshop into the initial hypotheses to develop the **final hypotheses**. The final hypotheses covered the most important strategies and factors affecting them. Once finalised, these hypotheses then formed the basis of the survey and the expert interviews. A summary of all strategies and the final hypotheses can be found in Figure 6.

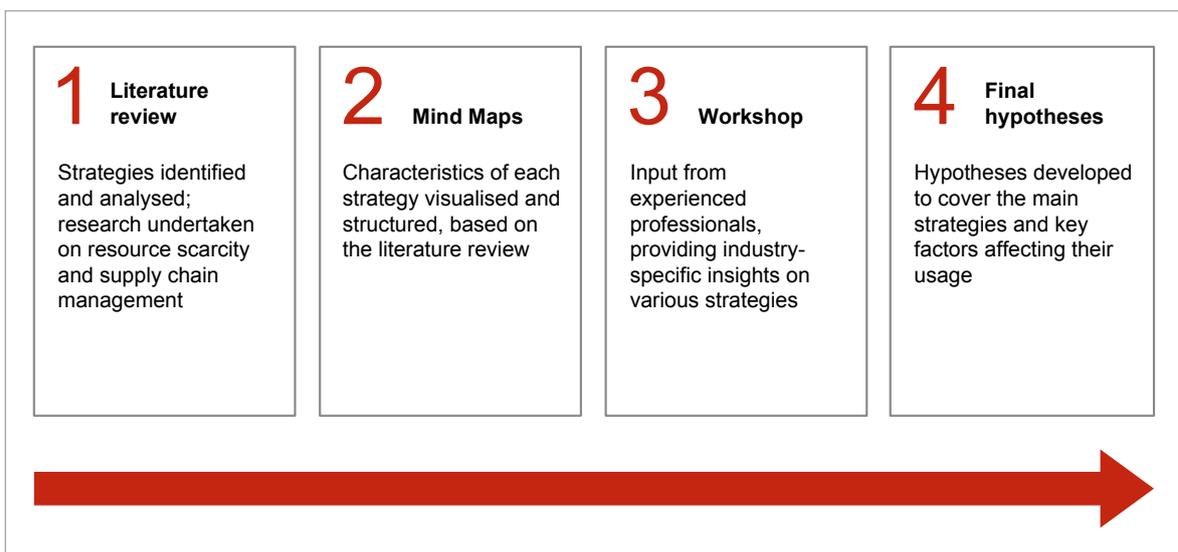


Figure 4: Development of hypotheses





Figure 6: Overview of hypotheses

## 2.3 Survey

The next step was to develop a questionnaire for the survey. The responses to the survey served as the basis for the topics addressed in the expert interviews, and as the foundations of the recommendations for action.

The questionnaire was developed and refined together with DERA/BGR and the industry associations to ensure that the questions were clear and pertinent. The target group was identified using the Capital IQ company database from S&P Global Market Intelligence and refined in coordination with DERA/BGR. The target group selection process is outlined in Figure 7. The first step involved examining Japan, France, South Korea, the US, Italy, Canada and the UK, and selecting the 400 largest companies in each country. Based on the Global Industry Classification Standard (GICS) industry classifications, all companies that could not be assigned to the **automotive**, **manufacturing** or **telecommunications** industries were filtered out. Finally, companies with

limited raw material requirements (e.g. in the telecommunications industry) were also filtered out. This was performed by analysing descriptions of individual business segments. The final selection contained 526 companies, including companies recommended for inclusion by DERA/BGR and the industry associations. To ensure reliable responses, only employees in managerial or executive positions were contacted for the survey; common positions included Global Supply Chain Lead and Commodities Procurement Manager.

The selected companies were contacted either directly or through PwC's network of firms worldwide. The questionnaire was created and monitored using an online survey software package commonly used for analytics.

The questionnaire included comprehensive questions on the strategies, levels of usage of the strategies, and their effectiveness, along with market-specific, country-specific and company-specific factors in the raw material procurement market. The questionnaire included ques-

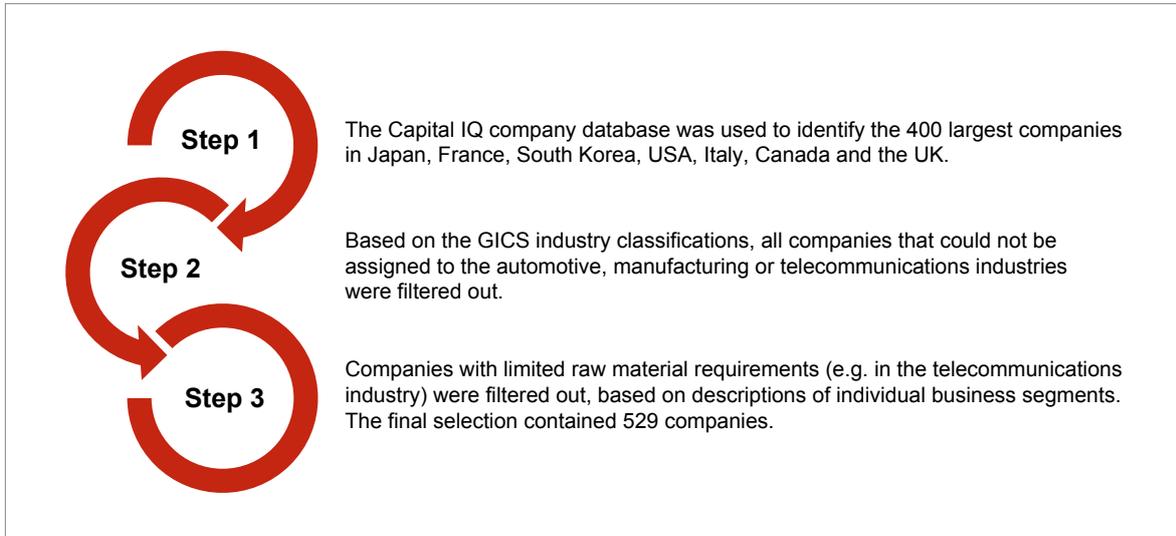


Figure 7: Target group sampling strategy

tions on both current usage of the strategies and on planned usage – indicating current and future trends – and on the effectiveness of the strategies. The respondents were also asked which raw materials were needed in their company, and were asked to assess the price risk and supply risk associated with these materials. Finally, the respondents were asked to assess specific factors which enable or hinder the introduction of specific strategies. Most questions – such as those relating to level of use of the strategies – were structured using a scale, with respondents asked to choose between “high”, “medium” and “low”. A “not applicable” option was also provided to avoid distortion of results in the analysis.

The survey was conducted between February and May 2021; a total of 59 responses were received. As shown in Figure 8, 64% of the companies surveyed had revenues in 2019 between USD 50m and USD 10bn, 29% had revenues between USD 10bn and USD 20bn, and 7% had revenues exceeding USD 20bn. In terms of total assets, 59% of the companies had total assets between USD 400m and USD 10bn, 29% had assets between USD 10bn and 50bn, and 12% had assets exceeding USD 50bn. Under the GICS, 12% of the companies surveyed can be classified as telecommunications companies, 22% as automotive companies and 66% as manufacturers. Among the seven countries targeted, Italian

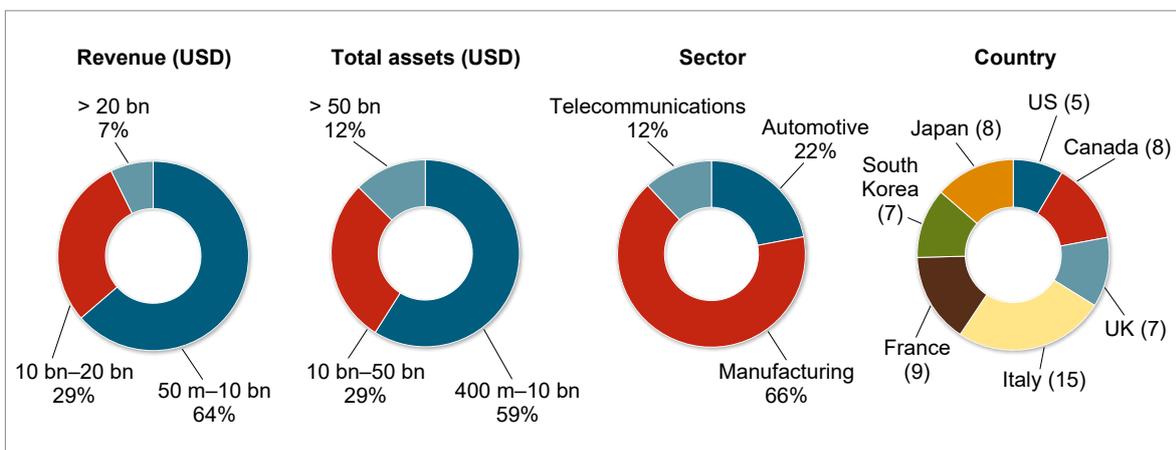


Figure 8: Overview of survey respondents

companies had the highest response rate, with 15 supply chain experts and executives completing the survey. As stated above, the survey was aimed at gaining an initial insight into the usage and effectiveness of the various strategies, rather than examining a representative sample. With between five and fifteen responses per country, the potential for country-specific evaluation is limited. However, the total of 59 responses is sufficient to identify general trends and developments in securing raw materials among non-German companies.

## 2.4 Expert interviews

The issues identified from the responses to the survey formed the basis of the expert interviews. The objective of these interviews was to gain deeper insights into the strategies for securing raw materials used in the selected countries. The interviewees were asked for their expert assessment of reasons for the use of specific strategies, the opportunities and challenges of each strategy, and the conditions and success factors for each strategy. The process of implementing the strategies and recommendations for action were also discussed in the interviews.

This section of the study comprised 44 interviews with experts from all seven countries examined. Thirty-eight of the interviewees were **company representatives**, and the remaining six were representatives of **investors** or specialised investment advisors. The location and affiliation of the interviewees is shown in Figure 9. A comprehensive list of all interviewees who agreed to being identified can be found in the Appendix.

Two different **guideline-based interviews** were developed: one for the company representatives, the other for the investors. The interviews were designed so that the experts had the freedom to highlight key aspects of the strategies. These aspects formed an important basis for assessing current and future relevance, opportunities and challenges, critical success factors, and recommendations for action for the strategies under consideration.

Various strategies and channels were used to contact the experts. Some experts were identified and approached through the global PwC network.

Others were contacted following searches on business social media platforms. The interviews lasted approximately 30 to 60 minutes. All interviews were conducted and recorded as video conferences and transcribed using voice-to-text transcription software. The results of the expert interviews were qualitatively evaluated to identify the critical success factors and recommendations for action for each strategy.

## 2.5 Critical success factors and recommendations for action

Utilising the insights gained in the previous steps, trends in the use of the strategies and reasons for their use were identified. The opportunities and challenges of each strategy were also assessed, and the hypotheses were evaluated. Based on these findings, **critical success factors** and recommendations for action were identified and developed for each individual strategy as well as for the overall strategy development and implementation process. The opportunities and challenges for each strategy are intended to help companies in evaluating the different strategies. The critical success factors aim to define the conditions under which a strategy can successfully be implemented and deliver positive results. This enables companies to assess how well they could implement a given strategy under current conditions and identify which changes would be required for successful implementation. Finally, **recommendations for action** were developed, which provide practical advice for establishing the relevant success factors and implementing each strategy.

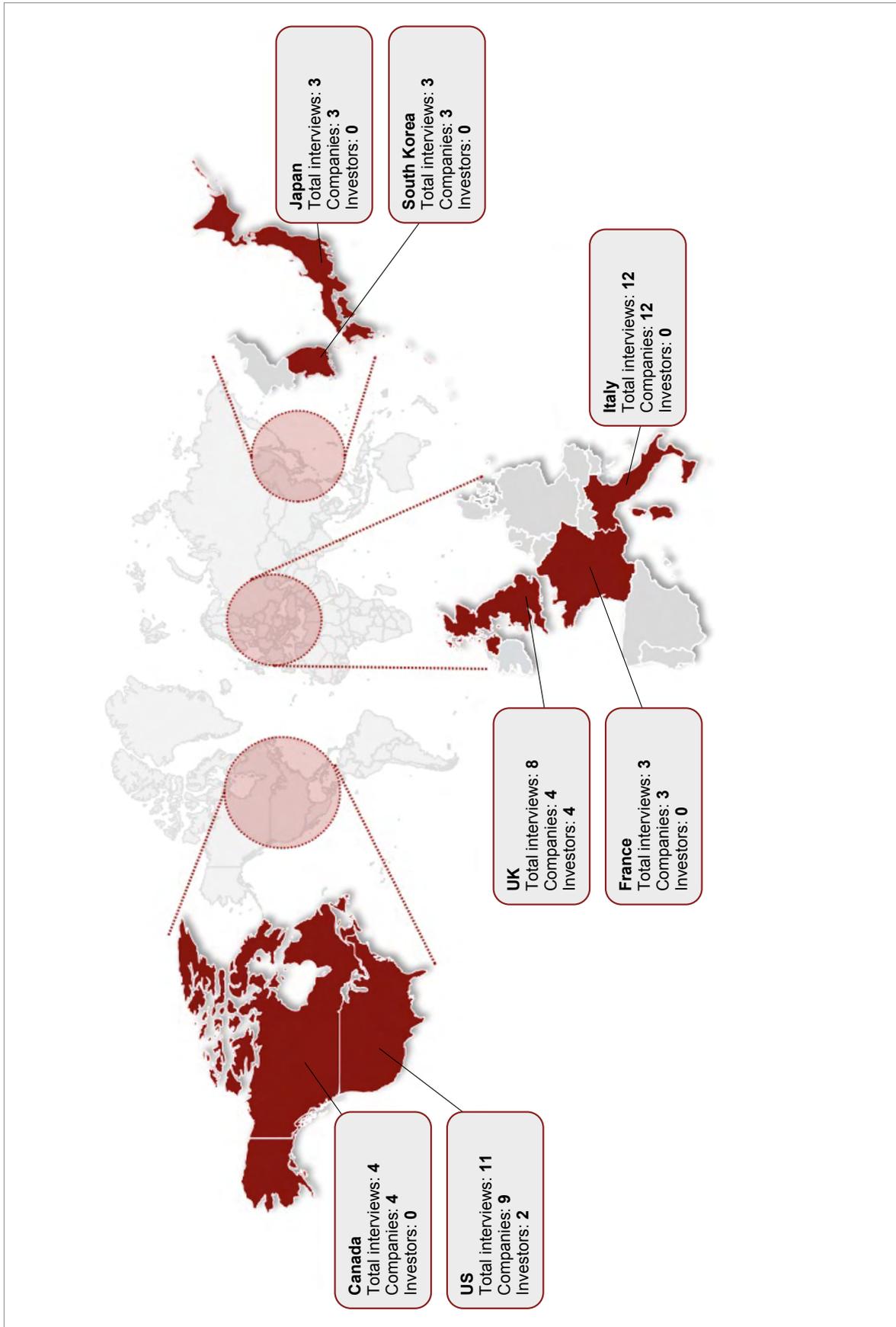


Figure 9: Location and affiliation of interviewees

### 3 General conditions in countries examined

#### 3.1 Japan

##### Country profile

**GDP:**

USD 5.1tn (world's 3<sup>rd</sup> largest)

**Share of GDP generated by industry:**

29.1%

**Top industries:**

transport equipment, automotive, chemicals, telecommunications, food and beverages, tobacco

**Selected resources produced:**

sulphur, salts, bentonite, talc, selenium, titanium sponge

**Resource strategy:**

stockpiling, exploration abroad, marine exploration, recycling, substitution, resource diplomacy

##### Economic situation

Japan is the world's third-largest economy, with a gross domestic product (GDP) of more than USD 5.1tn in 2019 (WORLD BANK, 2021a). The industrial sector generated 29.1% of the country's GDP in 2018 (WORLD BANK, 2021b). Japan's most important industries are the transport equipment, automotive, chemicals, telecommunications, food and beverages and tobacco industries (METI, 2021). A particular characteristic of Japanese industry are keiretsu, which are networks of legally independent companies that have interlocked business relationships and cross-shareholdings, and are centred on a bank which is part of the network. There are horizontal and vertical keiretsu. Vertical keiretsu are also called industrial keiretsu, as they link suppliers, manufacturers and distributors within an industry. Mitsubishi, Sumitomo, Toyota and Mitsui are key examples of keiretsu. Due to their size and degree of interconnection, keiretsu play a major role in Japan's economy (KUTSCHKER & SCHMID, 2010). In 2019, Japan had a trade surplus of 3.4% of its GDP (OECD, 2021a). Its most important trading partners are China, the US and South Korea (OECD, 2021a).

##### Raw materials situation

Japan only has access to small and poor-quality mineral reserves, mainly silver, zinc, lead, copper, sulphur, gold, coal and iron ore, and smaller quantities of other minerals. Mining is a declining industry in Japan with small mines that are not economically viable, except for facilities quarrying limestone and extracting gold (JANSEN et al., 2021). Yearly production of minerals decreased from 7.72m tonnes in 2015 to 7.17m tonnes in 2019 (BMLRT, 2021)<sup>2</sup>. Minerals produced in significant quantities in 2019 included, in nominal figures, 3.33m tonnes of sulphur, 0.93m tonnes of salt and 0.25m tonnes of bentonite (BGR, 2021a). In global terms, Japan was responsible for 27.5% of worldwide selenium production in 2019; this is the only notable figure in this regard (OECD, 2020). Selenium has a variety of technological and medical applications. In 2017, the country's material resource imports (748m tonnes) exceeded exports (114m tonnes) by a factor of 6.6 (OECD, 2021b)<sup>3</sup>. Most base metals and products derived from them are delivered from China and South Korea (WITS, 2020). In terms of rare earth metals, Japan is heavily dependent on imports (YAN & ZHONGXUE, 2019). Deposits of 16m tonnes have been found off-shore in the country's exclusive economic zone at a depth of 6,000m (TAKAYA et al., 2018), but research in this field is still ongoing: new economically viable mining technologies need to be found, and the ecological impact of noise and sediment plumes has not yet been assessed (NATURE RESEARCH CUSTOM MEDIA, 2021).

##### Resource strategy

The key player in Japan's resource strategy is the Japan Oil, Gas and Metals Corporation (JOGMEC), an independent administrative agency under the Ministry of Economy, Trade and Industry (METI). JOGMEC was officially formed in 2004, when the Metal Mining Agency of Japan (established in 1963) and the Japan National Oil Corporation (established in 1967) were merged to become JOGMEC (JOGMEC, 2021). As of 1 July 2021, JOGMEC had 637 employees (JOGMEC, 2021). According to the corporation's 2020 Integrated Report, its total assets amounted to approximately USD 12bn in 2020, while subsi-

2 Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

3 Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

dies and investments in affiliates, including those associated with exploration projects, totalled approximately USD 3.8bn (JOGMEC, 2020).

JOGMEC has a metals strategy and exploration unit within the rare metals stockpile department (JOGMEC, 2021). The mission of this unit is to ensure a stable supply of resources for Japan. To this end, it collects and disseminates geological information, conducts surveys overseas in collaboration with Japanese companies, subsidises surveys, and has been stockpiling raw materials since 1983. In case of shortages or price surges, JOGMEC sells stockpiled resources to mitigate the impact of these events and ensure supply. In addition, JOGMEC enters into farm-in agreements with partners in developing countries that provide property for exploration. These agreements involve JOGMEC acquiring equity options; the options are then transferred to Japanese companies if exploration produces promising results. JOGMEC also supports private mining activities by means of loans, investments and guarantees (KUNITOMO, 2017).

Japan has two major agencies that provide support for foreign trade. Nippon Export and Investment Insurance (NEXI) covers political and commercial risks using export credit and buyer credit insurance, and also offers loan insurance for overseas resource development projects (NEXI, 2021). The Japan Bank for International Cooperation (JBIC) provides loans, overseas investments, guarantees and equity participation in energy and natural resources, infrastructure, and manufacturing projects. Untied loans in particular are offered to finance projects that aim to import goods and secure Japan's supply of raw materials (JBIC, 2021).

In 2017, there were also attempts to excavate deep-sea mineral deposits. Massive sulphide ore was mined on the seafloor and transported to Okinawa. Ecological concerns and economic considerations mean that seafloor excavations have not yet become mainstream practice, although Japan continues to fund research in this field (LUSTY & MURTON, 2018).

Japan has constantly introduced new policy papers and laws since 2001 to enhance recycling and material substitution, among other issues. These include the Rare Earth Recycling Act,

which has led to a nationwide recycling system for rare earths being introduced (MEZ et al., 2019).

On the international level, Japan advocates transparent and open resource markets. The country's foreign policy promotes a free and open economic system, overseas business expansion and resource diplomacy (MOFA, 2021).

In summary, Japan has a proactive resource strategy based on JOGMEC, a multi-purpose state-owned enterprise. Its focus is on securing the country's physical access to critical materials by means such as promoting mining projects abroad and stockpiling. Other measures such as marine exploration, recycling, material substitution and resource diplomacy also support Japan's national resource strategy.

## 3.2 South Korea

### Country profile

**GDP:**

1.6tn (world's 10<sup>th</sup> largest)

**Share of GDP generated by industry:**

32.8%

**Top industries:**

electronics, chemicals, automotive, steel, shipbuilding, telecommunications

**Selected resources produced:**

sulphur, feldspar, talc/pyrophyllite, kaolin, titanium, salt, iron, diatomite, cadmium

**Resource strategy:**

investments and exploration abroad, stockpiling, recycling, research, domestic production

### Economic situation

South Korea has become one of the world's leading industrialised, high-tech countries in recent decades. Having been one of the world's poorest countries after the Korean War, its GDP was USD 1.6tn in 2020, making it the tenth-largest economy in the world (WORLD BANK, 2021a). This unparalleled ascent can be attributed to President Park Chung-hee's industrial policies in the 1960s of subsidising export-oriented industries and promoting domestic production (GRAHAM, 2003). The main factor in the country's economic growth has been chaebols – large industrial conglomerates consist-

ing of many diversified affiliates, often managed by the same family group. Major chaebols include Samsung, LG Group, Hyundai and Hanwha. Due to their size and interconnected nature, the chaebols have a considerable influence on the South Korean economy (JIYOUNG, 2017). In 2019, the country had a trade surplus of 3.6% of its GDP (OECD, 2021a). South Korea's industry generated 32.8% of its GDP in 2020 (WORLD BANK, 2021b), including important sectors such as electronics, chemicals, automotive, steel, shipbuilding and telecommunications (THE HERITAGE FOUNDATION, 2021a). Even though mining is a growing sector in South Korea, 90% of metal ores and concentrates used in the country are imported, as domestic production is insufficient to meet demand (USGS, 2018). China, the US, Vietnam and Japan are South Korea's most important trading partners (OEC, 2021g).

#### Raw materials situation

South Korea has very limited access to domestic mineral deposits. Coal, iron ore, graphite, gold, silver, tungsten, lead and zinc make up two thirds of the country's mineral resources (HAHN et al., 2021). Total annual national production of minerals decreased from 6.27m tonnes in 2015 to 5.06m tonnes in 2019 (BMLRT, 2021)<sup>4</sup>. Minerals produced in significant quantities in 2019 included, in nominal figures, 2m tonnes of sulphur, 0.4m tonnes of feldspar, 0.33m tonnes of talc/pyrophyllite, 0.32m tonnes of kaolin, 0.17m tonnes of titanium content within 0.3m tonnes of rutile/ilmenite, 0.26m tonnes of salt, 0.21m tonnes of iron (in 2018), 0.04m tonnes of diatomite and small quantities of lead, zinc, silver, copper and gold (BGR, 2021a). Cadmium is the only raw material for which South Korea makes a significant contribution to global production – 20% in 2019 (OECD, 2020). Cadmium is needed for nickel-cadmium rechargeable batteries, for solar cells, as a plastic stabiliser, and to protect iron and steel against corrosion (DOL, 2021). In other raw material markets, South Korea has no significant role as a raw material producer.

South Korea is heavily dependent on imports, including imports of rare earth elements, and the

import is therefore vulnerable to geopolitical supply risk. South Korea's two most important trading partners for base metals and products derived from them are China, which provides 31.4% of Korea's base metal imports; and Japan, which provides 20.3% (WITS, 2020). Overall, South Korea imported four times as many material resources (556m tonnes) as it exported (138m tonnes) in 2017 (OECD, 2021b)<sup>5</sup>.

#### Resource strategy

A variety of public institutions are involved with resource security in South Korea. The department in charge of raw material policy is the Office of Energy and Resources of the Korean Ministry of Trade, Industry and Energy (MOTIE) (MOTIE, 2021). An important industry association is the Energy and Mineral Resources Development Association of Korea (EMRD), whose members are state-owned enterprises (e.g. KOMIR, formerly KORES, KEPCO, KOGAS and KNOC), private producers, and consumers. EMRD contributes to South Korea's resource strategy and provides advice and support for implementing the government's resource policies (EMRD, 2021). The state-owned Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR) plays an important role in the practical implementation of the government's strategies.

KOMIR was established in September 2021, when the Korea Resources Corporation (KORES) merged with Mine Reclamation Corporation (MIRECO) (Moody's, 2021). According to the corporation's financial statement, KORES mining assets totalled KRW 978bn (approx. USD 821m) in 2019 (KORES, 2020). After failure of a nickel mine project in Madagascar and a copper mine project in Mexico, KORES merged with MIRECO to form KOMIR (BYUNG-WOOK, 2021a). KOMIR continues to be responsible for developing mining and processing capacity abroad (BARICH, 2021). In the past, KORES provided equity to finance many mines. However, according to a MOTIE official, KOMIR intends to focus more on providing loans to private companies to support exploration and development of mineral deposits abroad. (BYUNG-WOOK, 2021a).

4 Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

5 Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

Other state institutions also provide financing and support alongside KOMIR: the Export-Import Bank of Korea (KEXIM), the Korea Trade Insurance Corporation (K-SURE) and the Korea Trade-Investment Promotion Agency (KOTRA). KEXIM provides export credits to promote exports of goods, as well as loans to support overseas investments and resource development projects (KEXIM, 2021). K-SURE focuses on providing insurance programmes to cover the risks arising from exporting and importing products, or from construction work and investments abroad (K-SURE, 2021). KOTRA advises foreign companies and institutions on investing in and exporting to South Korea (KOTRA, 2021).

In addition to the development of mineral and metal production overseas, state stockpiling is another key component of South Korea's raw materials strategy. The raw materials stockpile is managed by the Public Procurement Service (PPS). PPS is a governmental organisation and is under the control of the Ministry of Economy and Finance. As well as rare and non-ferrous metals, the stockpile also includes construction materials, forest products, recyclable materials and materials required in emergencies. After approval by the Ministry of Economy and Finance, stockpiled materials are released when this is deemed necessary to stabilise prices. Small and medium-sized enterprises (SMEs) in particular can then buy these materials at reasonable prices (PPS, 2020). The South Korean Government has recently announced plans to expand stocks of 35 critical metals from the current average of 56.8 days' supply to an average of at least 100 days' supply as part of its comprehensive industrial policy aimed at achieving a dominant position in the battery industry (HUI, 2021)

Recycling has also become increasingly important in South Korea's raw material strategy. According to Korea's Resource Circulation Plan, which is in force until 2027, the country aims to increase the recycling rate for electrical and electronic products from 6 kg to 8 kg per capita. The plan also sets out objectives for reducing waste and increasing circular material use rates (LEE & CHA, 2021).

South Korea also has various support programmes to promote raw material research and the development of domestic resource deposits. Exploration, research and development are key

tasks for the Korea Institute of Geoscience and Mineral Resources (KIGAM). KIGAM is a government-funded geoscience research organisation, which manages national geological databases and carries out geological surveys. It also helps with mineral exploration by conducting research projects, such as in the Taebaek area of South Korea. In addition, KIGAM develops key technologies for mineral exploration, mining, processing and recycling. For example, KIGAM has developed a technology for recovering metals from electrical and electronic waste (KIGAM, 2021).

In summary, South Korea follows a comprehensive approach focused on securing the country's physical access to critical materials by supporting companies conducting mining projects abroad and stockpiling critical materials. The strategy is similar to Japan's. Recycling, research and the promotion of domestic production also play a role in the strategy.

### 3.3 Canada

#### Country profile

**GDP:**

USD 1.6tn (world's 9<sup>th</sup> largest)

**Share of GDP generated by industry:**

24%

**Top industries:**

mining, food, chemicals, petroleum, metal products, machinery, transportation equipment

**Selected resources produced:**

iron, potash, salt, sulphur, aluminium, gypsum, natural diamonds, niobium, palladium, nickel

**Resource strategy:**

supporting domestic mining industry, resource diplomacy

#### Economic situation

Canada's economy has undergone stable growth throughout recent decades. A major contributor to this has been the country's abundant natural resources, particularly oil and natural gas in the western provinces. Another crucial factor is Canada's close relationship with the US, which has led to free trade agreements. A total of 73% of Canadian exports go to the United States and 57% of Canadian imports have their origin in the US. Further

important trading partners include China, Mexico and the UK (OEC, 2021b). Canada has the world's ninth-largest GDP, which totalled USD 1.6tn in 2020 (WORLD BANK, 2021a), and the country had a small trade deficit of 2.1% of its GDP in 2019 (OECD, 2021a). Important industries include mining, automotive, petroleum, and forest products (THE HERITAGE FOUNDATION, 2021b). Industry generated 24% of Canada's GDP in 2017 (WORLD BANK, 2021b).

### Raw materials situation

Canada plays a prominent role in the global natural resources market. Thanks to its favourable geology, Canada is one of the world's leading mineral producers and has access to numerous resources across the Canadian Shield, the Appalachians and the Western Cordillera, although resources are distributed unevenly. Domestic deposits include asbestos, cadmium, coal, copper, diamonds, gold, iron ore, lead, nickel, petroleum, potash, silver, sulphur, titanium, uranium and zinc. Mining has been a key driver of the country's development, with public infrastructure often built explicitly for the mining industry (HALL et al., 2021; NRCAN, 2019).

Yearly national production of minerals increased from 447.93m tonnes in 2015 to 499.04m tonnes in 2019 (BMLRT, 2021)<sup>6</sup>. In nominal figures, Canada produced 31.5m tonnes of iron in 2018, and 12.27m tonnes of potash, 11.94m tonnes of salt, 6.94m tonnes of sulphur, 2.85m tonnes of aluminium and 2.83m tonnes of gypsum in 2019 (BGR, 2021a). The country produced 32.4% of the world's potash (mainly used in fertilisers), 25.3% of the world's natural diamonds (used in industrial applications and as jewels or ornaments) and 10.3% of the world's niobium (improves the strength of alloys and is used in jet engines, rockets, in construction and on oil rigs) in 2019 and is, therefore, one of the world's leading producers (OECD, 2020).

Canada exports a large share of the minerals it produces. In 2017, the country exported 2.3 times as many material resources (506m tonnes) as it imported (217m tonnes) (OECD, 2021b)<sup>7</sup>. Canada's imports of base metals and base metal prod-

ucts predominantly come from the United States (48.4%) and China (16%) (WITS, 2020).

### Resource strategy

Canada's policies on securing raw materials are shaped by the country's domestic abundance of natural resources and by a political and legal framework that shares responsibilities across the federal system. Consequently, Canada focuses on domestic production and a number of regional initiatives rather than federal safeguards. Although the provinces and regions are ultimately responsible, resource policies are coordinated at the national level.

The provincial governments are responsible for regulating mining within their jurisdictions. Provincial or territorial governments also hold most mineral rights, except for the territory of Nunavut, where mineral rights are held by the federal government (NRCAN, 2021c). Individuals or companies can lease land and commit themselves to mining for raw materials (DOLATA, 2013). The federal government is responsible for making knowledge available and setting binding environmental standards. Federal and regional policies are coordinated at the annual Energy and Mines Ministers' Conference (GOVERNMENT OF SASKATCHEWAN, 2021).

Natural Resources Canada (NRCAN), a federal government department, has drawn up a Critical Minerals List of 31 minerals deemed critical due to their importance for economic security and for Canada's transition to a low-carbon economy (NRCAN, 2021a). Numerous critical minerals on the list – such as cobalt, graphite, lithium and nickel – are abundant in Canada (NRCAN, 2021b).

In 2018, Canada's Minister of Natural Resources and his provincial and territorial counterparts agreed on common strategic directions, compiled in the Canadian Minerals and Metals Plan (CMMP). The plan was published by NRCAN (NRCAN, 2019).

The CMMP sets out various measures to promote a competitive, sustainable and responsible

6 Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

7 Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

minerals and metals industry. These measures include low tax rates in order to facilitate mineral exploration, reliable regulations, investor-friendly access to land, sufficient infrastructure in remote areas and public geoscience. Working together with territorial and provincial bodies, the Geological Survey of Canada (GSC) provides free geoscience knowledge to help public and private players make informed decisions (NRCAN, 2019).

The CMMP is operationalised by a series of action plans, the first of which was published in 2020 and will be followed by further action plans in 2021 and 2022. The action plan is not a binding reference document, but it presents an overview of pan-Canadian initiatives and strategic directions. These strategic directions cover aspects of economic development and competitiveness, concerns of indigenous people, the environment, science and technology, communities, and global leadership. The plan outlines several specific initiatives and various measures at the federal and regional levels. These include funding exploration or development programmes for specific deposits, supporting initiatives to address issues related to orphaned and abandoned mines, launching a mining innovation roadmap to support competitiveness, hosting meetings and tours for international audiences, and harmonising Canada's regional geological surveys (NRCAN, 2020).

The country's foreign policy supports Canadian companies by means of free trade agreements and foreign investment promotion and protection agreements (GAC, 2020). Canada works extensively with countries such as the US, Japan and Australia and with the EU to promote common interests in securing supply chains and strengthening links between Canadian and international companies and investors. To this end, Canada plans and maintains "mineral dialogues" and action plans with these countries.

In summary, Canada's natural resource policy is primarily focused on promoting its domestic mining industry due to the country's wealth of natural resources. Strategic direction is set by the federal government, with policies which include economic, environmental and social factors. Responsibility for promoting the industry and implementing these measures lies with the provincial or territorial governments.

### 3.4 United States

#### Country profile

**GDP:**

USD 20.9tn (world's largest)

**Share of GDP generated by industry:**

18.2%

**Top industries:**

machinery and equipment, chemicals, electronics, automotive, aerospace, petroleum refinery, pharmaceuticals, food processing

**Selected resources produced:**

salt, iron, gypsum/anhydrite, lime, sulphur, kaolin, beryllium, silica, diatomite, bentonite, molybdenum, gypsum

**Resource strategy:**

supporting research and development, enhancing international trade, supporting domestic raw material production, supplying geological data

#### Economic situation

Although the US only accounts for 5% of the world's population, the country generated 24.7% of the world's total GDP – USD 20.9tn in 2020 (WORLD BANK, 2021a). The country's economic success is driven by a free-market economy that allows companies to operate without bureaucratic delays, benefit from a flexible labour market and enjoy low tax rates (WEISBERGER et al., 2021). Industries in the US are highly developed, the most important ones being the machinery and equipment, chemical, electronics, automotive, aerospace, petroleum refinery, pharmaceutical and food processing industries (U.S. CENSUS BUREAU, 2019). The industrial sector contributed 18.2% of the country's GDP in 2019 (WORLD BANK, 2021b); in the same year, the US had a slight trade deficit of 2.2% of its GDP (OECD, 2021a). Canada, Mexico and China are the US's most important international trading partners (OEC, 2021c).

#### Raw materials situation

The US has access to a variety of important mineral resources, including iron ore, copper, magnesium, lead, zinc, gold, silver, molybdenum, manganese, tungsten, bauxite, uranium, vanadium, nickel, phosphates, potash, sulphur, stone and clays (WEISBERGER et al., 2021). From 2015 to 2019, yearly national mineral production increased from 2.16bn tonnes to 2.34bn tonnes

(BMLRT, 2021)<sup>8</sup>. Minerals produced in significant quantities in 2019 included, in nominal figures, 42m tonnes of salt, 31.3m tonnes of iron (in 2018), 20m tonnes of gypsum, 8.71m tonnes of sulphur, 5.06m tonnes of kaolin and large quantities of several other resources (BGR, 2021a). The US made notable contributions to global production of several minerals (OECD, 2020): 68% of the world's beryllium (used to increase electrical and thermal conductivity or as a structural material in satellites, missiles and aircraft), 37.4% of the world's silica (used in construction, for the production of glass and in the chemical industry), 33.8% of the world's diatomite (used in filters for liquids), 25.4% of the world's bentonite (used in construction, mining and for cosmetic products), 15.2% of the world's molybdenum (used in steel alloys to increase strength, hardness and electrical conductivity), 14.3% of the world's gypsum (used in construction, medicine and fine art), 13% of the world's kaolin (used for the production of white porcelain and as a pigment and filler), and 12.7% of the world's perlite (used in construction materials and for insulation of buildings).

With material resource exports of 673m tonnes in 2017, the US is one of the world's largest producers of a variety of resources, but the country's high resource consumption means that it is still dependent on imports (713m tonnes in 2017) (OECD, 2021b)<sup>9</sup>. China was the origin of 19.5% of American imports of base metals and base metal products in 2019, just ahead of Canada, which provided 17.7% (WITS, 2020).

The Department of the Interior (DOI) has recognised the strategic and military importance of resource security and laid out a list of 35 critical minerals in 2018 (DOI, 2018). Many of the 35 critical minerals are produced in the US, but production is often not sufficient to meet the country's high demand. For figures up to 2017, the country was 100% reliant on imports<sup>10</sup> for 14 critical minerals; these included graphite, manganese, niobium, rare earths and tantalum. The US was also 75% import reliant for a further ten critical minerals, including bauxite, potash, uranium and antimony.

Domestic production met more than a quarter of the country's demand for the remaining nine critical minerals (HUMPHRIES, M., 2019).

### Resource strategy

In the United States, several government departments and agencies deal with resource policy. At the federal level, the DOI, the U.S. Department of Energy (DOE), the U.S. Department of Defense (DOD), the U.S. Department of Commerce (DOC) and the Office of the U.S. Trade Representative (USTR) all contribute to resource security. Governmental agencies involved include the U.S. Geological Survey (USGS), the Defense Logistics Agency (DLA) and the Export-Import Bank of the United States (EXIM). Activities undertaken by the USGS include conducting geological research on mineral deposits, mapping geological data, and assessing the environmental impact of mining (USGS, 2021). From a national defence perspective, the DLA is responsible for stockpiling raw materials that can be released for military, industrial and civilian needs if required for defence (DLA, 2018; 2021). Among other things, EXIM supports mining projects, such as Roy Hill Holdings in Australia and Oyu Tolgoi in Mongolia (EXIM, 2021).

Resource security has been recognised as a relevant issue by the US government. The most recent strategy papers dealing with the US's strategy for enhancing resource security were published by the DOC and the DOD. These strategy papers include a variety of different measures and goals. Overall, they can be grouped into four main categories: supporting R&D, enhancing international trade, supporting domestic raw material production, and supplying data (THE WHITE HOUSE, 2021a; DOC, 2019).

In general, the US intends to expand R&D projects for recycling, material substitution and material efficiency. To this end, the country is planning to increase support for R&D in private companies and academic institutions in the next few years by expanding grants, loans and other incentives. Greater promotion of public-private partnerships (e.g. with national laboratories and universities)

<sup>8</sup> Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

<sup>9</sup> Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

<sup>10</sup> "Net import reliance" is a measure of dependence, giving the percentage of a commodity used by the US that has to be imported.

is also a substantial part of government efforts to strengthen R&D.

To promote international trade in raw materials, policies in the US focus on lowering export barriers, expanding production in allied countries, enhancing transparency, and promoting the export of US mining equipment and engineering services through EXIM. To reduce export barriers, the US is increasingly using free trade agreements and challenging unlawful practices under international trade law. To increase the potential for higher raw material imports, US policies aim for closer cooperation with allied countries in resource identification and exploration, R&D, and investment and acquisitions.

Plans in the US to promote domestic raw material production generally involve increasing incentives for local production and reducing bureaucracy. Incentives to promote local production include various different tax credits and exemptions, along with loan instruments such as subsidised interest rates and loan guarantees. Measures to reduce bureaucracy when setting up new extraction facilities focus mainly on revising land-use plans and enhancing transparency – for example, by establishing online systems which track how long it takes public agencies to issue permits.

Efforts in the US to provide more data include data on raw material deposits in the country and on the scarcity of different raw materials. Increasing the number of geological surveys in the US will enable new deposits to be found and developed by private companies, while analysing the scarcity of raw materials on a regular basis helps companies to avoid shortages (THE WHITE HOUSE, 2021a; DOC, 2019).

In summary, the US has large domestic reserves of raw materials but is still reliant on imports. As a result, the US uses various strategies to secure its supply of raw materials. This primarily involves measures to support the American mining industry and to improve geological data. US policy also supports R&D for recycling, material substitution and material efficiency, and promotes international trade to reduce reliance on imports of critical raw materials from certain countries.

## 3.5 France

### Country profile

**GDP:**

USD 2.6tn (world's 7<sup>th</sup> largest)

**Share of GDP generated by industry:**

16.3%

**Top industries:**

automotive, chemicals, metals, mechanical engineering, electronics, food, textiles

**Selected resources produced:**

salt, gypsum, sulphur, feldspar, talc, bentonite

**Resource strategy:**

providing information on critical materials, recycling, research, state guarantees for international mining projects

### Economic situation

France has the world's seventh-largest and Europe's third-largest economy by GDP, generating USD 2.6tn in 2020 (WORLD BANK, 2021a). The French economy is one of the most advanced in Europe, and is known for its technological sophistication, high R&D spending and resilience to external shocks. Domestic demand also plays a key role in the French economy (FITCH SOLUTIONS, 2021). The automotive, chemical, metals, mechanical engineering, electronics, food, and textile industries are the country's most important industries (BERNARD et al., 2021). Industry generated 16.3% of France's GDP in 2020 (WORLD BANK, 2021b). France's most important trading partner is Germany, followed by Belgium, the US and Italy (OEC, 2021d). France had a small trade deficit of 0.3% of its GDP in 2019 (OECD, 2021a).

### Raw materials situation

Although iron ore and bauxite were once produced in France, the metal industry has become unprofitable in recent decades and has declined as a result, with domestic metal supplies being replaced by imports. Apart from stone, sand and gravel, most mineral reserves in France are now depleted (BERNARD et al., 2021). Total yearly mineral production increased only slightly from 11.91m tonnes in 2015 to 12.39m tonnes in 2019 (BMLRT, 2021)<sup>11</sup>. Minerals produced in significant quantities in France in 2019 included, in nominal figures,

<sup>11</sup> Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

5.88m tonnes of salt, 3.26m tonnes of gypsum, 0.5m tonnes of sulphur, 0.5m tonnes of feldspar and 0.35m tonnes of talc (BGR, 2021a). The only mineral for which France makes a significant contribution (6.8%) to global production is talc. Talc is used in cosmetic products, medicinal products and plastic products. The country imported 1.7 times as many material resources (317m tonnes) as it exported (184m tonnes) in 2019 (OECD, 2021b)<sup>12</sup>. In 2019, most French imports of base metals and base metal products came from Germany (19%), Italy (12.1%) and Belgium (11.2%) (WITS, 2020).

### Resource strategy

In France, the Ministry of the Economy and Finance is the main ministry which deals with resource policy. For certain aspects, the Ministry of the Ecological Transition, the Ministry of Armed Forces, and the Ministry for Europe and Foreign Affairs are also involved, along with agencies such as the Agency for Ecological Transition (ADEME) or the French Development Agency (AFD) (SAINT-AUBIN, P., 2019; WASSENBERG, 2013). Another important player is the French Geological Survey (BRGM), which provides scientific research, education and training (BRGM, 2021). Bpifrance, the country's export credit agency and public investment bank, provides state guarantees for international mining projects that are in France's national economic interest (BPIFRANCE, 2021).

According to the Economic, Social and Environmental Council (CESE)<sup>13</sup>, France does not have a comprehensive raw material strategy. However, two committees have been formed to deal with resource security (SAINT-AUBIN, P., 2019). Following the rare earth crisis in 2010, the Committee on Strategic Metals (COMES) was established in 2011 to provide a forum for dialogue and assist the government on resource security issues. Its members are representatives of ministries, public bodies, manufacturers and professional federations. The committee aims to raise awareness and share knowledge of raw material supply risk, and develop recommendations for the public and private sectors. For example, COMES publishes analyses and position papers, supported by the BRGM. These include information such as a

matrix of the criticality of individual materials for the French economy, forecasts of growth in metal consumption, or recommendations to increase recycling of strategic metals in France (MINÉRAL-INFO, 2020). COMES is supported by the French Strategic Committee of Industry (CSF), which was formed in 2018 as part of the French National Council of Industry (CNI). The CSF mainly serves as an advisory board, producing strategy papers for the government. Topics addressed by the CSF include development of standards for responsible mining, digitalisation in the metals industry, reduction of greenhouse gas emissions, and development of an integrated lithium battery recycling industry and other recycling projects. In collaboration with the General Council for the Economy, Industry, Energy and Technology (CGEJET), the CSF also examines the supply of raw materials to French industrial companies (CSF, 2021).

In summary, France's government efforts focus on raising awareness, publishing information and supporting R&D projects, especially in the field of recycling. Support from the French Government is also available for international projects that will provide important raw materials for the French economy, in the form of state guarantees.

## 3.6 Italy

### Country profile

**GDP:**

USD 1.9tn (world's 8<sup>th</sup> largest)

**Share of GDP generated by industry:**

21.5%

**Top industries:**

automotive, textiles, metals, engineering, chemicals

**Selected resources produced:**

salt, feldspar, sulphur, gypsum, kaolin, talc, bentonite

**Resource strategy:**

state-sponsored research, resource diplomacy, providing information

<sup>12</sup> Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

<sup>13</sup> CESE acts as a constitutional consultative assembly which advises the government and parliament, participates in policy development, contributes to reviews of public policies, promotes constructive dialogue with local governments and other countries, and helps to inform the public. CESE helps with development and review of economic, social and environmental policies (CESE, 2021).

### Economic situation

Italy is Europe's fourth-largest economy, with a GDP of USD 1.9tn (WORLD BANK, 2021a). Italy is known for its export-oriented manufacturing industries, particularly the automotive, engineering, chemical, metals, and textile industries (MARINO et al., 2021). In 2019, Italy had a trade surplus of 3.2% of its GDP (OECD, 2021a). The industrial sector accounted for 21.5% of Italy's GDP in 2020 (WORLD BANK, 2021b). The industrialised north is the country's economic powerhouse, contrasting with the south which has a larger agricultural industry (MARINO et al., 2021). Germany and France are Italy's most important trade partners regarding both exports and imports (OEC, 2021e).

### Raw materials situation

Italy is a geologically young country, making it poor in natural resources except for some industrial minerals, rocks, and earth (MARINO et al., 2021). The country's yearly mineral production decreased from 17.8m tonnes in 2015 to 13.95m tonnes in 2019 (BMLRT, 2021)<sup>14</sup>. Minerals produced in significant quantities in 2019 included, in nominal figures, 1.54m tonnes of salt, 2.2m tonnes of feldspar, 0.55m tonnes of sulphur, 0.3m tonnes of gypsum, 0.25m tonnes of kaolin, 0.17m tonnes of talc and 0.08m tonnes of bentonite (BGR, 2021a). Feldspar is the only raw material for which Italy makes a significant contribution (15.4%) to global production (OECD, 2020). Feldspar is used to produce porcelain, dentures and stoneware tiles.

In general, mining plays a negligible economic role in Italy and is more prevalent in the south of the country. Italy once produced notable amounts of pyrites, asbestos, fluorite and salt (MARINO et al., 2021), but the country's mining industry has declined in recent decades, particularly since the 1990s. Thus, Italy is dependent on imports (BENJAMINS & HILPERT, 2013). According to estimates for 2019, Italy imported 2.3 times as many material resources (303m tonnes) as it exported (134m tonnes) (OECD, 2021b)<sup>15</sup>. Germany is Italy's most important source for imports of base metals and base metal products, providing 16.9%;

a further 7.6% come from China and 7.5% from France (WITS, 2020).

### Resource strategy

In Italy, the Ministry of Economic Development (MISE) is the most important public entity for resource policy (MISE, 2021a). As well as direct involvement with government policy, MISE has also founded the Raw Materials Laboratory (LAB-MP) in collaboration with other government entities, research institutes and industry representatives, which deals with raw material scarcity and policy (ISPRA, 2021; BENJAMINS & HILPERT, 2013). The Department of Geological Survey<sup>16</sup> also contributes to Italian raw material policy by collecting geological data and carrying out studies (ISPRA, 2021). Italy's export credit agency, SACE, does not have any dedicated programmes to support projects in the raw material sector (SACE, 2018).

As the highest-ranking governmental authority responsible for raw material matters, MISE takes the lead in bilateral negotiations, in developing policies to secure Italy's supply of raw materials, in dealing with local mining projects and in shaping the framework for the domestic mining sector. MISE also has an impact on operations in the domestic mining sector through the National Mining Office for Hydrocarbons and Geo-resources and the Directorate General for Safety of Mining and Energy Activities. Activities include preparing development plans, authorising and supervising exploration and production projects, and developing safety standards (MISE, 2021b; BENJAMINS & HILPERT, 2013). LAB-MP primarily promotes research and provides a platform for relevant stakeholders, i.e. government entities, research institutes and the mining industry. Additional LAB-MP objectives include collaborating with the EU's Raw Materials Initiative, collecting data on production in the mining sector, and identifying strategic and critical materials. LAB-MP also carries out analyses (e.g. economic development of the mining sector in Italy) and provides recommendations to facilitate policy development (MISE, 2021a). LAB-MP has made various rec-

<sup>14</sup> Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

<sup>15</sup> Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

<sup>16</sup> The Department of Geological Survey is part of the Italian Institute for Environmental Protection and Research, a public research body (ISPRA, 2021).

ommendations to improve national policy on raw materials; these include updating legislation on mining, taxation reforms to facilitate mining activities, and improved public communication about mining (LAB-MP, 2019).

In summary, Italy promotes research on raw material scarcity, encourages coordination with European partners, provides a platform for discussion between private and public organisations, and provides information and holds conferences for knowledge sharing. According to LAB-MP, the country does not have a comprehensive national raw material strategy (LAB-MP, 2019).

### 3.7 United Kingdom

#### Country profile

##### GDP:

USD 2.7tn (world's 5<sup>th</sup> largest)

##### Share of GDP generated by industry:

16.9%

##### Top industries:

food, beverages and tobacco, engineering, chemicals, paper, textiles

##### Selected resources produced:

natural stone, iron ore, salt, limestone, gypsum, kaolin, sulphur

##### Resource strategy:

research, recycling, efficiency

#### Economic situation

The UK is known for its service sector, including its large financial sector. The service sector generated 72.8% of British GDP in 2020 (WORLD BANK, 2021c). With a total GDP of USD 2.7tn, the British economy is the second largest in Europe, just ahead of France. As in other western countries, the service sector has gained importance in the UK in recent years. However, industrial production still accounted for 16.9% of British GDP in 2020, with the most important industries being the food, beverages and tobacco, engineering, chemical, paper, and textile industries (WORLD BANK, 2021b;

BARR et al., 2021). Agriculture, forestry, fisheries and other industries account for the remainder of the country's GDP. Germany is the UK's largest import partner, accounting for 12.9% of the country's total imports, and the second-largest export partner (9.9%) after the US (14.5%) (OEC, 2021f). The UK has an overall trade deficit of 3.1% of its GDP (OECD, 2021a).

#### Raw materials situation

Domestic mineral deposits, especially metals, are very limited in the UK. Iron ore mining has essentially been abandoned. Domestic mining continues for tin, serving half of the country's demand, and zinc. The UK has ample reserves of non-metallic resources and construction materials such as sand, gravel, limestone, clay and crushed rock (BARR et al., 2021). From 2015 to 2019, yearly mineral production decreased from 95.1m tonnes to 89.41m tonnes (BMLRT, 2021)<sup>17</sup>. In nominal figures, the UK produced 4.7m tonnes of salt, 1.4m tonnes of gypsum, 0.72m tonnes of kaolin and 0.13m tonnes of sulphur in 2019; the country does not make a significant contribution to global production of any mineral (BGR, 2021a). In 2019, material resource imports (270m tonnes) exceeded material resource exports (149m tonnes) by a factor of 1.8 (OECD, 2021b)<sup>18</sup>. Among base metal and base metal product imports in 2019, 15% were sourced from Germany and 12% from China (WITS, 2020).

#### Resource strategy

Resource security is mainly seen as the responsibility of private-sector players in the UK (POST, 2019). The main government institutions dealing with resource policy are the Department for Business Innovation & Skills (BIS), the Department for Environment, Food & Rural Affairs (DEFRA) and the Department for Business, Energy & Industrial Strategy (BEIS). Another government organisation involved with resource strategy is the British Geological Survey (BGS). The BGS is one of the world's leading geological surveys, providing geological data, research, and work on related economic, environmental and social issues (BGS, 2021). The UK's export credit agency, UKEF, has no particular focus on supporting projects in the raw material sector. In 2021, 1.8% of the projects

<sup>17</sup> Raw materials covered in these statistics include iron and ferrous alloys, non-ferrous metals, precious metals, industrial minerals and mineral fuels. The statistics refer to crude ore or concentrate produced from it, but indicate the quantity of recoverable valuable elements and compounds (BMLRT, 2021).

<sup>18</sup> Material resources covered in these statistics include metals (ferrous, non-ferrous), non-metallic minerals (construction minerals, industrial minerals), biomass (wood, food) and fossil fuels (OECD, 2021b).

supported by UKEF were related to the mining and quarrying sector (UKEF, 2021).

The UK Government currently has no overall national resource strategy (POST, 2019). However, in 2018, DEFRA outlined plans to revive its 2012 Resource Security Action Plan (POST, 2019; DEFRA, 2018). The measures in this plan primarily aimed to facilitate a high degree of recovery of critical materials from secondary sources, to improve waste management and to support innovation and research. Specific actions included creating an Innovation Challenge Fund for closed-loop projects in local economies, launching a new critical resources dashboard, and establishing an industry-led consortium to improve government-industry linkages to address resource opportunities and issues (DEFRA & BIS, 2012). In particular, the focus on reusing waste, funding research and improving data on raw materials was revisited by DEFRA in a policy paper in 2018. This policy paper envisages the UK moving towards a circular economy, minimising waste and promoting resource efficiency. Accordingly, the paper contains many measures aimed at improving recycling rates in the UK, incentivising consumers to purchase sustainable products, banning plastic products and tackling waste-related crime. To stimulate innovation in resource efficiency, the UK continues to operate research funds and has modified research priorities for government research departments. The UK also supports authority- or industry-led business clusters that aim to increase resource efficiency. To address resource security, the UK is expanding initiatives to improve government oversight of supplies of raw materials critical to the British economy and material supply chains required to meet the UK's wider clean growth targets. Following a successful initial phase, a project to create a national "datahub" on the availability of raw materials and secondary materials will also be continued (DEFRA, 2018).

In summary, the UK Government's efforts focus on recycling, sustainable use of raw materials and support for innovation and research. The state plays a minor role in securing raw material supplies in the UK (POST, 2019). However, DEFRA's reinvigoration of measures to improve resource security in its 2018 policy paper shows that the subject has become more of a political priority in recent years.

## 4 Investigation results

### 4.1 Critical raw materials

Reliable access to commodities is a growing concern, both within the EU and around the world. Critical raw materials are raw materials which are of great economic importance and are also subject to price risk and supply risk (e.g. due to concentration of reserves in a small number of countries).

In this study, company representatives were asked to state their company's five most important non-fuel raw materials and to give an assessment of the risks of price increases and shortages of these materials. Figure 10 shows the most common raw materials together with their average price risk and supply risk, as rated by the respondents.

Copper was the raw material with the greatest difference between price risk and supply risk. The respondents assessed its supply risk at between low and medium, but its price risk was more than twice as high. As Goldman Sachs described in a 2021 research paper, copper is as valuable as oil (SNOWDON et al., 2021). This is due to its many applications in wiring, piping, batteries and motors. The CRU Group predicts that there will

be a supply deficit of 5m tonnes by 2030 as the energy and transport sectors transition to renewable energy (ATTWOOD, 2021). To address this shortfall, significant investment in copper mines will be required. Copper pricing has been difficult to predict in the past due to regulations and taxes imposed in top producing countries, such as Chile and Peru. Chile's share of global production has decreased to 28%, but South America remains the most important copper-producing region. The DRC has now become the top producer in Africa, indicating a general trend of copper production shifting to unstable and high-risk countries (DORNER, 2020).

Aluminium is also a key raw material for the energy transition and supply shortages are expected to arise, despite it being the most abundant metal in the Earth's crust. Aluminium is used in lightweight applications, such as vehicles, and in solar energy systems – for example, in mountings and frames for photovoltaic panels (IEA, 2020). Aluminium is produced from bauxite, a sedimentary rock which is first refined into aluminium oxide. Bauxite is primarily mined in Australia, Guinea, China, Brazil, Indonesia and India. However, global supply of refined aluminium oxide and aluminium hydroxide is dominated by China, which accounts for 56% of global output (DERA, 2021). China also accounts for approximately the same proportion of global demand, and has recently shifted to become a net

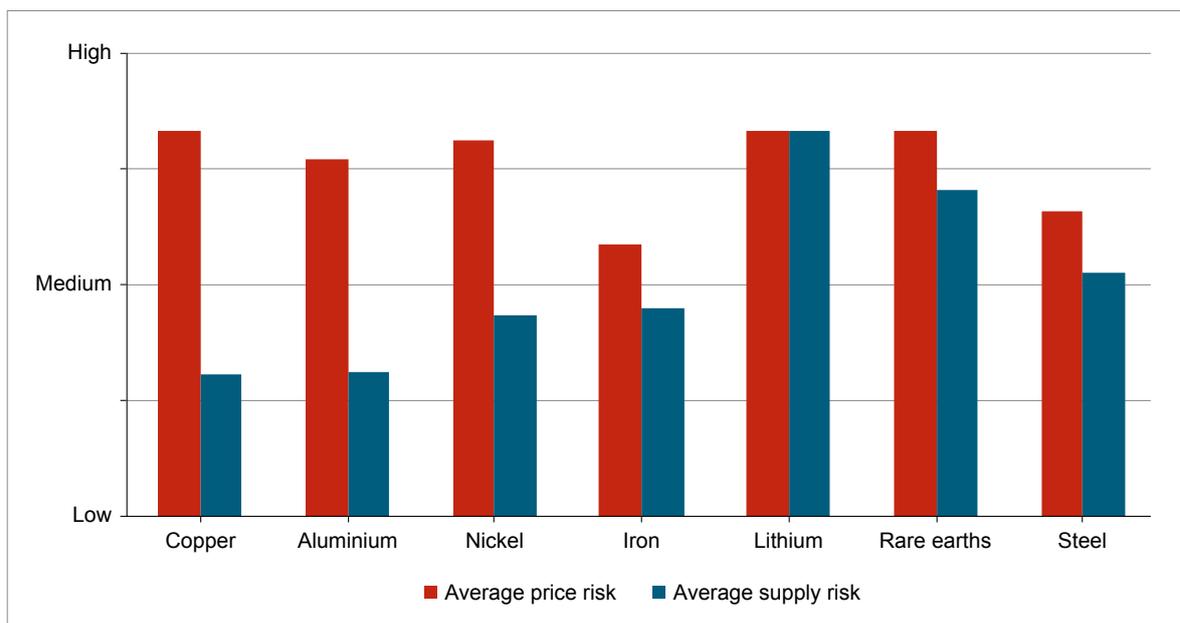


Figure 10: Comparison of price risk and supply risk of specific raw materials

importer of aluminium (KINCH, 2021). Due to the structural increase in demand for aluminium and concentration of production in specific countries, the respondents considered the price risk of aluminium to be higher than its supply risk.

Nickel is primarily used in the manufacture of stainless steel, and is used to improve steel's durability and corrosion resistance. Currently, only about 5% of nickel is used in the production of lithium-ion batteries (BUECHEL et al., 2021). However, this is expected to increase significantly; by 2030, batteries could account for approximately 20% of global nickel consumption. Nickel is also used as the basis of cathodes and for the production of superalloys and non-ferrous alloys which are used in industries such as the aerospace industry (USGS, 2021). Optimism around the transition to clean energy has led to the price of nickel increasing significantly over recent years. More than 2,000 nickel mining projects are currently under development, with the main producing regions being Southeast Asia and Oceania (SZURLIES, 2021). The main producing country is Indonesia, which accounts for 26% of global nickel production, followed by the Philippines (15%) and Russia (9%) (DERA, 2021). Like copper and aluminium, the respondents rated the price risk for nickel higher than its supply risk.

Iron is estimated to be the second-most abundant metal in the Earth's crust. The survey respondents assessed the supply risk for iron at slightly below medium, and the price risk at slightly above medium. These risks are underpinned by the significant demand for one of iron's main applications: steel, especially for the automotive, construction, machinery, and manufacturing industries (LEE, 2020). Australia (37% of global iron ore production), Brazil (19%), and China (14%) are the largest iron ore mining countries (DERA, 2021). China consumes more iron than any other country; almost two-thirds of global iron exports go to China, making it the largest iron importer. Prices have generally increased since 2015, although they have yet to return to the record high seen in 2011 (GARSDALE, 2020).

The respondents judged the price risk and supply risk of steel to be similar to those of iron. Both risks were rated as medium, being only slightly higher than the risks associated with iron. Global steel production totalled more than 1.8bn tonnes

in 2018, 51% of which is produced in China. The second- and third-largest producers are India and Japan, accounting for around 6% each (DERA, 2021). Major consumers of steel include end-use sectors such as the construction and automotive industries. Demand for steel is expected to reach 2.7bn tonnes per year by 2026, with this growth being primarily driven by China's continuing industrialisation and urbanisation (GLOBE NEWSWIRE, 2021). Economic development in India, Southeast Asia and Africa will also contribute to increasing demand (IEA, 2021). As well as rising global demand, the increasing concentration of supply is another trend in the steel sector. In China, the authorities and steel producers have intensified their efforts to consolidate the domestic steel sector, with an official goal that the ten largest Chinese steel producers should account for 60% of total Chinese steel production by 2025. Currently, these companies produce 37% of Chinese steel (OECD, 2021c). A technological transition is also expected in the steel sector alongside these developments, with the aim of cutting energy consumption and CO<sub>2</sub> emissions. The extent of any steel price increases will depend on which mandatory emissions reduction policies are implemented (IEA, 2021); however, a number of experts expect that rising demand, concentration of supply and the green transformation of the sector will increase price risk and supply risk (CHEVELEY, 2021).

Lithium was rated as a high-risk raw material, both in terms of prices and security of supply. The price of lithium has already risen significantly in recent years: for example, the average annual price of lithium carbonate rose from USD 6,607 per tonne in 2012 to USD 20,228 per tonne in 2021 (BLOOMBERG, 2021), an increase of 306%. Rising demand for lithium for electric vehicles, energy storage systems, 5G devices and internet of things (IoT) devices is expected to continue over the next few decades, resulting in increasing prices (FASTMARKETS, 2021). According to BUECHEL et al. (2021), about 9% of lithium produced in 2000 was used for batteries. This share had risen to 66% in 2021 and is expected to rise to over 90% by 2030. This is especially due to the growth in production of electric vehicles, which – in one scenario – is expected to account for 80% of total global battery capacity by 2030 (ROSKILL, 2021b). Other applications of lithium include ceramics, glass and lubricants; demand

for these applications generally grows in line with overall economic growth. The most important lithium producer is Australia, accounting for 61% of global lithium production, followed by Chile (19%) and Russia (8%) (DERA, 2021). Supply has not been able to keep up with demand: getting new projects into operation takes several years and requires high capital investment, while some producers also have to face environmental opposition and lengthy approval procedures. Experts predict that this mismatch between fast-growing demand and slow-growing supply will continue, leading to further increases in price risk and supply risk (RAMKUMAR, 2021).

Finally, survey respondents assessed rare earth elements as having high price risk and above-medium supply risk. Rare earth elements are relatively abundant in the Earth's crust, but most of them rarely occur in sufficient quantities in a single location to make extraction economically viable. Rare earth elements are required for many modern technologies (MIT, 2016). Neodymium, for example, is used for its magnetic properties in electronic devices, electric vehicles and wind turbines. Likewise, praseodymium is used in the production of permanent magnets for electric vehicles. Yttrium is used in the production of liquid-crystal displays, lasers and superconductors. Lanthanum is used in rechargeable batteries, as a petroleum cracking catalyst or in the manufacturing of optical glasses. However, the largest end use for rare earth minerals will remain in permanent magnet applications; these will account for approximately 40% of total demand by 2030 (ROSKILL, 2021c). The main producing country is China, which accounts for 69% of global rare earth oxides production, followed by Australia (11%) and Myanmar (9%) (DERA, 2021). Processing facilities are also concentrated in China (86% of global production of refined rare earths), making the country the dominant force in the market (DERA, 2021; BGR, 2021b). Due to China's dominant position in the rare earth market, the current lack of processing capacity outside China, and the increasing demand for rare earth elements, market experts predict continued upward pressure on rare earth prices (ROSKILL, 2021c).

## 4.2 Overview of strategies: extent of usage and effectiveness

The companies surveyed use various different strategies to secure the raw materials that they need. Each individual strategy has different objectives, benefits and drawbacks, and the extent to which each strategy is used varies as a result. This section provides a comparative overview of these strategies, while Section 4.4 examines and explains the individual strategies in more detail.

Figure 11 shows an overview of the strategies, and the extent of both current usage and planned usage in the next three to five years. As can be seen, the most common strategy among the companies surveyed is currently the use of long-term contracts, followed by supplier diversification and passing on increased raw material prices to the customer. Vertical integration (e.g. involvement in extraction of raw materials) and the formation of purchasing groups with other companies are not used to any significant extent.

Respondents were asked to state whether they intend to use each strategy in the next three to five years, and to indicate the extent to which they intend to use them. Overall, usage of all strategies is set to increase. However, a particularly strong increase in usage is planned for strategies that contribute to sustainability (such as increasing material efficiency, recycling and material substitution). Another noticeable upward trend is in the use of IT-powered business tools in raw material procurement. This is being driven by technological developments such as big data analytics, AI, cloud computing, blockchain and predictive analytics. Nevertheless, long-term contracts and supplier diversification are set to remain the most extensively used strategies in absolute terms.

In line with planned levels of usage, supplier diversification and use of long-term contracts are also the strategies that were rated as most effective by the survey respondents. Commodity price hedging took third place, and was considered a useful tool to secure prices. Vertical integration, stockpiling and material substitution were rated as the least effective strategies. Figure 12 shows the effectiveness of each strategy as assessed by the respondents.

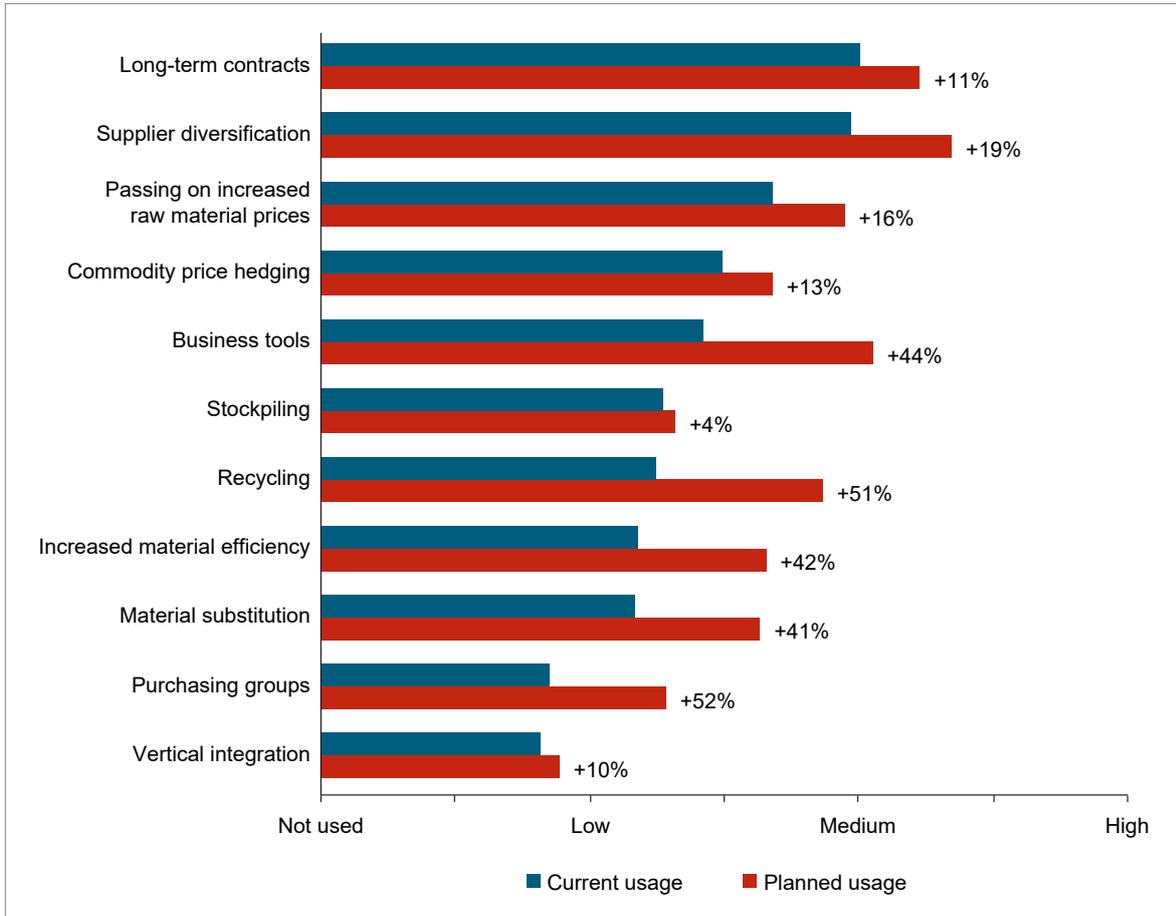


Figure 11: Usage of strategies in companies surveyed

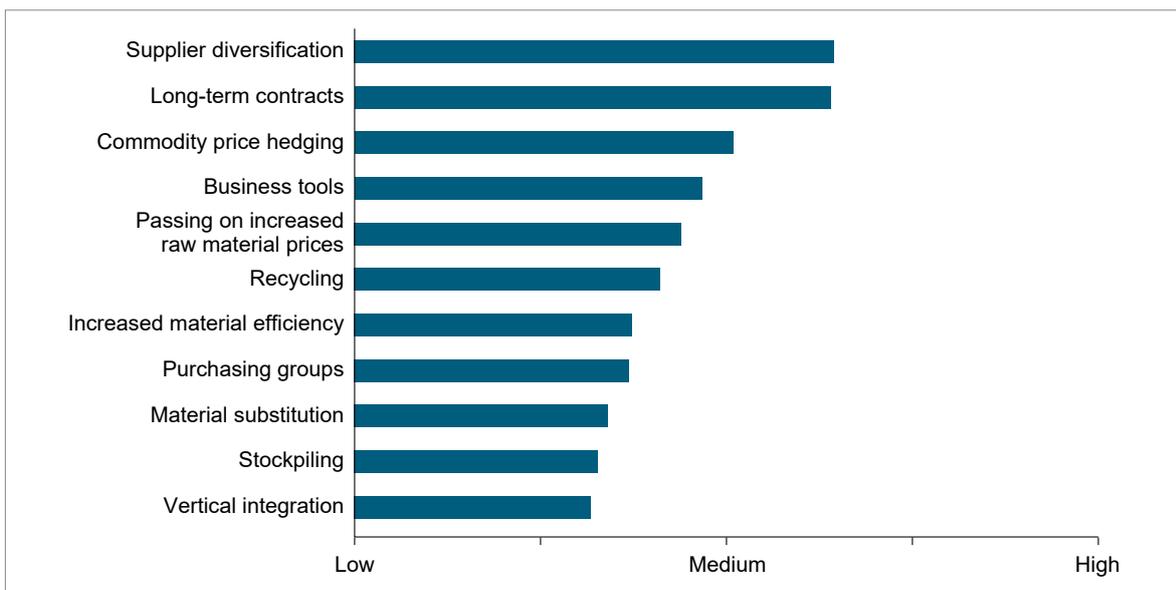


Figure 12: Effectiveness of each strategy as assessed by the survey respondents

### 4.3 Influence of market-specific and country-specific factors on raw material procurement

Procurement of raw materials is influenced not only by company characteristics, but also by **market-specific and country-specific factors**. This section provides a general overview of some of the market-specific and country-specific factors which have an impact on company exposure to price risk and supply risk, and which therefore play a role in selecting strategies for securing raw materials. These external factors were examined in both the survey and the expert interviews. Section 4.4 provides more detail on the factors that facilitate the use of individual strategies and on the conditions that must be met for successful implementation of these strategies.

Figure 13 shows how the respondents assessed the influence of various **market factors** on the strategies used by their companies to secure raw materials. These factors were identified during the literature review and were discussed with representatives of German industry associations.

Overall, the respondents stated that dependence on individual suppliers has the biggest impact on their companies' strategies: 58% of respondents

stated that dependence on individual suppliers had a high impact and 35% said that it had a medium impact. Only 8% ranked its impact as low.

Short-term supply chain disruption due to external factors such as force majeure was ranked as the second-most important factor. Even though disruption of this nature is rare, it can have a significant impact on business operations and company strategies for securing raw materials: the Suez Canal blockade at the end of March 2021 demonstrated the large ripple effect that short-term disruption can have on the broader market (STEVENS, 2021).

Dependence on individual countries is ranked as the third-most influential factor on company strategies for securing raw materials. An example of this can be observed in the rare earths market, which is dominated by China: China controls a large proportion of global rare earth production, while also imposing restrictive export conditions and limiting access to foreign direct investment (SCHMID, 2020).

Increases in tariffs were also considered to have a major influence on corporate strategies to secure raw materials. Increasingly protectionist trade policies imposed by countries such as the US and

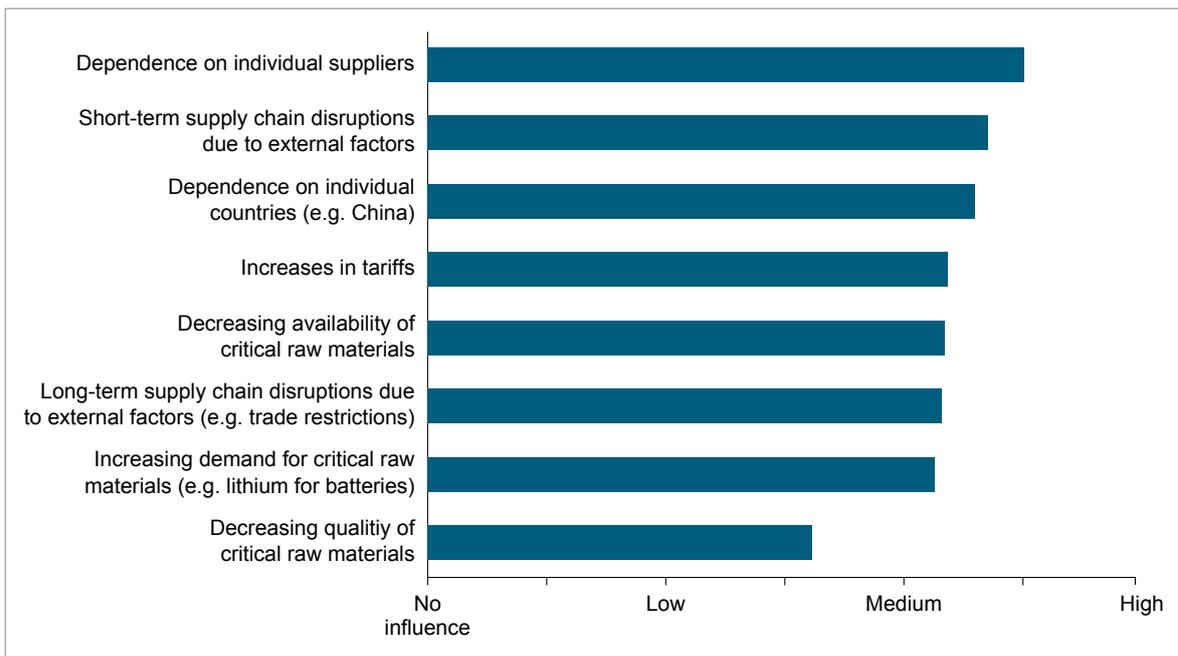


Figure 13: Market-specific factors and extent of influence on strategies for securing raw materials

China have restricted trade and led to increased prices of goods. Political tensions, which in some cases have led to protectionism, are a cause of concern for companies, and affect flows and availability of raw materials.

The risk of long-term supply chain disruption caused by external factors, the increasing demand for critical raw materials and the decreasing availability of critical raw materials were also assessed as having a major impact on strategies to secure raw materials. Decreasing quality of raw materials, on the other hand, was not considered to be such a relevant factor.

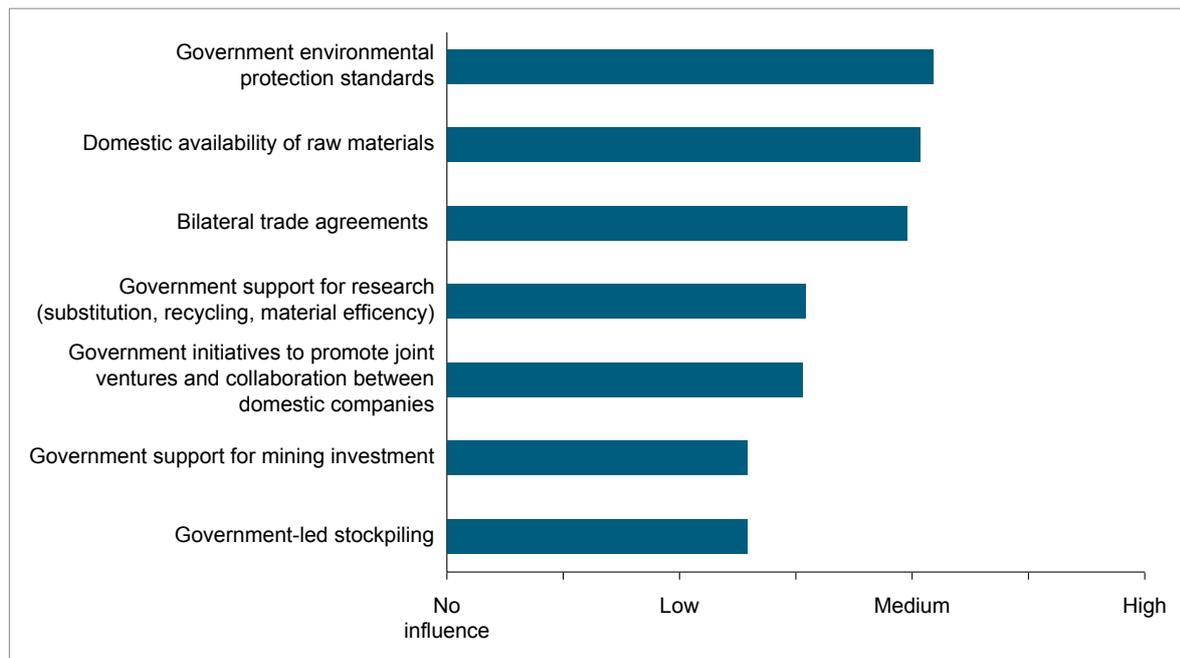
In sum, the survey results show that there are several market factors which have a significant influence on how companies secure their raw materials. The expert interviews also show that companies have already taken measures to deal with market-specific factors. For example, dependence on individual countries has been mitigated by diversifying supply chains. Some companies have also used this strategy – along with stockpiling – to minimise the risk of short-term supply chain disruption causing production stoppages.

The most important **country-specific factors** (see Figure 14) were identified from the sec-

ondary literature and further refined in collaboration with representatives of industry associations. Country-specific factors are defined as high-level features of individual countries that play a role in strategies for securing raw materials, such as environmental protection standards, domestic availability of raw materials, and bilateral trade agreements with countries rich in raw materials.

The survey respondents rated government environmental protection standards as the most influential factor. As sustainability has become increasingly important at the regulatory level, governments have implemented various directives to encourage sustainability in the last few years. For example, the European Commission has made this a key priority, launching its Raw Materials Initiative to promote sustainable procurement of raw materials from European sources while ensuring a level playing field for resources from third countries (EUROPEAN COMMISSION, 2021).

Domestic availability of commodities was rated as the second-most important factor. In general, a high concentration of domestic raw material deposits makes a specific strategy to secure materials on the international market unnecessary.



**Figure 14: Country-specific factors and extent of influence on strategies for securing raw materials**

Bilateral trade agreements were also considered to have a major influence on company raw material procurement. These agreements establish open trading systems that allow for smoother movement of goods across borders, and companies in countries which have bilateral trade agreements are therefore more likely to develop cross-border supply chains. These systems allow free movement of goods without them being subject to customs duties, quotas or import bans, which otherwise selectively restrict the quantities of goods that can be traded.

Other country-specific factors include government support for research in material substitution, recycling and improving material efficiency. All of these strategies enable more efficient use of raw materials and minimise the waste generated during processing. Both the survey and the expert interviews confirm that companies predominantly use strategies such as these if government support is available.

Government initiatives to promote joint ventures and collaboration between domestic companies can similarly be useful for companies working together to secure raw materials. Collaboration is particularly beneficial in areas where large-scale investment is necessary – such as R&D or vertical integration – and where coordinated planning is an option, such as in purchasing groups. The legal framework in place also determines the extent of collaboration between businesses: anti-trust law, for example, may impose limits.

Another form of government support is aimed at investment in mining. Generally, exploration and mining projects involve a high degree of uncertainty, heavy capital expenditure and long pay-back times. Government support, such as exploration subsidies, can therefore be beneficial for companies planning to invest in mining. However, the survey indicates that government support of this nature only has a minor impact on company raw material strategies. This is because even with government support, significant uncertainties remain and major capital expenditure is still required.

Governments can also establish raw material storage facilities, in the form of strategic reserves of raw materials. However, the survey and the expert interviews showed that this is not very important

for company strategies: the survey respondents rated the influence of this factor on their strategies at just above low.

#### 4.4 Examination of strategies

This section covers the main findings of this study by examining the eleven raw material strategies using the information gathered from the survey, expert interviews and secondary research. Each sub-section is divided into six parts. The strategy in question is first defined, explained and illustrated, including a real-life example. Part two focuses on the survey results, showing the extent to which the respondents currently use the strategy, the extent to which they plan to use it in the next three to five years, and how effective they perceive the strategy to be. The reasons for increasing or decreasing use of the strategy are also explained, along with how German companies assess the strategy (based on secondary research). Part three describes the opportunities and challenges involved in using the strategy, showing both potential benefits and the effort and risks that the strategy may entail. Based on this, part four presents the necessary conditions and success factors – these are the internal and external factors that are important for successful implementation of the strategy. Part five then provides recommendations for action to help implement the strategy and lay the foundations for the various success factors. Each sub-section is concluded with a summary of the key findings.

### 4.4.1 Commodity price hedging



#### Definition

Hedging refers to the use of financial products to counteract financial risks – such as rising exchange rates or commodity prices – and thus stabilise prices in volatile markets (SCHMID, 2020). Unlike some of the other strategies discussed in this study, such as long-term contracts or supplier diversification, commodity hedging is not a strategy to minimise supply risk; instead, it is limited to reducing price risk. The process of hedging involves buying or selling a commodity future, forward, swap or option of a size equal to a risk position held in the physical market. This establishes an equal and opposite position, so that a loss in one market will be offset by a gain in another (HULL, 2014). While suppliers or raw material producers usually hedge against falling prices, procurement professionals in manufacturing industries deploy these instruments to hedge against price increases (WILDEMANN, 2009).

**Forward contracts** are customised, over-the-counter commitments to deliver or take delivery of a specified quantity and quality of a commodity during a specified month in the future, at a price agreed at the time of the commitment. The buyer in a forward contract agrees to take delivery of the underlying commodity, and the seller, in turn, agrees to make the delivery. Profit or loss is equal to the difference between the original purchase or sale price and the price of the offsetting transaction (HULL, 2014).

**Futures contracts** are in many ways similar to forward contracts, but they are traded on an exchange such as the London Metal Exchange (LME)<sup>19</sup>, standardised, settled daily, and more liquid. As they are settled daily, futures contracts tend to have higher liquidity risks, as any drop in prices will lead to margin calls being made, rather than only one payment being due at the end of the contract (LME, 2021a; HULL, 2014).

**Options contracts** are also traded on exchanges like futures. However, as the holder is not under

#### Corporate example

##### Nippon Steel Co Ltd (Japan)

Japanese steel producer Nippon Steel buys swap agreements to avoid volatility in the price of nickel, thus stabilising costs for one of its primary raw material inputs. Using these over-the-counter agreements with trading houses or raw material producers, Nippon Steel takes a long position on the nickel price, which is balanced out by its own production output. If the price of nickel goes up, Nippon makes money from the swap agreement and loses the same amount on production; if the price of nickel falls, the opposite happens. When the contract expires, the contract is cash settled. Nippon's hedging strategy has gained importance in recent years: the company's use of commodity swaps increased from USD 3m in Q1 2018 to USD 343m in Q1 2021 (NIPPON STEEL, 2019; NIPPON STEEL, 2021).

any obligation to exercise the option, options contracts offer greater upsides if commodity prices decline. An example of this is a long hedge, where the buyer buys a call option on a futures contract. If prices rise, the buyer's profits made on the call option would balance out the losses when the option is exercised. If prices fall, the option expires: the buyer would then only lose the price paid for the option, and they would profit from lower physical commodity prices (HULL, 2014). Options can be classified as conditional contracts that allow the buyer to purchase or sell an underlying asset at a certain price in return for paying a premium, and they are only binding on the seller of the option – i.e. they are only unilaterally binding. Futures, on the other hand, are unconditional contracts: both parties undertake to buy or sell the underlying asset at a certain price after the expiration of a fixed term, making them binding for both buyer and seller (WILDEMANN, 2009).

Like forwards, **commodity swaps** are not traded. In essence, they are a series of futures contracts, with the two parties agreeing to exchange a series of cash flows at predetermined dates, based on an underlying asset, such as copper. One party agrees to pay the other a fixed rate, while the other pays a variable rate (HULL, 2014).

<sup>19</sup> For a further brief explanation of hedging, please refer to the LME's "Physical and financial hedging – a beginner's guide" (LME, 2020). For a more detailed explanation of hedging, please refer to "Hedging Commodities" by Slobodan Jovanovic (JOVANOVIC, 2014).

### Usage and effectiveness

The survey revealed that **current usage** of commodity price hedging is at a moderate level (see Figure 15). Among the eleven strategies studied, commodity price hedging was the fourth-most widely used strategy. Only 19% of the respondents said that they are not currently using hedging; 81% are using hedging, with 27% of those using the strategy ranking their level of usage as high. This strategy is used more extensively in the countries surveyed than in Germany: in INVERTO's 2021 raw materials management survey, which mostly surveyed German companies, only 14% of the companies were using commodity hedging. Usage of commodity price hedging has even decreased among these companies, from 20% in 2015 to 14% in 2021 (INVERTO, 2017; 2021). When asked why they used hedging, most representatives of the companies participating in the present study said that they had chosen to do so because of the predictability of their raw material needs, high price pressure on sales markets and high volatility of raw material prices. Companies not using hedging usually mentioned the current high level of raw material prices – indicating an expected return to lower prices – along with lack of knowledge and lack of hedging products available. In Germany, INVERTO found similar barriers, namely a lack of adequate hedging

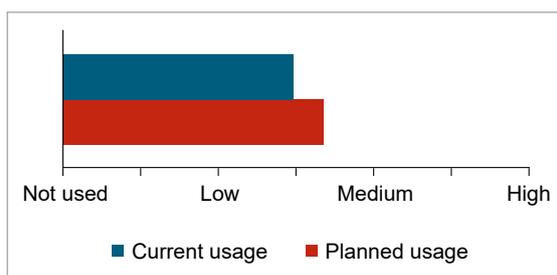


Figure 15: Usage of commodity price hedging



Figure 16: Effectiveness of commodity price hedging

products or financial knowledge. According to an INVERTO study from 2018, commodity price hedging has a bad reputation in Germany and is perceived as a speculative and risky approach to stabilising prices (INVERTO, 2018).

The survey participants rated the **effectiveness** of hedging as medium (see Figure 16), making it the third-most effective strategy. In line with its perceived effectiveness, **planned usage** of hedging among the companies surveyed is slightly higher than current usage (see Figure 15). The percentage of respondents not using hedging is set to decrease from 19% to 11%, while the proportion of companies making a medium or high level of usage of the strategy is expected to increase from 57% to 64%. Respondents are not only planning to increase their use of the strategy due to its perceived effectiveness, but also due to market-specific and company-specific factors, such as rising levels of market price volatility, changes in risk management and access to hedging tools and platforms. Higher market price volatility has been caused by the interconnection of global production and vulnerability to external factors, such as political changes and economic fluctuations. For example, China's increasing dominance in the steel business can lead to considerable fluctuations if circumstances change in the country or between countries. There is also a general trend towards improved risk management, which makes risks easier to quantify and adverse developments easier to cope with. Further simplification of processes and easier access to platforms, tools and banks are additional factors which are driving companies to expand their hedging activities.

### Opportunities and challenges

Commodity price hedging is associated with various opportunities and challenges. The opportunities can be grouped into two categories: **reliable planning, calculation and reporting**; and **suitable for companies of any size**. Challenges can be grouped into **increased costs and expenses**, **additional effort and risks**, and **complexity for inexperienced companies**.

The various price hedging instruments all enable commodity prices to be secured by taking suitable offsetting positions, and both groups of opportunities help companies to reduce financial

*“In the current volatile environment, commodity price hedging is very important, as it combines secure supply with sufficient agility to exploit market opportunities.”*

Director at a multinational technology company

risks. Dependable prices and the **reliability in planning, calculation and reporting** that these create are key benefits of hedging, particularly in times of high volatility and fluctuation, as price increases can be partially or completely offset. This certainty also has the advantage that **margins can be protected**, enabling an undivided focus on the company’s core business. Another important aspect is that commodity price hedging is not limited to large companies: it is also **suitable for SMEs**. The fact that the strategy can be implemented quickly without any need for expensive, time-consuming preparation is one of its major benefits (IW, 2013; SCHMID, 2020). Companies with small raw material needs can hedge small quantities of certain metals on the LME using “LMEminis” – these are futures contracts with a lot size of just 5 tonnes (LME, 2021b). However, it should be noted that hedging is a strategy for minimising losses and improving reliability in planning, not for generating revenues.

Alongside the opportunities associated with hedging, there are also various challenges and risks. One of the key challenges is **costs**, which include transaction costs, information costs and market access costs (e.g. through intermediaries). Costs vary depending on the financial instrument used

(IW, 2013). For example, futures allow hedging at relatively low costs, whereas the premiums associated with options are much higher. Since these premiums have to be paid before the company can sell its final product, this has a negative impact on the company’s working capital. Although they do not involve high premiums, futures contracts come with the risk of **margin calls** being made if prices change contrary to expectations, requiring payments to be made to the counterparty as collateral. These payments can be problematic for SMEs if personal guarantees have been issued to cover margin calls. Moreover, there is always the risk of losing to speculation and paying higher commodity prices than competitors. If a company hedges and prices subsequently fall, the company will be unable to benefit from the lower prices. Competitors may be able to gain an advantage and produce their products more cost-effectively. Hence, **timing** is a further challenge when hedging, although this can be mitigated with appropriate knowledge of the market.

External parties represent another challenge, as they can lead to additional work being required and increase risk exposure. Wide-ranging **regulations**, which impose obligations such as additional reporting, must be taken into account when considering hedging. Complying with these regulations then requires additional resources and appropriate IT infrastructure. A further challenge lies in identifying in advance whether a counterparty has sufficient liquidity. Implementing hedging to secure raw material prices thus also introduces **counterparty risk** (i.e. default risk) to the company.

Opportunities	Challenges
<p><b>Reduced financial risks:</b></p> <ul style="list-style-type: none"> <li>– More reliable planning, calculation and reporting</li> <li>– Margins protected</li> </ul> <p><b>Suitable for companies of any size:</b></p> <ul style="list-style-type: none"> <li>– Quick implementation without the need to commit significant resources</li> <li>– LMEminis for small quantities of raw materials</li> </ul>	<p><b>Increased costs and expenses:</b></p> <ul style="list-style-type: none"> <li>– Unexpected market dynamics and capital becoming tied up</li> <li>– Margin calls and additional lines of credit</li> </ul> <p><b>Additional risks and work required:</b></p> <ul style="list-style-type: none"> <li>– Regulations requiring adequate reporting</li> <li>– Dependence on counterparties (e.g. risks of default)</li> </ul> <p><b>Complexity for inexperienced companies:</b></p> <ul style="list-style-type: none"> <li>– Knowledge required among staff, acceptance required among management</li> <li>– Choosing the right financial instruments is complex</li> </ul>

Hedging instruments are not available for all raw materials. This limits the applicability of hedging. Commodity price hedging through financial market products is currently most evident for metals – particularly steel, aluminium and copper – but is also occasionally seen in industrial minerals and other non-metals. The situation is further complicated for some raw materials, such as rare earths, by the fact that these commodities are not currently traded on commodity exchanges. Instead, trading is usually conducted directly between producers and consumers, using established structures and specialised traders.

Hedging is thus associated with a certain degree of complexity, and requires an appropriate level of expertise. This is one of the reasons why many companies are reluctant to use commodity price hedging. The challenge therefore lies in maintaining or developing relevant knowledge within the company, convincing decision-makers of the advantages of commodity price hedging and **choosing appropriate financial instruments**. If companies wish to hedge currencies as well as commodities, they will need even higher levels of internal knowledge due to the greater complexity of currency hedging.

### Conditions and success factors

Various conditions and success factors are essential to successfully hedge commodity prices. These factors can be summarised under the three points explained below: **sound market knowledge and analytical skills, expertise in implementing financial instruments and confidence in their effectiveness and availability of resources**.

*The study participants confirmed the hypothesis that a lack of knowledge prevents many companies from using commodity price hedging. This shows that developing knowledge – for example, by hiring experts, training existing staff, or consulting external sources – is an important first step towards successfully using this strategy to reduce price risk and gain a competitive advantage.*

(Hypothesis no. 1)

- Firstly, an essential underlying condition for successful hedging is that commodity prices have not yet peaked: signing contracts to protect against rising market prices only makes sense if a price increase is expected. Current price levels and their expected development therefore play a crucial role in deciding whether or not to conclude a hedging contract. In turn, companies need to be able to accurately assess current and anticipated market prices, which requires sound **market knowledge and analytical skills**.
- Secondly, the complexity inherent in implementing hedging means that **expertise in implementing financial instruments** in the company is essential. Alongside this, the company's financial experts and key decision-makers must have **confidence** that hedging can help significantly reduce risk, despite its costs. In some sectors, awareness of the relevance of risk mitigation strategies for commodities remains low; cooperation and in-depth dialogue between all parties involved (e.g. purchasing, engineering, finance and treasury departments) is therefore vital.
- Thirdly, implementing a company-wide hedging mechanism requires coordination between different business units and hierarchical levels, meaning that support and coordination from top-level management is needed. General company strategy must therefore be aligned with procurement strategy to ensure effective hedging. This includes ensuring **availability of resources** – for example, to comply with regulations, to prepare forecasts, and to implement suitable IT infrastructure to meet these demands. Since hedging also requires financial resources or additional lines of credit, sufficient financial resources or a strong balance sheet are essential as well.

### Recommendations for action

Various recommendations for action can be made to help successfully implement commodity price hedging, depending on the extent to which a company already uses the strategy. The first step is to create **awareness** of the need to expand risk management activities. Next, relevant **decision-makers** within the company need to be

convinced that commodity price hedging is an effective risk mitigation strategy. Since the deployment process entails a certain level of complexity, **expertise** in hedging instruments must either be developed internally or bought in, as illustrated in the following section. It seems that there is still a lot of room for improvement in this regard, especially in SMEs, as reluctance to use commodity price hedging can be at least partly attributed to a lack of know-how (PALM, 2011).

To assess, plan and implement hedging, identifying **gaps in knowledge** is very important. This will show where to develop and maintain knowledge and the necessary human capital. Knowledge within the company can be developed by hiring new employees, training existing staff, or consulting external sources such as advisory firms or academic institutions. For example, an Italian transmission manufacturer interviewed for this study is currently collaborating with a university to conduct research-related preliminary work to prepare for implementation of hedging instruments. Successful knowledge management, however, involves more than just acquisition: it also covers development, transfer, storage and use of know-how.

As introducing hedging is a complex process, establishing and promoting internal **cross-departmental skills teams** is recommended – these might involve purchasing, finance, sales and management. Interdepartmental cooperation still represents a weak point in many companies, so measures to foster it need to be developed. The focus needs to be on clear allocation of responsibilities, open communication, and formulation of common purchasing strategy goals. Decisions on which hedging instruments to use should be left to the cross-departmental team of experts.

Once the decision to hedge has been made and the necessary expertise is available within the company, suitable analyses (e.g. cost structure analyses) need to be carried out to identify the **raw materials** to be hedged (GABATH, 2010). Companies use commodity price hedging to reduce risks rather than to generate financial profits. To avoid unnecessary financial risks, hedging should not be used in markets where prices are very likely to fall, as this involves running the risk of paying higher locked-in prices than competitors: concluding hedging transactions only makes sense when volatility and price increases are expected.

The issue of choosing the right time to hedge can best be addressed by regularly conducting comprehensive market analyses and forecasts of price developments. Various software providers offer **forecasting or analytics tools** that can make a remarkable difference to the accuracy of estimations (see Section 4.4.11). In addition to forecasting price developments, companies should also prepare predictions of **how demand will develop** to determine whether the potential risk of exposure to higher locked-in prices can be justified.

Because hedging covers a wide variety of financial instruments and can take many different forms, it is also important to examine the available options in order to **identify the most suitable hedging strategy**. Cost-benefit considerations, financial products available, liquidity on the market and availability of know-how all need to be taken into account. In the metals industry, for example, futures and swaps are widely used, whereas options are fairly rare. However, there are also differences between individual commodities: while aluminium, for example, can typically be hedged relatively easily using futures on the LME, hedging steel can be more difficult because of the low levels of liquidity among the financial products available. Where liquidity is low or non-existent, the recommended approach is over-the-counter solutions, in the form of forward contracts: as explained above, these are not traded on an exchange, and their conditions are determined individually between the buyer and the seller (GABATH, 2010).

Another important recommendation is to consider what **percentage of the company's raw material needs** is to be hedged. The key question here is whether hedging should be used for all of the company's raw materials or only some of them. Companies without any hedging experience are advised to initially hedge only a portion of their raw material needs to slowly familiarise themselves with the strategy and to limit the consequences of any errors. However, this is not just recommended for beginners: even experienced companies report that they aim to combine hedging with other strategies rather than using hedging for 100% of their raw material needs. Since long-term contracts with fixed prices also serve to secure prices, companies should consider both strategies. If, however, companies have long-term

contracts with fixed quantities but variable pricing, hedging can be used as the sole means of locking in prices.

These recommendations clearly indicate that companies need to allocate sufficient **resources** for successful use of commodity price hedging: this includes both human resources (e.g. for

analyses and reporting) and financial resources. Despite the challenges described above, hedging is a valuable strategy; it is recommended that SMEs in particular intensify their efforts in commodity price hedging, as there are few comparable alternative strategies available to these companies to counteract price volatility.

**Table 1: Summary of commodity price hedging**

 <b>Usage: current</b>	<p>No usage  High</p> <p>Among the eleven strategies examined, commodity price hedging is the fourth-most used.</p>
 <b>Usage: next three to five years</b>	<p>No usage  High</p> <p>This strategy is set to have the sixth-highest level of usage over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  High</p> <p>Commodity price hedging was rated as the third-most effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Sound market knowledge and analytical skills to forecast prices</li> <li>• Expertise in application of financial instruments</li> <li>• Confidence in strategy among company financial experts and key decision-makers</li> <li>• Availability of financial and human resources</li> <li>• Appropriate IT infrastructure</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Create awareness, convince decision-makers, develop or buy in expertise</li> <li>• Form cross-departmental skills teams to close knowledge gaps</li> <li>• Conduct comprehensive analysis of market development and own requirements, with external help if necessary</li> <li>• Identify most suitable hedging instruments for the company's level of expertise</li> <li>• Keep the company's level of expertise in mind and don't hedge more raw material than necessary</li> <li>• Allocate sufficient resources to successfully pursue the strategy</li> </ul>

#### 4.4.2 Passing on increased raw material prices to customers



##### Definition

Price pass-through (also known as cost pass-through) refers to increasing the price of a final product because of input cost increases. Like commodity price hedging, this strategy is limited to mitigating price risk and does not address supply risk. Price pass-through can be implemented by means such as unilateral price adjustments (e.g. for mass-produced products), price escalation clauses (e.g. in index-based pricing), renegotiation clauses for specific events, or raw material surcharges (SCHMID, 2020).

Commodity prices are subject to trends and are heavily dependent on general economic developments. Price increases can also be caused by export restrictions (e.g. China's export quotas for rare earth minerals in 2011), structural shifts in demand (e.g. due to new technological developments), global crises (e.g. the 2007–2008 financial crisis) and many other factors. Geopolitical events can have impacts that are not evenly distributed, as tariffs and export restrictions are sometimes deliberately designed to weaken industries in specific countries. Cases such as these make price pass-through more difficult in competitive environments, as some companies will be affected while others are not (SCHMID, 2020).

Contribution margins can cover usual price fluctuations, but the situation becomes challenging when prices surge by hundreds of per cent, as experienced in 2011 for some rare earth elements. In a theoretical best-case scenario, companies would directly pass increased input costs on to their customers by applying a raw materials surcharge. In practice, companies initially absorb increased input costs, or pass on only a portion of the increase (SCHMID, 2020). There is evidence to support partial pass-through from commodity prices to producer prices and, to a lesser degree, to consumer prices (JIMÉNEZ-RODRÍGUEZ & MORALES-ZUMAQUERO, 2021). However, failure or hesitancy to adjust prices at first may lead to a jump in prices later, which has the potential to damage customer relations. Passing on higher

##### Corporate example

###### VILPE (Finland)

In 2021, VILPE, a Finnish manufacturer of ventilation and roofing products, experienced difficulties due to raw material shortages and price increases, which affected the manufacturing and delivery of fasteners, roof fans and fan control systems. The company took three measures to tackle these problems: the issues were openly communicated to customers; customers were asked to divide orders over a longer time so that demand could be met by available stock; and prices were increased by 8% in July and by 5% in October (VILPE, 2021).

costs can thus be a part of a proactive, long-sighted and analytical pricing policy (ABDELNOUR et al., 2021).

##### Usage and effectiveness

**Current usage** of price pass-through is higher than most of the other ten strategies (see Figure 17). Passing on prices was the third-most used strategy among the companies surveyed: 90% of respondents said that they use this strategy, with 23% of those doing so reporting a high level of usage. These results are in generally in line with the findings of INVERTO's 2021 raw materials management survey, which focused on German companies: 62% of INVERTO respondents used the strategy in 2021, up from 35% in 2015 (INVERTO, 2017; 2021). This strategy is therefore one of the most widely used strategies in Germany (INVERTO, 2021). When asked for circumstances under which price pass-through would be used, most participants in the present study said that they would use the strategy if raw materials affected by price increases made up a major proportion of the final product, or if raw material costs already had a strong influence on the price of the final product. The main reason given for using the strategy was to protect margins and to avoid losses. In contrast, interviewees stated that they would not use the strategy if customers were very price-sensitive or if their company operates in highly competitive markets. In INVERTO's 2021 study, 42% of respondents expected to be able to apply this strategy to more than half of their raw materials, whereas 58% expected to have to cover increased costs for the majority of their raw

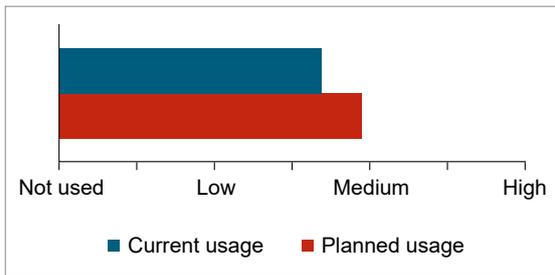


Figure 17: Usage of price pass-through

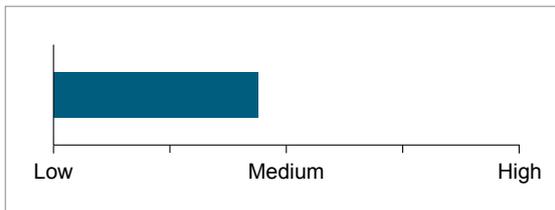


Figure 18: Effectiveness of price pass-through

materials themselves (INVERTO, 2021). These results support the findings of the present study that price pass-through is only an option in certain market environments. INVERTO also identified that a lack of close coordination between procurement, sales and finance departments prevents the strategy from being used to its full potential (INVERTO, 2019).

The study participants assessed the **effectiveness** of price pass-through as medium (see Figure 18). In line with this, **planned usage** over the next three to five years is slightly higher than current usage (see Figure 17): the percentage of respondents not using price pass-through is set to fall from 10% to 6%. Interviewees stated that because prices for certain raw materials are generally expected to rise, passing on these price rises in whole or in part is increasingly becoming accepted by customers, and that the strategy is therefore an adequate means of dealing with the problem. The interviewees also stated that the growing use of data analytics tools is increasing the relevance of this strategy, especially for companies which operate in mass markets. More extensive use of available data regarding factors such as prices, supply, and demand enables better assessment of the possible consequences of price increases on customer purchasing habits; this, in turn, enables companies to better manage product prices and profitability.

### Opportunities and challenges

Passing on increased commodity prices is associated with various opportunities and challenges. The opportunities can be grouped into two categories: **protection of margins** and **speed of implementation**. Challenges can be grouped into **lack of acceptance**, and **timing and extent of price increases**.

*“Nowadays, all companies are starting to prioritise price risk mitigation over price reduction, making price pass-through a widespread practice.”*

Senior procurement director at an international company offering heating solutions

As outlined above, passing on increased prices to customers does not address raw material supply risk, but it does enable cost management. More precisely, it serves as a method to **transfer price risk** to downstream parties in the value chain, in turn reducing the company’s own price risk and margin risk. Increased commodity prices would normally reduce margins (and thus company profitability), but this can be mitigated in proportion to the level of price pass-through. The benefit of this strategy lies primarily in **protection of margins and profitability**, and is all the more relevant if raw material costs make up a large proportion of the overall product costs. In some cases where margins are already very low, such as in the automotive industry, use of this strategy might even be considered essential.

Another advantage of price pass-through is that it is **quick to implement**: this is because the strategy uses existing contract structures and does not involve any intermediaries. If raw material prices rise, a quick response in the form of passing the price rise on to customers is therefore relatively easy. Meanwhile, if raw material prices fall, customers can immediately seize the opportunity to benefit from lower selling prices – provided that this response is as quick as the increase was.

Interviewees were divided on the issue of customer acceptance of price pass-through. Some expert interviewees expected high acceptance due to customers having an understanding of the situation and other suppliers employing sim-

Opportunities	Challenges
<p><b>Maintaining profitability:</b></p> <ul style="list-style-type: none"> <li>– Margins protected</li> <li>– Price risk transferred downstream</li> </ul> <p><b>Speed of implementation:</b></p> <ul style="list-style-type: none"> <li>– Price changes can be passed on immediately</li> <li>– No other parties involved</li> </ul>	<p><b>Customer churn and loss of market share:</b></p> <ul style="list-style-type: none"> <li>– Lack of acceptance by customers</li> <li>– Lack of acceptance by sales department</li> </ul> <p><b>Timing and extent of price increases:</b></p> <ul style="list-style-type: none"> <li>– Contractual obligations can block price increases</li> <li>– Estimating appropriate increases in opaque markets is difficult</li> </ul>

ilar strategies. Other interviewees considered this a major challenge, believing that customers could feel deceived. This, in turn, risks **customer churn**, leading to **reduced demand and sales** (SCHMID, 2020). Price pass-through can also be controversial within companies: **sales staff aim to maintain close and long-standing customer relationships** on the one hand, and have to communicate price rises on the other. Lack of acceptance, either internally or externally, can put the company's reputation at risk, which can lead to long-term disbenefits.

In this context, the **timing of price pass-through is a challenge**. If passing on price increases is unavoidable, there is a risk of losing market share. If competitors are also being forced to pass on price rises, the **extent** of any price increase is also crucial. Failure to follow market conditions regarding either of these aspects can put a company at a disadvantage compared to its competitors, leading to customer churn. Customer churn is also a major risk if customers are unable to pass on their price increases.

The right timing is also important due to the time lag between commodity price increases – which are usually short-term – and contract renegotiation cycles. **Contractual obligations** therefore often dictate whether prices can be passed on to customers; and, if so, when they can be passed on – clauses which prevent price increases for a specified period are not uncommon. This is especially true for companies at the beginning of the value chain, as prices are usually set for longer periods in this environment. Companies passing on rising prices to customers must also be aware that they will face the challenge of renegotiations to reduce prices if raw material prices fall.

Several developments in recent years have made price pass-through more difficult: these include increasing customer expectations, greater customer pressure on costs, and more intense competition. As explained above, it is often impossible to pass on price rises in full, which means that the first consequence of increased raw material prices is a reduction in margins. Estimating the **extent** to which price increases can be passed on to customers thus represents a further challenge: both **lack of transparency in the market** and lack of analytical capabilities make this difficult for companies.

### Conditions and success factors

Various conditions and success factors are essential to successfully pass on increased prices to customers. These factors can be summarised under the four points explained below: **situation in the sales market and price elasticity, individual customer characteristics and open communication, customer contracts and analytical capabilities and internal collaboration**.

*The experts confirmed the hypothesis that passing on raw material prices to customers in the short term is largely determined by competitive pressure on the sales market. Comprehensive market knowledge and methods for predicting how competitors and customers will behave when prices change, such as business analytics tools, are therefore helpful in implementing this strategy.*

(Hypothesis no. 2)

- First and foremost, the **competitive situation in the company's sales market** must be considered. A low level of competitive pressure is an important success factor, as the probability of losing market share after price pass-through will be lower in such an environment. This is due to **price elasticity of demand**, which describes the relationship between a change in demand for a product and a change in its price. If demand is elastic, a given price increase – say 10% – will lead to a drop in demand greater than the price increase (i.e. more than 10%). If, on the other hand, demand is inelastic, the drop in demand will be smaller than the price rise. Demand is said to be completely inelastic if it does not react at all to price changes (BPB, 2016). Low or non-existent price elasticity of demand is thus a key success factor for passing on prices to customers. Price elasticity of demand increases with the number of companies on the market, meaning that companies in monopolies or oligopolies, or which are at the beginning of the value chain, have a competitive advantage when considering use of this strategy.
- Secondly, **individual customer characteristics** must be considered. The length and closeness of customer relationships – and thus, the demand elasticity of each specific customer – determines the success or failure of this strategy. Long-standing customers tend to accept price increases being passed on, whereas smaller, price-focused and less quality-oriented customers are more willing to change suppliers. This can lead to customer churn and loss of market share. Therefore, **open communication with customers** and transparent justification of price increases is crucial.
- Thirdly, **contracts with individual customers** can either prevent use of the strategy altogether, or limit when and to what extent the strategy can be used. Fixed-price contracts without any provision for price increases or renegotiations completely prevent price pass-through from being used. Variable-price contracts, on the other hand, do allow this strategy, even though stipulations such as fixed renegotiation cycles, price escalation clauses or price limits may still impose restrictions.
- Fourthly, this form of price management requires both **analytical capabilities** and **interdepartmental collaboration**. To obtain the necessary analytical capabilities, companies often use AI-powered forecasting tools to predict how the procurement and sales markets – and hence, prices – will develop. Cross-departmental collaboration refers to close collaboration between the purchasing, sales, marketing and finance departments. This involves raising awareness among employees who, to avoid damaging customer relationships, may be reluctant to pass on price increases even though this is necessary.

### Recommendations for action

Various recommendations for action can be made to help successfully implement price pass-through. The first step is to **analyse market conditions, observe competitors and assess customer behaviour in the sales market**. To analyse market conditions, it is necessary to obtain an overview of both historic and expected supply and demand, and to assess the likelihood of price increases. To determine the timing and level of price pass-through, companies need to be aware of current market cycles and assess them. For example, if supply continuously increases at a greater rate than demand, prices will generally fall, and price increases would not be appropriate given the market conditions of excess supply. If, on the other hand, demand continuously increases at a greater rate than supply, prices tend to rise due to excess demand in the market. Since price elasticity of demand as described above serves as an indicator of the feasibility and likely success of this strategy, it is vital for companies to assess any historical or current use of price pass-through by competitors and partners in the same or similar industries. The impact of this on demand will give an idea of the sensitivity of the market to price increases.

Next, companies are advised to carry out **detailed analysis of competitors' pricing strategies** before passing on price increases. Competitors' price increases should ideally be compared with their profit and loss statements (if available) to estimate the impact of these increases on net sales, operating income, net profit and profit margins. Examination of how competitors use the

strategy thus provides insights into what represents appropriate timing and level of price pass-through. A company can therefore use market reaction and its impact on competitors as an indicator of the financial effect that passing on price increases may have. However, the characteristics of both the individual company and its customers must be also considered to paint a reliable picture.

Before passing on prices, companies should also **investigate the behaviour of their customers**. As shown above, price elasticity of demand reflects market price sensitivity. Companies and their price sensitivity can be similarly analysed. Here, it is necessary to consider the extent to which customers pass on increased prices to their end customers, and how those end customers react to increases. Based on this, customer-specific pricing models can be created, taking company characteristics and existing relationships into account. It is also advisable to assess the potential negative impact of customer churn and margin erosion.

After analysing market conditions, competitors and customer behaviour, companies need to decide on the scope and timing of price increases, and create scenarios based on this. The extent to which an individual company passes on increased raw material prices will depend on company-specific factors, such as forecasted commodity prices, associated procurement costs, and target margins. These variables must be considered when evaluating different price scenarios and deciding on the timing and scope of price increases. In general, it is best to broadly follow what competitors are doing and to **avoid hasty price increases**. Typically, price leadership is held by the market leader, and any changes are then mirrored by competitors. However, this then presents the challenge of customers demanding price reductions when commodity prices fall. Although a pricing strategy based on material procurement prices may seem like a good idea, there are negative aspects to consider. For example, sudden price reductions are not advisable, as they could trigger a price collapse: it is much better to **gradually reduce prices**, especially because it is difficult to raise prices again once they have been lowered. Striking the right balance is very important.

The recommendations outlined above emphasise the fact that companies need to have **compre-**

**hensive analytical capabilities**. If these capabilities are not already available, they can be developed by hiring new staff, training existing staff, or buying in external support. Attention should also be paid to creating a **data management system**, as this will help improve the company's overview of the market and transparency on its customers. In particular, a well-maintained customer relationship management (CRM) system will enable the company to use insights into transactions and contracts to identify quick wins – for example, contracts that are due to expire and therefore offer an opportunity for renegotiation. It is also advisable to use **advanced analytics tools** to predict changes in commodity costs, supply-demand imbalances and resulting price changes in end customer markets. This will help to build capabilities for the company to proactively change pricing and contract design depending on the current commodity situation.

As mentioned above, use of this strategy requires **appropriately structured contracts** which do not completely prevent price changes. This is a less important factor for companies selling products in business-to-customer (B2C) markets, such as car manufacturers, but companies such as original equipment manufacturers (OEMs), which sell large quantities of parts in business-to-business (B2B) markets, are much more dependent on the structure of their contracts. If a company concludes a contract in which a fixed price is agreed over a longer period, there is no simple way for the company to demand extra payment from the customer to compensate for any increases in raw material prices. The situation is different if the contract contains provisions such as price escalation clauses or periodic renegotiation. Price escalation clauses allow automatic adjustment of selling prices, based on either indices or market prices. There are also more specific solutions, such as the alloy surcharge used in the stainless steel business. This surcharge is levied in addition to the steel price, and is recalculated every month based on the LME prices of the materials added to the steel (e.g. chromium, nickel, titanium). Companies should therefore deal with contractual pricing arrangements – especially the choice between a fixed-price or variable-price contract – at an early stage, and identify the best solution for their needs. Since some legal specifics must be considered when drafting contracts, companies are recommended to seek **legal advice**.

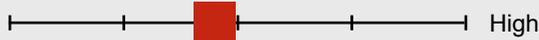
However, the strategy of passing on prices should not be limited to existing contracts: companies should also evaluate how they can use the strategy to attract new customers. Further contractual options are listed in Section 4.4.5.

As price increases are ultimately implemented by **sales staff** rather than the purchasing department, it is important to get the relevant employees involved and coordinate with them from an early stage. It is advisable to hold training for the sales teams to improve their confidence in effectively discussing price changes. Sales staff also need to be able to anticipate buyers' questions so that

they can conduct professional price discussions with the procurement department.

Finally, **open communication** with customers is very important to reduce annoyance, increase acceptance and mitigate potential reputational damage. Price increases should be justified by providing a comprehensive explanation to the customer of when prices rose and by how much. Many companies are implementing comprehensive training programmes for sales teams for this purpose, including training on effectively arguing in favour of a price increase, handling objections, and selling value.

**Table 2: Summary of passing on increased raw material prices to customers**

 <b>Usage: current</b>	<p>No usage  High</p> <p>Among the eleven strategies studied, price pass-through is the third-most used.</p>
 <b>Usage: next three to five years</b>	<p>No usage  High</p> <p>This strategy is set to have the fourth-highest level of usage over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  High</p> <p>Price pass-through was rated as the fifth-most effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Low level of competition on sales market</li> <li>• Low or non-existent price elasticity of demand</li> <li>• Low price sensitivity among individual customers</li> <li>• Open communication and justification of price increases</li> <li>• Flexible contracts with individual customers (inflexible contracts prevent or limit use of this strategy)</li> <li>• Analytical capabilities to assess market reaction to price increases</li> <li>• Interdepartmental collaboration</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Comprehensively analyse market conditions</li> <li>• Assess past and future development of supply and demand</li> <li>• Analyse competitors and their pricing strategies</li> <li>• Investigate customer behaviour</li> <li>• Be aware of company characteristics and existing relationships</li> <li>• Avoid hasty price increases</li> <li>• Develop comprehensive analytical capabilities and transparent data management systems</li> <li>• Avoid drafting contracts that prevent price increases</li> <li>• Communicate price increases openly to customers</li> </ul>

### 4.4.3 Stockpiling



#### Definition

Stockpiling refers to increasing stocks of raw materials to provide a buffer against supply risk and price risk, extending the period a company can keep production lines running without receiving a delivery of raw materials. Higher stock levels are not particularly suited to mitigating long-term events, but they do reduce dependence on the upstream supply chain, allowing companies to bridge short- to medium-term bottlenecks and disruption. This makes stockpiling a highly relevant strategy, both against the backdrop of increasing raw material shortages and as a means of mitigating losses due to transport risk or natural disasters affecting suppliers (SCHMID, 2020).

#### Usage and effectiveness

**Current usage** of stockpiling within the companies surveyed is fairly moderate compared to other strategies (see Figure 19). Overall, raw material stockpiling is used in most of the companies surveyed, with 88% of respondents stating that they maintain stockpiles. However, only 6% of respondents using the strategy said that their level of usage was high; most (62%) rated their usage as low. Interviewees stated that their use of stockpiling was limited because it involves significant costs, ties up working capital and is subject to fluctuating demand, which can lead to companies ending up with excessive stockpiles. Implementation of the strategy also depends on the degree of government support available: countries such as Japan and South Korea, for example, maintain state-run stockpiles that are used if shortages develop. Large-scale stockpiling is uncommon in German companies, as the majority use just-in-time manufacturing to reduce storage costs and lead times (STAUFEN, 2016). In addition, high levels of unused stock are a burden on company balance sheets (VETTER, 2020).

The study participants assessed the **effectiveness** of stockpiling as below medium (see Figure 20). In line with this, **planned usage** over the next three to five years is only slightly higher than current usage (see Figure 19). Although there are five strategies which rank behind stockpiling in terms

#### Corporate example

##### Toyota Motor Corporation (Japan)

Toyota has a stockpile of chips which will last for up to four months, reducing the company's dependence on the supply situation in the chip market. In contrast to some other car manufacturers, Toyota was able to continue production when the current global chip crisis began in 2020. Toyota also kept suppliers up to date with its short-term and long-term production plans, further reducing the impact of the global chip shortage on the company (SUN & MUNROE, 2021).

of current usage, all five are expected to undergo a greater increase in usage than stockpiling. This low level of usage of stockpiling can be explained by the low perceived effectiveness of the strategy. The interviewees explained that they perceived the strategy's effectiveness as low because of its disadvantages, such as storage costs, tying up of liquidity and fluctuating stock levels at times of unstable demand. Industries such as the automotive industry widely use just-in-time production (also known as lean production), associated with economical and efficient use of resources – and characterised by low inventory levels. Study participants also stated that the cost and effort involved with implementing and using the strategy in the long term was disproportionately high compared to the resulting benefits. Stockpiles are only beneficial when there are actual shortages or

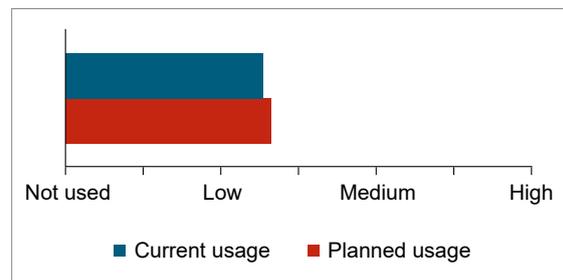


Figure 19: Usage of stockpiling

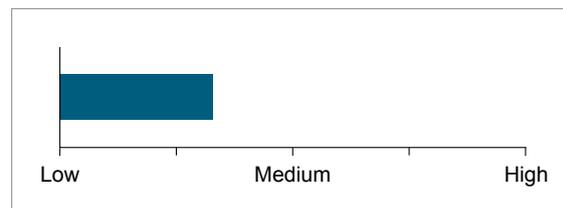


Figure 20: Effectiveness of stockpiling

there is a constant high risk of supply being interrupted; at all other times, they are simply an additional cost with no visible benefits.

### Opportunities and challenges

Stockpiling is associated with various opportunities and challenges. The opportunities can be grouped into two categories: **maintaining production in times of market stress** and **faster order-to-cash cycle**. The challenges can be grouped into **being left with excess inventory, capital tied up** and **increased storage expenses**.

*“Everything that we keep stockpiled is not being used on a project. It’s a big burden on our costs.”*

Head of commodity management at a multinational company specialising in industrial automation

Sufficient stock provides an important buffer against shortages of materials and supply chain disruption. Stockpiles help companies to **maintain production in times of market stress**. They play a role in good management of unexpected risks, such as the Covid-19 pandemic, and they make the company **less dependent on constant supply**, in turn reducing exposure to supplier default risk.

Stockpiling gives companies the option to benefit from price volatility by purchasing raw materials in bulk at cheaper prices than would be available

for multiple smaller orders. The company can then either resell the raw materials at a profit when market prices rise, or it can use its lower procurement costs to reduce selling prices on its products and gain a competitive advantage.

The results of this study show that rapid availability of raw materials – as enabled by stockpiling – helps to meet customer demand. This, in turn, generates revenue more quickly, **shortening the order-to-cash cycle**. Stockpiling raw materials also enables companies to largely **avoid contractual penalties for late delivery** due to delays on the supply side.

However, stockpiling also presents various challenges, most of which are financial in nature. One challenge is **being left with excess inventory**: while price volatility, as described above, can enable companies to acquire raw materials in bulk at cheaper prices, it can also lead to companies paying excessive prices and being unable to clear stock if stockpiles need to be replenished when market prices are high. A drop in demand leading to a fall in the company’s sales can also lead to unprocessed raw materials sitting idle in storage: this ties up capital, drains resources and occupies storage space.

The negative **impact of stockpiles on a company’s working capital** is another important factor. Working capital is the difference between a company’s current assets and current liabilities, and is an important indicator of liquidity, operational efficiency and short-term financial health. Stockpiles have a negative impact on working capital because they **tie up large amounts of capital**.

Opportunities	Challenges
<p><b>Maintaining production in times of market stress:</b></p> <ul style="list-style-type: none"> <li>– Mitigation of supply chain disruption and material shortages</li> <li>– Reduced vulnerability to supplier problems</li> </ul> <p><b>Faster order-to-cash cycle:</b></p> <ul style="list-style-type: none"> <li>– Customer requests can be processed more quickly</li> <li>– Supply-side delays do not necessarily lead to contractual delay penalties</li> </ul>	<p><b>Being left with excess inventory:</b></p> <ul style="list-style-type: none"> <li>– Company may be unable to clear inventory if prices fall after purchase</li> <li>– Company may be unable to process inventory if demand falls after purchase</li> </ul> <p><b>Capital tied up:</b></p> <ul style="list-style-type: none"> <li>– Increased working capital</li> <li>– Financing increased stock</li> </ul> <p><b>Increased storage expenses:</b></p> <ul style="list-style-type: none"> <li>– Increased material overheads</li> <li>– Maintenance and labour expenses</li> </ul>

This, in turn, can have an influence on financing. Banks, for example, are often reluctant to finance stockpiles – mainly due to the price risk involved, but also the risk of one asset being fraudulently used as collateral for multiple loans. This is most common in China, but is also increasingly being seen in Germany. Furthermore, it is difficult for banks – especially when prices are very volatile – to value raw materials and thus provide an appropriate sum of working capital loans. Credit-worthiness from a strong balance sheet and profit and loss account are also essential, and many banks require proof that the sale of the stock to be financed has already been agreed at a certain price.

Finally, **increased storage expenses** are a challenge. These are due to direct cash outflows (e.g. electricity and maintenance), larger storage facilities and rental expenses, and interest for any debt financing. Storage expenses also result from the need to maintain proper storage conditions to ensure that the raw materials do not degrade; problems such as water ingress pose a particular risk for industrial minerals.

### Conditions and success factors

Various conditions and success factors are essential for successful implementation and use of stockpiling. These factors can be summarised under the three points explained below: **constant demand and predictable sales, material specification and raw material prices and availability of financial resources.**

*The interviewees confirmed the hypothesis that stockpiling is not seen as a long-term strategy because it involves high costs and ties up liquidity. Instead, stockpiling is primarily useful for bridging short- to medium-term supply chain disruption.*

(Hypothesis no. 3)

- Firstly, **constant demand** for stockpiled raw materials and **predictable sales** are crucial conditions for effective stockpiling. If internal demand for stockpiled materials is not constant, there is a risk that the materials will remain unused, unnecessarily tying up

storage capacity for long periods. Striking the right balance to maintain constant internal demand requires exact knowledge of customers and their needs. Regarding predictability of sales, large customers may provide long-term forecasts of their requirements; this, in turn, allows companies to better predict their future sales, justifying lower stock levels. Having a significant share of customers in faster-moving markets, on the other hand, increases the importance of keeping sufficient stock, as sales in these markets are less predictable.

- Secondly, the **specification of the material to be stockpiled** is another factor to consider. The less the material has been processed, the higher the chances that stockpiling can be successfully used. There are two reasons for this: the cost of procuring unprocessed materials is lower than that of materials which have been extensively processed; and there are many more options for using or reselling unprocessed raw materials. Demand for heavily processed materials, on the other hand, can change drastically after procurement, potentially leaving the company with stockpiled material that it cannot get rid of.
- Thirdly, **raw material prices and availability of financial resources** ultimately determine the success of this strategy. Current raw material prices are very important, as it makes most sense to build up stocks when prices are low, and it is important to find an appropriate balance between optimising procurement costs and meeting the company's raw material needs. As stockpiling always involves costs, sufficient financial resources must be available. Many banks are reluctant to finance stockpiles, so extra requirements often need to be fulfilled when seeking external financing – these include a strong balance sheet and proof that sale of the materials to be financed has already been agreed.

### Recommendations for action

Various recommendations for action can be made for stockpiling, based on the wide variety of success factors and conditions related to the strategy.

In view of the fact that keeping stockpiles reduces the risk of stock being unavailable but also involves a large accumulation of capital, it is advisable for companies to consider what their **optimal stock levels** are. This requires strategic analysis to factor in the individual needs of the company in question.

This process should start with **analysis of the company's customers** in terms of predictability of sales. This is due to the fact that – as mentioned above – an increase in inventory is particularly important for serving faster-moving markets where demand is volatile, while slower-moving markets can justify lower inventory levels. Based on the nature of their customers, companies must first assess whether stockpiling is an appropriate strategy. If so, the next step is to **create a reliable forecast** to estimate how demand will develop. This reduces the risk of the company being unable to get rid of stockpiled material or of suffering losses if raw material prices fall. As well as quantitative forecasts based on past customer data, qualitative forecasts based on expert knowledge must be conducted; both types of forecast should be combined for the best insights. Ideally, forecasting should incorporate analytical business tools (see Section 4.4.11). In light of the Covid-19 pandemic, including error terms in demand forecasts will help to consider worst-case scenarios and thus make them more manageable. Ideally, in contrast to traditional planning, the forecast should cover various scenarios and the probability that they will occur. The predicted future demand for the company's products can then be used to calculate the resulting raw material demand and the size of stockpiles required.

The next step is to analyse which raw materials are to be stockpiled and their **suitability for storage**. Unprocessed raw materials are more suitable for storage than processed materials, particularly because they offer greater flexibility if customer requirements change, and they require less processing in advance. The total quantity to be stockpiled and the storage space required must be taken into account, and this may make it necessary to reassess storage systems and methods. There are also material-specific requirements to consider, such as weather resistance, legal regulations and climatic conditions. In addition, companies should ask whether it makes sense to outsource warehousing – either to third-party

providers, or to the supplier in the case of unprocessed raw materials. Even if future demand for their own products requires stock to be increased, companies should not completely disregard current **price levels**: it is generally preferable to build up stock when prices are low, as this reduces the direct cash outflow involved and the risk of loss. Purchasing at times of low demand may also yield higher-quality materials because pressure on the raw material extraction processes will be lower.

Cross-departmental **enterprise resource planning (ERP) systems** help to monitor, evaluate and efficiently plan supply processes and inventory. They are also useful for optimising the analyses mentioned above, as well as for implementing and further developing business analytics. Analytics features integrated in ERP software will improve forecasts, such as for predicting raw material needs. Even SMEs may benefit from the use of ERP systems, though finding and implementing the most suitable system is often a major challenge (BMWK, 2021b). Help is available on this issue from external consultancies. A further recommendation which is practicable with modern ERP systems is to identify and consider **relevant KPIs** to help manage processes, measure the achievement of targets, improve coordination and take decisions. These KPIs should be considered both over time and between different sectors; examples include inventory cost, inventory turnover and average storage period.

Companies should also focus on the **costs** and the negative effects on their **working capital and liquidity ratios** resulting from the capital commitments and direct cash outflows involved in stockpiling. Maintaining sufficient liquidity is essential so that liabilities can be paid promptly and financial support can be obtained from banks: this can be extremely important for many of the strategies considered in this study, including stockpiling. Stockpiling is therefore more advisable for companies that already have high liquidity and in which the commercial benefits of the strategy justify its costs. As well as financial resources and financial management, commercial and tax regulations must also be considered when making decisions of this nature; companies are advised to consult external experts when dealing with these issues.

As is clear from the points outlined above, companies are well advised to **weigh up the negative**

**effects** of stockpiling on their finances against the security of having sufficient material to satisfy customer demand. This should be considered at an early stage to determine how much inventory is required. However, with increasing shortages

of raw materials in today's markets, the negative aspects of stockpiling are becoming increasingly insignificant when compared to the major competitive advantage that the strategy offers.

**Table 3: Summary of stockpiling**

 <p><b>Usage: current</b></p>	<p>No usage  ----- ----- ----- -----  High</p> <p>Among the eleven strategies studied, stockpiling is the sixth-most used.</p>
 <p><b>Usage: next three to five years</b></p>	<p>No usage  ----- ----- ----- -----  High</p> <p>This strategy is set to have the third-lowest level of usage over the next three to five years.</p>
 <p><b>Effectiveness</b></p>	<p>Low  ----- ----- ----- -----  High</p> <p>Stockpiling was rated as having the second-lowest level of effectiveness.</p>
 <p><b>Conditions and success factors</b></p>	<ul style="list-style-type: none"> <li>• Constant raw material demand and predictable sales</li> <li>• Stockpile unprocessed raw materials</li> <li>• Low raw material prices and availability of sufficient financial resources</li> </ul>
 <p><b>Recommendations for action</b></p>	<ul style="list-style-type: none"> <li>• Conduct comprehensive analysis of future demand for company products</li> <li>• Work out how much raw material is required to meet customer demand</li> <li>• Conduct forecasts to gain an overview of storage scenarios</li> <li>• Consider outsourcing storage, e.g. to supplier</li> <li>• Implement KPIs to monitor inventory</li> <li>• Implement advanced ERP software on a large scale to plan raw material stockpiling</li> <li>• Make sufficient financial resources available and manage costs</li> </ul>

#### 4.4.4 Supplier diversification



##### Definition

Supplier diversification refers to increasing the number and/or geographical spread of raw material suppliers used by a company with the aim of obtaining a more secure supply of materials. Overall, there are four different sourcing strategies concerning the number of suppliers: single sourcing, sole sourcing, dual sourcing and multiple sourcing. Single sourcing and sole sourcing both refer to sourcing materials from only one supplier. Single sourcing aims to build a relationship with one chosen supplier, whereas sole sourcing is the term used in monopolistic environments where only one supplier is available. Dual sourcing involves two different suppliers for one product, with the aim of building relationships with both while reducing dependence on any one supplier. Multiple sourcing refers to having more than two suppliers for one product to promote competition between suppliers and increase independence. Each strategy is normally used for different products: single sourcing is usually used in situations where working with the supplier on the development process would be beneficial, whereas multiple sourcing is more often used with standardised goods such as raw materials (WERNER, 2017).

##### Usage and effectiveness

**Current usage** of supplier diversification within the companies surveyed is higher than most other strategies (see Figure 21). Out of the eleven strategies examined, this strategy is the second-most extensively used: 97% of the survey respondents currently use the strategy, with 25% of those doing so reporting a high level of usage. Supplier diversification is used more extensively in the countries surveyed than in Germany. In INVERTO's 2021 raw materials management survey, which primarily surveyed German companies, only 65% of respondents stated that they use the strategy, although this had increased from 40% in 2015 (INVERTO, 2017; 2021). In the workshop undertaken for the present study, the representatives of German industry associations also confirmed that this strategy is increasingly important to German companies. When asked why they were diversifying their suppliers, most study participants said

##### Corporate example

###### LG Display (South Korea)

Based in South Korea, LG Display is one of the world's largest manufacturers of displays. When Japan announced export restrictions on several raw materials in 2019 (including hydrogen fluoride), LG Display responded by both expanding their stockpile and taking on additional suppliers. To mitigate the risk posed by increasing global trade tensions, LG Display is planning to further diversify its supply chain over the medium term to reduce the company's dependence on individual countries (YANG & PARK, 2019).

that they wanted to make their companies less dependent on individual suppliers and avoid the risk of shortages, in order to prevent production stoppages. However, the interviewees also stated that a major reason against diversifying suppliers is the fact that the strategy eliminates economies of scale: distributing raw material needs between several suppliers prevents companies from obtaining bulk discounts and increases the costs involved in transport and coordinating different suppliers. INVERTO found that German companies are both diversifying their suppliers and shifting their raw material sources to other locations run by the same supplier; this is a result of growing trade disputes around the world (INVERTO, 2020).

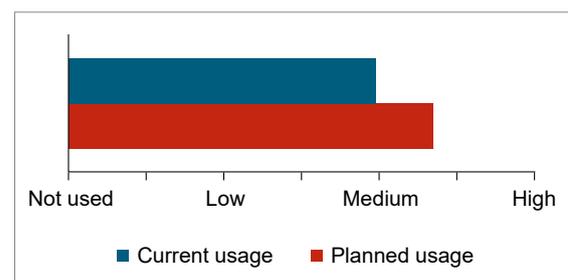


Figure 21: Usage of supplier diversification

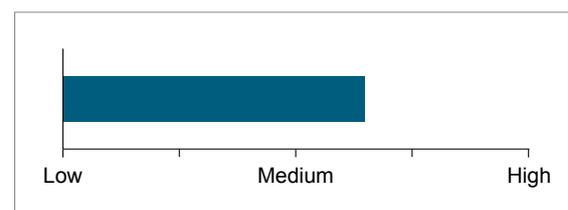


Figure 22: Effectiveness of supplier diversification

The study participants rated the **effectiveness** of supplier diversification between medium and high (see Figure 22); this was the highest effectiveness rating of the eleven strategies examined. In line with this result, most respondents expressed **plans to increase their usage** of this strategy over the next three to five years (see Figure 21). The percentage of companies using the strategy is set to increase from 97% to 98%, while the proportion of companies reporting a high level of usage is expected to rise from 25% to 46%. Supplier diversification will thus become the most used strategy. In line with these findings, the INVERTO study also shows that this strategy is considered very effective by most of the German companies surveyed (INVERTO, 2021). Likewise, the representatives of German industry associations involved in the workshop for the present study consider supplier diversification a very relevant strategy for German companies. As well as its perceived effectiveness, the increasing market volatility that many companies have experienced in recent years – driven by international political tensions and disruption to logistics – is also driving companies to diversify their suppliers. Other reasons given by the study participants included the rising awareness of supply risk created by the impacts of the Covid-19 pandemic, and the general advance of globalisation.

### Opportunities and challenges

Supplier diversification is associated with various opportunities and challenges. The opportunities can be grouped into two categories: **reduced dependence on individual suppliers** and **increased competitiveness**. Challenges can be grouped into **identifying and selecting suitable suppliers, maintaining supplier relationships and oversight, and costs**.

*“We can see that the Covid-19 pandemic has created tremendous difficulties in the supply chain, and we need to ensure that we always have the opportunity to find new suppliers from different continents and countries.”*

Chief purchasing officer at an international construction company

First and foremost, this strategy **reduces dependence on individual suppliers** while simultaneously increasing available capacity. This enables company raw material demand to be met at all times, with fewer interruptions in supply; depending on the raw material and market situation, this may also increase security of supply. This is a particular advantage in the Covid-19 pandemic, which has been characterised by shortages of raw materials and supply chain bottlenecks. If a company has a diversified set of suppliers, it can simply fall back on alternative suppliers if a supplier experiences issues such as delivery problems or financing difficulties. Supplier diversification is therefore a means of reducing supply risk.

If suppliers are spread across various parts of the world, supplier diversification also offers the opportunity to **circumvent global political risks** – in particular, national or international political sanctions or export restrictions. Having suppliers spread across multiple countries provides **sufficient flexibility for unforeseen changes** – for example, if price risk rises, a supplier defaults, or further political risks arise. This, in turn, creates an additional competitive advantage for the company.

Diversifying suppliers **expands the company’s business network**. This is particularly advantageous if new suppliers need to be called upon at short notice. At the same time, interaction with a diversified, international supplier network makes markets significantly more transparent and comparable, enabling the company to understand the market better for benchmarking, forecasting and developing purchasing strategies. This allows the company to react to relevant information and market developments at an early stage, and to profit from knowledge transfer and supplier innovation. A diversified set of suppliers therefore offers the opportunity to improve the company’s competitiveness.

Use of this strategy can also go hand in hand with **cheaper, better-quality raw materials**. Having multiple suppliers available allows companies to choose the supplier that offers the best value for money, and competition can stimulate suppliers to provide better-quality materials at lower prices. As a result, supplier diversification can also act as a cost management measure.

Opportunities	Challenges
<p><b>Reduced dependence on individual suppliers:</b></p> <ul style="list-style-type: none"> <li>– Supplier delivery issues or financial difficulties no longer have knock-on effects for purchaser</li> <li>– Political risks (e.g. export restrictions) can be circumvented</li> <li>– Increased flexibility to adapt to unforeseeable market risks</li> </ul> <p><b>Improved competitiveness:</b></p> <ul style="list-style-type: none"> <li>– Larger global network</li> <li>– Improved market insights</li> <li>– Competition between suppliers drives down prices and drives up quality</li> </ul>	<p><b>Identifying and selecting suitable suppliers:</b></p> <ul style="list-style-type: none"> <li>– Limited number of suppliers for some materials</li> <li>– Qualification process is labour-intensive and costly</li> </ul> <p><b>Maintaining supplier relationships and oversight:</b></p> <ul style="list-style-type: none"> <li>– Establishing and maintaining loyal relationships with multiple suppliers</li> <li>– Additional evaluation of suppliers is necessary (price, quality, sustainability)</li> </ul> <p><b>Reduced economies of scale:</b></p> <ul style="list-style-type: none"> <li>– Smaller quantities purchased from each supplier</li> <li>– Fewer discounts available, higher logistics costs</li> </ul>

However, there are also challenges. The first challenge lies in **identifying and selecting suitable suppliers**. While there are large numbers of suppliers for common raw materials such as steel or copper, the number of suppliers for more specialised raw materials of particular grades is usually limited. Rare earths are a good example of this: China currently controls production of 170,000 tonnes of rare earth materials (mainly oxides) per year, which represents about 80% of global output. Six state-owned mining companies are responsible for this, and they are required to meet fixed production targets. These companies thus have a monopoly on rare earth production (KULIK, 2019).

Once potential partners have been identified, the next challenge is **qualification and selection**. This process requires a lot of time and resources, and is therefore costly. Proper qualification involves a multitude of factors, such as technical specifications, national and international standards, customer-specific or market-specific requirements, and environmental and social standards. Social standards include issues such as working conditions and respect for human rights: these are becoming particularly important in the supplier selection process, and failure to consider them can have serious consequences for the company's reputation. Apple, for example, was confronted with such a problem when a Chinese supplier – Suyin Electronics – was found to have used child labour. Apple was accused of knowing about the problem but failing to adequately respond in order to save money (BECKER, 2021).

Once suppliers have been selected, **building and maintaining supplier relationships** is another challenge. An increase in the number of suppliers also means an increase in the costs of **oversight** for the company's supplier network. As diversification means purchasing smaller quantities of raw materials from any one supplier, supplier loyalty to the company may end up decreasing. This can result in less comprehensive support and service, delays in delivery, or restricted deliveries in the event of material shortages. The challenge therefore lies in efficiently allocating resources in order to handle the work involved in maintaining supplier relationships.

The work inherent with an increased number of suppliers – carrying out quality control and comparing and adjusting prices – generates additional procurement costs. In general, distributing raw material orders among multiple suppliers is likely to cause **a reduction in economies of scale**. This is partly due to smaller bulk discounts or higher logistics costs for each supplier. In some cases, however, the increased competitive pressure between suppliers can offset cost increases.

Finally, there are also **cultural, political and temporal challenges** to diversification on an international level. These include issues such as legal difficulties, language barriers or infrastructure problems.

### Conditions and success factors

Various conditions and success factors should be taken into account for successful supplier diversification. These factors can be summarised under the three points explained below: **identification of suitable suppliers, geographical distribution and political stability** as well as **local presence and sufficient resources**.

*The study participants confirmed the hypothesis that larger companies with a high demand for raw materials can more successfully diversify their suppliers to minimise supply risk. This is because these companies procure larger quantities of raw materials, and also because they have better negotiating positions, extensive international contacts through foreign subsidiaries, and sufficient resources.*

(Hypothesis no. 4)

- Firstly, **identifying suitable suppliers** that meet the company's requirements is crucial for the success of this strategy. Companies need a sufficiently broad supplier base to deliver the quality and quantity of raw materials required at a particular price point. A **comprehensive qualification process** is therefore key for selecting and continuously auditing suppliers, and enables the company to develop a broad-based and reliable supplier network.
- Secondly, a high degree of diversification contributes to the success of this strategy. Every supply chain is different, reflecting both the company's characteristics and its raw material needs; but irrespective of these variations, **geographical distribution** among suppliers helps to mitigate country-specific supply risk. **Political stability** in the countries from which raw materials are sourced is essential for reliable, uninterrupted supply.
- Thirdly, the study results have shown that having a **local presence** in different countries contributes significantly to the success of supplier diversification. This means that the strategy is best suited to larger companies, and the extra work involved in coordinating diversified suppliers – particularly for building and maintaining relationships – means that **sufficient resources** (e.g. human resources, financial resources, IT communication resources) must be available.

### Recommendations for action

Based on the opportunities, challenges and success factors described above, the following recommendations for action can be made for diversifying suppliers. As explained above, decisions on diversifying suppliers must be made on a company-specific, **case-by-case basis**. Multiple sourcing can mitigate the supply risk inherent in single sourcing or dual sourcing. However, this risk mitigation comes at the cost of price increases due to the smaller size of each order, whereas single sourcing and dual sourcing offer the opportunity to benefit from bulk discounts. Lower levels of diversification are therefore more suitable for strategic materials that require longer-term collaboration and partnerships, as well as for specific materials which involve high upfront investments by the supplier. Increased diversification, on the other hand, is particularly recommended for critical materials subject to increased supply risk or where few suppliers are available on the market. These aspects also show that companies situated at the upstream end of the value chain in particular (e.g. purchasing goods directly from mines) should aim for a high degree of supplier diversification.

In addition, diversification should generally not only involve increasing the number of suppliers, but also expanding the **geographical distribution** of suppliers – although choosing the extent of this approach (i.e. global, Europe-wide, or limited to certain countries) is very much a company-specific decision. In some cases, local or regional procurement can also offer advantages. Although this increases dependence on individual suppliers and may be more expensive, it can simplify logistics, reduce uncertainty, costs, delivery times and pollution, and improve the company's image. As well as geographical diversification, companies should also consider diversifying their sourcing options, such as purchasing from different mines, purchasing different primary and secondary raw materials, or purchasing alternative materials.

Having made these considerations, it is then necessary to assess whether the company is capable of dealing with the more extensive supplier management processes that will be required. This assessment needs to consider the variety of different materials to be purchased, the specifications of the various materials and their geo-

graphical distribution. This is necessary to decide whether diversifying suppliers is feasible and economically sensible, and if so, to what extent. For many SMEs, it is advisable to **avoid relying on a single supplier** to mitigate supply risk, although excessive diversification is not recommended.

Following an in-depth examination of the question how much diversification makes sense for the company, supplier preselection and qualification need to be carried out. These are the first steps in a comprehensive supplier management process, which is covered in more detail in Section 5.2. Preselection – also known as supplier scouting – involves drawing up a long list of eligible suppliers. When doing this, it is well worth consulting both internal sources of information (e.g. existing offers, company supplier database) and external ones (e.g. trade fairs, recommendations, advertising brochures, self-disclosure from suppliers). After preselection, the potential suppliers go through a comprehensive qualification process, resulting in a shortlist. This serves to ensure adequate quality and to check that the suppliers meet requirements according to relevant standards, such as ISO 9001 or IATF 16949. Fundamentally, the starting point for developing a **company-specific qualification process** should always be the corporate strategy and the targets derived from it. The qualification process should then include a wide variety of relevant exclusion criteria and evaluation criteria based on these targets: these criteria may refer to aspects such as technical specifications, compliance with national or international standards, meeting social expectations, prices, certifications, delivery deadlines or emergency planning.

As well as commercial considerations, procurement is critical to a company's **environmental, social and governance** (ESG) leadership. The supplier qualification process is an excellent opportunity to enhance a company's ESG profile, as many ESG issues extend beyond the company itself: 80–90% of greenhouse gas emissions, for example, are indirect emissions that occur across the entire supply chain. The further upstream a supplier is, the more difficult it is to monitor its adherence to ESG criteria (CHEREL-BONNEMAISON et al., 2021). As a first step to addressing this, a company can analyse its situation by assessing its upstream ESG footprint and carrying out sustainability benchmarking against competitors. Next,

specific sustainability objectives for procurement need to be defined, and the company needs to set up internal and external guidelines, principles and initiatives. Specific high-priority initiatives can be used to pursue goals such as a carbon-neutral supply chain, a circular supply chain, waste reduction and zero tolerance on human rights violations (CHEREL-BONNEMAISON et al., 2021). The supplier qualification process must be designed to ensure compliance with specific ESG factors. An example set of relevant criteria, based on general economic metrics with the addition of social and environmental aspects, can be found in Figure 23.

Evaluation criteria must be weighted, specified in detail, and finally compiled to form a **scorecard**, which then can be used to systematically rank pre-selected suppliers. In this framework, suppliers are considered qualified if no exclusion criteria apply and the sum of their weighted evaluation criteria exceeds a specified threshold. This can also be extended depending on company requirements, including options such as points-based ABC analysis to classify suppliers or creating a panel of suppliers based on aspects such as price and quantity. At the end of the process, the guidelines must be reviewed, refined, and deployed at scale, aiming to move the entire organisation to the new system – not just procurement.

The sample scorecard in Figure 24 illustrates how suppliers can be evaluated according to selected criteria. A defined scale is essential – in this example, five levels of performance are used to assign a score for each criterion: fail (1), poor (2), average (3), good (4) or outstanding (5). The scores for each dimension are then added up to give a cumulative score, and multiplied by the appropriate weighting to give a weighted overall score for each dimension. Finally, adding up these overall scores gives a total score for all aspects: this reflects the supplier's overall performance, enabling comparison with other potential suppliers.

Initial qualification is not the end of the process. It is also important to reassess suppliers regularly – ideally on an annual basis – to ensure that quality is maintained. Specific actions can be initiated based on the outcome of these audits, ranging from presenting awards for excellent performance, to organising training for below-average performance, or even cancelling contracts for very poor performance.

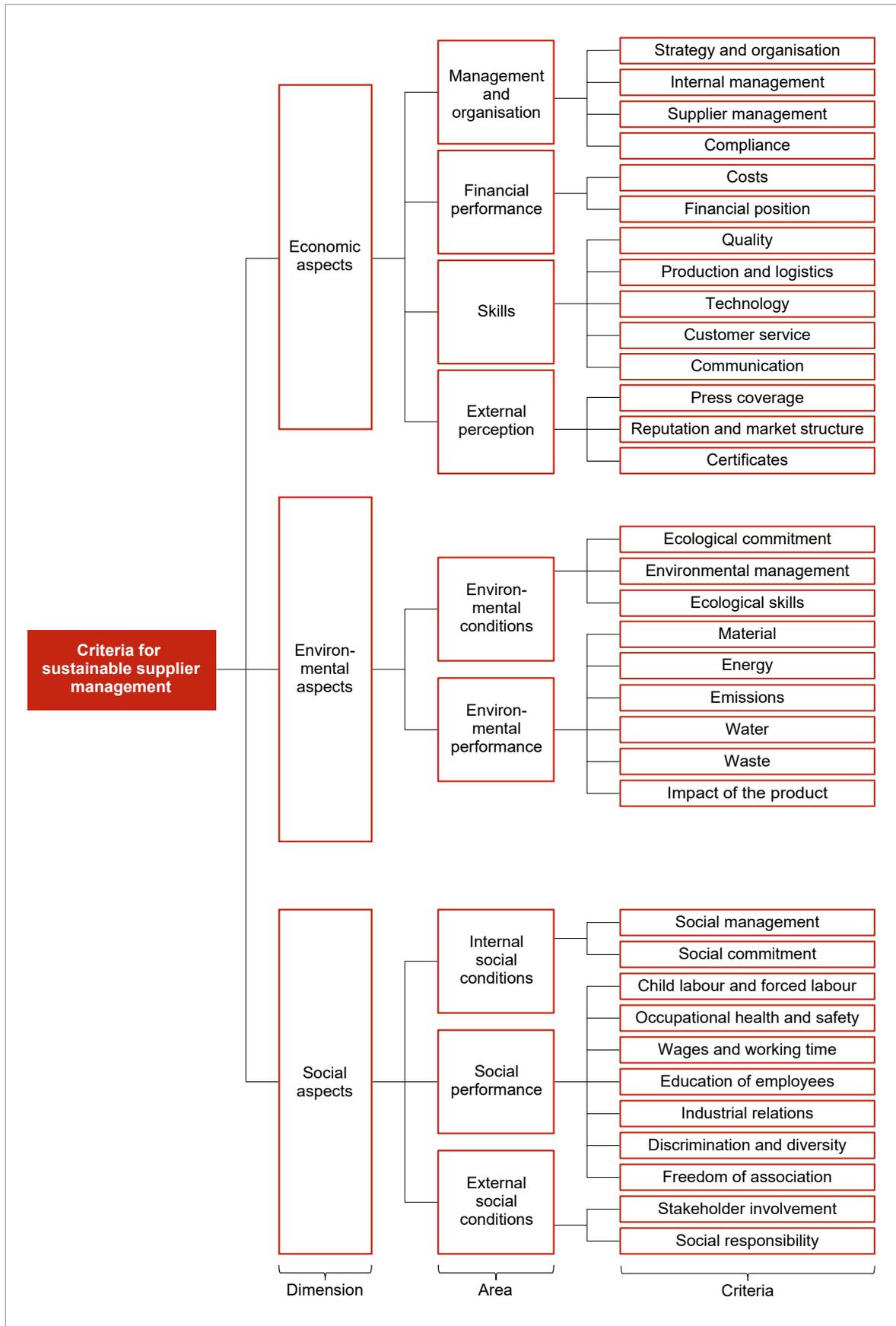


Figure 23: Selection criteria for the supplier qualification process

Performance of supplier X 01/2020–12/2020	Weighting	Grade	Score	Weighted score
<b>Social aspects</b>				
Discrimination and diversity	30%	Average	3	0.90
Freedom of association	20%	Outstanding	5	1.00
Child labour and forced labour	30%	Outstanding	5	1.50
Education of employees	20%	Fail	1	0.20
...	...	...	...	...
<b>Cumulative score</b>				<b>3.60</b>
<b>Overall social score (weighted)</b>		<b>25%</b>	<b>0.90</b>	
<b>Environmental aspects</b>				
Water	20%	Average	3	0.60
Waste	30%	Outstanding	5	1.50
Emissions	50%	Poor	2	1.00
...	...	...	...	...
<b>Cumulative score</b>				<b>3.10</b>
<b>Overall environmental score (weighted)</b>		<b>20%</b>	<b>0.62</b>	
<b>Economic aspects</b>				
Costs	40%	Good	4	1.60
Quality	20%	Good	4	0.80
Financial position	20%	Poor	2	0.40
Customer service	20%	Average	3	0.60
...	...	...	...	...
<b>Cumulative score</b>				<b>3.40</b>
<b>Overall economic score (weighted)</b>		<b>55%</b>	<b>1.87</b>	
<b>Total of all aspects</b>		<b>100%</b>	<b>3.39</b>	

Figure 24: Sample scorecard

Since the qualification process and many other aspects require comprehensive information and analytical skills, companies should also establish an **information management system** and ensure that they have sufficient analytical capabilities available. Setting up IT interfaces with suppliers is also recommended: this enables automated exchange of information in real time and reduces the effort involved in coordination and monitoring. Modern **supplier relationship management (SRM) systems** offer a variety of functions for mining, analysing and evaluating supplier data, and help foster transparency when working with suppliers. This software is thus another valuable addition to supplier management processes. As a rule, however, SRM products are very expensive; it is therefore important to undertake a detailed

assessment of whether a system's features meet the company's needs.

When working with suppliers, both **building and maintaining supplier relationships** are crucial. While business networking and personal interaction are cornerstones, relationship management also involves aspects such as properly considering both parties' interests in supplier contracts, and involving suppliers in internal business processes such as the development of new products. This can pay dividends for security of raw material supply: when shortages arise, suppliers are more likely to support companies if they are good customers. Therefore, companies should not neglect relationship building even when taking additional suppliers on board; and, if possible, diversification

should not be taken so far that personal relationships cannot be maintained. However, it is also important to retain enough flexibility to allow some supplier relationships to be less close than others (and hence, require less work to maintain them), depending on considerations such as criticality of the material in question.

Supplier management is an expensive, time-consuming and long-term process, so providing sufficient **resources** is also an important consid-

eration. During the Covid-19 pandemic, some companies have managed to save resources by streamlining supplier management, which demonstrates that there may be untapped potential for other companies. Companies which already have an established qualification process should therefore critically examine this process to identify any opportunities for improvement. The same applies to any IT-based processes or software products that have already been implemented.

**Table 4: Summary of supplier diversification**

 <p><b>Usage: current</b></p>	<p>No usage  -----  High</p> <p>Among the eleven strategies studied, supplier diversification is the second-most used strategy.</p>
 <p><b>Usage: next three to five years</b></p>	<p>No usage  -----  High</p> <p>This strategy is set to be the most used strategy over the next three to five years.</p>
 <p><b>Effectiveness</b></p>	<p>Low  -----  High</p> <p>Supplier diversification was rated as the most effective strategy examined in this study.</p>
 <p><b>Conditions and success factors</b></p>	<ul style="list-style-type: none"> <li>• Suitable suppliers that meet requirements need to be identified</li> <li>• Political stability in source countries</li> <li>• Supplier qualification and re-qualification process</li> <li>• Diverse geographical distribution of suppliers</li> <li>• Sufficient resources to monitor supplier relationships</li> <li>• Local presence in source countries</li> </ul>
 <p><b>Recommendations for action</b></p>	<ul style="list-style-type: none"> <li>• Identify whether diversification is suitable for the company and its raw material needs</li> <li>• Be aware that geographical distribution will vary depending on the raw material in question</li> <li>• Implement and improve supplier selection and management process</li> <li>• Create a comprehensive scorecard to select and continuously evaluate suppliers</li> <li>• Implement information management systems and SRM systems</li> <li>• Set up IT interfaces to enable automated exchange of information</li> <li>• Invest effort in building up and maintaining supplier relationships</li> <li>• Make resources available – supplier diversification requires both human and technological capital</li> </ul>

#### 4.4.5 Long-term contracts



##### Definition

Long-term contracts are commonly used in raw material procurement. If they include specific price clauses, they can help ensure sustained supply of raw materials and reduce price risk.

The essential components of a supply contract are the price, quantity and quality of material, and the duration of the contract. All four components are subject to negotiation between the two parties, structured in compliance with the relevant national and international legal frameworks. Highly specialised **pricing** provisions can be included to enable both sides to mitigate risks and maximise benefits: straightforward examples include fixed prices, spot prices and index-linked prices (price escalation clauses). Price floors or price caps are also not uncommon, as they offer both parties a certain amount of stability. Long-term contracts may include more complex pricing formulas which factor in predefined price increases (WANNENWETSCH, 2021). Contractual arrangements regarding the **quantity** of material to be delivered can also be freely structured. Some contracts specify fixed quantities, or a certain percentage of overall production, while others use more sophisticated agreements including minimum quantities (DAS & ABDEL-MAREK, 2003). Supply contracts usually also specify **quality** requirements, such as chemical or physical properties, size, minimum grade and impurity limits. Contracts may provide for penalties in case of failure to meet the specified quality requirements (WANNENWETSCH, 2021). The **duration** of a supply contract also depends on many factors, such as market dynamics and expectations, contractual agreements on prices and quantities, and the parties' bargaining power. Contracts lasting for more than five years are usually referred to as long-term contracts, but there is no uniform definition in the literature, nor is there a universal understanding of what constitutes "long-term": this depends on factors such as the raw material, product, industry or market in question. In general, longer-term contracts help to reduce supply risk, but reduce flexibility to react to market developments.

##### Corporate example

###### LG Energy Solution (South Korea)

LG Energy Solution manufactures advanced lithium-ion batteries for electric vehicles, which require large quantities of critical raw materials. To secure supplies of these materials, LG Energy Solution uses long-term contracts. These include a six-year contract with Australian Mines Ltd. for mixed nickel-cobalt hydroxide (71,000 tonnes of nickel per year and 7,000 tonnes of cobalt per year) (ROSKILL, 2021d), and a six-year contract with Sigma Lithium Corp. for battery-grade lithium concentrate (60,000 tonnes in 2023, rising to 100,000 tonnes per year from 2024 to 2027) (KUMAR, 2021).

##### Usage and effectiveness

Among the eleven strategies examined, long-term contracts have the highest level of **current usage** (see Figure 25). Only 4% of the companies surveyed are currently not using long-term contracts; 96% are using the strategy, with 28% of those doing so rating their level of usage as high and 51% as medium. Long-term contracts are also widely used in Germany – a survey by INVERTO which primarily surveyed German companies found that 60% of respondents used long-term fixed-price contracts in 2021 (INVERTO, 2021). This had increased from 42% in 2015, showing that German companies consider long-term contracts to be a suitable means of securing raw materials (INVERTO, 2017; 2021). This finding was also supported by the representatives of German industry associations consulted in the workshop for the present study. Alongside securing raw material supplies, interviewees also stated that their companies had implemented long-term contracts because they enable better planning: long-term contracts with fixed prices and delivery dates simplify both financial planning and the planning of operational processes. In some cases, interviewees stated that they conclude long-term contracts to meet minimum durations and quantities imposed by suppliers. For example, mining projects often use project financing: this requires stable and predictable cash flows, making long-term contracts with fixed quantities essential. The main reason given for not entering into long-term contracts was their lack of flexibility. Long-term contracts commit companies to purchasing and paying for a set amount of raw material, even if subsequent changes in demand

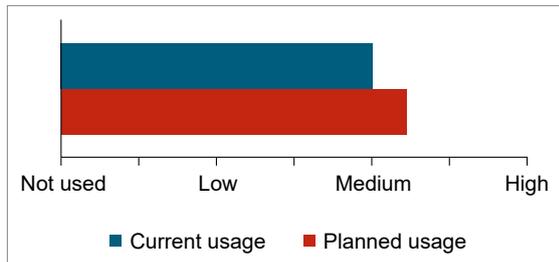


Figure 25: Usage of long-term contracts

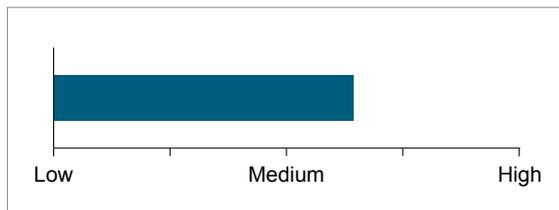


Figure 26: Effectiveness of long-term contracts

for the company's products mean that less material is ultimately needed.

Long-term contracts were rated as the **second-most effective** strategy (see Figure 26). In line with this, the companies surveyed are **planning to increase their usage** of long-term contracts over the next three to five years (see Figure 25). As the strategy already plays an important role in most companies surveyed, this increase is set to be relatively minor. Long-term contracts have the second-highest level of planned usage, exceeded only by supplier diversification. According to the study participants, a major reason for increasing use of long-term contracts is the expectation of material shortages in the future (especially for raw materials used in technological products), which is prompting companies to take measures to minimise their exposure to supply risk. A number of participants also expect volatile prices for some raw materials, which can be circumvented by including fixed prices in long-term contracts. Another consideration is that demand for certain raw materials is expected to increase in the future due to technological changes (e.g. electrification), and that these raw materials are concentrated in certain countries. If sources and suppliers of these materials are available in other countries, long-term contracts offer a means of binding these suppliers to the company, thus reducing country risk.

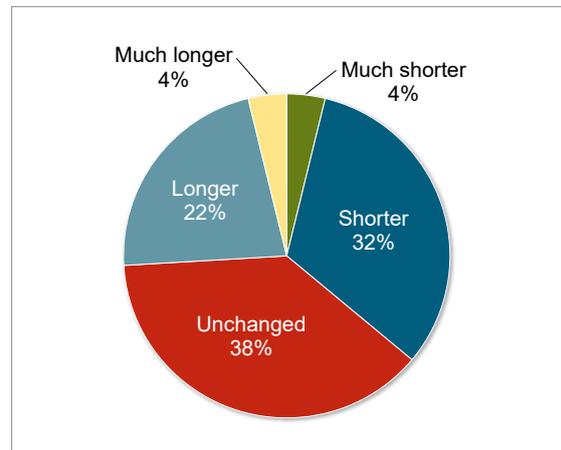


Figure 27: Changes in contract duration

The general expectation of increasing shortages of raw materials may lead to raw material producers gaining better contract negotiating positions, enabling them to force purchasers to accept shorter-term contracts. Given these changes in market dynamics, the survey respondents were asked whether the **duration** of their raw material contracts has changed over the last two years. However, this did not reveal a strong overall trend (see Figure 27): contracts have become shorter for 32% of the companies and much shorter for 4%, but longer for 22% and much longer for 4%. Contract duration has generally not changed for the remaining 38% of the companies. These contrasting statements show that changes in contract duration depend on a variety of factors, including the market and raw material under consideration as well as its scarcity. However, the interviewees stated that suppliers tend to enforce shorter-term contracts for raw materials which are scarce or where future demand is expected to be strong (e.g. lithium): this suggests that producers of these raw materials expect to be able to negotiate better contracts in the future. By contrast, suppliers offer (or even require) longer-term contracts for raw materials where a relatively good balance of supply and demand is expected.

### Opportunities and challenges

Long-term contracts are associated with various opportunities and challenges. The opportunities can be grouped into three categories: **security of raw material supply, long-term transparency for customers and increased supplier loyalty.**

Challenges can be grouped into **limited flexibility, preparing reliable forecasts** and **isolation from the market**.

*“Given the expected increase in raw material prices due to the huge amounts of money that are currently flowing, long-term contracts are very important both now and for the future.”*

Raw material expert at a law firm

Prices, quantities, quality or duration can all be fixed in a long-term contract. In line with the focus of this study on securing raw material prices and supply, the following discussion includes contracts with variable prices, fixed prices, variable quantities and fixed quantities. All contracts discussed below are assumed to be long-term contracts giving fixed quality of raw materials.

Supply contracts can be drafted with various different combinations of price and quantity clauses, as shown in Figure 28. Option 1 is an example of a five-year, fixed-price, fixed-quantity combination; option 2 retains the fixed price, but allows variable quantities. Option 3 gives variable prices for fixed quantities, and option 4 combines both variable prices and variable quantities. The following section discusses the advantages and disadvantages of the various combinations. In general, surcharges are payable for fixed quantities, whereas fixing a low price may put a company at a disadvantage if shortages arise.

**Security of raw material supply** – and hence, long-term reduction of supply risk – is a major advantage of quantity assurance clauses in long-term contracts, whether the contract provides for a fixed or a variable quantity. Having this security enables companies to better manage warehouse utilisation and storage capacity, and even to reduce them if necessary. This generates benefits

in the form of reduced capital commitments and reduced costs for stockholding.

While securing a supply of raw materials is a major goal of long-term contracts, it is not possible to make a single general statement about price security, as fixed prices and dynamic price agreements are both common.

Price fixing offers the advantage of avoiding unexpected cost increases over a long period, which helps improve the reliability of planning and budgeting. It also enables **increased price transparency for customers**, helping the company to pass on stable prices to customers. **Reliable delivery** is another positive aspect of long-term contracts, which offers benefits for product distribution and customer satisfaction: long-term contracts mostly secure supply, avoiding production stoppages due to lack of materials. This, in turn, enables a constant output of goods to meet customer demand.

Most long-term contracts today include indexed pricing, either with or without a markup. A long-term aluminium supply contract, for example, might permit prices to be adjusted every month based on the LME aluminium price. Another way of setting prices in long-term contracts is to fix a price range; prices are renegotiated if they subsequently move outside this fixed range. The power of a long-term contract to secure prices is thus heavily dependent on the contract's exact provisions. Variable pricing, especially indexed pricing, enables companies to exploit any drops in market prices to reduce procurement costs.

Another advantage of long-term contracts is that they **strengthen supplier relationships**, which increases supplier loyalty. Because these contracts are, by definition, long-term, it is in the supplier's interest to focus more strongly on the needs of the purchasing company than would

	Fixed quantity		Variable quantity	
Fixed price	1.	10 tonnes/month at EUR 100/tonne for 5 years	2.	5% of total monthly production at EUR 100/tonne for 5 years
Variable price	3.	10 tonnes/month at LME index price for 5 years	4.	5% of total monthly production at LME index price for 5 years

**Figure 28: Simple combinations of prices and quantities for supply contracts**

Opportunities	Challenges
<p><b>Security of raw material supply:</b></p> <ul style="list-style-type: none"> <li>– Long-term contracts with suppliers</li> <li>– More reliable planning for storage capacity and warehousing</li> </ul> <p><b>Long-term transparency for customers:</b></p> <ul style="list-style-type: none"> <li>– Prices fixed with suppliers</li> <li>– Shorter lead times because new supplier relationships do not need to be established</li> </ul> <p><b>Increased supplier loyalty:</b></p> <ul style="list-style-type: none"> <li>– Long-term, mutually beneficial supplier relationships</li> <li>– Joint product development projects and/or profit sharing</li> </ul>	<p><b>Limited flexibility:</b></p> <ul style="list-style-type: none"> <li>– Long-term purchasing commitment, risk of contractual penalties</li> <li>– Reduced opportunities for supplier diversification</li> </ul> <p><b>Preparing reliable forecasts:</b></p> <ul style="list-style-type: none"> <li>– Production and purchasing needs to be planned for the long term</li> <li>– Banks/investors need reliable forecasts</li> </ul> <p><b>Isolation from the market:</b></p> <ul style="list-style-type: none"> <li>– Purchasers may be unable to benefit from falling prices</li> <li>– Reduced competition between suppliers</li> </ul>

otherwise be the case – for example, by getting involved in joint product development projects. Some interviewees only mentioned advantages for suppliers, but others believe that approaches need to be adjusted to keep long-term contracts sufficiently attractive for both parties – for example, by sharing profits at the end of the year.

Much like the opportunities, the challenges associated with long-term contracts are also heavily dependent on their exact provisions – in particular, whether the contracts fix quantities, prices or both. Fixed quantities present the **risk of increased inflexibility**. If demand for manufactured products declines and less material is needed, a company with a fixed-quantity contract will still be contractually obliged to take delivery and will thus end up with surplus material. Failure to take delivery may trigger penalties, depending on the exact provisions of the contract. If a single contract provides a large portion of the company’s total raw material needs, opportunities to diversify suppliers will be limited.

When making a long-term commitment to a given quantity of raw materials, creating a **reliable forecast** of raw material needs is a major challenge. This is particularly difficult in industries that are currently undergoing the upheaval of electrification, although many companies consider surpluses to be a tolerable risk: their focus is on ensuring sufficient access to raw materials. In some cases, companies use debt capital to finance larger orders of raw materials; reliable forecasts are also needed in these cases to allow banks to carry out credit assessments. A loan may

be unavoidable if a long-term contract requires a down payment that cannot be covered by the company’s own liquid assets.

All long-term contracts – regardless of whether they include fixed prices or fixed quantities – run the risk of the company becoming **isolated from the market**. Fixed prices combined with fixed quantities prevent companies from taking advantage of any falls in prices, resulting in additional costs: as a rule, the longer the contract, the higher the risk of these costs. Long-term contractual ties with suppliers can also weaken competition between suppliers: this may lead to the company receiving lower-quality or more expensive materials, while being unable to change suppliers. Variable-price, fixed-quantity contracts present the risk of exposure to market-driven price increases.

Most companies prefer to fix prices but not quantities. This poses a challenge when negotiating, as suppliers usually prefer to fix quantities. To protect themselves against market developments, suppliers may offer fixed prices which are slightly higher than current market prices.

**Conditions and success factors**

Various conditions and success factors need to be considered when implementing long-term contracts. The success factors are described under the three points below: **reliable forecasts, adequate bargaining power** and **retaining sufficient flexibility**.

*The majority of experts confirmed the hypothesis that raw material suppliers have more bargaining power than purchasers when negotiating long-term contracts. This makes it essential for purchasing companies to develop internal negotiating expertise and build good relationships with multiple suppliers.*

(Hypothesis no. 5)

- Firstly, **reliable forecasts** are important when drafting long-term contracts: they need to accurately consider sales market dynamics, the impact of long-term contracts on the company's own product portfolio, and shifts in supply and demand in the procurement market. Forecasts are necessary because long-term contracts only make sense if the company has a clear overview of its raw material needs and a good understanding of whether suppliers can meet this demand in the long term. This success factor will only become more important in the future, as innovation cycles are becoming ever shorter and companies will therefore need to consider new raw materials more frequently.
- Secondly, the **company's bargaining power, legal expertise and the resulting contractual provisions** need to be considered. As mentioned above, suppliers usually prefer to fix quantities, while purchasing companies aim to fix prices. To resolve this conflict of objectives and achieve a favourable outcome, companies need to go into negotiations with good bargaining power. This can be developed through a combination of purchasing large quantities of raw materials, leveraging legal expertise, and offering attractive conditions for the supplier that go beyond simply exchanging money and materials – this might include providing marketing for the supplier by adding the supplier's logo to the company's products or website. Although purchasing large quantities of material offers good bargaining power, it is still important to take the company's actual requirements into account as far as possible, as explained above. Leveraging legal expertise and offering attractive contractual provisions requires the negotiations to be professionally prepared and conducted, but can offer considerable

benefits: transparent contractual frameworks that adequately consider supplier interests will not only secure raw materials, but also lay the foundations for long-term supplier relationships.

- Thirdly, **retaining sufficient flexibility** despite having a long-term commitment is critical if the company is to remain competitive. Supplier diversification and implementing a variety of contracts – long-term and short-term, fixed and variable prices and quantities – are therefore crucial to prevent the disadvantages of this strategy outweighing its advantages.

### Recommendations for action

A number of recommendations for action can be made to ensure successful preparation and implementation of long-term contracts, as outlined below. Companies should start by asking the question of whether long-term contracts are suitable for their needs, and if so, to what extent. This requires **knowledge of future raw material needs** based on the company's product portfolio, as well as an understanding of the availability of the raw materials required and of potential contractors (i.e. suppliers). To gain these insights, companies need to **analyse market trends and holistically evaluate suppliers**: the use of business tools (see Section 4.4.11) is recommended for predicting trends in raw material demand, supply and availability. This, in turn, requires the company to have sufficient analytical skills; these must be developed if they are not already available. Analysis and evaluation of suppliers must also include a financial assessment to determine whether the supplier can maintain its business operations in the long term.

Having done this, it is essential to pay close attention to the contract drafting process, as the provisions of the contract will form the cornerstone of the long-term supplier relationship in question. As explained above, long-term contracts vary depending on whether prices or quantities are fixed or variable, and depending on their duration: contractual arrangements are determined by the decision on whether to mitigate price risk or supply risk. Generally speaking, **fixing prices** makes sense if prices are predicted to increase, whereas

**variable-price** agreements are advisable if prices are expected to fall. Thorough assessment and forecasting of market trends is therefore highly recommended when making this decision. To further minimise price risk, price adjustment clauses in fixed-price contracts or bulk discount agreements in variable-price contracts are recommended, and companies should also consider additional strategies such as commodity price hedging (see Section 4.4.1).

If, however, companies are looking to obtain raw materials which are likely to become subject to shortages, securing the lowest possible prices becomes a secondary consideration: the focus in this situation must be on uninterrupted supply of raw materials. If both criticality and demand for a given raw material are rising, companies should enter long-term contracts to secure supply. In general, committing to **fixed quantities** (and the resulting obligation to purchase) is advisable if the company can reliably forecast market demand, development of criticality and its own material needs. The company must also be in a position to deal with tied-up capital and excess inventory if sales unexpectedly decrease. If these conditions cannot be fully met, **variable quantities** are more advisable. Various arrangements can be used in this situation. For example, purchaser and supplier might agree a contract which obliges the purchaser to accept part of a given quota of raw materials, and gives the option to purchase some or all of the remaining part of the quota. Other types of variable-quantity contracts include option-based contracts and periodic variable-quantity agreements which allow quantities to be changed at fixed intervals (WILKE, 2012). It is important for companies to remember that variable quantities increase uncertainty for the supplier and therefore attract higher prices (WILKE, 2012). The ratio of fixed-quantity to variable-quantity solutions is a company-specific decision that must be made in light of the factors mentioned above (e.g. supply risk, market forecasts, expected demand for company products).

Although circumstances may vary in different companies, it is generally advisable to **combine long-term contracts with short-term contracts**. Including short-term contracts in a company's supply portfolio helps to increase flexibility and opens up opportunities to exploit improvements in the market (e.g. falling prices); it also offers

the opportunity to shift suppliers frequently. This increases competition between suppliers, driving down prices and improving quality. It is therefore not uncommon for companies to strike a balance between contracts of different lengths to combine their advantages: this might involve procuring 50% of the company's raw material needs through long-term contracts, 30% through medium-term contracts and the remaining 20% through the spot market (i.e. short-term). Combining contract lengths can be made even more effective by spreading the contracts across multiple suppliers. When striking a balance of this nature, it is also advisable to consider the length of customer contracts, as alignment between contract periods (e.g. three-year contracts with customers and three-year contracts with suppliers) can be useful for reliable planning and inventory management. **Existing contracts** should also be critically examined alongside the drafting process for new contracts. The results of this examination should be incorporated into new contracts and used to renegotiate existing contracts wherever possible.

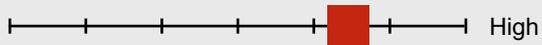
**Building up and maintaining relationships** with suppliers is very important when long-term contracts are involved, and companies are advised to devote sufficient time and resources to these relationships. This not only helps in negotiations, but can also lead to the supplier making concessions if adverse market developments occur (e.g. if prices fall but the company holds a fixed-price contract). Indeed, it makes sense to go a step further and **develop relationships beyond long-term contracts** into partnerships between companies and their suppliers. This can enhance business relationships, bring prices down and provide insights into the supplier's profitability.

To effectively negotiate supplier contracts and manage price renegotiations, it is very important for companies to ensure that they have **sufficient negotiating skills**. These negotiations often present a challenge; the extent of the challenge depends on the company's bargaining power, which in turn is determined by its liquidity, reputation and the total quantity of material to be purchased. Bargaining power held by SMEs in these negotiations may therefore be limited. However, SMEs which sell their products to large and therefore influential customers can use these relationships to improve their bargaining power with large suppliers: SMEs in this position are recommended

to ask large customers for support in negotiating. Providing this support is in these customers' interests, as they will also benefit from a well-negotiated relationship between the SME and the

supplier. Companies are strongly advised to train procurement staff in negotiation and contract law to ensure a reliable understanding of the topic.

**Table 5: Summary of long-term contracts**

 <b>Usage: current</b>	<p>No usage  High</p> <p>Among the eleven strategies studied, long-term contracts are the most used strategy.</p>
 <b>Usage: next three to five years</b>	<p>No usage  High</p> <p>This strategy is set to be the second-most used strategy over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  High</p> <p>Long-term contracts were rated as the second-most effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Reliable forecasts of external material supply and internal material needs</li> <li>• Sufficient bargaining power</li> <li>• Retaining flexibility despite having a long-term commitment</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Decide whether to fix prices, quantities or both</li> <li>• Assess and forecast market trends</li> <li>• Put effort into drafting compliant and beneficial contracts</li> <li>• Balance and combine fixed and flexible solutions</li> <li>• Balance and combine long-term and short-term contracts</li> <li>• Build up and maintain relationships with the suppliers</li> <li>• Develop relationships beyond long-term contracts</li> <li>• Ensure negotiating skills are available within the company</li> </ul>

### 4.4.6 Purchasing groups



#### Definition

Purchasing groups are a strategy for multiple companies to secure their individual raw material needs: several companies pool resources to jointly purchase their raw materials, while remaining legally and economically independent. Purchasing groups can be formed either vertically or horizontally, and are not usually location dependent (SCHUH et al., 2014).

Purchasing groups enable several synergies to be achieved. Firstly, purchasing groups have greater bargaining power than the individual companies would, allowing them to obtain better prices and larger quantities of material in times of scarcity (SCHMID, 2020). Pooling demand in purchasing groups allows multiple sourcing while still purchasing large quantities of raw materials. The strategy also reduces administrative costs, as negotiations are conducted by a single purchasing group instead of multiple companies (NOLLET & BEAULIEU, 2005). Purchasing groups need not limit collaboration to procurement – extending their activities to other functional areas and services (e.g. supply chain consulting, sharing expertise, collaborative component development) can offer benefits for the individual companies far beyond procurement (BARTH et al., 2015).

#### Usage and effectiveness

The survey revealed that purchasing groups have the second-lowest level of **current usage** of all the strategies examined (see Figure 29). Although 68% of survey respondents are currently using this strategy, 82% of those doing so said that their level of usage was low. These results are in line with INVERTO’s 2021 raw materials management survey, which found that only a small proportion of German companies (14%) currently use this strategy, down from 19% in 2015 (INVERTO, 2017; 2021). Reasons for not using purchasing groups given by interviewees in the present study included risks related to sharing purchasing data and strategy with other companies – especially competitors – along with each company’s focus on its own interests and concerns about antitrust laws. Collaboration with companies from

#### Corporate example

##### Hino Motors and TRATON Group (Japan and Germany)

In 2019, Japanese and German truck and bus manufacturers Hino and TRATON established HINO & TRATON Global Procurement. By combining their sourcing activities, the companies expect to expand their global footprint and supplier base and achieve synergies. Yoshio Shimo, Hino’s CEO, stated that the joint venture will enable Hino to offer appropriately priced products more quickly to meet customers’ needs (HINO & TRATON, 2019).

other industries was often not considered a viable option due to the anticipated challenge of jointly agreeing on strategies and the difficulties involved in communication and coordination. However, if these barriers could be overcome, the interviewees said that the strategy would be helpful for negotiating better prices and conditions.

The survey respondents rated the **effectiveness** of purchasing groups below medium (Figure 30), and the strategy ranked eighth out of the eleven strategies examined. The companies surveyed are **planning to increase** usage over the next three to five years, although it must be noted that current usage is very low (Figure 29). The percentage of respondents using purchasing groups

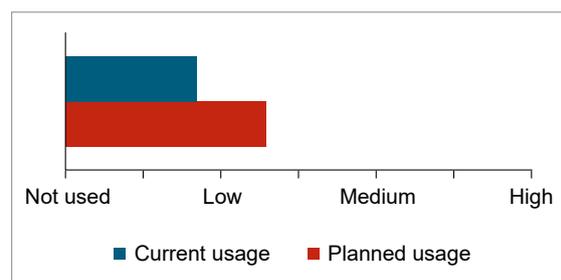


Figure 29: Usage of purchasing groups

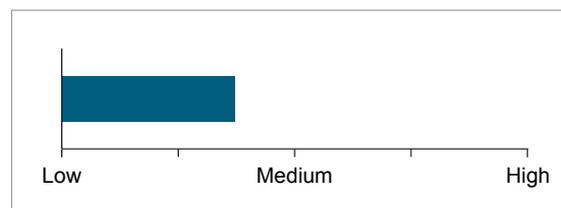


Figure 30: Effectiveness of purchasing groups

in some form is set to increase from 68% to 81%, but only a small proportion (9%) are planning high levels of usage of the strategy. The majority of respondents who intend to use this strategy in the future are only planning minor usage of the strategy, although the level of usage will still increase on average. The interviewees stated that purchasing groups are becoming more important because of the increasing concentration of supply among fewer raw material producers, and the growing bargaining power held by raw material producers as certain raw materials become more scarce. The companies expect that pooling their raw material needs will enable them to negotiate better prices and improve security of supply.

### Opportunities and challenges

Purchasing groups involve various opportunities and challenges. The opportunities can be broadly grouped into three categories: **reduced procurement prices, reduced costs, and concentration of knowledge and expertise**. Challenges can be grouped into **complex preparation, conflicts of interest and legal issues**.

Purchasing groups offer the opportunity to **reduce**

*“The relevance of purchasing groups will increase, as they help improve competitiveness – in terms of costs, time and quality.”*

Purchasing manager at a leading company in the packaging industry

**procurement prices**. Pooling demand from multiple companies within a purchasing group increases the total quantity of materials being procured, making a deal more attractive for suppliers and thus improving the companies' bargaining power. This represents a particularly substantial advantage for SMEs, given the typically small size of their raw material needs.

Purchasing groups also help **reduce costs** for the individual companies. Lower procurement costs due to reduced purchase prices will increase **product margins**, while outsourcing order management and procurement processes to purchasing alliances will reduce administrative costs and procurement overheads. Reorganising logistics within the group can also open up potential for

improvements – for example, creating a single logistics hub for distributing raw materials to group members may enable cost savings.

Another advantage of purchasing groups is the **concentration of knowledge and expertise** which they enable. This offers the opportunity to share services and experiences within the purchasing group, in turn strengthening collaboration between group members. It also enables group members to gain insights into processes and behaviour of the other members, allowing operating models and best practices to be adopted. Finally, purchasing groups enable companies to draw on larger supplier bases, which in turn offers the opportunity for increased supplier diversification and decreased dependence on individual suppliers.

However, purchasing groups also present a number of challenges which need to be mastered before the strategy can be implemented. The first one lies in the **complex preparation process**: the companies have to analyse their internal requirements and carry out external research about suitable suppliers, and the difficulties involved in this become even greater when very specific raw materials are required. Each company's raw material requirements (i.e. quantity, quality and delivery times) need to be aligned with those of the other companies in the group.

Further early-stage challenges can arise if the companies involved are very different: for example, decision-making might be quicker in some companies than others. Likewise, unequal distribution of power between companies may result in some companies becoming dependent on others. Language barriers and cultural differences also cannot be ruled out as problems. **Conflicts of interest** are another challenge: individual companies will tend to focus primarily on their own interests rather than those of the group, which will cause difficulties when attempting to collaborate. A further issue with purchasing groups related to conflicts of interest is **disclosure of sensitive company information**. It is not uncommon for purchasing groups to provide other parties – such as competitors – with insights into purchasing processes and trade practices, potentially leading to unwanted transfer of knowledge which would otherwise represent a competitive advantage. This is particularly important in the current market con-

Opportunities	Challenges
<p><b>Lower procurement prices:</b></p> <ul style="list-style-type: none"> <li>– Improved bargaining power</li> <li>– Larger quantities of material procured</li> </ul> <p><b>Increased product margins:</b></p> <ul style="list-style-type: none"> <li>– Lower procurement prices</li> <li>– Reduced administrative costs (e.g. due to outsourced procurement processes)</li> </ul> <p><b>Concentration of knowledge and expertise:</b></p> <ul style="list-style-type: none"> <li>– Shared experiences and services within the group</li> <li>– Processes and service modules can be adopted from group members</li> </ul>	<p><b>Complex preparation:</b></p> <ul style="list-style-type: none"> <li>– Companies must be able to predict their requirements</li> <li>– External research on potential partners</li> </ul> <p><b>Conflicts of interest:</b></p> <ul style="list-style-type: none"> <li>– Unequal power can create conflict when selecting suppliers</li> <li>– Disclosure of sensitive information is unavoidable</li> </ul> <p><b>Legal issues:</b></p> <ul style="list-style-type: none"> <li>– Antitrust laws</li> <li>– Monitoring by authorities</li> </ul>

text, as supply chain management and reliable access to raw materials are vital for business continuity and have become critical for setting companies apart from their competitors.

A final challenge concerns **legal issues**, which vary from country to country. Although purchasing groups are not inherently problematic under antitrust law, they are nonetheless monitored by the relevant authorities to ensure that they do not engage in downstream market abuse or prohibited forms of collusion, or form alliances to the detriment of suppliers. Thorough compliance with all applicable laws and regulations is therefore very important for smooth operation of purchasing groups.

**Conditions and success factors**

Various conditions and success factors are essential for successful implementation and use of purchasing groups. These success factors can be summarised under the three points explained below: **identifying suitable partners, close cooperation and collaboration** and **the competitive environment**.

*The experts confirmed the hypothesis that purchasing groups between companies in different sales markets are the most viable option due to the low level of competition between members.*

(Hypothesis no. 6)

- Firstly, the process of **identifying and teaming up with suitable partners** is a key initial success factor. This process should not be underestimated and needs to be approached systematically, taking the company's individual requirements into account. Relevant requirements when searching for partners include quantity of materials to be purchased, targeted price, choice of suppliers, business ethics and legal framework.
- Secondly, it is vital for companies to be **willing to cooperate and collaborate**. Once companies have formed or joined a purchasing group, they must be geared towards **creating added value for all parties involved** and promote joint, holistic thinking. In the case of transnational purchasing groups, good **communication** across both language barriers and cultural barriers is also very important. As well as the uniform, unambiguous use of technical terms, regular face-to-face meetings are essential to avoid misunderstandings.
- Thirdly, the **competitive environment** in which the companies operate must be taken into consideration: according to some experts interviewed for this study, purchasing groups do not make sense if the companies in the group are competing for similar clients.

### Recommendations for action

Various recommendations for action can be made for a systematic approach to either joining or forming a purchasing group. The recommendations are structured as a process, divided into four steps: **identify raw material needs, identify potential partners, join or form a purchasing group and manage and maintain a purchasing group**. The first and second steps of the process are focused on answering the important question of whether or not to opt for this strategy. It is essential for companies to answer this question before moving onto subsequent steps.

**Identify raw material needs:** before investigating potential partners or existing purchasing groups, companies need to **identify their future raw material needs**. This requires both internal and external research to predict future sales figures, and hence calculate the quantity of raw materials needed to satisfy customer demand. Companies then need to determine the share of their raw material needs that will be met by joint procurement. Purchasing all raw materials through the purchasing group may not be the preferable solution, as pursuing additional procurement strategies can achieve further cost savings and will reduce risk (NOLLET & BEAULIEU, 2005).

**Identify potential partners:** once raw material needs are clear, companies should create a benchmarking system to **compare potential partners**. There are many potential variables to consider when benchmarking; the significant ones are dependent on the company's individual situation. The most relevant aspects when joining or forming purchasing groups are total expected quantity of materials, expected purchase price, sourcing strategy and supplier base. However, as described above, factors such as power distribution between purchasing group members should not be overlooked, and the competitive environment must be assessed: partnerships with direct competitors are best avoided due to the risk of disclosing company secrets. Companies should also consider any extra services that they want to obtain through the members of the purchasing group, such as safety initiatives, technology assessments or process improvements. Finally, the total cost of membership for the company joining a purchasing group must be considered – both in terms of recurring costs (e.g. membership fees)

and upfront costs (e.g. establishing new procurement channels). To gather information on these costs, companies should speak to members of existing groups and seek external data.

**Join or form a purchasing group:** having identified potential partners or existing groups, companies need to examine the legal structure of their potential purchasing group. Any **legal issues must be solved before entering the group:** purchasing groups of a certain size may exceed problematic thresholds under national antitrust laws, while a legally compliant framework under international contract law is an essential foundation for a sustainable and trusting relationship between the group members. **Open communication** within the group is very important for transparency regarding joint activities and to create trust between members. Trust can also be promoted by drawing up codes of conduct and other compliance guidelines in addition to legally binding contracts.

**Manage and maintain a purchasing group:** companies will benefit most from purchasing groups if they **understand and welcome the collaboration** brought about by the strategy, rather than simply seeing it as a means of bundling raw material orders. When bringing together professionals from different companies, sharing best practices and exchanging information is recommended, but it is nevertheless important to address the risk of disclosing sensitive information that may destroy a company's competitive advantage. To **protect sensitive information**, transparency and insights must therefore only be granted to group members where this is necessary. Purchasing groups should also monitor market activities and put effort into reverse marketing, which is a systematic approach by purchasers to **identify and jointly convince potential suppliers** to collaborate. Finally, members of purchasing groups should consider collaboration at other levels, such as jointly developing and running recycling plants or investing in mines.

**Table 6: Summary of purchasing groups**

 <p><b>Usage: current</b></p>	<p>No usage  -----    -----  High</p> <p>Among the eleven strategies studied, purchasing groups currently have the second-lowest level of usage.</p>
 <p><b>Usage: next three to five years</b></p>	<p>No usage  -----    -----  High</p> <p>This strategy is set to have the second-lowest level of usage over the next three to five years.</p>
 <p><b>Effectiveness</b></p>	<p>Low  -----    -----  High</p> <p>Purchasing groups were rated as the eighth-most effective strategy examined in this study.</p>
 <p><b>Conditions and success factors</b></p>	<ul style="list-style-type: none"> <li>• Suitable partners must be available and willing to collaborate</li> <li>• Added value for all parties involved</li> <li>• Communication and group culture must respect the individual companies' cultures</li> <li>• Competitive environment must allow a trusting partnership</li> </ul>
 <p><b>Recommendations for action</b></p>	<ul style="list-style-type: none"> <li>• Clearly identify which benefits and targets are being aimed for by entering a purchasing group</li> <li>• Calculate raw material needs and establish benchmarks to identify potential partners</li> <li>• Holistically compare potential partners and communicate with them</li> <li>• Solve legal issues before joining a purchasing group and build a solid contractual framework</li> <li>• Strive for inclusive communication and welcome collaboration in various business areas</li> <li>• To avoid unwanted transfer of knowledge or technology, only disclose sensitive information where absolutely necessary</li> </ul>

#### 4.4.7 Increased material efficiency



##### Definition

Material efficiency describes how much material is used and wasted to make a product. High material efficiency indicates low levels of waste and overall material usage. Increasing material efficiency therefore reduces the quantity of material required for a given product, and in turn reduces supply risk because less material needs to be sourced overall (IW, 2013).

Material efficiency can be increased by changes in product design, technological innovations or gradual improvement of manufacturing processes. For instance, material efficiency can be improved by additive layer manufacturing (3D printing), multi-purpose furnaces or improved laser cutters<sup>20</sup>. Management tools and digitalisation can also help to examine operational processes and identify sources of error. Eliminating those enables increased efficiency (VDI, 2017; FRAUNHOFER IPA, 2015).

Increased material efficiency helps to reduce the quantity of raw materials required per product produced, thus reducing supply risk. It also reduces total material costs and spare part costs. These efficiency gains can contribute to offsetting raw material price increases. However, increased material efficiency only has a limited effect on other risks. For instance, politically induced supply chain disruption can strike regardless of how efficient a manufacturer is – although a company with high material efficiency could successfully ride out such a crisis with smaller stocks of raw materials (IW, 2013).

##### Usage and effectiveness

The survey found a moderate level of **current usage** of increased material efficiency as a strategy (see Figure 31). Among the companies surveyed, 76% are currently conducting projects to increase material efficiency, but only 4% of those using the strategy said that their level of usage

#### Corporate example

##### Airbus (France)

European aircraft manufacturer Airbus has used additive layer manufacturing, also known as 3D printing, since 2017. According to the company, the technology helps to reduce raw material consumption by up to 90% in the production of specific parts. Decarbonisation of aviation is the main motivation for using the technology: 3D-printed parts are lighter than their conventional counterparts, which saves fuel and therefore reduces CO<sub>2</sub> emissions. Other advantages include the flexibility of 3D printing (parts can be designed, printed and tested quickly) and reduced costs, as spare parts can be printed individually as needed instead of being held in storage (AIRBUS, 2021).

was high. Usage of this strategy is also fairly moderate in German companies. According to the 2021 INVERTO raw materials management study, which largely surveyed German companies, 30% of companies had implemented material efficiency projects; this figure had varied between 30% and 46% in previous studies (INVERTO, 2017; 2019; 2021). When asked for the reasons behind the adoption of this strategy, most experts interviewed

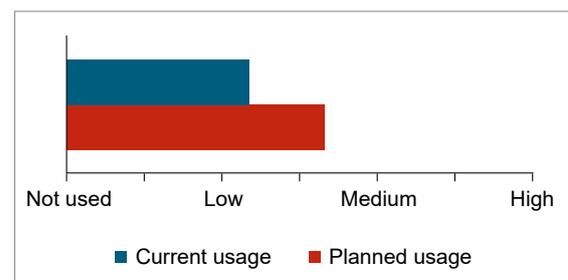


Figure 31: Usage of increased material efficiency

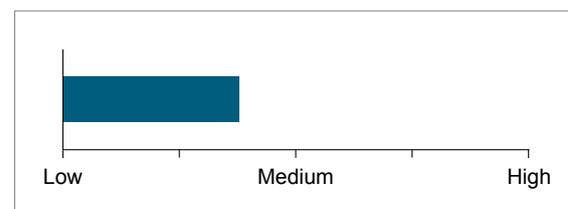


Figure 32: Effectiveness of increased material efficiency

<sup>20</sup> Recycling of waste generated during production (e.g. offcuts) also increases material efficiency. This measure is addressed in Section 4.4.8.

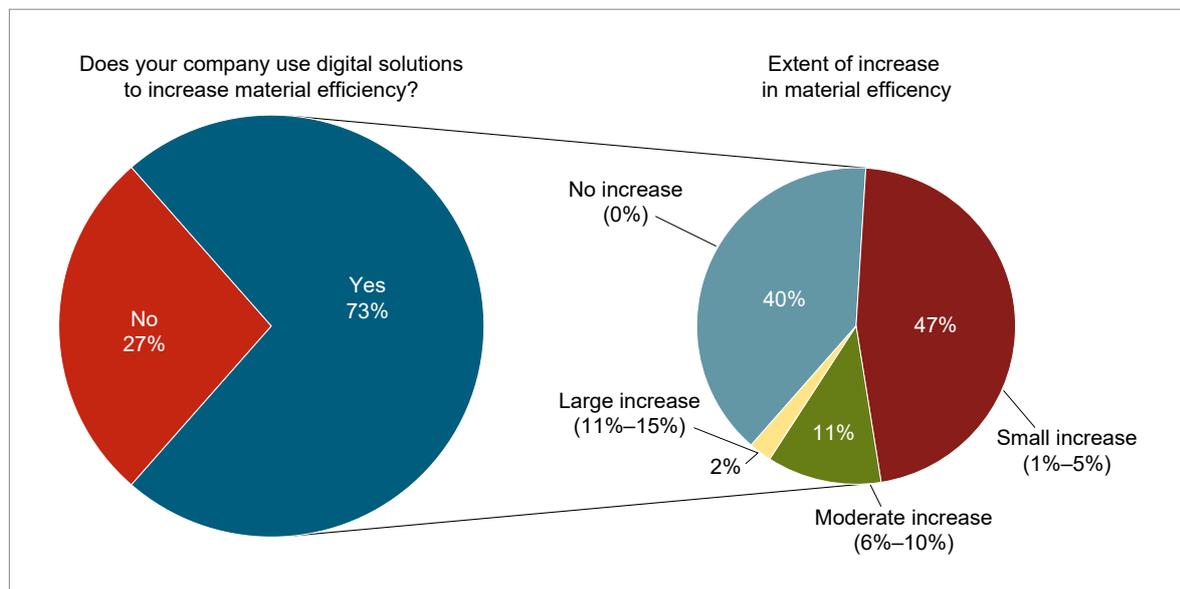
for the present study stated that the rising costs of raw materials had prompted them to increase material efficiency. They also mentioned expectations in society, and general legal and governmental frameworks which promote sustainability. The experts also stated that product designs are often modified to use less material in order to reduce weight, which is beneficial in many fields. Reasons given by the experts for not using this strategy include the investment required, the time involved (e.g. in modifying products and production processes to suit new machines and technologies) and lack of potential to make further efficiency savings.

The survey respondents assessed the **effectiveness** of increased material efficiency projects as below medium (see Figure 32). Despite this, many of the companies surveyed are **planning to greatly increase their use of this strategy** over the next three to five years (see Figure 31). In addition to cost savings, most of the study participants stated that the focus on sustainability is a key reason behind increasing material efficiency within their company. Sustainability is fundamentally transforming society and the economy, and is firmly rooted in many of the companies surveyed. As well as pressure from society, government initiatives and incentives are also driving companies to devote more attention to material efficiency projects.

Alongside traditional technological approaches, **digitalisation** has been identified as an additional opportunity to increase material efficiency in industry (IW, 2017). Sensor technology and digital networks, for example, allow observation and tracking of each step in the production process, enabling sources of error and inefficiencies to be identified and the process to be improved accordingly (IW, 2013). In light of this, the survey participants were asked whether they use digital solutions to increase material efficiency; and, if so, how large an increase in material efficiency had been achieved (see Figure 33). Overall, 73% of survey respondents use digital solutions to increase material efficiency. Among the companies using these solutions, 40% stated that they had not observed any increase in material efficiency, while 60% had experienced an increase: 47% reported efficiency gains of between 1% and 5%; 11% recorded efficiency gains of between 6% and 10%; and 2% achieved efficiency gains of between 11% and 15%. Given the constant development of digital technologies, these solutions are likely to offer more potential for using materials more efficiently in the future.

**Opportunities and challenges**

There are various opportunities and challenges involved with increasing material efficiency. The opportunities can be grouped into three catego-



**Figure 33: Usage and effectiveness of digital solutions for increasing material efficiency**

ries: **increased profitability and competitiveness, increased sustainability and improved corporate image.** The challenges can be grouped into **limited scope for action, significant investment and long lead times.**

*“Reduction of material usage, together with substitution and recycling, will become increasingly important given the CO<sub>2</sub> agenda.”*

Steel expert at a multinational steel producer

**Increased long-term profitability and competitiveness** are key opportunities which can be created by increasing material efficiency. As explained above, increasing material efficiency reduces material usage, thus reducing the material costs per item manufactured. This, in turn, drives up margins and profitability. Although these projects have rather long lead times, increased material efficiency enables higher production output from a given material input in the long run. This makes it possible for the company to serve a larger number of customers, thus increasing competitiveness.

Increased material efficiency can also have a positive effect on a company’s **ESG or sustainability** credentials. Using raw materials has a wide variety of environmental impacts, ranging from air, water and soil pollution and greenhouse gas emissions to the destruction of biodiversity or entire ecosystems. Efficient use of resources and avoiding unnecessary waste therefore contribute to reducing the company’s environmental impact.

ESG and sustainability are representative of a global trend influencing purchasing habits among large corporations. Many companies include ESG

considerations in their supplier evaluation or contract award criteria. As a result, proactive efforts to improve material efficiency help to enhance the company’s **corporate image** and better meet potential customers’ requirements.

Nevertheless, increasing material efficiency also involves challenges. **Limited scope for action** is an important example: further increasing material efficiency may be difficult or impossible due to industry characteristics, technical requirements placed on the product, or the properties of the material in question – increasing material efficiency must not compromise product safety, durability or compatibility. Efficiency measures already taken may also limit the potential for further action: many companies have already been trying to manage production processes and use materials as efficiently as possible for many years, such that only marginal improvements remain to be achieved. According to the expert interviews, the costs of making further improvements may outweigh the benefits in these cases.

However, this is contradicted by the results of a 2017 study by the Fraunhofer Institute for Manufacturing Engineering and Automation (Fraunhofer IPA), which estimated that total potential for material savings remains significant (around 7% annually) and is insufficiently exploited. According to the study, the potential for improvements in material efficiency depends on the sector, but is particularly high in the automotive and mechanical engineering sectors, and raw material-related sectors such as metal production and plastics processing (FRAUNHOFER IPA, 2017). It can therefore be expected that as technology advances, there will always be more potential for increasing material efficiency.

Opportunities	Challenges
<p><b>Increased profitability and competitiveness:</b></p> <ul style="list-style-type: none"> <li>– Lower costs, higher margins</li> <li>– Increased output, synergies between material efficiency and process improvements</li> </ul> <p><b>Improved sustainability:</b></p> <ul style="list-style-type: none"> <li>– Increased material efficiency reduces pollution per product</li> </ul> <p><b>Improved corporate image:</b></p> <ul style="list-style-type: none"> <li>– ESG compliance and environmental awareness</li> </ul>	<p><b>Limited scope for action:</b></p> <ul style="list-style-type: none"> <li>– Industry characteristics, technical requirements or material properties</li> </ul> <p><b>Significant investment required:</b></p> <ul style="list-style-type: none"> <li>– Projects are expensive and technologically demanding</li> </ul> <p><b>Long lead times:</b></p> <ul style="list-style-type: none"> <li>– Impacts of material efficiency projects take a long time to materialise</li> </ul>

The levels of **investment** involved in this strategy are a serious challenge, as improving material efficiency requires financial and technical resources and involves considerable **lead times**. Initial R&D investment to exploit potential improvements and to develop appropriate plant and machinery (e.g. improved laser cutters) is time-consuming and costly. Redesigning production processes takes time and involves production stoppages, costly downtime for test runs, and staff training. Making changes to product designs to increase material efficiency runs the risk of losing customers. In light of these challenges, other strategies may be preferable if immediate results are required. Finally, it should be mentioned that the wide variety of possible levers and starting points make this strategy complex to implement (FRAUNHOFER IPA, 2017).

### Conditions and success factors

Various conditions and success factors need to be taken into account when increasing material efficiency. These success factors can be summarised under the three points explained below: **corporate culture; flexibility and adaptability; and investing in advance**.

*The interviewees confirmed the hypothesis that material efficiency projects require a corporate culture of continuous improvement. This has been found to be especially important for companies lacking the resources to operate a dedicated research department.*

(Hypothesis no. 7)

- Firstly, an **innovation-friendly corporate culture** of continuous improvement is an important condition which must be met for successful implementation of this strategy. Continuous review of existing processes is essential to identify potential to further increase material efficiency.
- Secondly, sufficient **flexibility and adaptability** to make improvements are crucial success factors. Companies must acknowledge that theoretical maximum efficiency has not yet been achieved, and that market-driven innovations (e.g. substitute materials or modern manufacturing processes) may create poten-

tial for improvement – although this aspect must also be critically questioned because marginal further improvements may involve disproportionately high costs.

- Thirdly, willingness to make the necessary **investments in advance** is another key success factor. Expenditure on efficiency projects must, of course, offer a return on investment: in light of current expectations in society, improved sustainability can also be considered a return.

### Recommendations for action

Based on the opportunities, challenges and success factors described above, the following recommendations for action aim to provide suggestions on how to increase material efficiency and identify untapped potential. The first part focuses on creating the necessary corporate culture. The second part, based on FRAUNHOFER IPA (2017) study, introduces organisational and technological approaches to implementing this strategy.

When it comes to raw material efficiency, companies should start by acknowledging that there will always be potential to further increase efficiency (FRAUNHOFER IPA, 2017). Once companies have internalised this idea, they need to develop an **innovation-friendly corporate culture that rewards efforts to increase efficiency**. Innovation friendliness goes beyond R&D into the culture of the workforce, so it is important to involve all internal stakeholders when making decisions on material efficiency: this is because efficiency projects can affect many parts of the manufacturing process, such as production management, inventory management, waste management or quality assurance. An important part of creating an innovation-friendly culture lies in rewarding efforts to find and exploit untapped potential for improvement: this should take the form of financial incentives for employees to contribute to material efficiency. Doing this will motivate employees to integrate continuous improvement into their work routines.

Facilitating and encouraging flexibility and creativity will also help create an innovation-friendly corporate culture. Companies can increase **flexibility and adaptability** by means such as estab-

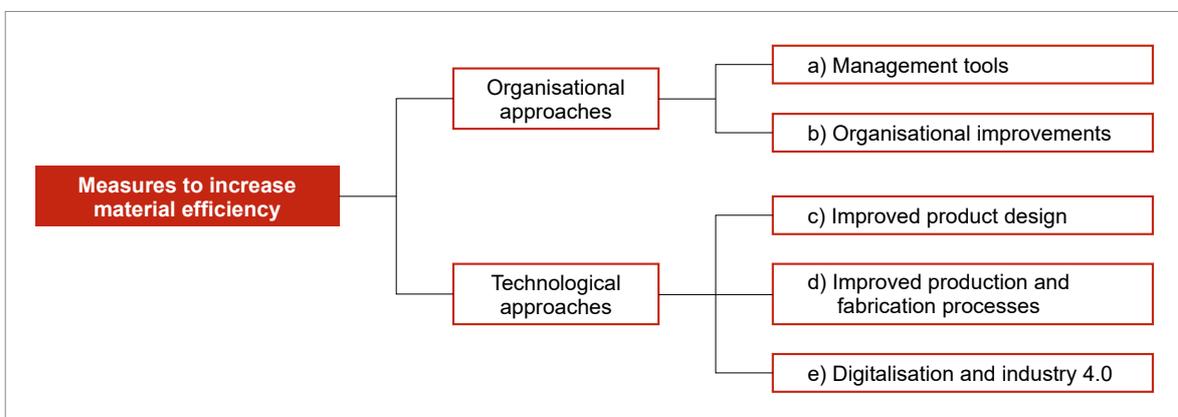
lishing modular production lines, or building up a trained team of engineers and technicians to enable rapid introduction of new machinery. **Creativity** can be encouraged by studying examples (e.g. production processes or warehouse management systems used by competitors) or by establishing an interdepartmental innovation hub to develop new ideas using crowd intelligence and joint ideation. Companies are also advised to take a **holistic perspective** when searching for potential improvements, considering both internal company processes and the entire supply chain (including joint efficiency projects with suppliers or customers). To gain this holistic perspective, it is important to create transparency in material flows, and to identify and systematically improve weak points throughout the supply chain, including the company's own processes.

There are two main approaches to implementing material efficiency projects: **organisational approaches** and **technological approaches**. These are based on measures outlined in the 2015 Fraunhofer IPA study. Organisational approaches include management tools and organisational improvements, while technological approaches cover improved product design, improved production and fabrication processes, digitalisation and Industry 4.0 (see Figure 34).

- In terms of **management tools**, companies should start with status quo analyses. These analyses examine existing operational processes to identify sources of waste, such as

high reject rates. A substance flow analysis is a particularly useful place to start, although it is important to have an understanding of process duration, material flows and internal data management to successfully conduct this analysis. Once completed, the results should be used to develop a system of **KPIs**, which will enable continuous review of the status quo and help to track progress (e.g. quantity of waste per item manufactured). **Improving quality assurance** is another recommendation which falls under management tools: this allows weak points to be identified at an early stage, thus reducing the quantities of materials wasted. Companies can implement this recommendation by making changes such as conducting more frequent audits of the manufacturing process (FRAUNHOFER IPA, 2017).

- **Organisational improvements** can pave the way for material efficiency improvements, as these are usually low-cost measures. These improvements focus on employee-related activities, such as the **formation of material efficiency working groups**. These groups help to sensitise employees to the issue of material efficiency, educate them on the topic, and ensure their collaboration on material efficiency projects. Employees should also be specifically trained on material efficiency and its positive impacts. To help staff in their efforts, companies should consider implementing techniques such as lean manufac-



**Figure 34: Categories of measures to increase material efficiency (Source: PwC, based on FRAUNHOFER IPA, 2015)**

turing<sup>21</sup> or Six Sigma<sup>22</sup> to increase process efficiency.

- **Improved product design** represents an important technological approach to increasing material efficiency. Alongside replacing critical raw materials with alternatives (see Section 4.4.9), lightweight construction and miniaturisation (i.e. reducing the size of components while retaining their full range of functions) can both substantially improve material efficiency. These techniques should be used to improve existing products as well as on newly developed products. Companies should also consider how product usage could be intensified – this includes extending product lifetime (IW, 2017).
- **Improvements to production and fabrication processes** also help improve material efficiency. Companies should carefully examine their facilities to identify where and how enhancements can be made: this might involve introducing material-efficient equipment and specialised machines, such as improved laser cutters. Reducing the use of materials for additives or minor components is also important. If these measures do not result in sufficient improvements, companies should consider completely **replacing existing manufacturing processes** or implementing new technologies. Assessing whether this is feasible or necessary requires continuous review of technological innovations. Finally, **internal circulation of materials** and in-house recycling must not be overlooked; this is discussed in detail in Section 4.4.8.
- **Digitalisation and Industry 4.0** offer a multitude of opportunities to increase material efficiency. For example, IoT networks featuring smart sensors can be used to connect a company's manufacturing equipment, forming a unified, intelligent system which allows detailed observation, tracking and improvement of how materials are used. Data mining is important for gaining insights from sensor data – this involves extracting new information from existing data sources, and recognising patterns or relationships in the data. Introduc-

ing and using digital systems such as these is a complex process, so companies should focus on either developing know-how internally or procuring it from external providers (VDI, 2017).

A final recommendation is to **gather information about possible consulting and funding initiatives**. A key player in this field is the German Federal Ministry for Economic Affairs and Climate Action (BMWK), which has a variety of nationwide initiatives in support of material efficiency. These include the “go-inno” initiative, which supports external consultants in preparing and implementing innovations for both products and processes (BMWK, 2021c), and the annual German Raw Material Efficiency Award.

21 Lean manufacturing is a production process based on the idea of maximising productivity while simultaneously minimising waste.

22 Six Sigma (6σ) is a management system for process improvement, providing methods and statistical targets for quality management.

Table 7: Summary of increased material efficiency

 <b>Usage: current</b>	<p>No usage  High</p> <p>Among the eleven strategies studied, increased material efficiency is the eighth-most used strategy.</p>
 <b>Usage: next three to five years</b>	<p>No usage  High</p> <p>This strategy is set to have the seventh-highest level of usage over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  High</p> <p>Increased material efficiency was rated as the seventh-most effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Innovation-friendly corporate culture</li> <li>• Acknowledgement that there is always room for improvement in material efficiency</li> <li>• Flexibility and adaptability</li> <li>• Willingness to make necessary investments in advance</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Establish an innovation-friendly corporate culture that rewards efforts to increase material efficiency</li> <li>• Facilitate and encourage openness and creativity</li> <li>• Take a holistic perspective, including both internal processes and the entire supply chain</li> <li>• Conduct a substance flow analysis</li> <li>• Develop KPIs and enhance quality assurance</li> <li>• Form material efficiency working groups</li> <li>• Rethink product design</li> <li>• Improve production and fabrication processes</li> <li>• Replace manufacturing processes if necessary</li> <li>• Increase digitalisation (e.g. IoT systems)</li> <li>• Obtain information about consulting and funding initiatives</li> </ul>

### 4.4.8 Recycling



#### Definition

Recycling is defined as returning materials to the production process by reusing or reprocessing them (WERNER, 2017). This includes both the recycling of materials from end-of-life products and the recycling of residues from the production process.

Reusing or reprocessing end-of-life products requires infrastructure to collect waste and to separate it into its components. As it can be difficult to dismantle complete products, especially electronic products, recyclability should be considered at the product development stage. Reusing or reprocessing residues produced in the factory, on the other hand, is easier and requires fewer resources. If this material cannot be directly reused, it can be recycled within the company or sent to outside recycling facilities. However, as production residues usually do not need to be separated and are already on site, the recycling process is often more economically feasible (SCHMID, 2020). The recycling process in general confronts companies with a make-or-buy decision: material can either be recycled in-house or by third-party specialists (WERNER, 2017).

Recycling and the use of recycled materials reduces the quantity of primary raw materials that a company needs. This makes the company less dependent on suppliers, supply chains and the availability of the primary raw material, reducing the company’s exposure to both supply risk and price risk. Reduced demand for primary raw materials also reduces the negative effects of primary raw material extraction, helping to improve the company’s reputation. Difficulties in recycling usually arise from technical or economic feasibility issues (SCHMID, 2020).

#### Usage and effectiveness

**Current usage** of recycling among the companies surveyed is moderate (see Figure 35). Among the eleven strategies studied, recycling is the seventh-most used strategy: 81% of the companies surveyed currently use recycling, with 11% of companies using the strategy reporting a

#### Corporate example

##### Hitachi Group (Japan)

In response to recent tensions on raw material markets, Hitachi has launched a programme to collect and recycle used products. For example, the company recycles used domestic appliances, such as refrigerators and air conditioners, as a source of raw materials such as steel, copper and aluminium (HITACHI, 2020). Hitachi has also developed technologies for recycling electronic equipment (e.g. hard disk drives, MRI scanners) to obtain rare earth magnets. This has made a considerable impact: in 2019, recycling provided the company with about 10% of its total rare earth magnet needs (HITACHI, 2019).

high level of usage. Recycling has also become increasingly important in Germany. Expansion of recycling and the circular economy features in the German Federal Government’s raw materials strategy, and the Government intends to support R&D for recycling (BMWK, 2020b). The results of the 2021 INVERTO raw materials management study, which mainly surveyed German companies, similarly reflect an increase in focus on recycling: only 9% of German companies recycled materials in 2015, but 27% were doing so in 2021 (INVERTO, 2017; 2021). When asked why companies are recycling, most experts interviewed in the present study explained that the strategy offers the potential to save costs, mitigate mate-

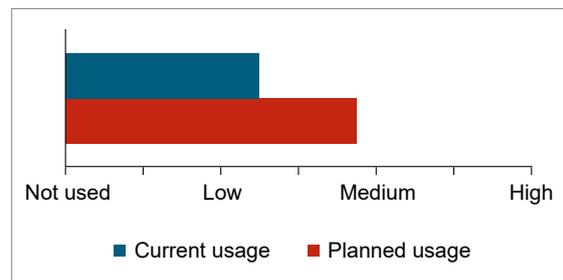


Figure 35: Usage of recycling

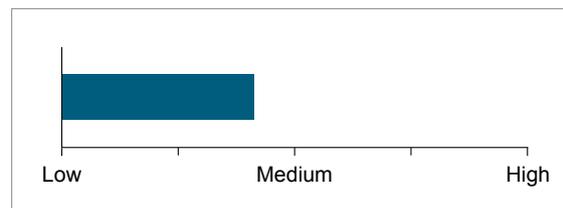


Figure 36: Effectiveness of recycling

rial shortages, improve sustainability and may be necessary to comply with regulations. Reasons given by the experts for not recycling include high recycling costs for some materials, technical difficulties and logistical issues.

The survey respondents assessed the **effectiveness** of recycling as medium (see Figure 36), making this the sixth-most effective strategy of the eleven strategies examined. The respondents are also **planning to significantly increase recycling** in the next three to five years (see Figure 35): currently only a small proportion of the companies surveyed report a high level of usage of the strategy, but this is set to increase to 35%. The expert interviews revealed various reasons for this sharp increase: these include the transition towards a more sustainable and environmentally friendly economy, legal requirements (e.g. environmental laws), expectations from society, and government support for research.

### Opportunities and challenges

Recycling presents various opportunities and challenges. The opportunities can be grouped into three categories: **improved sustainability, cost savings and increased cost-effectiveness** and **reduced dependence on primary producers**. The challenges can be grouped into **minimum viable quantities, increased market risk** and **major investment required**.

*“Recycling provides a solution to the problem of medium-term raw material shortages, but it is not yet widespread.”*

Commodity expert at a leading economic research consultancy

As stated above, **improved corporate sustainability** is a key opportunity offered by recycling. Recycling often results in lower energy consumption, less waste materials, reduced emissions and thus less pollution per product manufactured, with logistics playing a key role in reducing emissions. Whereas primary raw materials are often produced in distant regions of the world and require long-distance transport, which typically causes large amounts of pollution, secondary raw materials are more often produced near to where

they are used: factors such as government support or adequate infrastructure may incentivise companies to do this. Since increased corporate sustainability is increasingly being demanded by both society and governments, recycling has the potential to improve the company's corporate image. Recycling also enables companies to contribute to the EU's net-zero strategy, which aims to make the EU climate neutral by 2050 (EUROPEAN COMMISSION, 2018).

Most experts interviewed for this study stated that recycling can help companies make **cost savings and increase cost-effectiveness**, as the strategy enables savings in procurement prices, logistics costs and contract costs. However, there is a risk that these savings may be outweighed by higher expenses: the net outcome of the strategy will vary depending on the industry, raw material and technologies in question. Companies can maximise net cost savings by forming business alliances to jointly develop and run recycling plants, as larger quantities of input materials will enable economies of scale to be achieved more quickly.

An obvious opportunity offered by recycling is **reduced dependence on primary producers**, which helps to mitigate the risk posed by medium-term shortages of raw materials. In this regard, the finite nature of most raw material resources is an important consideration: recycling offers the opportunity to obtain raw materials even if the material in question is no longer being produced.

However, recycling also involves a number of challenges. One fundamental challenge is achieving an adequate **rate of recycling** – i.e. the proportion of used products or scrap which are returned to a circular economy. Although there is a relationship between market growth and quantity of waste, the extent to which it is returned to the economy varies by industry and country. High recycling rates have already been achieved in the German beverage can market, for example, but there is still a lot of room for improvement in the country's automotive industry. This can be attributed to long product life cycles, which means that raw materials are held in products (and therefore are unavailable for recycling) for long periods, along with insufficient incentives to recycle.

The **quality and properties** of products returned for recycling also present a challenge. This

Opportunities	Challenges
<p><b>Improved sustainability:</b></p> <ul style="list-style-type: none"> <li>– Smaller carbon footprint</li> <li>– Reduced long-distance logistics</li> </ul> <p><b>Cost savings and increased cost-effectiveness:</b></p> <ul style="list-style-type: none"> <li>– Lower procurement prices, logistics costs and contract costs</li> <li>– Joint recycling plants enable economies of scale</li> </ul> <p><b>Reduced dependence on primary producers:</b></p> <ul style="list-style-type: none"> <li>– Reduced risk posed by medium-term material shortages</li> <li>– Material available regardless of output from primary producers</li> </ul>	<p><b>Reaching minimum viable quantities:</b></p> <ul style="list-style-type: none"> <li>– Insufficient recycling rates</li> <li>– Insufficient quality of materials for recycling</li> </ul> <p><b>Increased market risk:</b></p> <ul style="list-style-type: none"> <li>– Rising demand for scrap</li> <li>– Significant scrap exports</li> </ul> <p><b>Major investment required:</b></p> <ul style="list-style-type: none"> <li>– Developing new recycling processes and raw material processing systems</li> <li>– Quality assurance for recycled materials is labour-intensive</li> </ul>

includes issues around extracting processed raw materials: extracting composite materials in particular from finished products is a difficult, energy-intensive process. In addition to the challenges of procuring suitable materials for recycling, the strategy can only be justified if the company can produce a **minimum viable quantity** – i.e. if the recycling plant can break even. If, for example, recycled materials can only meet 10% of a company’s raw material needs, it is unlikely that the strategy will be worthwhile.

This shows that although increased recycling can make companies less dependent on primary producers, they are likely to become dependent on other factors. The increasing importance of recycling will increase **market risk**: shortages and price increases may occur in markets for recyclable materials, just as can happen in the primary raw material markets. Increased demand for scrap and used products is also reducing the availability of recyclable materials. This is being exacerbated in the EU by significant **scrap exports** – 3.6m tonnes of scrap steel alone were exported from the EU to non-OECD countries in 2019. The same problems apply to externally sourced secondary raw materials, as they will be subject to similar market forces as primary raw materials.

Developing knowledge and carrying out R&D to develop recycling processes and adapt raw material processing systems are also major challenges for recycling. In-house recycling plants in particular may require enormous **investment**, potentially totalling tens of millions of euros. Companies must also have sufficient internal capacity to ensure

that product quality can be maintained despite changes in input materials. **Quality assurance** for secondary raw materials is particularly labour-intensive, but is essential to ensure that quality is consistent and comparable to that of primary raw materials.

**Conditions and success factors**

Various conditions and success factors need to be taken into account for successful recycling. These success factors can be summarised under the three points listed below: **adequate recycling rate, comparable and consistent quality and knowledge and resources.**

*The interviewees confirmed the hypothesis that recycling is mainly used to improve sustainability and corporate reputation, rather than as a means of securing a supply of raw materials.*

(Hypothesis no. 8)

- First and foremost, companies must ensure that recycling and use of secondary raw materials is feasible in the markets in which they operate. This includes ensuring that **adequate recycling rates** can be achieved and that both internal and external infrastructure is in place for returning recyclables to the company. Based on this, companies need to ensure that they can achieve the **minimum viable quantity** for their recycling plants, as explained above.

- Secondly, the properties of the material in question must be considered, as some materials are more suitable for recycling than others. Companies also need to ensure rigorous **quality assurance**, as explained above: it is crucial that the quality of secondary raw materials is almost the same (or in some applications, exactly the same) as that of primary raw materials, and quality must be consistent between batches.
- Thirdly, companies need sufficient **knowledge, R&D capabilities and financial resources**. External sourcing of primary raw materials is considerably simpler than developing and running recycling plants or creating new life cycles for products or raw materials.

### Recommendations for action

Based on the factors explained above, various recommendations for action can be made to guide companies in implementing recycling, as outlined below. Some companies are already in a good position to use this strategy, but others will need to start by generally **increasing their focus on sustainability** – and use of secondary raw materials must be the first consideration, whether these materials are recycled in-house or purchased externally. According to a report by the Federation of the German Waste, Water and Raw Materials Management Industry, the creation of a circular economy will play a key role in achieving the goals in the European Green Deal by 2050. A circular economy will accelerate sustainable development and help companies to counteract rising production costs resulting from global shortages of primary raw materials (BDE, 2020).

Another factor to consider at an early stage is the integration of recyclability into product development and design. If recycling cannot produce secondary raw materials of the same quality as went into the product, companies are advised to consider using these materials in alternative, lower-quality applications. Recycling can also take the form of reusing entire components. In this case, companies must ensure that these components are designed to be sufficiently durable to avoid the need for refurbishment.

An important decision which companies must make is whether to purchase secondary raw materials from an external supplier or operate in-house recycling plants. This is a company-specific decision: the main arguments for using external suppliers are the lower levels of investment and know-how required, but this option also requires a laborious supplier qualification process and makes the company more dependent on third parties. When considering external suppliers, companies are advised to closely **examine product quality and recycling processes** offered by potential suppliers. Product quality can be compared to primary raw material using characteristics such as durability, density or composition, while an assessment of a supplier's recycling process should consider the processes and technologies used, resource consumption (e.g. energy) and environmental impact (e.g. greenhouse gas emissions).

The advantages and disadvantages of in-house recycling plants are described in detail above: they make the company less dependent on external suppliers and the primary raw materials market, but are costly to develop. To reduce these costs, companies are recommended to **consider joint recycling facilities** in alliance with other companies: this strategy can either be used to build new recycling facilities, or to provide access to existing plants. The right choice will vary by company, but it is generally more advisable for SMEs to either purchase secondary raw materials or use shared recycling facilities than to develop and operate in-house facilities.

If, however, companies decide that in-house recycling is the right option, further recommendations need to be considered. Firstly, companies need to assess the recyclability of the material in question – in particular, whether and to what extent recycling changes the composition of the material. Those changes can affect the quality of end products, so it is important to determine whether any changes are acceptable. It is also important to ensure that **sufficient financial resources, know-how and R&D capacity** are available to meet the major demands that developing and establishing a recycling plant will place on the company. Coordination of processes and technologies must be considered as well, as introducing a recycling plant may change internal material flows.

Another important recommendation is to ensure that sufficient scrap or end-of-life products will be returned to the company to sustain a recycling plant: this is often not the case at present. To address this problem, companies should consider **establishing waste collection networks and cooperating with other companies** in their business ecosystems. For example, companies can provide customers with containers for returning waste to the company under specified conditions. Take-back systems can also be used, providing customers with an incentive to return old products. Leasing models represent another good opportunity to ensure that end-of-life products are

returned to the manufacturer on a large scale, in both B2B and B2C markets.

Finally, **internal waste management processes** must also be modified to help recycling plants reach their minimum viable quantity as described above: it is important for companies to collect and separate waste cuttings and rejects, and appropriate internal infrastructure must be in place. Clear responsibilities are vital to keep this process working properly. Companies should also carry out continuous economic analysis of their waste collection and storage processes, and consider adopting best practices from other companies.

**Table 8: Summary of recycling**

 <p><b>Usage: current</b></p>	<p>No usage  -----  High</p> <p>Among the eleven strategies studied, recycling is the seventh-most used strategy.</p>
 <p><b>Usage: next three to five years</b></p>	<p>No usage  -----  High</p> <p>This strategy is set to have the fifth-highest level of usage over the next three to five years.</p>
 <p><b>Effectiveness</b></p>	<p>Low  -----  High</p> <p>Recycling was rated as the sixth-most effective strategy examined in this study.</p>
 <p><b>Conditions and success factors</b></p>	<ul style="list-style-type: none"> <li>• Adequate recycling rates must be achievable</li> <li>• Minimum quantities must be available for recycling plants to be economically viable</li> <li>• Quality of secondary raw materials must be consistent and comparable to that of primary raw materials</li> <li>• Knowledge and resources must be available in the company</li> </ul>
 <p><b>Recommendations for action</b></p>	<ul style="list-style-type: none"> <li>• Increase focus on sustainability</li> <li>• Consider recyclability in product development and design</li> <li>• Examine product quality and recycling processes offered by suppliers</li> <li>• Consider joint recycling facilities</li> <li>• Assess recycled material to determine whether product quality will be affected</li> <li>• Ensure sufficient financial resources, know-how and R&amp;D capacity</li> <li>• Establish waste collection networks and cooperate with other companies to increase amount of material available for recycling</li> <li>• Modify internal waste management processes to support recycling</li> </ul>

#### 4.4.9 Material substitution



##### Definition

Material substitution is the replacement of critical raw materials with alternatives. This makes the manufacturer less dependent on the critical raw materials in question, enabling long-term reduction of the company's exposure to supply risk and price risk.

Material substitution can either take the form of replacing materials in an existing product, or of developing new products or technologies that serve the same purpose but are based on different raw materials (HESSE, 2019). An example of substituting materials in an existing product is the replacement of steel with carbon fibre-reinforced plastic in sectors such as the automotive industry (BEECHAM, 2019). Materials that serve a specific function in a product can sometimes be replaced by materials with similar chemical or physical properties without any loss of performance (e.g. palladium or platinum in catalytic converters). However, different materials often have different properties, making them poorly suited as substitutes (HESSE, 2019). In such cases, material substitution would either require significant R&D to maintain performance, or the manufacturer would have to accept lower performance. In some cases, substitution involves replacing critical materials with other critical materials: although less effective than eliminating critical materials, this can still increase flexibility if one material becomes more expensive or harder to obtain than the other (SCHMID, 2020). New technologies or products have also enabled materials to be replaced. An example of this is the development of fibre-optic cables in the telecommunications industry (HESSE, 2019), which replaced copper cables and led to a decline in demand for copper (SCHMID, 2020).

Developing substitutes usually requires companies to carry out extensive R&D, expand their supply chains to source alternative materials on a large scale, and – in many cases – change their manufacturing processes. This means that developing substitutes is often a long-term strategic project, not a quick response to short-term crises. However, once substitutes have been developed, they represent a long-term solution for avoiding

##### Corporate example

###### Samsung SDI (South Korea)

Battery and electronics manufacturer Samsung SDI has developed a high-nickel battery for electric vehicles to reduce dependence on cobalt (KIM, 2021). Cobalt is the most expensive raw material for batteries, and is susceptible to shortages and price volatility (LME, 2021). To combat this, Samsung SDI increased the percentage of nickel in its battery cathodes from 88% in 2015 to 91% in June 2021. This, in turn, reduces the amount of cobalt required, reducing the company's exposure to cobalt price risk (SAMSUNG SDI, 2020; BYUNG-wook, 2021b). Thanks to their longer run time, Samsung SDI's high-nickel batteries also have a competitive advantage over lithium iron phosphate batteries, a market segment which is currently dominated by Chinese competitors (KIM, 2021).

supply risk and making the company less dependent on the original raw material. Substitutes can also create extra flexibility if materials are in short supply: provided the changeover costs are reasonably low, the company can avoid a shortage of one material by simply switching over to using the other (SCHMID, 2020).

##### Usage and effectiveness

**Current usage** of material substitution among the companies surveyed is low (see Figure 37), with the strategy having the third-lowest level of usage. Although 84% of the companies surveyed have substituted materials, only 4% of those using the strategy assessed their level of usage as high. Most companies only make minor use of this strategy. Material substitution is also not very extensively used in German companies. INVERTO's 2021 raw materials management survey, which primarily surveyed German companies, found that only 26% of companies were using the strategy, down from 33% in 2015 (INVERTO, 2017; 2021). According to the experts interviewed for the present study, the low level of usage of material substitution is mainly due to specific material properties being required, technical limitations and customer requirements (e.g. product performance). Because of these constraints, many companies consider substituting materials to be difficult or impossible. The significant investments of capital, R&D and time required to develop sub-

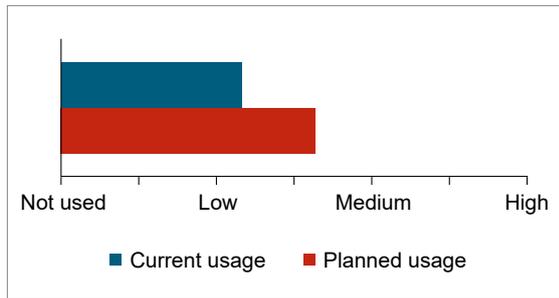


Figure 37: Usage of material substitution

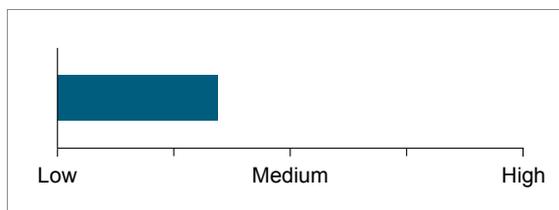


Figure 38: Effectiveness of material substitution

stitutes also deter companies from using the strategy and lead to them choosing other strategies in the short term. Some companies stated that scarcity currently affects so many raw materials that it is difficult to find plentiful alternatives.

The respondents rated the **effectiveness** of substitution at below medium (see Figure 38). This is the third-lowest effectiveness rating recorded in the survey. Nevertheless, the companies surveyed are **planning to increase their usage** of the strategy over the next three to five years (see Figure 37): the percentage of respondents not using the strategy at all is set to fall from the current 16% to just 10%. According to the experts interviewed for this study, material substitution is becoming increasingly popular because of the growing difficulties in procuring certain critical raw materials and the increasing focus on sustainability issues in society. Against this background, companies are trying to develop substitutes that can be produced using renewable or more environmentally friendly resources, or that reduce the company's carbon footprint. Government funding for research is also driving companies to devote more attention to developing substitutes.

### Opportunities and challenges

Raw material substitution presents various opportunities and challenges. The opportunities can be grouped into three categories: **mitigating raw material scarcity, reduced dependence on individual suppliers** and **improved ESG performance**. The challenges can be grouped into **identifying and selecting alternative materials** and **high costs**.

*“Substitution of critical raw materials can offer a way of circumventing the problems associated with their finite nature.”*

Procurement and operational excellence specialist at an international supply chain and strategy consultancy

The main benefit of this strategy is that it enables companies to avoid using critical raw materials that may be difficult to obtain due to depletion of reserves or political restrictions. Raw material substitution therefore **mitigates raw material scarcity**, and diversifying to use multiple materials may protect the company from the risks posed by shortages for decades. If alternative materials have been identified and are ready for use at short notice, the benefits using a broader selection of raw materials also extend to increasing resilience to price volatility: as explained above, companies in this position can simply sidestep price fluctuations by switching over to their alternative materials. In a best-case scenario, substitute materials might even be cheaper than the originals, giving a cheaper product with similar properties or a higher-quality product at the same costs.

Diversifying to use multiple raw materials also makes the company **less dependent on individual suppliers for certain materials**. A common example is the substitution of rare earths in electric vehicles. With current tensions on the market, US car manufacturers are reducing their dependence on rare earth imports by replacing high-performing neodymium magnets with alternatives. Although vehicles produced using these alternatives have a smaller range, their production is less dependent on rare earths, thus reducing the risk posed by price increases or shortages of these materials. Proactive development of substitute materials may also enable companies to gain a **technological advantage**, which can then be

translated into a competitive edge – with positive impacts on the company's cost structure and corporate image.

Procuring raw materials locally is particularly beneficial – delivery times and costs will be reduced and export restrictions will become irrelevant – but even importing substitute materials will still offer the benefits of a diversified supply chain. Sourcing raw materials locally, purchasing materials with a smaller carbon footprint and considering a wider selection of producers – which may have better working conditions than previous suppliers – also enables companies to **improve their ESG performance**.

However, there are also a number of challenges that companies need to be aware of before substituting materials. The biggest challenge is **identifying and selecting suitable substitutes**. Continuous efforts to improve product quality mean that new raw materials must meet high quality standards. Thorough research is necessary to ensure that any potential materials meet these standards, and limitations in internal funding for research mean that this strategy is unfeasible as a reliable short-term solution. Substituting materials always involves **significant costs**, although there are two distinct scenarios. In a best-case scenario, the new material can be processed in the same way as before. Thorough testing is still required, but existing processes and machinery can remain in use. However, it may be the case that new materials need processing in a different way. This significantly increases the costs of implementation:

new equipment must be acquired, and tests must be undertaken on the process and the equipment as well as on the new material.

Another major issue is the risk that a large-scale trend towards substitution may spark **renewed competition for materials**, which would shift current shortages to other raw materials. This is an aspect which only comes into play if viable alternatives are found that achieve the benefits mentioned above. However, it has the potential to reduce or eliminate any cost savings or additional security of supply created by this strategy.

A final challenge when substituting materials lies in gaining customer acceptance. Substitution often alters product specifications, which may lead to concerns over poor product quality or other shortcomings. However, this is a relatively minor downside if the alternative would be product shortages or increased prices.

#### Conditions and success factors

Various conditions and success factors need to be taken into account for successful material substitution. These success factors can be summarised under the four points listed below: **availability of capital, C-suite support, room for manoeuvre on product quality and long-term planning**.

- Firstly, having **sufficient capital available** is vital. Large amounts of capital are required to make the necessary changes and to enable

Opportunities	Challenges
<p><b>Mitigating raw material scarcity:</b></p> <ul style="list-style-type: none"> <li>– Shifting to alternative sources of raw materials</li> <li>– Diversification of scarce resources</li> </ul> <p><b>Reduced dependence on individual suppliers:</b></p> <ul style="list-style-type: none"> <li>– Procuring additional materials gives the company a more diverse range of suppliers</li> <li>– Proactive development of substitutes can offer technological advantages and create a competitive edge</li> </ul> <p><b>Improved ESG performance:</b></p> <ul style="list-style-type: none"> <li>– Potential to use more eco-friendly materials</li> <li>– Reduced carbon footprint from logistics if materials can be sourced locally</li> </ul>	<p><b>Identifying and selecting suitable materials:</b></p> <ul style="list-style-type: none"> <li>– Continuous product improvement demands high standards from substitutes</li> <li>– Limited R&amp;D budgets prevent short-term implementation</li> </ul> <p><b>High costs:</b></p> <ul style="list-style-type: none"> <li>– New materials may require new equipment</li> <li>– Thorough testing necessary to ensure quality</li> </ul>

*According to the interviewees, substituting raw materials is a major undertaking that often requires changes to production, procurement and logistics processes as well. The interviewees therefore confirmed the hypothesis that substitution is a strategic business decision which affects many processes throughout the company and requires the full support of senior management.*

(Hypothesis no. 9)

processing of new materials with different properties. Capital is also needed for R&D on new products using different materials – this is a process which requires strategic, long-term investment and does not yield short-term benefits.

- Secondly, **C-suite support** is essential. This is because introducing new raw materials has wide-ranging impacts across multiple functions within the company, including procurement, processing, marketing and R&D.
- Thirdly, having **room for manoeuvre on product quality** is a crucial success factor. Having this flexibility lowers the threshold at which substitute raw materials become a viable alternative. Rigid quality expectations, on the other hand, make substitution more challenging because any substitutes have to meet higher standards.
- Fourthly, **long-term planning** is crucial to the success of this strategy. Identifying, introducing and testing new raw materials is time consuming, as are the processes of improvement to achieve the full potential of these materials. The strategy therefore only makes sense if implemented from a long-term perspective.

### Recommendations for action

Various recommendations for action can be made for material substitution projects based on the findings of this study. The first step must be for companies to identify whether there is a via-

ble material available to replace the original. If so, companies must then assess whether they are ready to introduce a substitute, as outlined in SCRREEN's **substitution strategy guide** (SCRREEN, 2019)<sup>23</sup>. This guide introduces the concept of the Substitution Readiness Level (SRL), which can be used to:

- Create a unified and comprehensive picture of the maturity and fit of a substitute material or technology
- Help with decisions on developing substitutes
- Help with decisions on introducing substitutes
- Help with managing risks

The SRL scale ranges from one (basic research has started and is now shifting towards applied research) to nine (successful identification, integration and deployment of the substitute) (SCRREEN, 2019). SRL should ideally be used by employees in R&D departments who are looking to use substitution to solve critical raw material supply issues. It can also help other players in the value chain to **select the right substitution solution according to specific market and industry constraints**. Overall, SRL identifies the readiness of substitutes by assessing how close they are to being market-ready, and is a useful starting point for a substitution strategy.

Having assessed company readiness, the next step is to evaluate potential substitutes. A study by Farag found two methods to examine potential substitutes; the study focused on automotive components, but these methods can be applied to other sectors as well (FARAG, 2008):

- **Performance/cost analysis** (FARAG, 2008) can be used to find a cheaper material of the same quality, or a higher-quality material at the same cost.
- **Compound objective function (COF)** (FARAG, 2008) compares materials based on a number of weighted performance requirements.

These methods help to identify suitable alternatives to replace or even improve on existing raw materials. Depending on the new materials in

<sup>23</sup> An example SRL scale can be found at <http://screen.eu/wp-content/uploads/2019/06/SCRREEN-D5.2-Substitution-strategies-guide-for-RDI-V2.pdf>

question, two scenarios may arise, as explained above:

- If the substitute has similar or identical properties to the existing material, costs can be kept relatively low because existing production processes and equipment can be retained.
- If the substitute has different characteristics from previous materials, it may be necessary to invest in new production processes.

The first scenario requires **less complex preparation and yields medium-term benefits**, so companies are advised to include projects of this nature in their medium-term strategies. Nonetheless, the risk of changes in the final product must still be taken into account. Any changes in product quality or properties must be communicated to customers at an early stage so that they can modify their own processes if necessary. Before introducing the new material into the production line, extensive testing is also necessary to ensure that product durability will be maintained and to minimise any negative effects on existing processes (e.g. unwanted chemical reactions). These tests mean that even cheaper substitution projects must still be considered medium-term solutions, not short-term ones.

The second scenario needs **more extensive R&D but yields long-term benefits**; it involves greater expense, but offers greater opportunities for improvement. These improvements may give the company a competitive edge, or even lead to a paradigm shift in manufacturing. The new processes and equipment required in this scenario make it necessary to carefully evaluate whether the time and new machinery involved represent sound investments, and the risk of the new process producing inferior-quality products should not be overlooked. However, the potential benefits are substantial, including reduced dependence on scarce raw materials, material cost savings, better performance and increased sustainability.

To help efficiently allocate R&D resources and funding for identifying substitutes, it is a good idea for companies to join or form **research groups**.

As with purchasing groups outlined in Section 4.4.6, pooling resources to form research groups consisting of multiple companies with similar raw material needs is likely to achieve synergies. Joint projects run by research groups are likely to achieve results faster than individual companies testing similar approaches in parallel, while also mitigating the risk of capital losses because costs are shared between the group members. Production downtime for testing can also be reduced because a single test by one member can yield results for the entire group. These synergies also apply to the process of refining newly developed products.

Another research-related recommendation is for companies to develop a competitive edge by carrying out joint research with universities and other research institutes. The study participants considered collaboration with public research institutes to be particularly beneficial. Collaboration of this nature can range from funding research to jointly developing new equipment, including using company factories to carry out tests under real-world conditions. Projects such as these can also make use of **public research funding for material substitution**. Examples in Germany include the nationwide ProMat\_KMU<sup>24</sup> programme; or ReTech-BW<sup>25</sup>, which offers subsidies for companies in Baden-Württemberg. Public research funding provides a further opportunity for companies to reduce the risk posed by high costs and uncertain profitability.

Although there are a number of factors which make returns hard to predict (e.g. political restrictions, price changes, new technologies, quality improvements), material substitution – along with recycling (see Section 4.4.8) – is the only strategy considered in this study that can make companies completely **independent of supplies of scarce raw materials**. Companies are therefore advised to execute research on material substitution as soon as possible in order to evaluate possible substitutes, and to use the strategy to reduce risk exposure and develop a competitive edge.

<sup>24</sup> More information about ProMat\_KMU can be found here: [www.bmbf.de/bmbf/de/forschung/innovativer-mittelstand/kmu-innovativ/kmu-innovativ-materialforschung-promat\\_kmu/kmu-innovativ-materialforschung-promat\\_kmu.html](http://www.bmbf.de/bmbf/de/forschung/innovativer-mittelstand/kmu-innovativ/kmu-innovativ-materialforschung-promat_kmu/kmu-innovativ-materialforschung-promat_kmu.html)

<sup>25</sup> More information about ReTechBW can be found here: <https://pure-bw.de/de/retech-bw>

**Table 9: Summary of material substitution**

 <b>Usage: current</b>	<p>No usage  -----    -----  High</p> <p>Among the eleven strategies studied, material substitution has the third-lowest level of usage.</p>
 <b>Usage: next three to five years</b>	<p>No usage  -----    -----  High</p> <p>This strategy is set to have the eighth-highest level of usage over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  -----    -----  High</p> <p>Material substitution was rated as having the third-lowest level of effectiveness.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Capital available for investment</li> <li>• C-suite support</li> <li>• Room for manoeuvre on product quality</li> <li>• Long-term planning</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Conduct SRL assessment</li> <li>• Evaluate materials (performance/cost analysis and COF)</li> <li>• Focus on materials with similar properties for medium-term results, in combination with research groups</li> <li>• Collaborate with universities and other research institutes</li> <li>• Invest in R&amp;D</li> <li>• Examine sources of funding research (e.g. public subsidies)</li> </ul>

### 4.4.10 Vertical integration



#### Definition

Vertical integration refers to expansion of business activities within a company’s own supply chain. Vertical integration projects vary in terms of the means used to expand business activities, the degree of integration and its direction (forward or backward). Means of integration include acquisition of an existing business, or expanding the company’s own business activities to a new area of the supply chain. The degree of integration can range from a minority shareholding in a company to outright ownership of the business. Vertical integration is not necessarily limited to financial investment in another company, but it always has a strategic motive: in other words, companies acquire stakes in other companies with the aim of creating benefits for their own business. The direction of vertical integration can either be forward or backward. Forward integration refers to integration with downstream companies in the value chain (i.e. closer to the end consumer) – for example, a manufacturer acquiring a stake in a retail chain. Backward integration refers to integration with upstream companies in the value chain (i.e. closer to raw material producers), such as an automotive manufacturer acquiring a stake in a supplier of components (REGNÉR et al., 2019). As securing supplies of raw materials is the subject of this study, this section will focus on backward integration.

A simplified illustration of a supply chain is shown in Figure 39. Modern specialised manufacturing

#### Corporate example

##### Toyota Tsusho (Japan)

Toyota Tsusho, the trading arm of Toyota, acquired a 15% stake in the lithium mining company Orocobre for USD 224m in 2018. In the same year, they expanded the capacity of Orocobre’s Olaroz mine in Argentina from 17,500 tonnes per year to 42,500 tonnes per year to meet growing demand for lithium. Direct investment, support and development of the mine give Toyota more control over the mine’s lithium production than would be possible with long-term contracts. Toyota Tsusho stated that the investment will provide the company with a “long-term, stable supply of lithium in response to growing global demand” (WOODHOUSE, 2018; TOYOTA TSUSHO, 2021).

typically involves products from a variety of different suppliers, which in turn also use products from multiple suppliers, making supply chains complex. For example, automotive manufactures need rare earths to produce permanent magnets used in the drivetrains of electric vehicles. Producing permanent magnets from the raw mined material is a multi-step process, including processing of mixed rare earth carbonate, separation to rare earth oxides, production of rare earth metals, and production of rare earth alloys. The various stages are very often carried out by different companies (GOLEV et al., 2014). To secure raw materials and avoid country-specific risks, just holding a stake in a mine is often not enough: supply chains from these mines also need to be developed. Investing in suppliers and raw material producers is very capital-intensive, but it allows direct access to raw materials or products, reducing both dependence on other companies and the risk posed by short-

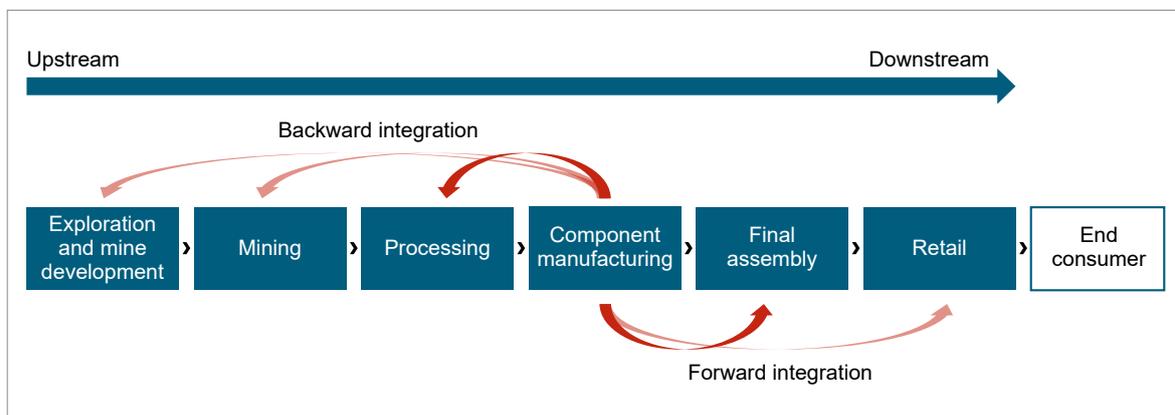


Figure 39: Vertical integration in the value chain (simplified example)

ages. Other positive effects of vertical integration and reasons to use the strategy include cost savings, synergies, and its adaptability to the company's specific requirements (KOLMYKOVA, 2016). Whereas the majority of the strategies examined in this study enable companies to mitigate either price risk or supply risk, vertical integration offers an opportunity to manage both risks.

**Usage and effectiveness**

**Current usage** of vertical integration within the companies surveyed is very low compared to the other strategies (see Figure 40): 41% of survey respondents do not use the strategy at all, and only 9% of the companies using the strategy reported a high level of usage. This makes vertical integration the least used strategy examined in this study. Usage of vertical integration is very limited in Germany, too: vertical integration was also the least used strategy in the 2021 INVERTO study, which primarily surveyed German companies. Only 5% of INVERTO respondents used the strategy in 2021, almost unchanged compared to the 2015 figure of 4% (INVERTO, 2017; 2021). Most participants in the present study said that companies chose to use vertical integration to achieve synergies with existing business units, to reduce dependence on other companies, and to align raw material production with company

needs. Reasons against using vertical integration include financial barriers, loss of flexibility, and poor compatibility with overall company strategy.

The survey respondents also rated vertical integration as the **least effective strategy** out of the eleven strategies examined (see Figure 41). The interviews found that companies perceive vertical integration as ineffective due to the considerable barriers involved in implementing the strategy, as significant capital investments are required. In line with this low level of perceived effectiveness, **planned usage** in the next three to five years is only marginally higher than current usage (see Figure 40), and vertical integration will remain the least used strategy. Once again, this is due to the considerable barriers to using the strategy and the huge expense involved.

The companies in our survey were also asked to state which type of company (in terms of position in the supply chain) they have invested in or are planning to invest in (see Figure 42). The least popular options, in terms of both current investments and planned investments, are **existing mines and mine development** projects, whereas manufacturers which serve as suppliers are the most popular targets for vertical integration. According to the study participants, the reasons for the low popularity of mining investments go beyond the major barriers and large capital investments involved. Firstly, a company needs a sufficiently high level of demand for a given raw material. Insufficient demand would make investments in mines disproportionately expensive. Secondly, the company's position in the value chain is crucial. The closer a company is situated to the end consumer, the less attractive mining investments are: this is because investing in companies that are closer to a company's own position in the value chain offers greater potential for synergies and cost savings. Thirdly, the experts stated that they consider investments in mines to be more financially risky than investments in suppliers of intermediate products. This is particularly true for mining projects in politically unstable countries. In addition, structural changes in the market (e.g. technological change causing raw material prices to drop) can lead to mine closures, with severe impacts on mining companies. Investing in a supplier of an intermediate product, on the other hand, leaves more options open if the supplier is adversely affected by structural change.

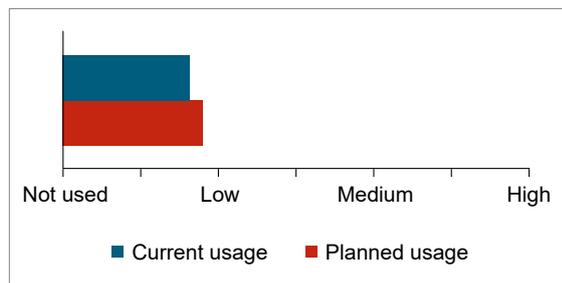


Figure 40: Usage of vertical integration

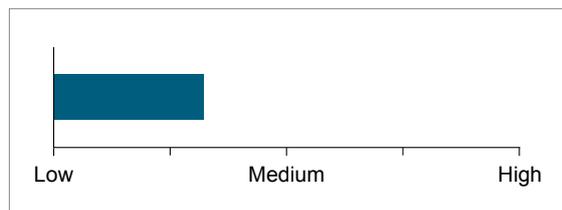
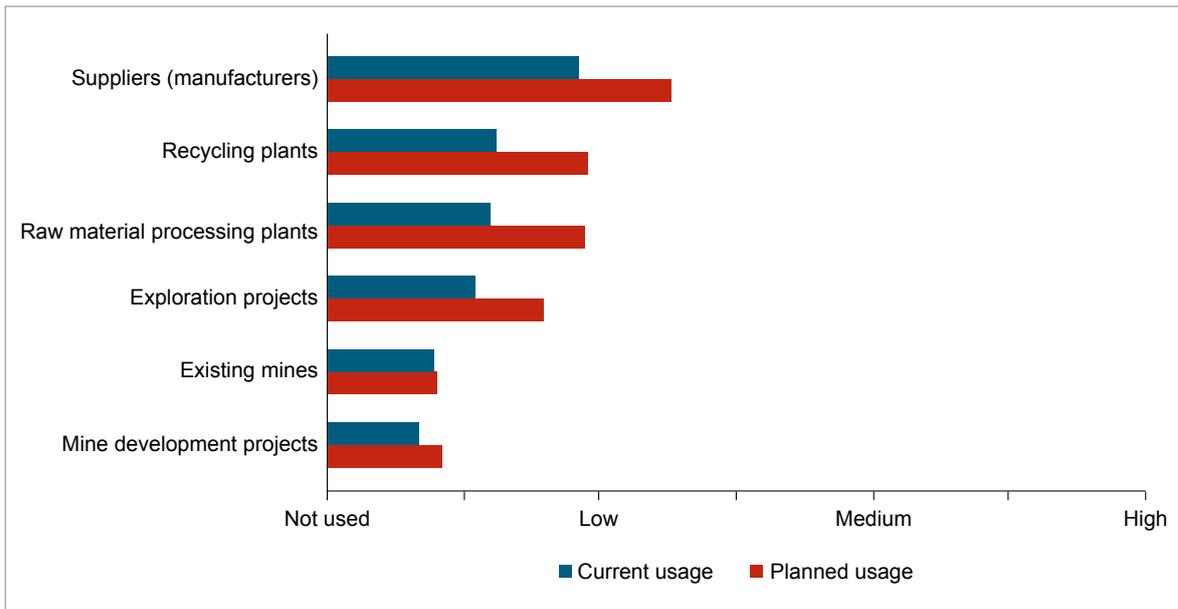


Figure 41: Effectiveness of vertical integration



**Figure 42: Popularity of different investment targets for vertical integration**

Reputational risk arising from pollution or violation of labour rights also discourages companies from investing in mines. The picture among German companies is very similar to that found in the present study: according to INVERTO, only a very small number of companies in Germany are examining whether investing in mines could be a way for them to secure a supply of raw materials (INVERTO, 2019). The representatives of German industry associations consulted in the workshop for the present study also stated that this strategy is of limited relevance for German companies, due to the high capital investments required, the major risks and uncertainties involved, the need to meet a minimum viable demand for raw materials, and the fact that the core business models of most German SMEs are too far removed from the business models of mining companies.

### Opportunities and challenges

Vertical integration involves various opportunities and challenges. The opportunities can be grouped into four categories: **more reliable procurement planning and supply of raw materials, multiple opportunities to increase profitability, increased knowledge and capabilities and greater independence from external suppliers.** The challenges can be grouped into **risk of negative return on investment (ROI), more complex**

*“Vertical integration can be a great way to expand the business and manage costs in the long term.”*

Steel and purchasing expert at a consulting firm

**corporate management as well as limited flexibility and increased dependence on individual players.**

As explained above, vertical integration can involve acquisition of upstream companies (backward integration) or downstream companies (forward integration) in the value chain. One of the major benefits of investing in upstream companies is **more reliable procurement planning and a dependable supply of raw materials** or related goods and services. This, in turn, reduces the risk of the company being affected by material shortages, price volatility or quality issues. Having this form of security is key for all manufacturers, but is particularly important when dealing with materials which are subject to high levels of uncertainty and risk.

A dependable supply of raw materials opens up **multiple opportunities to increase profitability.** Constantly having raw materials on hand is key to reliably meeting customer demand for products, and a manufacturer unaffected by volatility

Opportunities	Challenges
<p><b>More reliable procurement planning and supply of raw materials:</b></p> <ul style="list-style-type: none"> <li>– Reduced risk of material shortages, price volatility and quality issues</li> </ul> <p><b>Multiple opportunities to increase profitability:</b></p> <ul style="list-style-type: none"> <li>– Lower procurement prices, cost savings</li> <li>– Opportunity for additional revenue streams</li> </ul> <p><b>Increased knowledge and capabilities:</b></p> <ul style="list-style-type: none"> <li>– Increased market knowledge, joint R&amp;D</li> <li>– Opportunity to achieve strategic goals</li> </ul> <p><b>Greater independence from external suppliers:</b></p> <ul style="list-style-type: none"> <li>– Opportunity to influence local business culture</li> <li>– Drawbacks associated with external suppliers can be eliminated</li> </ul>	<p><b>Risk of negative ROI:</b></p> <ul style="list-style-type: none"> <li>– High initial investments and running costs</li> <li>– Costs may ultimately exceed benefits</li> </ul> <p><b>More complex corporate management:</b></p> <ul style="list-style-type: none"> <li>– Industry-specific expertise required</li> <li>– Former suppliers are now direct competitors, requiring monitoring and analysis</li> </ul> <p><b>Limited flexibility and increased dependence on individual players:</b></p> <ul style="list-style-type: none"> <li>– Long-term commitments to procure materials</li> <li>– Increased reliance on the political and socio-economic situation in one country</li> </ul>

in the raw material markets is therefore in a better position to satisfy and retain its customers. Vertical integration presents the opportunity to procure raw materials for less than current market prices, allowing manufacturers to reduce their prices and increase their profits. The strategy also enables companies to bypass transaction costs charged by intermediaries, and procuring large quantities of raw materials can create economies of scale. Any raw materials acquired in this way which are surplus to requirements can be sold to other companies, thus **creating an additional revenue stream**.

A further advantage of vertical integration is the opportunity to combine company-specific strengths. Integrating **increases the knowledge and capabilities** available to the investing company, potentially resulting in joint development projects for new products and services which benefit both parties, such as innovative logistics solutions. Even if joint projects are not initiated, the investing company will still gain know-how in exploring new markets. Vertical integration can also help achieve strategic goals set by individual companies, such as rapidly increasing the size of the company, expanding business activities, or increasing the company's market share.

Vertical integration also offers the opportunity for companies to **influence local business standards**: this includes applying companies' own ESG standards, as well as impacting corporate

culture and establishing efficient processes. ESG standards are particularly important for materials coming from regions of the world where practices such as child labour or slavery have yet to be eliminated (e.g. cobalt mining in the DRC). In similar vein, backward integration gives companies **greater independence from external suppliers** and reduces the negative impacts associated with these suppliers. For example, companies can avoid markups on raw material prices, or reputational damage caused by inadequate ESG standards among suppliers.

Nevertheless, backward integration also involves a number of challenges and risks. First and foremost are the **high levels of investment** required and the **cost-intensive** nature of the strategy. To implement vertical integration, companies need both strong finances and access to external financing, which are particular challenges for SMEs. Cost intensity takes the form of increased fixed costs resulting from mining investments, which can become a burden if material prices decrease to the point where the company can no longer cover these costs. In a worst-case scenario, these increased costs may even lead to a **negative ROI**.

Increased **complexity in corporate management** is another major challenge: management structures need to include competencies in both the company's original industry and the industry it has expanded into. Vertical integration with

one supplier means that other former suppliers become direct competitors, all of which need to be monitored. In this complex environment, there is a risk of companies losing focus on their core business. To avoid these risks, companies need comprehensive **expertise and analytical skills**. In the case of mining investments, for example, an understanding of mining in general, the country of origin and the necessary logistics is essential. Legal concerns are a particular issue requiring solid expertise, as a contractual framework for integration projects must be established in advance, taking account of different jurisdictions and both national and international law. Ensuring that this work is accurate enough to rule out various risks is a major challenge, especially when buying companies in politically unstable regions.

**Limited flexibility and increased dependence on individual players** are a further challenge inherent in vertical integration. Mining investments usually involve fixed long-term commitments to procure materials, goods and services. This can create risks: for example, if customer demand changes and the material being mined is no longer needed. The limited and often uncertain lifespans of mines can also be challenging; mines for heavy rare earths in particular are not very long-lived, constantly confronting businesses with the complex task of acquiring new ones. Loss of flexibility can have even more adverse effects if political unrest, geographical threats or socio-economic changes arise in the country where mining is being undertaken. Given the growing focus on ESG issues, the country in which an integrated mine is situated may even pose an inherent **image-related challenge**: while integration offers the opportunity to drive improvements in standards as described above, persistence of issues such as human rights violations can also be an increased threat to the integrating company's reputation.

#### Conditions and success factors

Various conditions and success factors need to be taken into account when implementing vertical integration. These success factors can be summarised under the four points listed below: **large company requiring large quantities of raw materials, flexible corporate organisation, strategic fit** and **specific know-how**.

*The interview participants confirmed the hypothesis that vertical integration is primarily used by companies in a strong financial position and with a substantial demand for raw materials. Vertical integration of suppliers is a long-term strategic decision, as it involves significant capital investment. Therefore, this strategy is only suitable for certain companies.*

(Hypothesis no. 10)

- Firstly, it must be emphasised that vertical integration is a strategy for **large companies requiring large quantities of raw materials**. The company also needs to be in a strong financial position and must have access to sufficient external finance to cover both the initial and ongoing costs.
- Secondly, a **flexible corporate organisation** is very beneficial for vertical integration. Clear interfaces and an open corporate culture help with integrating the target company into existing processes; the lower the complexity of the two companies, the easier integration will be.
- Thirdly, **strategic fit** is another important success factor. The integration project must be in line with overall corporate strategy, and integration will be easier if both companies have similar strategic goals.
- Fourthly, **specific know-how** is vital. Mining investments in foreign countries, for example, require economic and technical knowledge about mining, as well as knowledge about the country in question and its legal requirements. Insider knowledge and a broad professional network are also essential for identifying potential targets for integration.

#### Recommendations for action

Various recommendations for action can be made based on the findings of this study; these are explained below. In line with the subject matter of this study, the recommendations focus on backward integration.

In general, vertical integration is recommended in markets where **raw material production and**

**distribution are concentrated among a small number of suppliers.** As explained above, vertical integration can both ensure a reliable supply of raw materials and secure low prices, thus mitigating both supply risk and price risk. Pursuing this strategy makes sense if companies are heavily dependent on a small number of suppliers and, at the same time, subject to considerable supply risk. Nevertheless, it must be emphasised that vertical integration is a long-term strategy. To counter supply risk and price risk in the short term, strategies such as commodity price hedging or price pass-through are more suitable.

To reach a decision on whether this strategy is suitable, companies should carry out a **comprehensive make-or-buy analysis** to determine whether certain products or raw materials should be purchased from external suppliers or produced in-house. An analysis of this nature should consider risks, costs, liquidity, availability of resources, reputation and quality. If in-house production is chosen, companies should then decide whether to develop new production capacity or acquire existing suppliers.

As part of the preparation process for vertical integration, companies looking to integrate need to **analyse potential target companies and their market environment.** The goal is to identify and eliminate risks, and to discover and exploit opportunities. This analysis should start by taking a closer look at the company's organisation and areas of business. Complex organisations with many areas of business can complicate the integration process. Partial integration (possibly with majority) – a 50–85% stake in the target company, either by acquiring shares or assets – should be considered if some areas of the business do not fit the investing company's business purpose. It is also important to check whether the two companies have a good strategic fit. This includes examining the corporate cultural fit, which is a vital factor in the integration process, as well as the market environment and customer base. Backward integration is recommended if the industry in question is growing rapidly and demand is expected to rise. A broad customer base serves as an indicator of quality and reliability. The company's position in the value chain is also an important consideration. In general, companies should look for targets immediately upstream in the value chain – for example, companies that are not

involved in processing raw materials themselves should integrate their direct suppliers, rather than mines. Companies looking to integrate are then advised to examine the capital structure of their potential target company, and to research financial ratios and compare them with other companies in the same industry. These include ratios such as the asset coverage ratio, cash flow, equity ratio, return on equity, receivables turnover ratio, liquidity ratio, material cost ratio, personnel cost ratio, return on sales and debt ratio. Analysis of the target company's finances must also include the development of costs and earnings, and the underlying positions and drivers of any developments must be taken into account.

As outlined above, vertical integration involves financial investments and increased costs. As a result, an **economic analysis** is essential. Firstly, the value of the target company needs to be assessed. Various evaluation methods can be used, including the asset-based, earnings or market value approaches. However, decisions should never be based on results produced by only one valuation method; multiple different methods should be used to determine a maximum and a minimum value. Secondly, it is important to assess whether the company looking to integrate can cope with the heavy investments required (e.g. through loans) and the associated increase in expenses (e.g. due to interest). Raising sufficient funds can be a hurdle for SMEs in particular.

In addition to the costs of financing, it is also important to consider the direct costs and overheads arising from the target company, as outlined above. However, it should be noted that the increased costs may be offset by cost savings brought about by the integration project (e.g. bypassing intermediaries, less-than-market prices) as well as additional income from the sale of surplus materials. It is important to draw up a full cost plan, **considering a variety of scenarios:** these should take account of the overall corporate picture, and scenarios both with and without the integration project should be developed. Companies should pursue vertical integration if the scenarios suggest that this will generate a positive ROI.

It is also advisable to insure large integration projects, using products such as **warranty and indemnity insurance.** Warranty and indemnity

insurance protects buyers or sellers by transferring risks from their balance sheets to the insurer's balance sheet. In the case of large transactions, risk may be transferred to multiple insurers' balance sheets. Transferring risk in this way helps to solve the issue of risk distribution, which otherwise has the potential to undermine the entire deal in large mergers and acquisitions.

**Investigating state subsidies** is another sensible step, particularly when investing in mining projects: state credit institutions, credit insurance agencies and investment insurance agencies can be beneficial for vertical integration in providing financing and in bearing economic and political risks. State support is often provided for these projects in the companies examined in this study. In Germany, too, support of this nature is available, such as state guarantees for untied financial loans: these secure loans for commodity projects against economic and political default risk. Investment guarantees are also available from the German Government for German direct investment in developing and emerging countries, and the German Investment Corporation (DEG) offers partial funding for feasibility studies<sup>26</sup>.

Vertical integration means adding an extra business unit, and it is important to have sufficient human resources and knowledge available in the company to manage this unit. In addition to the **economic and legal know-how** described above, other knowledge needs to be developed within the company by targeted training and recruiting, supplemented by help from external sources such as specialist consultants. This additional knowledge should cover the following:

- **Technical and industry-specific know-how** – e.g. about the type of mining and technology used
- **Geopolitical know-how** – e.g. about the country in question, its legislature and its executive
- **Sociocultural know-how** – e.g. about the country's general culture, working culture, values and language

- **Environmental know-how** – e.g. about the environmental impact on the company and the country in question

Management plays a crucial role in the integration process. **Open, top-down communication** in integration projects helps to create acceptance and get important stakeholders involved. For example, vertical integration is not just a task for the finance department: the purchasing and production departments must also be prepared at an early stage. Vertical integration brings about changes in delivery times and conditions, making it necessary to rethink warehousing, internal material flows and existing production processes. Although integration projects require a lot of attention, it is important for companies not to lose focus on their core business; otherwise, the company may suffer a loss of turnover or profitability.

Another key recommendation is to **consider ESG criteria**, an issue which is becoming increasingly important for various stakeholders and shareholders. In the context of backward integration, this specifically means that the target company's ESG performance must be critically examined. For example, companies should carefully consider whether or not to make mining investments in countries where child labour, modern slavery, pollution or corruption are commonplace; projects of this nature can lead to considerable reputational damage. The increasing relevance of sustainability issues also makes it advisable to consider producers of secondary raw materials (i.e. recycling companies) as potential targets for vertical integration, as this may be beneficial for the investing company's ESG performance.

<sup>26</sup> More detailed information is available from the following websites:  
<https://www.bmwk.de/Redaktion/DE/Artikel/Aussenwirtschaft/garantien-fuer-ungebundene-kredite.html>  
<https://www.bmwk.de/Redaktion/DE/Artikel/Aussenwirtschaft/investitions Garantien.html>  
[www.deginvest.de/Unsere-L%C3%B6sungen/Machbarkeitsstudien/](http://www.deginvest.de/Unsere-L%C3%B6sungen/Machbarkeitsstudien/)

**Table 10: Summary of vertical integration**

 <b>Usage: current</b>	 <p>No usage  -----  High</p> <p>Among the eleven strategies studied, vertical integration is the least used strategy.</p>
 <b>Usage: next three to five years</b>	 <p>No usage  -----  High</p> <p>This strategy is set to be the least used strategy over the next three to five years.</p>
 <b>Effectiveness</b>	 <p>Low  -----  High</p> <p>Vertical integration was rated as the least effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Large company requiring large quantities of raw materials</li> <li>• Flexible corporate organisation</li> <li>• Strategic fit between company looking to integrate and target company</li> <li>• Economic, legal, geopolitical, sociocultural, environmental, technical and industry-specific know-how</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Consider vertical integration in market environments with few suppliers</li> <li>• Conduct a comprehensive make-or-buy analysis, including market environment and financials of potential target companies</li> <li>• Consider a variety of scenarios to determine likely ROI</li> <li>• Use insurance and state support to mitigate risks</li> <li>• Make human resources available and develop know-how</li> <li>• Ensure open, top-down communication</li> <li>• Consider ESG criteria, including shareholder and stakeholder interests</li> </ul>

#### 4.4.11 Business tools



##### Definition

Business tools are IT applications designed to enhance decision-making in managerial processes, such as planning, budgeting, assessing, measuring, forecasting and monitoring. As such, they are used in various aspects of business planning, from the supply chain to production planning (CHICKERUR et al., 2018).

Driven by technological developments in areas such as big data analytics, AI, automation, blockchain, cloud computing and predictive analytics, the number of business tools available has grown rapidly in recent years. Accordingly, business tools are becoming more important in procurement, and are being increasingly widely used.

Business tools for use in procurement draw on data collected from various sources: these might be internal sources, suppliers or specialised service providers. Based on this data, individual business tools can be developed to calculate, monitor and forecast KPIs, such as quantity of materials needed, availability of raw materials, reliability of supply, and prices. Broader considerations such as political stability, geopolitical events and natural disasters can also be factored in. This enables business tools to enhance real-time transparency and help companies individualise their approach to identifying risks related to relevant markets and materials. Some tools also process large quantities of market data and use this to automatically calculate product-specific target prices when raw material prices change. Other tools provide a common IT interface to integrate suppliers, which enables information to be exchanged and material flows monitored in real time. This facilitates early identification of risks (e.g. supply chain disruption) and better assessment of each supplier's performance and adaptability (WERNER, 2017; 2020).

As a result, business tools offer a variety of benefits, such as real-time monitoring of the supply chain and the market, forecasting of market changes, and identification of risks at an early stage. Business tools cannot secure supplies of raw materials on their own, but they can lay the foundations for important business decisions: they are essential for effective application of the

##### Corporate example

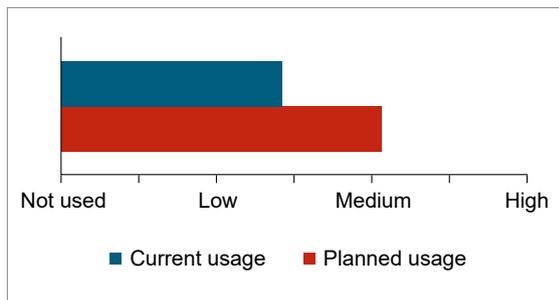
###### Illinois Tool Works (US)

Illinois Tool Works (ITW) is a US-based manufacturer of specialised industrial equipment, consumables and related services. To ensure that all vendors are the best possible fit for its goals and needs, the company implemented a supply chain management platform in 2015 (JAGGAER, 2020). This tool provides interactive dashboards, giving ITW a standardised overview of all supplier activities and risks. The tool also analyses data across the full source-to-pay process and provides automated risk alerts, while scorecards offer proactive input for improvements. Managing KPIs, documents and data through the system provides reliable compliance tracking for ITW, and the company can deal with any supplier issues at an early stage (JAGGAER, 2021).

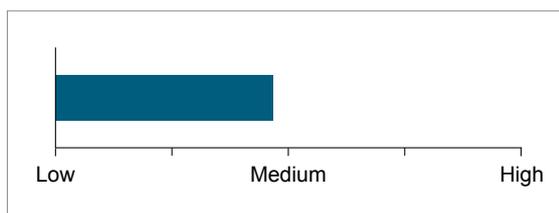
other strategies examined in this study, and they are most effective in combination with these strategies.

##### Usage and effectiveness

**Current usage** of business tools to secure supplies of raw materials within the companies surveyed is moderate (see Figure 43). Among the eleven strategies examined, business tools are the fifth-most used strategy: 90% of the companies surveyed are currently using business tools, with 9% of those doing so reporting a high level of usage. Business tools are less widely used in German companies: in INVERTO's 2021 raw materials management survey, which primarily surveyed German companies, only 19% of respondents reported using business tools (INVERTO, 2021). However, this represented a slight increase from 12% in 2015 (INVERTO, 2017). Most participants in the present study stated that companies chose to use business tools because of the increasing importance of integrated information and forecast-based operational planning. Combining information from various sources more quickly and accurately enables trends to be identified at an earlier stage, in turn enabling companies to gain a competitive advantage. Reasons against using this strategy include general scepticism that tools such as business intelligence software can accurately predict the future, and the huge amount of work required to integrate new software tools into existing IT infrastructure.



**Figure 43: Usage of business tools**



**Figure 44: Effectiveness of business tools**

The survey respondents judged the **effectiveness** of business tools to be medium (see Figure 44), although this is higher than most of the other strategies: business tools were ranked as the fourth-most effective strategy. Accordingly, many of the companies surveyed are **planning to increase their use of business tools** over the next three to five years (see Figure 43). The percentage of companies using the strategy is set to increase from 90% to 93%, and the percentage of those companies making a high level of usage is set to increase to 34%. The experts interviewed for this study stated that the most important reason behind this growth is the increasing availability of data – and with it, the increasing reliability of business tools. Other reasons include growing pressure on companies to use appropriate business tools where this would provide a competitive advantage, rapid advancements in IT, and the effects of the Covid-19 pandemic – many companies came under pressure to move to digital solutions, but also discovered how quickly and successfully this change can be implemented.

### Opportunities and challenges

Business tools offer various opportunities and challenges. The opportunities can be grouped into three categories: **advanced decision-making**,

**increased profitability and competitiveness**, and **improved corporate knowledge management**. The challenges can be grouped into **choosing and implementing the right solution**, **in-house expertise** and **limited accuracy and reliability**.

*“If we don’t know what we’re doing, will never improve what we’re doing. If we don’t measure exactly what we need to measure, we won’t improve. Because of this, the importance of business tools will increase in future.”*

Logistics and distribution expert at a consulting firm

**Advanced decision-making** capabilities are a key benefit of business tools. They offer the opportunity to collect data from both internal and external sources, process it into information, and display this information in the required format. If suitable data of sufficient quality is available, it is also possible to analyse historic and current developments of raw material prices, as well as to forecast future price developments. Decisions can then be made based on these analyses. For example, companies can use business tools to generate forecasts to help predict when market prices are likely to be lowest. Based on these forecasts, companies can then make **cost savings** by placing orders when market prices are favourable. Business tools can also help companies to forecast their raw material needs more precisely, based on analyses and forecasts of customer behaviour and supplier availability. This can help prevent companies ending up with excessive stocks of raw materials, and offers a means to identify potential for improvements in the supply chain to avoid shortages.

This potential for better procurement planning and budgeting means that business tools provide an opportunity to **improve profitability and competitiveness**. This is a particularly important benefit in markets where long delivery times, high prices and material shortages are commonplace: even marginally better information in these environments can give companies an all-important edge over their competitors.

Business tools offer the opportunity to gather and analyse various types of data from various sources, such as customer data from CRM sys-

Opportunities	Challenges
<p><b>Advanced decision-making:</b></p> <ul style="list-style-type: none"> <li>– Data from a variety of sources</li> <li>– Advanced forecasting</li> </ul> <p><b>Increased profitability and competitiveness:</b></p> <ul style="list-style-type: none"> <li>– Improved procurement planning</li> <li>– Cost savings in procurement</li> </ul> <p><b>Improved corporate knowledge management:</b></p> <ul style="list-style-type: none"> <li>– Vast quantities of data</li> <li>– Information can be effectively condensed, displayed, stored and archived</li> </ul>	<p><b>Choosing and implementing the right solution:</b></p> <ul style="list-style-type: none"> <li>– Existing tools may not meet company requirements</li> <li>– Integrating new tools into existing IT infrastructure is very complex</li> </ul> <p><b>In-house expertise required:</b></p> <ul style="list-style-type: none"> <li>– Appropriate quality and quantity of data</li> <li>– Analytical skills to interpret results</li> </ul> <p><b>Limited accuracy and reliability:</b></p> <ul style="list-style-type: none"> <li>– Results are least reliable in volatile scenarios</li> <li>– Avoiding over-reliance on tools is important</li> </ul>

tems, supplier data from e-procurement systems or price data from commodity exchanges. Based on this information, business tools can contribute to **corporate knowledge management**. They provide an opportunity to condense and display a variety of information from various sources, and this information can be effectively stored and archived.

Alongside these opportunities, however, there are considerable challenges. First and foremost is the fact that business tools themselves do not mitigate either price risk or supply risk. To generate a positive effect on procurement, business tools need to be used in combination with other strategies to enhance their effectiveness.

**Choosing the right solution**, or developing new ones if no suitable tools are available, is a major difficulty, involving a challenging make-or-buy decision at the very beginning of the project. Implementation is expensive and time-consuming, and lack of experience with digital solutions within the company may lead to the project going over budget. Even if these problems can be overcome, **integrating new tools into existing IT infrastructure** is a complex and laborious task, as established processes may need to be completely redesigned.

Data-driven decision-making is valuable for companies of any size, but a certain level of **in-house expertise in IT and analytics is essential**. Getting appropriate quantities and quality of data is also a major challenge. If an insufficient amount of data is available – typically on a very specific aspect – more data needs to be obtained; if there

is too much – typically on more general aspects – the challenge is to filter out irrelevant or less important data. In terms of data quality, the main challenge is to ensure that data can be properly processed by the business tool. This may make it necessary to prepare the data – for example, converting it to a common format – before it can be used. Preparation must be carried out by experienced staff. Once the data has been analysed, interpreting the results may be challenging: once again, this requires in-house skills and analytical know-how.

Applicability of business tools in **highly volatile scenarios** is another potential issue. Use of business tools is a particularly attractive idea in unpredictable situations, but their output is also least reliable in these circumstances. Over-reliance on business tools is therefore a major risk: it is important to remember that their outputs are **forecasts, not definite predictions**. Although they provide advanced analyses and forecasts which can inform decision-making, decisions must ultimately be made by humans.

### Conditions and success factors

Various conditions and success factors need to be taken into account when implementing business tools. These success factors can be summarised under the three points listed below: **suitable solutions for company needs, availability of data and combining machines and humans**.

- Firstly, it is very important for companies to choose **solutions which are suited to their**

*The study participants confirmed the hypothesis that business tools will become a widely used means of risk mitigation over the next few years. This development is being driven by advances in IT and the increasing availability of data.*

(Hypothesis no. 11)

**needs.** The features of any potential systems must be in line with the company's technical requirements, and the systems must be compatible with the company's existing IT infrastructure. However, requirements are often very specific, meaning that a standard solution with limited options for configuration is unlikely to deliver significant benefits. A detailed, needs-driven selection process is therefore essential, and companies should consider developing their own business tools if no suitable solutions are available on the market.

- Secondly, **sufficient availability of data** is essential, in terms of both quantity and quality. Business tools can only reach their full potential if provided sufficient quantities of appropriately structured data. If sufficient quantities of data are already available, unsuitable or irrelevant data must be filtered out; if this is not the case, sufficient data must be made available, ideally from both internal and external sources. Data cleansing may also be necessary before data is fed into business tools.
- Thirdly, **human expertise** in implementing and operating business tools has a significant influence on their success. Expertise is needed for tasks such as identifying use cases for business tools, selecting and implementing appropriate tools, operating and maintaining systems, selecting and preparing data, and interpreting and communicating results. This highlights the importance of collaboration between management, IT and other specialised departments (e.g. procurement), and adequate digital skills are essential in all three of these areas.

### Recommendations for action

Various recommendations for action can be made for implementing business tools based on the findings of this study. The amount of data available is continuously growing, so it is advisable for companies to take advantage of data-driven decision-making in volatile markets. However, the first step towards implementing business tools is to recognise their importance and potential for procurement. Raising awareness of business tools among both procurement staff and management will create a solid foundation to exploit their full potential.

The next important step is to carry out a **status quo analysis** to examine existing decision-making processes and the company's data situation. Once a transparent overview of all relevant decision-making processes has been created, companies must then identify which of these processes can be enhanced by business tools. Business tools have particularly great potential to enhance the more complex decision-making processes. **Complexity** in decision-making processes includes the following aspects:

- **Variety** – the need to consider many different data sources
- **Transparency** – the need to clearly illustrate non-intuitive relationships
- **Speed** – the need to make decisions quickly

The more applicable these aspects are, the greater the need for business tools. If, for example, there is no need to transparently link many different data sources, simple analyses may be sufficient (e.g. spreadsheet calculations). If, on the other hand, internal and external data sources need to be combined and visualised in real time, such as when planning raw material purchases to avoid high market prices, business tools are likely to be the more appropriate choice.

As outlined above, ensuring sufficient quality and quantities of data is crucial. Failure to meet this requirement can lead to a situation of "garbage in, garbage out": in other words, flawed inputs are likely to lead to flawed outputs, however advanced the tools are. Existing data sources must therefore be assessed to determine whether they are accurate, complete, reliable, relevant and up to date. As mentioned above, both internal (e.g. ERP sys-

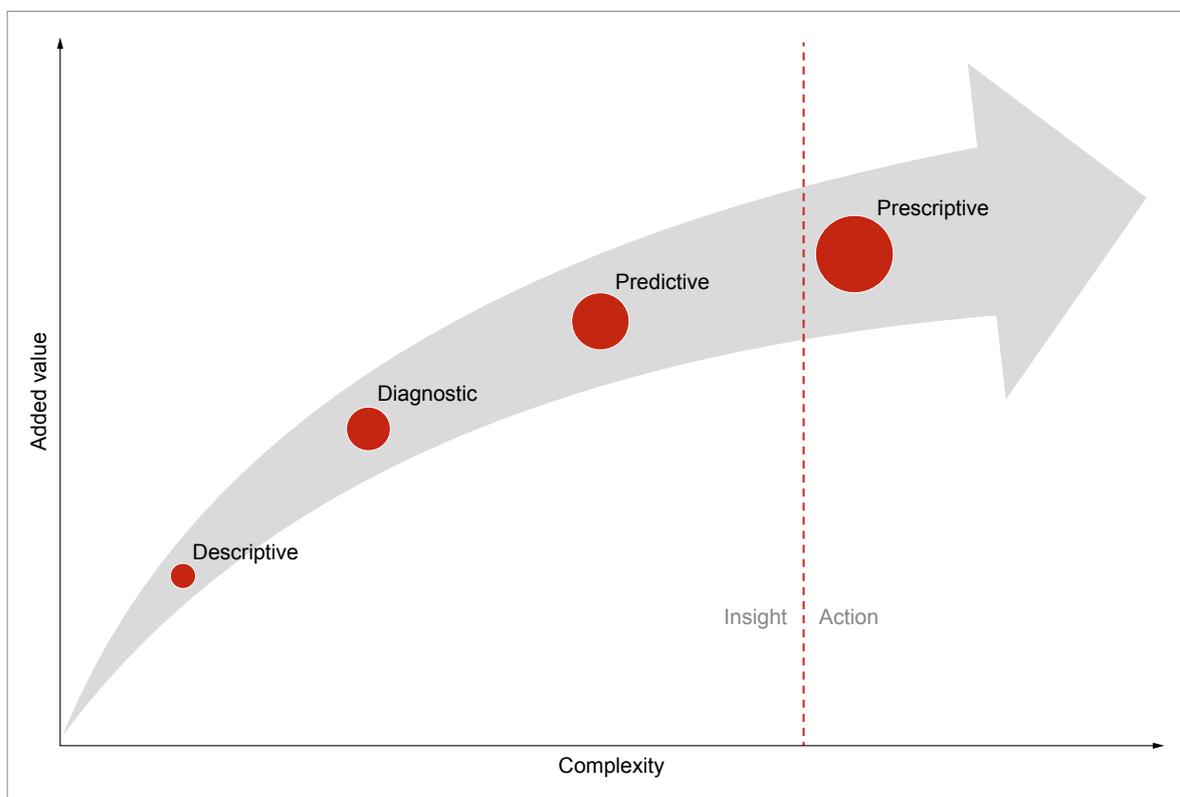
tems) and external data sources (e.g. commodity exchange databases) should be used, although this will vary by use case. Identifying relevant data sources and examining them with a critical eye is also very important: issues such as incorrect data, too much data or duplicated data can give counterproductive results and have a negative impact on decision-making. “Smart data instead of big data” (MANDL & MINNER, 2017) is the approach to aim for when selecting data sources.

Once relevant data sources have been selected, companies need to implement **an extract, transform, load (ETL) process** to feed data into the business tool. ETL is a data integration process run by an ETL system; some business tools have their own ETL systems built in, while others require an external ETL system. ETL systems ensure that data quality and consistency standards are maintained, delivering data in a format ready for other systems to use.

Companies are also advised to assess their individual use cases for business tools, as this determines which systems are suitable for the

company. This assessment needs to answer the question of which analytical methods are needed to strengthen the decision-making process. Descriptive analysis, for example, is based on past data and only determines what has happened, while diagnostic analysis tries to explain why it happened. Predictive analysis can identify patterns and thus enable forecasting, and prescriptive analysis – the most advanced analytical method – provides full data-driven support for decision-making, explicitly indicating which choices should be made.

Purely descriptive analysis using business intelligence solutions is no longer advisable, as this method does not identify causal relationships or enable forecasting. Instead, the focus is shifting towards prescriptive decision-making. In many cases, it is therefore advisable to **supplement descriptive business intelligence with prescriptive business analytics**. For companies to reach their goals, it is becoming increasingly important to go beyond the questions of “What happened?”, “When?” and “Where?” to include “What will happen?” and “What options do we



**Figure 45: Added value and complexity of implementing different methods of analysis**  
(Source: PwC, based on MANDL & MINNER, 2017)

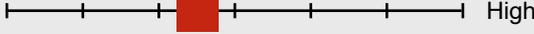
have?" (OMAR et al., 2019). These are questions which business analytics systems are designed to answer. Machine learning algorithms can also be used, allowing users to train the system to answer these key questions based on historic data.

It is also advisable to use machine learning algorithms and AI to continuously improve forecast analytics: these technologies can identify anomalies in the data and adjust the forecasting models accordingly to improve their accuracy. However, it must not be forgotten that although more advanced analytical methods can provide more added value, they are also more complex and expensive to implement (see Figure 45). Generally, using more advanced data-driven support makes sense when planning involves complex decisions and high risks. Because of this, companies should **compare the costs and the expected return** on a potential solution to identify whether it offers value for money.

Once the decision to use analytical tools has been made, companies should consider whether to develop their own systems or purchase off-the-shelf solutions. In-house development enables company requirements to be fulfilled better, simplifies integration into existing IT infrastructure and gives the company a high degree of independence. However, off-the-shelf solutions offer the benefit of ongoing updates; they also require less resources, offer better security and can be implemented more quickly. Although this is a company-specific decision, it is advisable for SMEs to purchase existing tools, as developing a solution in-house requires extensive knowledge and huge resources. Before buying solutions, companies are advised to **examine their scalability, compatibility, scope for customisation, complexity of implementation, support, and security, along with issues around maintenance and updates**. Modern software-as-a-service (SaaS) solutions are ideal in this regard, especially for SMEs: these are centrally hosted, cloud-based systems which can be accessed via a web browser, avoiding the need for complex on-premises installations. When choosing solutions, it is a good idea to ask for initial guidance from other companies which have already implemented business tools. It may also be necessary to consult external experts during the selection process if internal expertise is insufficient.

Implementing business tools requires **adequate IT infrastructure** in terms of factors such as performance, resilience and security, but **organisational infrastructure** is just as important. **Cross-departmental collaboration** between decision-makers in management or procurement and technical staff in the IT department is highly recommended. To achieve this, companies should designate IT business partners to improve coordination between IT and the business as a whole. Organisational infrastructure also includes developing the necessary skills within the company. As has already been outlined, analytics tools require high levels of knowledge even before implementation, and the software will only be able to add value if sufficient expertise is available to exploit its potential. Companies therefore need to train or recruit the necessary personnel – such as IT administrators, data engineers, data scientists and skilled users – at an early stage.

Table 11: Summary of business tools

 <b>Usage: current</b>	<p>No usage  High</p> <p>Among the eleven strategies studied, business tools are the fifth-most used strategy.</p>
 <b>Usage: next three to five years</b>	<p>No usage  High</p> <p>This strategy is set to have the third-highest level of usage over the next three to five years.</p>
 <b>Effectiveness</b>	<p>Low  High</p> <p>Business tools were rated as the fourth-most effective strategy examined in this study.</p>
 <b>Conditions and success factors</b>	<ul style="list-style-type: none"> <li>• Selecting suitable business tools that meet company requirements</li> <li>• Sufficient availability of high-quality data</li> <li>• Combination of machines and humans</li> </ul>
 <b>Recommendations for action</b>	<ul style="list-style-type: none"> <li>• Carry out status quo analysis and choose suitable business tool for company requirements</li> <li>• Ensure adequate quality and quantity of data</li> <li>• Implement an ETL process</li> <li>• Supplement business intelligence with business analytics</li> <li>• Consider how advanced the solution needs to be</li> <li>• Develop adequate IT infrastructure</li> <li>• Strengthen organisational infrastructure to facilitate cross-departmental collaboration and develop skills</li> </ul>

## 5 Strategy development and execution

The following chapter introduces an overarching **strategy development and execution cycle**. This is intended to guide companies in identifying, implementing and reviewing a raw material procurement strategy suited to their needs. The cycle includes a number of key steps and recommendations that are intended to complement the strategy-specific recommendations for action outlined in Sections 4.4.1 to 4.4.11.

Figure 46 shows the strategy development and execution cycle, which is influenced both by the corporate ecosystem and by macro trends. The cycle is divided into four phases, and it should be run continuously to achieve ongoing improvement of the company's raw material procurement strategy.

1. **Status quo and goals:** internal and external analyses are carried out to evaluate company requirements and procurement markets; goals and target state are set.
2. **Creating a level playing field:** strategies and suppliers are selected; internal resources are expanded as necessary.
3. **Implementation and execution:** strategies are implemented.
4. **Evaluation and adjustment:** strategies are assessed using KPIs; potential improvements are identified and used to inform the next cycle.

Strategy development and execution is also affected by various external influences, which can be divided into two groups:

- Corporate ecosystem
- Macro trends

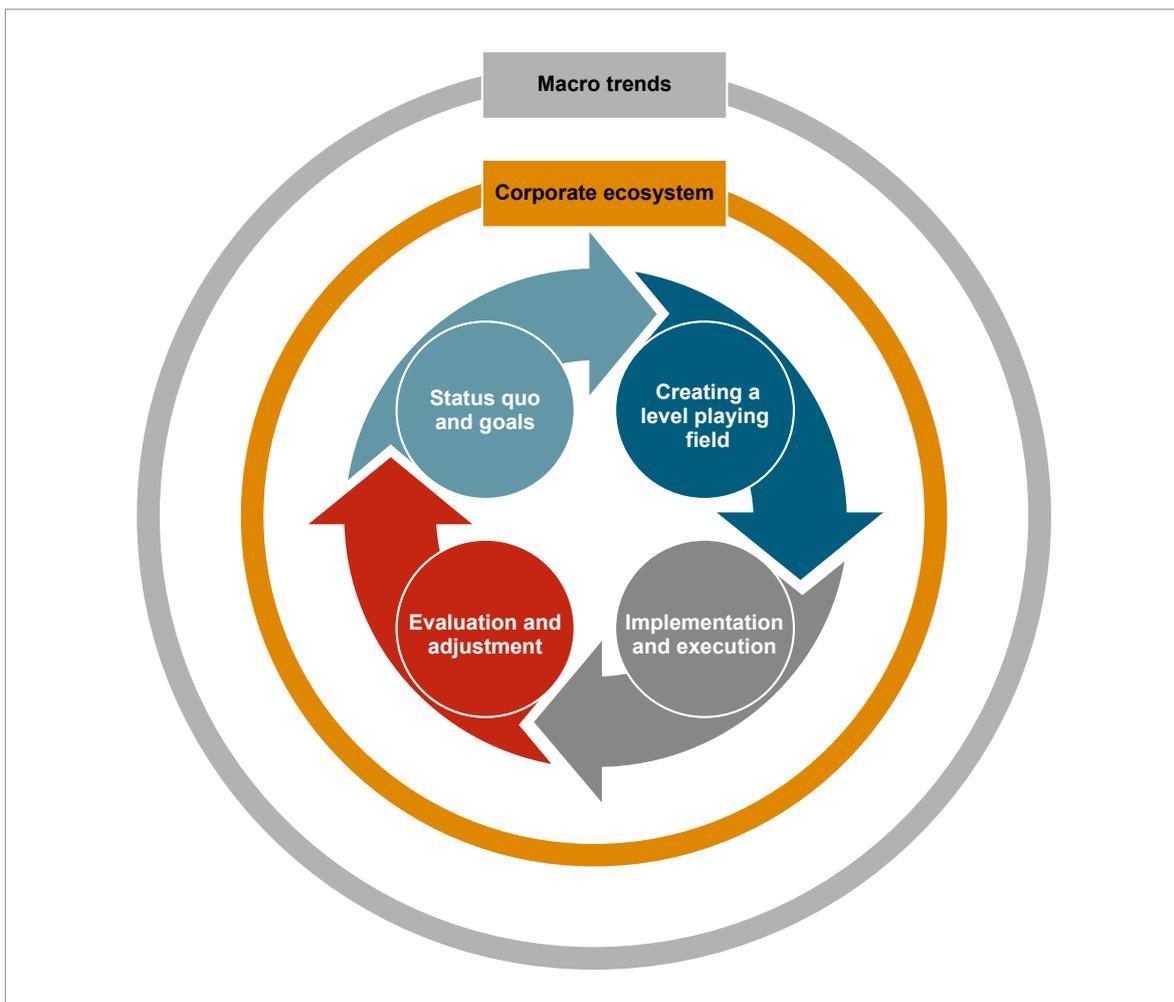


Figure 46: Strategy development and execution cycle

The **corporate ecosystem** describes the environment that the company can influence. This includes other businesses on which the company depends or may become dependent, and vertical or horizontal collaboration with other companies or countries, both upstream and downstream in the value chain. The term “ecosystem” also goes beyond the company’s own industry to include all other industries that are relevant to the company.

**Macro trends** are external factors over which the company has no control, but which have a direct

or indirect effect on the company. These include trends such as sustainability, globalisation vs. deglobalisation, and rising energy costs.

The following sections provide specific recommendations for action for each element of the strategy development and execution cycle. A checklist of key points can be found in Table 12. The checklist covers all four phases of the cycle and the two external aspects, giving a step-by-step guide to the entire process outlined in this chapter.

**Table 12: Checklist for strategy development and execution**

Checklist	
<b>1</b>	<p><b>Status quo and goals</b></p> <ul style="list-style-type: none"> <li>– Analyse company raw material needs and strategies used by competitors.</li> <li>– Formulate clear procurement objectives to avoid conflicts.</li> </ul>
<b>2</b>	<p><b>Creating a level playing field</b></p> <ul style="list-style-type: none"> <li>– Formulate a binding procurement strategy in line with suitable goals, raw material needs, and competitors.</li> <li>– Assess, select and combine strategies to minimise procurement risk.</li> <li>– Make clear commitments to provide resources in order to operationalise the selected strategies.</li> <li>– Select suppliers and develop a supplier management system, considering internal and external factors.</li> </ul>
<b>3</b>	<p><b>Implementation and execution</b></p> <ul style="list-style-type: none"> <li>– Establish interdepartmental interfaces to link departments and people involved in the procurement process.</li> <li>– Communicate regularly and create transparency to ensure continuous improvement of supplier relationships.</li> <li>– Implement the selected raw material strategies, in line with the overall procurement strategy.</li> </ul>
<b>4</b>	<p><b>Evaluation and adjustment</b></p> <ul style="list-style-type: none"> <li>– Establish clear evaluation systems and regularly evaluate both the overall procurement strategy and the individual raw material strategies.</li> <li>– Carry out continuous, KPI-driven adjustment and improvement of the procurement strategy and its implementation.</li> </ul>
<b>5</b>	<p><b>Corporate ecosystem</b></p> <ul style="list-style-type: none"> <li>– Identify and analyse the corporate ecosystem, and consider it in strategic decision-making.</li> <li>– Form alliances with ecosystem partners to increase potential for innovation.</li> </ul>
<b>6</b>	<p><b>Macro trends</b></p> <ul style="list-style-type: none"> <li>– Implement an effective raw material procurement strategy and take advantage of the corporate ecosystem to minimise dependence on political, geographical and economic factors.</li> <li>– “Think globally, act locally”: include glocalisation in company procurement goals and strategy to increase independence, reduce CO<sub>2</sub> emissions and save logistics costs.</li> <li>– Develop a corporate ESG agenda, apply it to the entire supply chain (upstream and downstream), and employ expert staff to monitor ESG compliance.</li> </ul>

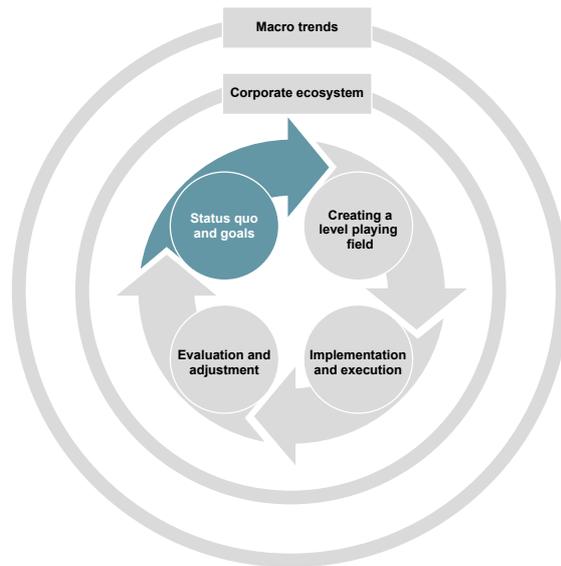
## 5.1 Status quo and goals

Assessing the status quo and setting goals make up the first phase of the strategy development and execution cycle. This section provides a comprehensive explanation of both parts of this phase, along with recommendations for action (see Table 13 for key takeaways).

### Assessing the status quo

The very first step towards applying the strategy development and execution cycle is to **obtain information about factors affecting raw material procurement**, including both current factors and any that may arise in the future. This requires procurement research, focusing on the company's requirements and market conditions. Procurement research is defined as the systematic collection, classification and analysis of data on all relevant factors concerning raw material procurement, and it lays the foundations for further decisions. Developing procurement goals and strategies is recommended as a means of mitigating procurement risks, so the research needs to identify which procurement risks the company faces, covering a wide range of internal and external topics. Internal considerations include analyses and forecasts of current and future raw material requirements in line with the company's product portfolio, as well as analyses of procurement costs, expected savings, and general company requirements (e.g. high sustainability standards). External considerations include the situation in the raw material markets, assessing potential suppliers and analysing strategies used by competitors.

When carrying out **internal analysis**, companies should start by **analysing their product portfolios**, and then calculate the quantity of raw materials necessary to meet demand for finished products. Precisely planning raw material needs for a given period requires appropriate forecasting methods. **Quantitative forecasting** can be carried out by applying analytical techniques such as moving averages, regression analysis or exponential smoothing to procurement data, and the results will help the company to exploit trends and predict how demand will develop. Companies are recommended to use predictive or prescriptive analytical tools to transform raw data into useful information. **Qualitative forecasting** aims to



enrich quantitative forecasts, and uses techniques such as the Delphi method or historical analogies to integrate expert knowledge on procurement and the market. For both quantitative and qualitative forecasts, companies should consider using appropriate software: this can shorten planning processes, facilitate interaction between the parties involved and make forecasts more precise (see Section 4.4.11).

Once these forecasts have been conducted and an initial estimate of raw material needs has been made, companies should **consider their safety stock**, which is very important for avoiding production stoppages if materials are not delivered as planned. Appropriate levels of safety stock vary depending on the raw material in question, the quantities needed in the company, and the company's supplier base. However, all safety stock serves to mitigate the risk of suppliers failing to meet deadlines or quality standards, and it is particularly important in situations where intense competition causes raw material shortages or global delays to logistics. Companies should consider even higher levels of safety stock if market volatility is such that raw materials may become unavailable (see Section 4.4.3).

**External procurement research** involves market analysis in three key areas. Companies should start by assessing the **locations, extractability and prices** of the raw materials that they need. The findings need to be examined and combined with the results of the internal analyses to develop a holistic picture of the company's situa-

tion. Assessment of locations involves examining where reserves of the material are found, along with assessing the geographical conditions at these locations: these conditions include environmental hazards such as flooding, earthquakes or volcanic eruptions. Extractability is a measure of whether reserves of the raw material are accessible. This includes assessing political and legal risks such as export restrictions, embargoes, sanctions or tariffs. Finally, prices and price risk need to be analysed and predicted, and it is important to remember that these are influenced by factors including location and extractability. Companies may find it helpful to consult external support from bodies such as DERA during this process.

Having researched the availability of the raw materials they need, companies should then analyse potential suppliers. This analysis needs to consider both the current performance and the expected future performance of each supplier, as well as their default risk. Comparing suppliers objectively is very important, and companies are recommended to **develop a benchmarking system and scorecards** for this purpose (see Section 4.4.4). More detailed recommendations for the supplier selection and management process can be found in Section 5.2.

Finally, companies should review raw material procurement **strategies used by their competitors**. Strategies, technologies or services which have been successfully implemented by competitors (e.g. logistics hubs, supplier management software, consulting services) can provide a useful guide for a company's own procurement staff, and adopting them can deliver benefits for the company. For maximum benefits, companies should keep their competitors under continuous observation so that any new strategies introduced by competitors can be assessed and adopted as soon as possible.

Procurement research can be undertaken either continuously or at regular intervals. The former includes continuous observation of raw material prices and general availability as part of day-to-day business in procurement or management, while the latter includes developing detailed forecast models to estimate the quantities of raw materials the company will need. Companies should undertake both types of research to

ensure a constant flow of information (VAN WEELE & EISSIG, 2017). However, it is also important to balance the costs and benefits of research, so the **scope of research and the resources provided** need to be laid down in advance. As comprehensive research is complex, it may be worthwhile for companies to engage external consultants to carry out this work.

### Setting goals

Although procurement research is an important first stage, companies still need to further assess any risks before setting procurement goals and drawing up strategies. Risks can be grouped into different categories; in many cases, raw material procurement risks can be classified as generating either price risk or supply risk. Dependence on a single country of supply, for example, may expose a company to price risk, as any export restrictions imposed by that country would drive up raw material prices. Logistical problems such as those caused by Covid-19, on the other hand, are an example of supply risk, as these issues may lead to shortages of raw materials. Companies need to thoroughly assess their exposure to risks of this nature, using tools such as **scenario-based risk assessments**.

Based on the insights gained from procurement research and risk assessment, the next step is to **set clear procurement goals** to tackle the risks and to secure prices and/or supply. Procurement goals can be classified as monetary or non-monetary. **Monetary procurement goals** are mainly concerned with raw material prices and their impact on financial figures and company profitability. These may include goals for cost savings and performance improvements, along with liquidity targets, such as reducing the average length of time that raw materials spend in storage before they are used (HESS, 2008). **Non-monetary procurement goals** primarily aim to secure supplies of raw materials, but they also cover material quality targets. Environmental or social targets, such as conserving scarce raw materials or sustainable sourcing, can also be considered non-monetary procurement goals.

It is important to note that conflicts between goals may arise, either within or between departments. Solving or minimising these conflicts in advance

is essential for effective goal-based procurement. Companies are therefore recommended to ensure **transparency around conflicts** and carefully **assess the importance of different goals**. For example, ensuring a reliable supply of raw materials is more important in some markets than paying the lowest possible prices. This might be because

a production stoppage due to lack of materials would be more costly than paying a premium for reliable supplies. To ensure clear procurement goals, companies should check that their goals meet the **SMART criteria**: **s**pecific, **m**easurable, **a**chievable, **r**ealistic, and **t**ime-bound.

**Table 13: Key takeaways: status quo and goals**

Key takeaway	Example
1 Analyse company raw material needs and strategies used by competitors.	Our company's medium-term raw material plans are aligned with raw material availability and supplier availability.
2 Formulate clear procurement objectives to avoid conflicts.	We need to avoid conflicts between cost savings and stockpiling.

## 5.2 Creating a level playing field

Creating a level playing field ready for effective implementation of company procurement strategies is the second phase of the strategy development and execution cycle. This phase can be divided into three parts: selecting and combining strategies, providing sufficient resources, and selecting and managing suppliers. The following section provides a comprehensive explanation of these three aspects, along with recommendations for action.

### Selecting and combining strategies

Once procurement goals have been set, the next step is to develop an overall raw material procurement strategy. Sections 4.4.1 to 4.4.11 above provide a portfolio of individual strategies for companies to use. Based on their procurement goals, companies must select an appropriate range of these strategies to mitigate price risk, supply risk, or both, as appropriate. To make this selection, it is advisable to examine which risks the strategies tackle and how effective they are. The strategies can then be classified as follows:

- Price strategies – primarily effective against price risk
- Supply strategies – primarily effective against supply risk
- Hybrid strategies – effective against both price risk and supply risk

As shown in Table 14, it is sensible to subdivide supply risk mitigation into short-term and long-term because some strategies are considerably better suited to the short term than others. This is not a significant issue with price risk mitigation.

Having classified their potential strategies, companies should then assess the resources required for each strategy. Based on the results of this study, six key demands that each strategy places on the company have been identified to serve as a framework for this assessment:

- Implementation time
- Initial investment
- Running costs
- Workforce required
- Expertise needed
- Minimum viable quantity of material

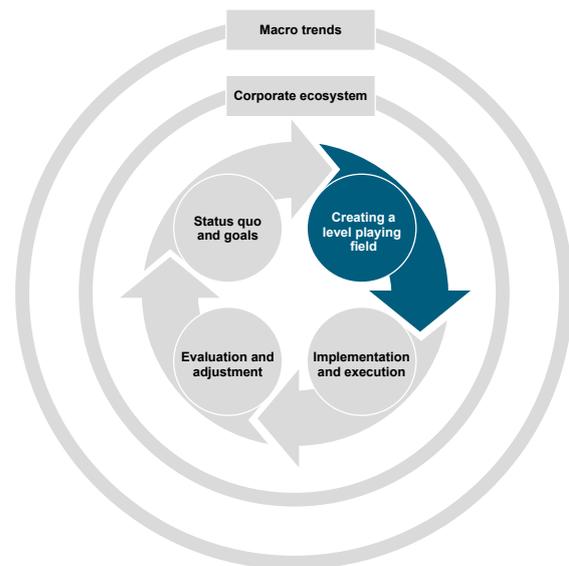


Table 14 offers a comparison of the level of resources each strategy requires in each of these areas. This may be a useful starting point for companies looking to select strategies for securing raw materials, but it should be noted that the table can only offer general information. Companies should draw up their own tables for assessment purposes, taking any company-specific requirements or other factors into account: for example, the long-term potential of recycling to mitigate supply risk is likely to be more limited in companies which have already implemented recycling systems.

Looking at the overall picture in Table 14, it is clear that strategies which primarily address price risk can generally be implemented more quickly and easily, while strategies which primarily reduce supply risk are significantly more time-consuming and costly. Nevertheless, companies should aim to implement a number of appropriate strategies, rather than relying on just one. Some strategies work well together, as their goals are similar and they offer the potential for synergies. For example, joining a purchasing group also helps with supplier diversification and can pave the way for new long-term contracts.

Alongside the opportunities offered by the strategies, companies also need to consider a number of internal factors in the strategy selection process. The company's **organisational structure** is particularly important, as raw material strategies are cross-functional in nature, and applying them in parallel requires interdepartmental collab-

**Table 14: Comparison of risk mitigation and resources required for each strategy**

Strategies	Effectiveness of risk mitigation			Resources required*					
	Price risk mitigation	Supply risk mitigation		Implementation time	Initial investment	Running costs	Workforce required	Expertise needed	Minimum viable quantity of material
		Short-term	Long-term						
Commodity price hedging	Medium	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
Passing on price increases	Medium	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
Stockpiling	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Supplier diversification	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
Long-term contracts	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
Purchasing groups	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Increased material efficiency	Low	Low	Medium	Low	Low	Medium	Medium	Medium	Medium
Recycling	Medium	Low	High	Low	Low	Medium	Medium	Low	Medium
Material substitution	Medium	Low	Medium	Low	Low	Medium	Medium	Low	Low
Vertical integration	High	Low	High	Low	Low	Low	Low	Low	Low
Business tools	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Legend				
Colour coding	Effectiveness of risk mitigation	Level of resources required	Short-term	Long-term
High	High	Low	< 1 year	> 3 years
Medium	Medium	Medium		
Low	Low	High		

\* All requirements refer to a hypothetical, average case, from planning to operation of each strategy. Resources required at the beginning of the implementation process fall under "implementation time" and "initial investment"; "running costs" refers only to the operating expenses incurred once the strategy is up and running. Workforce required, expertise needed and minimum viable quantity in the implementation phase may differ from later stages. The table shows hypothetical averages of these variations. For example, a large workforce is required when developing substitute materials, but only a small workforce is required once these materials are in use. This gives the average of "medium" shown in the table. Companies are strongly recommended to adapt the table to reflect their own situation and needs.

oration. For example, joining a purchasing group alongside diversifying suppliers and signing long-term contracts requires the legal department, the purchasing department, the finance department and a central representative in the purchasing group to work together. This team should ideally be considered as a single unit, and will need a suitable organisational framework for close collaboration. If necessary, organisational transformation should be carried out to **establish the necessary corporate structure**. This could take the form of a permanent specialist team for raw material procurement, or a temporary project team with

the skills to manage joint activities in purchasing groups and maintain supplier relationships.

**Availability of internal resources** is another important consideration when selecting strategies. For example, companies need to assess whether their available lines of credit and liquid funds are sufficient for the initial investments required. The same applies to the human resources and technological resources necessary to implement a strategy. Although companies can and should expand their internal resources if necessary (as examined below), it is important to consider whether this is

**Example 1: beginners****Company characteristics:**

Company 1 is a specialist parts manufacturer in the aerospace industry, with 60 employees and an annual turnover of EUR 20m. The company is reliant on supplies of copper and aluminium to produce corrosion-resistant components. Due to high demand for these materials in recent years, the company is increasingly being exposed to price risk, but it has only addressed this issue to a very limited extent.

**Recommended strategies:**

Long-term contracts, purchasing groups, passing on increased prices to customers.

**Explanation:**

Concluding long-term contracts with fixed prices will enable the company to take a first step towards mitigating supply risk and price risk. Long-term contracts offer various advantages: they only need a small workforce and relatively low levels of investment, ongoing expenditure and expertise. However, as negotiation of these contracts usually needs a certain level of bargaining power, it is advisable to join forces with suitable partners to form purchasing groups, which may also provide a useful forum to exchange expertise. Price risk can be reduced by passing on increased prices to customers. Like long-term contracts, this strategy only involves small initial investments and running costs, does not require a large workforce, and can be implemented with relatively low levels of expertise.

**Example 2: midfielders****Company characteristics:**

Company 2 is an electrical equipment manufacturer with 200 employees and an annual turnover of EUR 75m. The company is reliant on critical raw materials including lithium, cobalt and rare earths, which it needs in order to produce batteries. With these raw materials, the company is mainly exposed to supply risk, due to general shortages and dependence on a small number of suppliers. The company is well aware of this issue and has therefore already taken measures to secure its supply of raw materials.

**Recommended strategies:**

Supplier diversification, passing on increased prices to customers, commodity price hedging, analytical business tools.

**Explanation:**

Diversifying suppliers complements measures which a large and experienced company may already have taken, and gives the company a further opportunity to guarantee its supply of good-quality raw materials. This is because diversifying suppliers expands the company's business network and enables the company to procure larger quantities of materials than would be available from a single supplier. This strategy also makes the company less dependent on any one supplier, which is especially important with critical raw materials. Passing on price increases can help mitigate price risk; however, it is not always possible to pass on the full extent of any increases, so it is also advisable to hedge commodity prices in order to avoid cost increases when new suppliers are taken on board. This, in turn, requires healthy finances and more know-how within the company. If appropriate skills are available, the company should also implement analytical business tools to ensure effective hedging.

a realistic solution; strategies which would require unfeasibly large amounts of additional resources should be ruled out in the selection process.

Finally, companies also need to consider which **strategic planning period** they are addressing (i.e. short term, medium term or long term) when selecting strategies. The strategies vary significantly in terms of time required for implementation and level of staff training required, so different strategies are suitable for different timeframes. Passing on increased prices to customers, for example, is very effective in the short term; vertical integration, on the other hand, offers little ben-

efit in the short term, but can help ensure long-term price stability.

In summary, a variety of factors need to be considered in the strategy selection process: the strategies chosen need to address the company's stated procurement goals, and the company needs to assess whether it can realistically implement the strategies. For all companies, agility and flexibility are vital for a resilient portfolio of strategies. The examples below are intended to show how a suitable portfolio can be developed based on the risks faced by a company, both for beginners and more experienced procurement professionals.

### Providing sufficient resources

Once companies have selected their portfolios of strategies, they need to ensure that the necessary resources are available, either within the company or from external providers. This includes **human resources**, **technological resources**, and **financial resources**.

In terms of **human resources**, raw material procurement requires comprehensive knowledge in a variety of disciplines. To implement the strategies examined in this study, companies need to develop expertise in the following areas:

- Assessing criticality and quality of raw materials
- Warehousing and stock management
- Analysing procurement markets, supplier networks and competitors
- Selecting and managing suppliers
- Internal and external logistics
- Procurement technology (internal and external IT)
- Finance (e.g. budgeting)
- Law (e.g. contract law)

Companies should therefore identify any gaps in their knowledge and expand their human resources as necessary to fill these gaps. Companies can develop expertise by hiring new employees and training them if necessary, training existing staff, or consulting external organisations such as advisory firms or academic institutions.

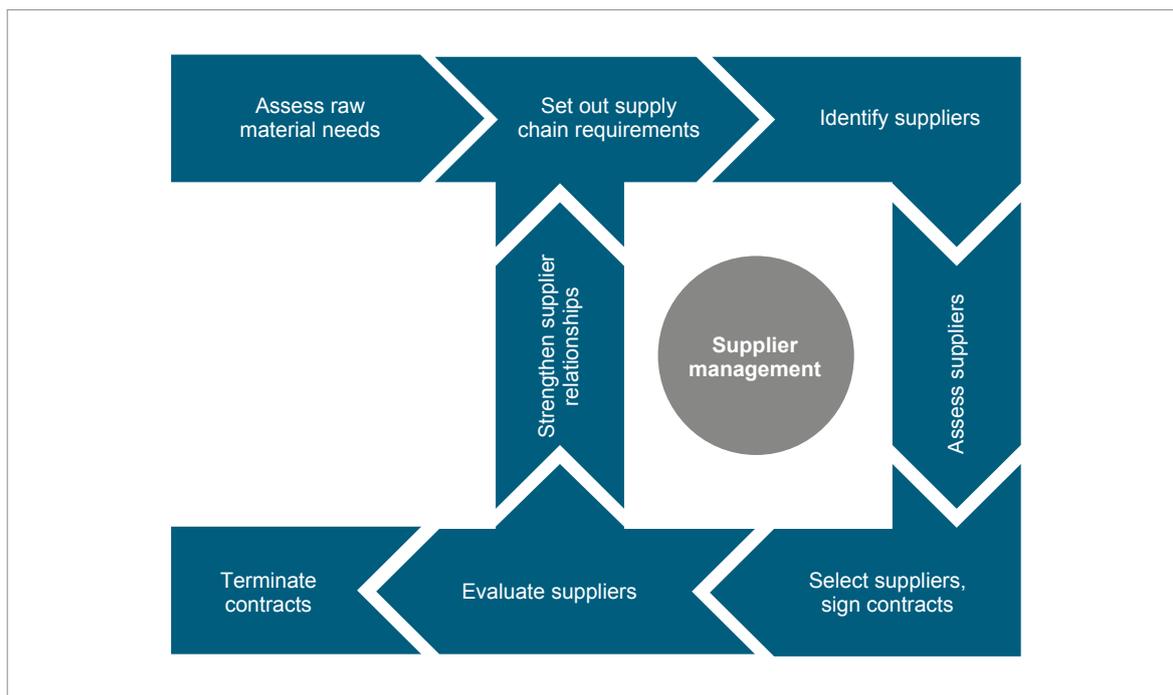
Some strategies, such as increasing material efficiency or stockpiling, may need **technological resources** going beyond the analytical business tools examined in Section 4.4.11. To determine which resources are needed, companies should start by mapping relevant business processes (e.g. the material ordering process) and their individual steps to identify where better technology is needed. The requirements placed on new hardware or software must then be clearly set out so that the company can decide whether to purchase an existing solution or develop a new one in-house. If the strategy in question requires a major technological change, such as implementing IoT, it is advisable to engage external consultants for support with change management and implementation. To ensure efficient execution of the strategies, companies should also keep

potentially useful tools under continuous review: these include tools for collaboration, such as SRM software, project management systems or company wikis.

Finally, companies must ensure that sufficient **financial resources** are available to cover both initial investments and running costs. Commitment to spending the money is also important: it is necessary to maintain cash outflows to procurement strategy projects (e.g. investment in new recycling plants) for a certain period so that the company can assess whether spending was adequate to achieve the expected results. Companies should consider various financing strategies to raise capital, from both internal and external sources. If internal financing (e.g. by retaining earnings) is not an option, companies should examine various different combinations of equity, debt and mezzanine financing that are suited to their current financial situations. For SMEs, new shareholder loans are a viable option if existing lines of credit have already been exhausted. Companies should also examine state support; various different programmes for SMEs are available from the BMWK. The ProMat\_KMU programme, for example, offers financial support for R&D into new materials. “Digital Now – Investment Support for SMEs” offers grants and aims to encourage companies to invest more in digital technology and employee qualifications. Both of these programmes have been developed to help SMEs in particular to exploit their economic potential.

### Selecting and managing suppliers

Whichever strategies a company chooses, effective supplier selection is vital in raw material procurement. Supplier selection is a focal point of supplier management; the overall goal of supplier management is to effectively manage supplier networks to ensure that the company can obtain raw materials of sufficient quality and quantity at reasonable prices. As such, supplier management is particularly crucial for the success of strategies such as supplier diversification, purchasing groups or long-term contracts. To help avoid logistical problems or shortages, supplier evaluation should also fully consider criteria such as the supplier’s default risk or the supplier’s exposure to economic and political risks. As shown in Figure 47, supplier management can be visualised as



**Figure 47: Supplier management cycle**

a cyclical process. Additionally Table 15 summarises the key takeaways for this section.

The first step in supplier management is to assess the **company's raw material needs** and set out **basic supply chain requirements** (e.g. maximum distance from company premises). It is then necessary to carry out supplier scouting to identify potential suppliers that satisfy these needs. This process should be based on the procurement research framework explained above, including both internal sources of information (e.g. existing offers, supplier database) and external ones (e.g. trade fairs). The end result of the scouting process is a long list of possible suppliers.

Next, an initial evaluation must be carried out to **produce a shortlist** of qualified suppliers. Eliminating unsuitable suppliers at this stage saves time and money being wasted on unnecessary detailed evaluation. Companies should then carry out a detailed and **systematic performance assessment** of the remaining suppliers; the final

selection is made based on the results of this assessment. Performance assessment requires company-specific evaluation criteria, which must be suitably weighted. More details of this process and an example can be found in Section 4.4.4. For SMEs in particular, it is important to ensure that supplier management and evaluation is carried out at reasonable costs and in a reasonable timeframe. The process should be led by an interdisciplinary team, including the design, production, quality assurance, finance and R&D departments in addition to procurement.

Finally, companies should note that the process of supplier management does not end once a final selection has been made and contracts have been negotiated. Ongoing supplier audits should be conducted to ensure that each supplier continues to meet all of the company's requirements. An active supplier management system should also include maintaining and strengthening relationships with suppliers; this process is further discussed in Section 5.3 below.

**Table 15: Key takeaways: creating a level playing field**

Key takeaway	Example
<b>1</b> Formulate a binding procurement strategy in line with suitable goals, raw material needs, and competitors.	To stabilise total costs in the medium term, our company's raw material prices will be pegged to current inflation for X years.
<b>2</b> Assess, select and combine strategies to minimise procurement risk.	We have chosen to minimise our exposure to raw material price risk by hedging commodities and passing on price increases to our customers.
<b>3</b> Make clear commitments to provide resources in order to operationalise the selected strategies.	Our company has appointed a hedging taskforce, and X% of company cash will be made available for hedging.
<b>4</b> Select suppliers and develop a supplier management system, considering internal and external factors.	We have implemented supplier relationship management software to evaluate and audit suppliers.

### 5.3 Implementation and execution

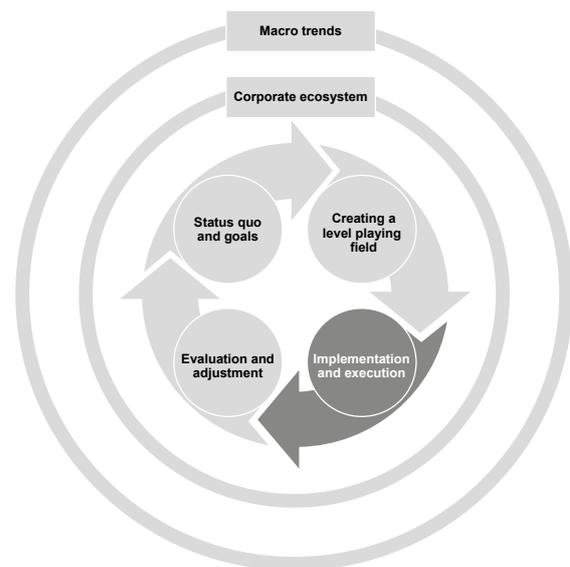
Implementation and execution make up the third phase of the strategy development and execution cycle. This phase can be divided into three parts: cross-departmental collaboration and knowledge transfer, developing and maintaining supplier relationships, and promoting competition. The following section provides a comprehensive explanation of these three aspects, along with recommendations for action.

#### *Cross-departmental collaboration and knowledge transfer*

Although establishing a suitable organisational structure (see Section 5.2) is an important step, companies need to go beyond this to ensure that strategies can be implemented by cross-departmental teams. All the strategies examined in this study require a high degree of cross-departmental **collaboration and communication** between R&D, procurement, production, waste management, quality assurance, and management. This exchange is vital to ultimately foster **knowledge transfer and general awareness** of the importance of raw material procurement. The following recommendations are aimed at fostering collaboration and communication when cross-departmental alliances are needed.

Collaboration involves three key considerations:

- **Leading by example:** for effective cross-departmental collaboration, leaders should regularly and visibly engage with other leaders and their teams involved in raw material procurement.
- **Cross-training:** offering employees frequent opportunities to gain a fresh perspective, job shadow each other, or train alongside and talk to colleagues in procurement can significantly boost collaboration. The idea is not to train everyone to do every job, but to avoid conflicts within the raw material procurement team by giving employees a basic understanding of how each department works.
- **Open feedback culture:** companies should consider establishing a system for team members and leaders to share feedback. Carefully



worded feedback and constructive criticism can help encourage rethinking and creativity, which are important components of the open approach to innovation needed when dealing with volatile markets.

Promoting communication involves two key aspects:

- **Leveraging the right technology:** providing appropriate platforms for teams can speed up communication between departments. This, in turn, can offer benefits when dealing with volatile raw material markets, as fast response times and precise timing can deliver considerable cost savings.
- **Regular meetings:** continuously assessing and improving procurement and the procurement strategy is important, and regular meetings are a key part of this. Meetings should be run efficiently and have a clear goal: this can help reduce email clutter and will enhance communication, while documenting the end results of meetings helps reduce the risk of miscommunication.

Close collaboration and communication between cross-divisional teams ensures knowledge transfer and also raises awareness, both of employees' work and of securing raw materials in general. Companies should also consider the following communication strategies in order to enhance general awareness of the importance of securing critical raw materials:

- Clear **top-down communication** of procurement goals, the procurement strategy, and measures to implement it helps ensure that staff and management are on the same page. It is up to management to explain the importance of a reliable supply of raw materials and to prioritise procurement. If this can be successfully explained, other departments will take procurement into consideration when making decisions – even departments that are not involved in securing raw materials.
  - **Open horizontal communication** between departments that are indirectly involved in raw material procurement is important to raise awareness and generate innovative ideas. Improvements suggested by staff who are indirectly involved (e.g. sales staff) will help companies to reflect on current procurement activities more effectively. These employees have an external view of procurement, which can help them to come up with innovative ideas.
- A formal SRM team or office at corporate level
  - A formal Relationship Manager or Supplier Account Manager role to offer a single point of communication with suppliers
  - A cross-functional steering committee, linking suppliers' strategies with the company's overall business strategy and raw material procurement strategy

Forming trusting relationships with suppliers requires close communication, supplier involvement in business activities, and transparency. Companies can improve **communication** with suppliers by using strategies such as the following:

- Supplier summits
- Executive-to-executive meetings
- Strategic business planning meetings
- Operational business reviews
- Open evaluation and feedback sessions

**Supplier involvement in business activities** can range from joint ideation right up to full vertical integration (see Section 4.4.10). Collaboration on various activities such as jointly developing new products (see Figure 48) is beneficial for both parties: companies with good supplier relationships can reduce their exposure to both price risk and supply risk, while suppliers can gain advance insights into which raw materials will be needed and worth supplying in the future. Other advantages for both parties include access to new technology and innovations, increased quality, and cost-effective development processes (BME, 2017).

**Transparency** is very important for building trusting relationships with suppliers. Contracts should respect the requirements of both parties, and use of appropriate technology such as SRM systems can also help to promote transparency. SRM systems help shed light on opaque procurement processes, making flows of data visible and comprehensible so that any discrepancies can be resolved quickly.

#### **Promoting competition**

As discussed above, developing close supplier relationships and concluding long-term contracts are good strategies for ensuring a reliable supply

#### **Developing and maintaining supplier relationships**

As shown above, internal collaboration between departments is a key success factor when implementing raw material strategies. However, companies also need to focus on external collaboration within their business networks – especially with direct suppliers, as this has a major impact on efficiently securing raw materials. SRM follows supplier selection and auditing in the supplier management cycle and is a cornerstone of long-term collaboration. SRM is also a key step in operationalising strategies such as supplier diversification, long-term contracts or purchasing groups (see also Table 16).

Effective SRM will give the company an advantage when renegotiating contracts, and suppliers may reward the company with preferential treatment; this can be a particular benefit if problems such as shortages arise. However, building trust also needs **a consistent approach, a defined set of supplier engagement techniques, and experienced employees**. Companies should design SRM into their organisations, which requires the following:



**Figure 48: Supplier involvement**

of raw materials; this requires resources and time, but will have a positive impact for the company. Nevertheless, rigid arrangements of this nature are not the only possible approach: **promoting competition between suppliers** can also offer a useful means of driving down raw material prices by exploiting market forces.

It should be emphasised that this recommendation is not universally applicable. Applicability will vary depending on company-specific factors, the raw material in question and the situation on the market. Companies therefore need to review the relevant raw material markets, material availability and prices to determine whether this approach is suitable. If the quantity of material that the company is looking to procure will represent a significant proportion of the total market volume, **switching suppliers at regular intervals** is likely to have a positive impact on prices, as suppliers which fail to win a contract in one round of nego-

tiations will usually offer lower prices in the next round. If the company's raw material needs are not this large, joining or founding a purchasing group (see Section 4.4.6) offers another opportunity to foster competition: the larger size of a purchasing group increases its bargaining power.

Companies are generally advised to aim for a diversified set of suppliers to mitigate risk and reduce dependence on any individual supplier (see Section 4.4.4). Competition among these suppliers can drive prices down, but this must be balanced against the risk of losing strategically important suppliers. Frequently switching suppliers can also lead to quality issues. As a result, switching suppliers is primarily recommended for **larger companies procuring large quantities** of materials. In addition, these companies should only apply this approach to some of their suppliers and aim to foster long-term relationships with others.

**Table 16: Key takeaways: implementation and execution**

Key takeaway	Example
1 Establish interdepartmental interfaces to link departments and people involved in the procurement process.	We have appointed a Raw Material Procurement Officer and developed company-wide workshops.
2 Communicate regularly and create transparency to ensure continuous improvement of supplier relationships.	Our suppliers are involved in company R&D processes.
3 Implement the selected raw material strategies, in line with the overall procurement strategy.	We have established a supplier account management taskforce to encourage suppliers to conclude long-term contracts.

## 5.4 Evaluation and adjustment

Evaluation and adjustment make up the fourth phase of the strategy development and execution cycle. This section provides a comprehensive explanation of this phase, along with recommendations for action.

Raw material procurement is the first step on the road to internal value creation. It has a major impact on the quality and the resulting prices of manufactured products. To save costs and improve quality, it is therefore essential to continuously review the effectiveness and the execution of procurement strategies. Untapped potential in procurement activities can often be traced to a lack of evaluation systems or KPIs for procurement strategies. Evaluation systems use measurable values to **track all relevant aspects** of procuring raw materials. KPIs enable procurement departments to evaluate the size, quality, costs, timing and sourcing of raw material purchases, and the impact of these factors on overall company performance. Having evaluated procurement activities, companies then need to **identify possible courses of action to improve strategies** and their execution.

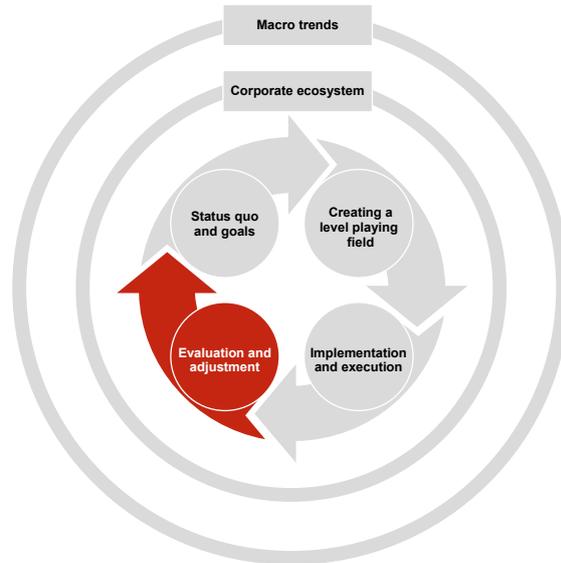
KPIs for assessing the development and execution of raw material procurement strategies are part of the company's procurement evaluation system, which addresses specified criteria and selected areas of evaluation. These **criteria** fall into three groups:

- Monetary criteria
- Quantitative criteria (non-monetary)
- Qualitative criteria

Assessment of raw material procurement needs to cover the following **areas of evaluation**:

- Raw material market
- Suppliers
- Raw material procured
- Internal procurement processes

Raw material procurement goals serve as the basis for identifying KPIs. The purpose of each goal is to define a clear target; and, in turn, the



purpose of each KPI is to **measure progress towards achieving goals**. As an example, consider a company which has set raw material procurement goals of reducing the risk of shortages and obtaining a reliable supply. To achieve these goals, a strategy of choice might be supplier diversification, as this would help the company to avoid political risk and reduce dependence on any one country. In turn, suitable KPIs for assessing suppliers include supplier availability<sup>27</sup>, which measures suppliers' ability to meet demand; or the supplier defect rate<sup>28</sup>, which allows the company to evaluate the quality of its suppliers.

Table 17 illustrates further possible KPIs for the criteria and areas of evaluation listed above. Different KPIs will be suitable for different companies, depending on company characteristics and the strategies selected. Therefore, suitable KPIs may be ratios, absolute numbers or qualitative statements.

Once companies have set up an evaluation system and the relevant KPIs, these **metrics need to be applied at regular intervals**. The right length of these intervals will vary depending on the area of evaluation in question, as well as on company-specific factors. Data collection and analyses necessary for qualitative KPIs, such as the closeness of supplier relationship, take a long time and are therefore only conducted on a quarterly or half-yearly basis. Quantifiable KPIs such

<sup>27</sup> Supplier availability (%) = (number of times raw material was available from supplier ÷ total number of orders placed with supplier) x 100

<sup>28</sup> Supplier defect rate (%) = (total substandard tonnage of raw materials ÷ total tonnage of raw materials inspected) x 100

Table 17: Examples of KPIs for evaluating and adjusting raw material procurement strategies

Criteria	Area of evaluation			
	External		Internal	
	Market	Supplier	Raw material	Procurement processes
<b>Monetary</b>	<ul style="list-style-type: none"> <li>– Current market price (EUR)</li> <li>– Highest and lowest YTD market prices (EUR)</li> <li>– Total market turnover (EUR)</li> </ul>	<ul style="list-style-type: none"> <li>– Delivery costs per tonne (EUR)</li> <li>– Trade credit granted (EUR)</li> <li>– Transaction costs (EUR)</li> </ul>	<ul style="list-style-type: none"> <li>– Purchase price per tonne (EUR)</li> <li>– Average purchase price per month (EUR)</li> <li>– Purchase price variance (EUR)</li> </ul>	<ul style="list-style-type: none"> <li>– Costs per purchase order (EUR)</li> <li>– Total procurement expenses per year (EUR)</li> <li>– Total procurement expenses per employee (EUR)</li> </ul>
<b>Quantitative (non-monetary)</b>	<ul style="list-style-type: none"> <li>– Market price change per year (%)</li> <li>– Market price volatility (%)</li> <li>– Materials traded per year (tonnes)</li> </ul>	<ul style="list-style-type: none"> <li>– Supplier availability (%)</li> <li>– Supplier defect rate (%)</li> <li>– Supplier lead time (hours)</li> </ul>	<ul style="list-style-type: none"> <li>– Materials procured per month (tonnes)</li> <li>– Inventory turnover (%)</li> <li>– Material efficiency (%)</li> </ul>	<ul style="list-style-type: none"> <li>– Procurement ROI (annual cost savings ÷ annual procurement cost) (%)</li> <li>– Purchase order cycle time (days)</li> <li>– Days payable outstanding</li> </ul>
<b>Qualitative</b>	<ul style="list-style-type: none"> <li>– Market transparency</li> <li>– Market accessibility</li> <li>– Perceived competition</li> </ul>	<ul style="list-style-type: none"> <li>– Closeness of supplier relationship</li> <li>– Capacity for innovation</li> <li>– Transparency</li> </ul>	<ul style="list-style-type: none"> <li>– Environmental impact</li> <li>– Social impact</li> <li>– Material quality</li> </ul>	<ul style="list-style-type: none"> <li>– Capacity for innovation</li> <li>– Effectiveness of improvements</li> <li>– Effectiveness of cross-departmental collaboration</li> </ul>

as delivery costs per tonne, on the other hand, are updated much more frequently: this might be performed every time an employee enters the relevant information in the company's ERP system. To do this effectively, suitable technology should be used to record and update KPIs and communicate them within the company; ERP systems are particularly useful, offering a means of collecting data and displaying key figures on dashboards. Table 18 summarises the key takeaways for this section.

After each evaluation cycle, the KPIs must be analysed to identify where and how improvements can be made, both in the raw material procurement strategies themselves and their execution. As the strategy development and execution cycle is intended to be continuous, it is advisable for companies to start implementing these improvements in phase one (see Section 5.1), and to adjust their

procurement goals if necessary. **Goals should be adjusted** if they no longer fit the prevailing circumstances (i.e. the situation on the market or within the company). Adjustments to goals are the most demanding alterations that can be made to a procurement strategy, but companies are strongly recommended to make these alterations before any others because procurement goals have a significant impact on subsequent stages. As goals are adjusted, action should then be taken to either improve the company's portfolio of strategies or provide more appropriate resources. Only once these changes have been made should companies look at improving the actual execution of their strategies. This, in turn, will require new evaluation systems and KPIs.

**Table 18: Key takeaways: evaluation and adjustment**

Key takeaway	Example
<b>1</b> Establish clear evaluation systems and regularly evaluate both the overall procurement strategy and the individual raw material strategies.	We are creating transparency on the cost savings enabled by our procurement strategy.
<b>2</b> Carry out continuous, KPI-driven adjustment and improvement of the procurement strategy and its implementation.	Our company's procurement goals have changed, so we are introducing new procurement strategies to achieve them.

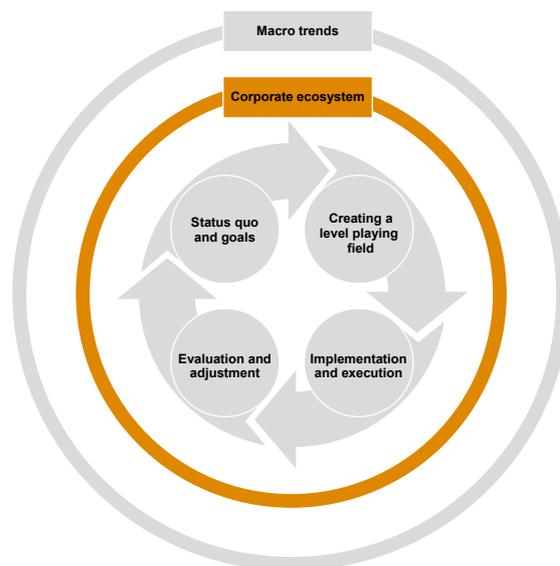
## 5.5 Corporate ecosystem

Corporate ecosystems are intertwined with company strategy development and execution cycles, with each having an influence on the other. The following section examines corporate ecosystems from a raw material procurement perspective and considers how companies can take advantage of them.

A corporate ecosystem encompasses all of the private organisations involved in the delivery of a company's products or services, including both competition and cooperation across value chains. Ecosystems usually form around a primary producer, which is surrounded by numerous partner organisations and a large customer network. Each entity in an ecosystem affects and is affected by the others, creating a **constantly evolving relationship** (MOORE, 1996).

Ecosystems are distinct from supply chains. Supply chains involve hierarchical, linear activities with the aim of increasing efficiency. Ecosystems, on the other hand, are modular; many companies in the ecosystem interact with each other simultaneously with the aim of jointly developing capabilities for a given purpose (e.g. procurement, material innovation). Entities in an ecosystem should ideally be viewed not as members of a single industry, but as parts of a broader network that **includes a variety of industries**. Public institutions, such as tax authorities, interact with corporate ecosystems but are not usually directly involved in delivering products, services or innovations, nor do their relationships with individual companies evolve in the same way as relationships between companies. In practical terms, public institutions have an indirect relationship with corporate ecosystems: this can mean both influencing corporate ecosystems (e.g. by passing industry-specific legislation) and being influenced by them (e.g. through lobbying).

As an example of a corporate ecosystem, consider a car manufacturer. Its ecosystem is not limited to its raw material suppliers, OEMs, logistics providers and end consumers – i.e. the members of its supply chain. Car manufacturers also interact with the financial industry (e.g. insurance companies and banks), the telecommunications industry (e.g. mobility platform providers and web mapping services), public institutions (e.g.



public research facilities and transport infrastructure providers), the manufacturing industry (e.g. machinery and equipment manufacturers), the utilities sector (e.g. energy and water companies), and the raw materials and mining industries (e.g. bauxite and rare earth mining companies). All of these companies, in turn, also have their own corporate networks which they interact with, as shown in Figure 49. The rings represent the distance in the value chain from the car manufacturer to each sector. Closer companies offer greater opportunity for integration: for example, it may be easier and more effective for the car manufacturer to acquire a raw material processing and distribution company (level 3) instead of a mining company (level 1).

To make the most of their ecosystems, companies should **identify potential partners** and **assess their position within the ecosystem**, repositioning themselves if necessary. Section 5.2 above describes how to identify suppliers and competitors within supply chains; companies should take this process as a starting point, but broaden their horizons to examine relevant industries and organisations throughout their ecosystem. Repositioning within the ecosystem may be deemed necessary, and the company may consider entering strategic alliances; if so, these factors should be fed into the strategy development and execution cycle, as they will have effects on a variety of business activities such as raw material procurement. Strategic alliances can involve innovations such as joint recycling plants with companies from different sectors. In many cases, there is a

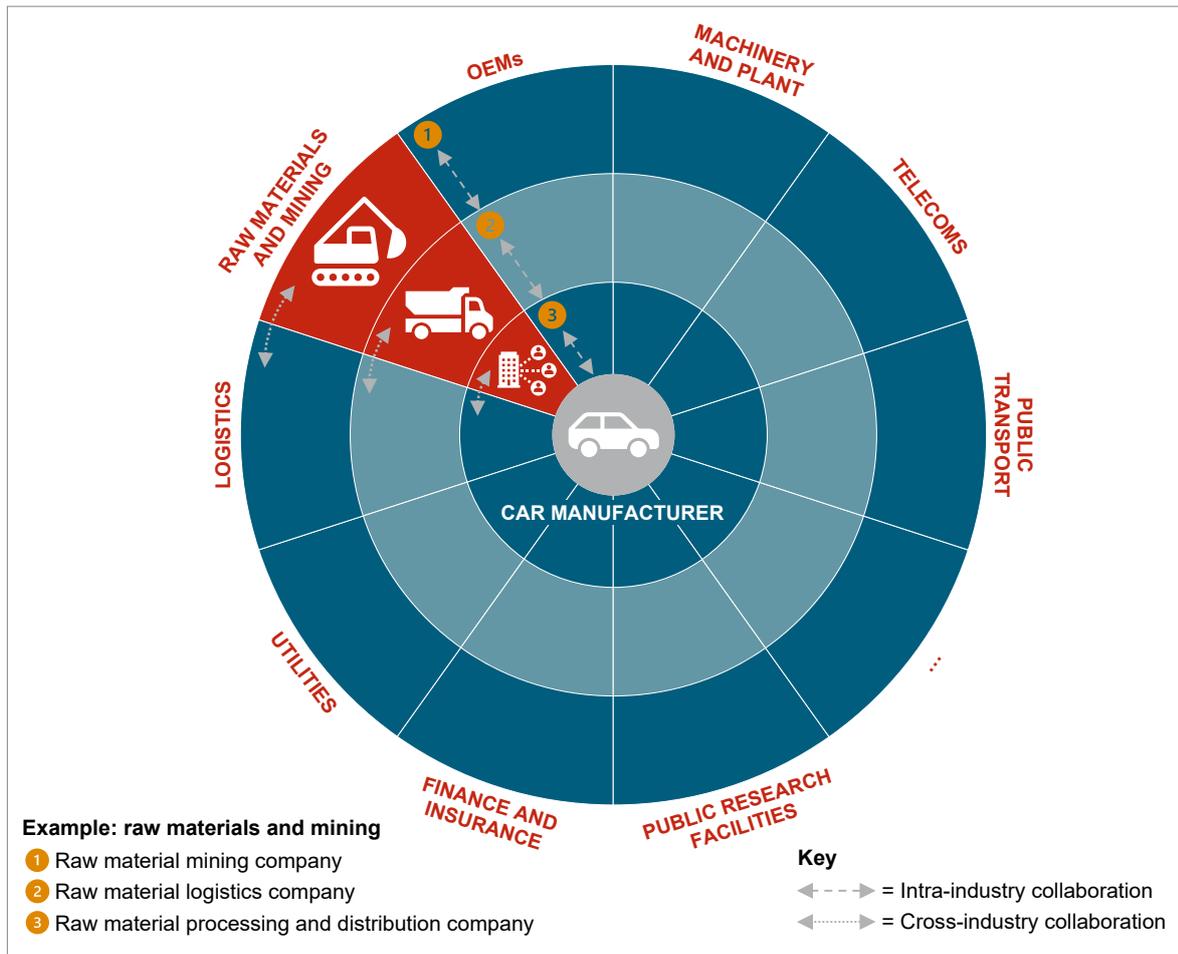


Figure 49: Corporate ecosystem of a car manufacturer

wide range of potential partners. A new aluminium recycling plant, for example, could be useful far beyond the automotive industry – aluminium is also needed in electrical engineering, electronics, civil engineering, construction, the aerospace industry, the packaging industry, the furniture industry and the lighting industry. As demand for secondary aluminium is expected to rise, these sectors offer many potential investors and busi-

ness partners to jointly develop or run a recycling plant. Ecosystems can thus provide opportunities to leverage raw material procurement strategies: collaboration, financial assistance, knowledge, services and products obtained through ecosystems can help reduce the amount of R&D required for innovation, overcome issues around high initial investments, and reduce running costs. Table 19 summarises the key takeaways for section 5.5.

Table 19: Key takeaways: corporate ecosystem

Key takeaway	Example
1 Identify and analyse the corporate ecosystem, and consider it in strategic decision-making.	We have examined all relevant industries and identified potential synergies with various companies from sectors X, Y and Z if we form an R&D alliance.
2 Form alliances with ecosystem partners to increase potential for innovation.	Our company has entered an R&D alliance with various companies from sectors X, Y and Z, and a new joint recycling plant is under development.

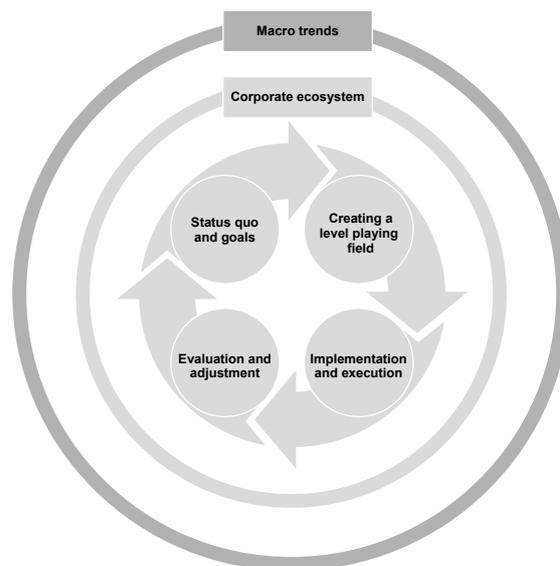
## 5.6 Macro trends

Macro trends are the final overarching element of strategy development and execution, affecting both the corporate ecosystem and the strategy development and execution cycle itself. This section examines macro trends and their impacts on companies and ecosystems in general, as well as specific impacts on raw material procurement. Table 20 summarises the key takeaways for this section.

Macro trends affect both companies and their entire ecosystems, but – unlike ecosystems – companies have little or no control over them. Macro trends can be either global or local; they may be on the horizon, or already having an effect. Companies should therefore carry out thorough analysis of trends. The results will reveal various opportunities and risks, and these will affect the usability of the various raw material procurement strategies. Multiple models exist for assessing macro trends, such as PESTEL analysis:

- **Political** trends – e.g. a company dependent on raw materials from a single country may be at risk of shortages if the country in question imposes export restrictions
- **Economic** trends – e.g. glocalisation, movement towards local sourcing and distribution of resources
- **Social trends** – e.g. growing environmental and ethical awareness resulting in demand for ESG compliance in procurement
- **Technological** trends – e.g. innovations in logistics, disruptive business tools
- **Environmental** trends – e.g. increasing frequency of extreme weather may pose risks for procurement
- **Legal** trends – e.g. ESG legislation such as Germany's Supply Chain Due Diligence Act

Relevance of individual trends will vary by company, but all six areas should be taken into account and regularly assessed. Companies then need to look to their business ecosystems to exploit the opportunities and avoid the risks resulting from these trends. The following paragraphs examine



three macro trends which have an impact on raw material procurement.

### *Dependence on external factors*

The major increase in demand for raw materials brought about by changing consumer habits, industrial dynamics and urbanisation has made companies increasingly **dependent on political, geographical and economic factors**. In raw material procurement, companies can either be dependent on other companies – i.e. their suppliers – or governments. In both cases, these factors can restrict the availability of raw materials, drive up prices and disrupt logistics. For example, China's export restrictions on rare earths have created shortages for companies dependent on Chinese exports of these materials.

In turn, this has given rise to a trend for companies to **minimise dependence** on these factors (see Section 4.4.4). To reduce exposure to political risks, companies should form independent private alliances, ideally with government support – this might include formal collaborative ventures within the corporate ecosystem to strengthen market power and pool demand for raw materials (see Section 4.4.6). Ventures of this nature can range from joint R&D into substitute materials, to forming lobby groups to exert political pressure. Governments are also expected to take measures to help companies to become more independent in terms of raw materials, such as providing companies with information or facilitating imports.

### Glocalisation

**Glocalisation** is an ongoing transition which is closely related to reducing dependence. However, glocalisation has emerged from social-environmental trends, whereas increasing independence in procurement is a political and economic issue. Glocal management reflects both local and global considerations, often summarised in business strategies as “think globally, act locally” – this might involve developing products at a global level, but adapting them to suit local markets. Glocalisation has become an important consideration when deciding on raw material procurement strategies, with the transition from globalisation to glocalisation being driven by three factors:

- Globalisation can make companies more dependent on economic, political and geographical factors, as explained above. This can cause supply chain and operations issues, which have a negative impact on the business. Recent raw material shortages on globalised raw material markets have also driven companies to develop local sourcing.
- The general public have become more aware of the need to support national and regional economies by sourcing raw materials locally. Doing so can also help to streamline supply chains, reduce logistics costs and cut emissions.
- Dealing with social, legal and environmental concerns from private customers or governments is easier in local markets and familiar jurisdictions.

As a result, companies are strongly advised to consider local sourcing or onshoring when creating an overall raw material procurement strategy, especially when selecting and diversifying suppliers (see Section 4.4.4). Expanding local sourcing can make the company less dependent on global markets and less susceptible to shortages, as well as reducing logistics costs, reducing emissions and strengthening local economies and business networks.

### Focus on ESG

**ESG requirements** reflect an increasing awareness of corporate social responsibility and environmental issues. These requirements cover both general corporate behaviour and the selection and management of suppliers in particular. Two main ESG aspects need to be considered in raw material procurement: reducing carbon emissions in line with Paris Climate Agreement (UN, 2015), and respecting human rights in line with the United Nations Guiding Principles on Business and Human Rights (UN, 2011).

In terms of environmental concerns, downstream partners and stakeholders expect that upstream businesses will comply with both national and international environmental standards and laws. Companies must run effective **environmental management systems** – ideally in compliance with ISO 14001 – to minimise environmental impacts and consumption of resources (e.g. energy, water, raw materials), and should conduct environmental audits. Ideally, these assessments should also be **integrated into the supplier identification and evaluation process** (see Section 4.4.4) to give transparency on activities to reduce emissions and environmental impacts throughout the supply chain – from raw material extraction, through distribution, to processing and recycling. This requires analysis of all emissions generated by the supply chain, which can be carried out by methods such as life cycle assessments or standardised CO<sub>2</sub> questionnaires. Finally, companies need to make ESG expectations clear to their upstream partners and stakeholders: deforestation or degradation of ecosystems due to resource extraction and distribution cannot be considered acceptable.

Companies procuring raw materials are also expected to ensure compliance with human rights law and worker protection laws throughout their supply chains. Since raw material procurement may involve doing business in politically unstable countries where human rights are not adequately protected by national law, companies are strongly advised to follow the UN’s **Guiding Principles on Business and Human Rights** (UN, 2011). In Germany, this expectation has recently been codified in the Supply Chain Due Diligence Act (*Lieferkettensorgfaltspflichtengesetz*), a federal law which places binding due diligence obligations on

companies to ensure that human rights are being respected in their supply chains. Requirements of this nature are expected to become increasingly common, so companies are advised to **take a proactive approach** to the issue, rather than simply reacting to external obligations.

As ESG considerations are increasingly being enshrined in law, companies are strongly advised to increase their capacity to handle ESG and compliance. Extra capacity can be obtained from external consultants, or companies can develop

in-house expertise in law, ecology, and strategy development and execution for ESG – both by hiring new staff and training existing employees. To help deal with ESG issues specific to raw material procurement, companies may find it useful to join or consult global initiatives such as the Raw Material Outlook (RMO). The RMO is “a platform helping users manage and remediate human rights risks and the environmental, social and governance (ESG) impacts of raw materials through value chain mapping and ESG risk identification” (RMO, 2021).

**Table 20: Key takeaways: macro trends**

Key takeaway	Example
<p><b>1</b> Implement an effective raw material procurement strategy and take advantage of the corporate ecosystem to minimise dependence on political, geographical and economic factors.</p>	<p>Besides diversifying suppliers and joining purchasing groups for certain raw materials, our company is developing joint recycling plants with other companies in order to make us less dependent on countries X, Y and Z.</p>
<p><b>2</b> “Think globally, act locally”: include glocalisation in company procurement goals and strategy to increase independence, reduce CO<sub>2</sub> emissions and save logistics costs.</p>	<p>Our goal is to secure raw material supply for the next X years by sourcing Y% of our total needs from Germany.</p>
<p><b>3</b> Develop a corporate ESG agenda, apply it to the entire supply chain (upstream and downstream), and employ expert staff to monitor ESG compliance.</p>	<p>Our supplier selection, evaluation and auditing process includes relevant ESG criteria that comply with national and international standards.</p>

## 6 Outlook

This study has shown how foreign companies secure their supplies of raw materials, which strategies they currently use and which strategies they are planning to use in the future. It has also examined the opportunities and challenges associated with each strategy. Based on this, success factors and recommendations for action have been identified and explained. Chapter 5 above condenses the recommendations for the individual strategies into an overarching strategy development and execution cycle. Examination of the strategies shows that there are a number of common factors which will influence company raw material procurement strategies in the future. In line with the expectations of the experts interviewed for this study, these common factors can be condensed into four global trends:

- Increasing complexity of raw material markets due to globalisation vs. protectionism
- Increasing frequency and greater impact of unforeseen events
- High price volatility and limited raw material availability in the short term
- Increasing sustainability requirements for the entire value chain

It is impossible to say with absolute certainty what the impact of these trends on company raw material procurement strategies will be. Nevertheless, it is still vital for companies to take these trends into account now when dealing with raw material procurement.

### ***Increasing complexity of raw material markets due to globalisation vs. protectionism***

Global demand for raw materials is expected to increase from 89bn tonnes in 2017 to 167bn tonnes by 2060 (OECD, 2019). This growing demand will require an increase in global production, and existing sources of raw materials alone will not be sufficient. Further sources will therefore need to be developed. This will lead to increasing globalisation and, at the same time, a growing focus on domestic raw materials. Governments and companies are already moving in this direction, and will continue to do so in the future. For example, the US Government published its Factsheet to Address Short-Term

Supply Chain Discontinuities in June 2021. This includes diversifying international trade relations, as well as increasing domestic capacity to produce, refine and recycle critical raw materials (THE WHITE HOUSE, 2021b). Simultaneous expansion of globalisation and protectionism will increase the complexity of raw material markets. These markets will become more internationally interconnected, while individual countries will try to prevent exports of domestically produced raw materials. Protectionism such as this will change the nature of competition in raw material procurement.

Despite increasing globalisation and free trade agreements, unpredictable political events can still have a considerable influence on markets. The interconnected nature of modern value chains means that protectionism by individual states – whether import restrictions, export restrictions or embargoes – affects the entire market. National regulations, such as tariffs and taxes, also increase complexity. An example of this is the 25% US steel tariffs imposed under the Trump administration at the beginning of 2018. These were aimed at China, but had an equally severe effect on other steel and aluminium exporters (LYNCH & PALETTA, 2018).

Due to the increasing complexity of procurement markets, companies are increasingly considering national or even regional raw material procurement strategies in addition to international ones. Diversifying suppliers to ensure that raw materials are procured and extracted from multiple countries is already a key issue for many companies. A trend towards domestic raw material extraction is already developing, helping companies to become both more competitive and less dependent on other countries. It remains to be seen how far regional exploitation of resources will be taken in the future and how far the national infrastructure necessary for extracting raw materials will be developed.

### ***Increasing frequency and greater impact of unforeseen events***

Increasing interconnection in global markets makes buyers, suppliers and other stakeholders increasingly dependent on one another. Expansion of supply networks involves both opportuni-

ties and risks. On the one hand, companies can diversify their suppliers and customer base to minimise individual supply risk and demand risk. On the other hand, global integration can increase the risk of being exposed to unpredictable, butterfly-effect events. It is expected that these events will occur more frequently in the future.

The butterfly effect is a metaphor used in chaos theory to describe how one small event can have a large impact on systems. The outbreak of the Covid-19 pandemic is an extreme example: it could never have been foreseen that a few minor events in a city such as Wuhan would trigger a global pandemic. However, the globalised and interconnected nature of today's world meant that the virus was able to spread rapidly and affect all areas of life. Another particularly relevant example for raw material procurement was the Suez Canal becoming blocked for almost seven days in 2021 when a cargo vessel, the *Ever Given*, ran aground. This caused another 150 ships to deliver their cargoes late, creating additional delays for huge numbers of customers (BUMP, 2021).

Events of this nature reveal weaknesses in supply chains, as was the case in the Suez Canal blockade. Companies with international strategies for securing raw materials are particularly sensitive to unforeseen events, and it can be assumed that increasing globalisation and interconnection between companies will make markets even more sensitive to these events in the future. Market players are rapidly becoming aware of this issue, and companies will need to increase their focus on supply chain resilience. However, it is not yet clear whether companies will establish new, sustainable systems in the post-Covid era, or simply return to pre-pandemic habits.

#### **High price volatility and limited raw material availability in the short term**

Global events such as the Covid-19 pandemic or the Suez Canal blockade are reflected in raw material prices. As markets are becoming increasingly sensitive to such events, it can be assumed that prices will remain volatile in the short term. Trends suggest that raw material prices will remain high, possibly reaching all-time highs. However, volatility also means that prices may fall; companies should expect prices to drop and

take advantage of them when they do. If global events shake the markets again in the near future, it is unclear what long-term effects this will have on prices. However, it is currently reasonable to assume that volatility will not dominate the markets for too long and that prices will ultimately stabilise.

Limited availability is one of the key reasons that prices of certain commodities are likely to rise. Global trends such as increasing population, economic growth, urbanisation, technological development and the energy transition may lead to demand for some materials exceeding supply. It remains to be seen whether cheaper substitutes will become available, or if new technologies will create demand for other raw materials. These trends and the limited availability of resources are forcing companies to rethink their procurement policies. In the past, the focus was on buying materials as cheaply as possible; today, the focus is on securing supply and meeting customer needs. It can generally be assumed that interconnection, digitalisation and automation will increase transparency regarding current availability and prices of raw materials. High market volatility, however, means that these factors are unlikely to become any more predictable. This will make it more difficult for companies to meet their needs and stay within their procurement budgets.

Uncertainty and raw material price rises mean that it is becoming normal for companies to pass on some or all of their cost increases to customers. Commodity price hedging is also becoming an important strategy. Alongside other strategies for securing prices, hedging is increasingly being combined with stockpiling to compensate for volatility and shortages. It remains to be seen how much of an effect price volatility will have on company viability: large companies are likely to have financial reserves to absorb impacts, whereas SMEs will have to face major challenges over the next few years.

#### **Increasing sustainability requirements for the entire value chain**

Moves towards sustainability in recent years are having an increasing impact on raw material procurement. Companies are coming under ever-greater pressure to ensure compliance with sus-

tainability standards throughout their value chains – both societal pressure and political, regulatory and corporate pressure. ESG is viewed as an important indicator of performance and is used as a benchmark to evaluate potential business relationships. Companies have already started taking first steps to meet sustainability requirements, suggesting that the importance of ESG standards will increase in the future. More and more companies are including ESG criteria in their supplier selection and evaluation processes, while end customers are also increasingly considering ESG compliance when selecting products. Banks, too, are now applying these standards as a criterion for assessing creditworthiness. Other scenarios of this nature can be expected in the future.

Sustainability is also becoming an increasing focus for political decision-making and legislation. Europe in general and Germany in particular are international pioneers in this field. The European Commission has developed the European Green Deal, an overarching framework for environmental sustainability aiming to achieve net zero greenhouse gas emissions in the EU by 2050. This deal has already led to new recommendations and regulations being introduced, and it is likely that more will be implemented in the future to reduce the environmental impact of business. An example is the Carbon Border Adjustment Mechanism, which will impose carbon tariffs on EU imports of carbon-intensive products and raw materials.

To meet ESG requirements, companies are increasingly looking to certify their work on sustainability. The most important certifications for ESG are the EU's Eco-Management and Audit Scheme, ISO 9001, ISO 14001, OEKO-TEX and SA8000. Just like ESG legislation, ESG certificates will become more widespread in the future, but also more diverse and less transparent. Consolidation of both legislation and certificates can therefore ultimately be expected; this will standardise the requirements, but it will not make them any less comprehensive.

Further measures will still be necessary for Green Deal-compliant ESG performance. The focus in the future will be on the huge investments necessary to reduce carbon footprints from company value chains and to develop both internal and external recycling facilities. Recycling is currently an underrepresented topic in procurement

strategies; this can be expected to change in the future. Similarly, projects to increase material efficiency or develop substitute materials are likely to become more widespread, even if they only achieve marginal efficiency gains. These investments and projects will bring two key benefits: they will improve company ESG performance, and also help overcome shortages in the primary raw material markets. Demand for recyclable materials and secondary raw materials is expected to increase significantly, as are imports of these materials. Companies are already preparing to join the circular economy and play their part in protecting the environment. However, it remains to be seen which specific measures will be necessary to meet internal and external sustainability requirements, and it is unclear how severely raw material procurement will be affected by changes in the climate and the environment.

### Conclusion

The four global trends examined above suggest that companies will need to become more flexible and agile to successfully navigate the highly dynamic raw material markets. This means that a flexible value chain and a broad portfolio of strategies will be essential to secure a reasonably priced supply of raw materials. Resilient procurement ecosystems are replacing linear value chains, while the increasing scarcity of critical raw materials means that SMEs are now in direct competition with global corporations. This is making it all the more important for SMEs to establish an overall raw material procurement strategy at an early stage, and to diversify their individual strategies. It remains to be seen which of the strategies examined in this study will ultimately make the greatest contribution to securing supplies of raw materials, and new strategies may arise in the future. However, whichever strategies prove most successful, it is clear that an open-minded and innovative procurement culture will help companies of all sizes to navigate dynamic raw material markets.

## 7 References

- ABDELNOUR, A., BAGES-AMAT, A., MOSS, S. & PRABHU, M. (2021): Defying cost volatility: A strategic pricing response. – Available at: <https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/defying-cost-volatility-a-strategic-pricing-response> [Accessed 20 October 2021].
- ACATECH, LEOPOLDINA & AKADEMIENUNION (2017): Rohstoffe für die Energiewende: Wege zu einer sicheren und nachhaltigen Versorgung. – Available at: <https://www.acatech.de/publikation/rohstoffe-fuer-die-energiewende-wege-zu-einer-sicheren-und-nachhaltigen-versorgung/download-pdf/?lang=de> [Accessed 16 October 2021].
- AIRBUS (2021): 3D-printing. – Available at: <https://www.airbus.com/public-affairs/brussels/our-topics/innovation/3d-printing.html> [Accessed 27 October 2021].
- ATTWOOD, J. (2021): The World Will Need 10 Million Tons More Copper to Meet Demand. – Available at: <https://www.bloomberg.com/news/articles/2021-03-19/the-world-will-need-10-million-tons-more-copper-to-meet-demand> [Accessed 30 June 2021].
- BARICH, A. (2021): South Korean mining agency urges closer critical minerals ties Down Under. – Available at: <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/south-korean-mining-agency-urges-closer-critical-minerals-ties-down-under-66945094> [Accessed 17 October 2021].
- BARR, N. A., CHANEY, W. A., KISHLANSKY, M. A., SMITH, L. B., BRIGGS, A., GILBERT, B. B., ATKINS, R. C., PRESTWICH, M. C., HASTINGS, M., COLLEY, L. J., JOYCE, P., KELLNER, P., SPENCER, U. M., JOSEPHSON, P. R., RAVENHILL, W., MORRILL, J. S., FRERE, S. S., WHITELOCK, D. (2021): Encyclopedia Britannica: United Kingdom. – Available at: <https://www.britannica.com/place/United-Kingdom> [Accessed 3 October 2021].
- BARTH, K., HARTMANN, M. & SCHRÖDER, H. (2015): Betriebswirtschaftslehre des Handels, 7th ed. – Wiesbaden; Springer Gabler.
- BDE – BUNDESVERBAND DER DEUTSCHEN ENT-SORGUNGS-, WASSER- UND ROHSTOFFWIRTSCHAFT E.V. (2020): Statusbericht der deutschen Kreislaufwirtschaft. – Available at: <https://www.bde.de/themen/statusbericht-kreislaufwirtschaft/> [Accessed 20 October 2021].
- BECKER, L. (2021): Verstöße bei Zulieferern: Apple schreitet angeblich nur langsam ein. – Heise online. – Available at: <https://www.heise.de/news/Verstoesse-bei-Zulieferern-Apple-schreitet-angeblich-nur-langsam-ein-5003003.html> [Accessed 16 October 2021].
- BEECHAM, M. (2019): Carbon fibre in car production – looking more promising? – Available at: <https://global.factiva.com/redirect/default.aspx?p=sa&an=JUAUT00020190509ef59000dx&cat=a&ep=ASE> [Accessed 28 October 2021].
- BENJAMINS, M. P. & HILPERT, H. G. (2013): Italien. – In: Hilpert H. G. & Mildner S. (eds): Nationale Alleingänge oder internationale Kooperation? Analyse und Vergleich der Rohstoffstrategien der G20-Staaten. – pp 100–104; SWP; BGR; Berlin.
- BERNARD, F., BISSON, T. N., POPKIN, J. D., FLOWER, J. E., BLONDEL, J. F.P., FOURNIER, G., DRINKWATER, J. F., ELKINS, T. H., HIGONNET, P. L., TUPPEN, J. N., BACHRACH, B. S., SHENNAN, J. H., WEBER, E., WOLOCH, I., WRIGHT, G. (2021): Encyclopedia Britannica: France. – Available at: <https://www.britannica.com/place/France> [Accessed 18 October 2021].
- BGR – BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (2020): Deutschland – Rohstoffsituation 2019. – 150 p.; Hanover.
- BGR – BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (2021a): Fachinformationssystem Rohstoffe. – unpublished; Hanover.
- BGR – BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (2021b): Seltene Erden – Informationen zur Nachhaltigkeit. – 20 p.; Hanover. – Available at: [https://www.bgr.bund.de/DE/Themen/Min\\_rohstoffe/Produkte/produkte\\_node.html?tab=Informationen+zur+Nachhaltigkeit](https://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Produkte/produkte_node.html?tab=Informationen+zur+Nachhaltigkeit) [Accessed 18 October 2021].
- BGS – BRITISH GEOLOGICAL SURVEY (2021): About BGS. – Available at: <https://www.bgs.ac.uk/about-bgs/> [Accessed 14 October 2021].
- BLOOMBERG (2021): Bloomberg Professional. – Available at: Subscription Service [Accessed: 16 November 2021]. s.l.: Bloomberg.

- BME – BUNDESVERBAND MATERIALWIRTSCHAFT, EINKAUF UND LOGISTIK E.V. (2017): BME-Leitfaden „Strategisches Lieferantenmanagement“. – 52 p.; Frankfurt.
- BMLRT – BUNDESMINISTERIUM LANDWIRTSCHAFT, REGIONEN UND TOURISMUS, ÖSTERREICH (2021): World Mining Data 2021. – Vienna. – Available at: <https://www.world-mining-data.info/wmd/downloads/PDF/WMD2021.pdf> [Accessed 17 October 2021].
- BMUB – BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ, BAU UND REAKTORSICHERHEIT (2016): Climate Action Plan 2050: Principles and goals of the German government's climate policy. – 91 p.; Berlin. – Available at: [https://www.bmuv.de/fileadmin/Daten\\_BMU/Pool/Broschueren/klimaschutzplan\\_2050\\_en\\_bf.pdf](https://www.bmuv.de/fileadmin/Daten_BMU/Pool/Broschueren/klimaschutzplan_2050_en_bf.pdf) [Accessed 17 October 2021].
- BMWK – BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (2020a): Schlaglichter der Wirtschaftspolitik. – Available at: [https://www.bmwk.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2020/03/onlinemagazin-schlaglichter-03-20.html?cms\\_textId=1659342&cms\\_artId=1659428](https://www.bmwk.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2020/03/onlinemagazin-schlaglichter-03-20.html?cms_textId=1659342&cms_artId=1659428) [Accessed 5 November 2021].
- BMWK – BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (2020b): Fortschreibung der Rohstoffstrategie der Bundesregierung. – Available at: <https://www.bmwk.de/Redaktion/DE/Downloads/P-R/rohstoffstrategie-kernaussagen.html> [Accessed 5 November 2021].
- BMWK – BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (2021a): Den digitalen Wandel gestalten. – Available at: <https://www.bmwk.de/Redaktion/DE/Dossier/digitalisierung.html> [Accessed 14 July 2021].
- BMWK – BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (2021b): ERP-Systeme. – Available at: <https://www.mittelstand-digital.de/MD/Redaktion/DE/Dossiers/A-Z/erp-systeme.html> [Accessed 14 September 2021].
- BMWK – BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (2021c): Schnell von der guten Idee zur erfolgreichen Beratung. – Available at: <https://www.innovation-beratung-foerderung.de/INNO/Navigation/DE/go-inno/go-inno.html> [Accessed 11 October 2021].
- BPB – BUNDESZENTRALE FÜR POLITISCHE BILDUNG (2016): Preiselastizität. – Available at: <https://www.bpb.de/nachschlagen/lexika/lexikon-der-wirtschaft/20312/preiselastizitaet> [Accessed 10 September 2021].
- BPIFRANCE (2021): Strategic project insurance. – Available at: <https://www.bpifrance.com/export-credit-agency/our-products/credit-insurance/insurance-for-french-exporters/strategic-project-insurance> [Accessed 28 November 2021].
- BRGM (2021): Activités. – Available at: <https://www.brgm.fr/fr/activites> [Accessed 13 October 2021].
- BUECHEL, C., BEDNARSKI, L. & WIETLISBACH, S. (2021): As lithium-ion battery materials evolve, suppliers face new challenges. – Available at: <https://ihsmarkit.com/research-analysis/lithiumion-battery-materials-evolve-suppliers-face-new-challenges.html> [Accessed 1 July 2021].
- BUMP, P. (2021): Why a ship stuck in Egypt threatens the economy in the United States. – The Washington Post, March 25, 2021. – Available at: <https://www.washingtonpost.com/politics/2021/03/25/why-ship-stuck-egypt-threatens-economy-united-states/> [Accessed 25 November 2021].
- BYUNG-WOOK, K. (2021a): Korea to launch new mining agency on Sept. 10. – The Korea Herald, Aug 24, 2021. – Available at: <http://www.koreaherald.com/view.php?ud=20210824000957> [Accessed 20 September 2021].
- BYUNG-WOOK, K. (2021b): Spent batteries could be the next plastics. – The Korea Herald, Jul 11, 2021. – Available at: <http://www01.koreaherald.com/view.php?ud=20210711000197> [Accessed 11 November 2021].
- CESE – CONSEIL ÉCONOMIQUE SOCIAL ET ENVIRONNEMENTAL (2021): Le CESE en bref. – Available at: <https://www.lecese.fr/> [Accessed 13 October 2021].
- CHEREL-BONNEMAISON, C., ERLANDSSON, G., IBACH, B. & SPILLER, P. (2021): Buying into a more sustainable value chain. – McKinsey & Company, September 22, 2021. – Available at: <https://www.mckinsey.com/business-functions/operations/our-insights/buying-into-a-more-sustainable-value-chain> [Accessed 17 November 2021].

- CHEVELEY, G. (2021): Steel markets follow the same path as fossil fuels. – Financial Times. – Available at: <https://www.ft.com/content/6f-378cad-a449-4e43-bb33-ab110a850196> [Accessed 17 December 2021].
- CHICKERUR, S., SHARMA, S. & NARAYANKAR, P. M. (2018): Forecasting the Demand of Agricultural Crops/Commodity Using Business Intelligence Framework. – In: M. Khosrow-Pour (ed): Encyclopedia of Information Science and Technology. – pp 847–861; IGI Global; Hershey. DOI: 10.4018/978-1-5225-2255-3.ch073.
- CSF – COMITÉ STRATÉGIQUE DE FILIÈRE (2021): Le contrat de la filière Mines et Métallurgie. – National Council of Industry; Paris.
- DAS, S. K. & ABDEL-MAREK, L. (2003): Modeling the flexibility of order quantities and lead-times in supply chains. – International Journal Production Economics, 11 08, 85(2): pp 171–181.
- DEFRA – DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (2018): Our waste, our resources: a strategy for England. – London.
- DEFRA & BIS – DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS & DEPARTMENT FOR BUSINESS INNOVATION & SKILLS (2012): Resource Security Action Plan: Making the most of valuable materials. – 51 p.; London. Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/69511/pb13719-resource-security-action-plan.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69511/pb13719-resource-security-action-plan.pdf) [Accessed 11 October 2021].
- DERA – DEUTSCHE ROHSTOFFAGENTUR IN DER BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (2020): Wachstumsraten-Monitor: Entwicklung der globalen Rohstoffproduktion und des globalen Rohstoffbedarfs mineralischer Rohstoffe. – DERA Rohstoffinformationen, 44: 124 p., Berlin.
- DERA – DEUTSCHE ROHSTOFFAGENTUR IN DER BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (2021): DERA-Rohstoffliste 2021. – DERA Rohstoffinformationen, 49: 108 p., Berlin.
- DLA – U.S. DEFENSE LOGISTICS AGENCY (2018): The Strategic and Critical Materials Stock Piling Act. – Fort Belvoir.
- DLA – U.S. DEFENSE LOGISTICS AGENCY (2021): Strategic Materials: Materials of Interest. – Available at: <https://www.dla.mil/HQ/Acquisition/StrategicMaterials/Materials/> [Accessed 22 September 2021].
- DOC – U.S. DEPARTMENT OF COMMERCE (2019): A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals. – Washington.
- DOI – DEPARTMENT OF THE INTERIOR (2018): Final List of Critical Minerals 2018. – Federal Register, 83(95): pp. 23295–23296.
- DOL – U.S. DEPARTMENT OF LABOR (2021): Cadmium – Overview. – Available at: <https://www.osha.gov/cadmium> [Accessed 11 October 2021].
- DOLATA, P. (2013): Kanada. In: Hilpert H. G. & Mildner S. (eds): Nationale Alleingänge oder internationale Kooperation? Analyse und Vergleich der Rohstoffstrategien der G20-Staaten. – pp 113–120; SWP; BGR; Berlin.
- DORNER, U. (2020): Rohstoffrisikobewertung – Kupfer. – DERA Rohstoffinformationen, 45: 58 p., Berlin.
- EMRD (2021): Introduction. – Available at: <https://www.emrd.or.kr/intro/intro.jsp> [Accessed 13 October 2021].
- EUROPEAN COMMISSION (2018): A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. – Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN> [Accessed 21 February 2022].
- EUROPEAN COMMISSION (2021): Raw materials, metals, minerals and forest-based industries. – Available at: [https://ec.europa.eu/growth/sectors/raw-materials\\_en](https://ec.europa.eu/growth/sectors/raw-materials_en) [Accessed 21 May 2021].
- EXIM – EXPORT-IMPORT BANK OF THE U.S. (2021): Project and structured finance transactions. – Available at: <https://www.exim.gov/what-we-do/project-structured-finance/transactions> [Accessed 15 October 2021].
- FARAG, M. (2008): Quantitative methods of materials substitution: Application to automotive components. – Materials and Design, 29(2): pp. 374–380.

- FASTMARKETS (2021): Lithium supply and demand to 2030. – Available at: <https://www.fastmarkets.com/article/3999803/lithium-supply-and-demand-to-2030> [Accessed 7 December 2021].
- FRAUNHOFER IPA (2015): Materialeffizienz – eine unterschätzte Größe. – Karlsruhe.
- FRAUNHOFER IPA, (2017): Materialeffizienz im verarbeitenden Gewerbe – eine Metastudie. – Stuttgart.
- GABATH, C. (2010): Absicherung gegen Preisrisiken durch Hedging. – Perspektive Mittelstand, 07.05.2010. – Available at: <https://www.perspektivemittelstand.de/Beschaffung-Absicherung-gegen-Preisrisiken-durch-Hedging/management-wissen/3395.html> [Accessed 25 October 2021].
- GAC – GLOBAL AFFAIRS CANADA (2020): Opening New Markets: Trade Negotiations and Agreements. – Available at: <https://www.international.gc.ca/trade-agreements-accords-commerciaux/index.aspx?view=d&lang=eng> [ACCESSSED 18 OCTOBER 2021].
- GARSDIE, M. (2020): Iron ore – Statistics & Facts. – Available at: <https://www.statista.com/topics/1919/iron-ore/> [Accessed 1 July 2021].
- GLOBE NEWswire (2021): Global Iron Ore Market Report 2021–2026 – Positive Steel Industry Outlook to Drive the Demand for Iron Ore. – Available at: <https://www.globenewswire.com/en/news-release/2021/11/16/2335609/28124/en/Global-Iron-Ore-Market-Report-2021-2026-Positive-Steel-Industry-Outlook-to-Drive-the-Demand-for-Iron-Ore.html> [Accessed 7 December 2021].
- GOLEV, A., SCOTT, M., ERSKINE, P. D., ALI, S. H., BALLANTYNE, G. R. (2014): Rare earths supply chains: Current status, constraints and opportunities. – Resources Policy, 41(1): pp 52–59; DOI:10.1016/j.resourpol.2014.03.004.
- GOVERNMENT OF SASKATCHEWAN (2021): Energy and Mines Ministers Conclude Annual Meeting. – Available at: <https://www.saskatchewan.ca/government/news-and-media/2021/september/10/energy-and-mines-ministers-conclude-annual-meeting> [Accessed 13 October 2021].
- GRAHAM, E. M. (2003): The Miracle with a Dark Side: Korean Economic Development under Park Chung-hee. – In: Graham, E. M: Reforming Korea's Industrial Conglomerates. – pp 11–50; Peterson Institute for International Economics; Washington.
- HAHN, B., LEW, Y. I., IM, H., LEE, C., YU, W. (2021): Encyclopedia Britannica: South Korea. – Available at: <https://www.britannica.com/place/South-Korea> [Accessed 20 September 2021].
- HALL, R. D., BERCUSON, D. J., NICHOLSON, N. L., MORTON, W. L., KRUEGER, R. R. (2021): Encyclopedia Britannica: Canada. – Available at: <https://www.britannica.com/place/Canada> [Accessed 21 September 2021].
- HESSE, K. (2019): Nachhaltige Rohstoffversorgung – Perspektive Kreislaufwirtschaft und Ressourceneffizienz. – In: Wellbrock, W. & Ludin, D. (eds.): Nachhaltiges Beschaffungsmanagement. – pp 91–111; Springer Fachmedien Wiesbaden GmbH; Wiesbaden.
- HESS, G. (2008): Supply-Strategien in Einkauf und Beschaffung. – Springer Gabler; Wiesbaden.
- HINO & TRATON GLOBAL PROCUREMENT (2019): Traton and Hino establish a procurement joint venture. – Available at: <https://www.hinotratongp.com/news/> [Accessed 22 October 2021].
- HITACHI (2019): Resource Recycling in Japan and How Hitachi is Keeping Pace. – Work on Resource Recycling in Hitachi, 68(5): pp 670–671.
- HITACHI (2020): Home Appliance Recycling for a Resource-efficient Society. – Smart Life Solutions for People Everywhere, 69(1): pp 74–78.
- HUI, M. (2021): South Korea is developing a critical metals strategy to back a lofty battery goal. – Available at: <https://qz.com/2044472/south-korea-unveils-critical-metals-plan-to-support-battery-goals/> [Accessed 20 September 2021].
- HULL, J. (2014): Options, futures and other derivatives. 9th ed. – 869 p; Pearson Education.
- HUME, N. & TERAZONO, E. (2021): Markets weigh prospect of new commodities supercycle. – Available at: <https://www.ft.com/content/f3650c8f-70a2-4f86-a648-9dc0b4434348> [Accessed 13 July 2021].

- HUMPHRIES, M. (2019): Critical Minerals and U.S. Public Policy. – 52 p.; Washington. – Available at: <https://crsreports.congress.gov/product/pdf/R/R45810/2> [Accessed 11 October 2021].
- IEA – INTERNATIONAL ENERGY AGENCY (2020): Aluminium. – Available at: <https://www.iea.org/reports/aluminium> [Accessed 30 June 2021].
- IEA – INTERNATIONAL ENERGY AGENCY (2021): Iron and Steel. – Available at: <https://www.iea.org/reports/iron-and-steel> [Accessed 7 December 2021].
- INVERTO (2017): Rohstoffmanagement in Zeiten politischer Unsicherheiten. – INVERTO GmbH in cooperation with Handelsblatt; Cologne.
- INVERTO (2018): Preis- und Versorgungssicherheit im Rohstoffmanagement. – INVERTO GmbH in cooperation with Handelsblatt; Cologne.
- INVERTO (2018): Rohstoffmanagement in wirtschaftspolitisch unsicheren Zeiten. – INVERTO GmbH in cooperation with Handelsblatt; Cologne.
- INVERTO (2020): Raw Material Management in times of COVID-19. – INVERTO GmbH in cooperation with Handelsblatt; Cologne.
- INVERTO (2021): Raw Materials Study 2021. – INVERTO GmbH in cooperation with Handelsblatt; Cologne.
- ISPRA – ISTITUTO SUPERIORE PER LA PROTEZIONE E LA RICERCA AMBIENTALE (2021): Our organization: Department of Geological Survey of Italy within ISPRA. – Available at: <http://portalesgi.isprambiente.it/en/structure> [Accessed 29 November 2021].
- IW – INSTITUT DER DEUTSCHEN WIRTSCHAFT (2013): Deutsche Unternehmen im Wettbewerb um Rohstoffe: Versorgungsrisiken und Absicherungsstrategien. – IW-Analysen, 93; Cologne.
- IW – INSTITUT DER DEUTSCHEN WIRTSCHAFT (2017): Digitale Strategien für mehr Materialeffizienz in der Industrie. – IW-Report 3/2017, Cologne.
- JAGGAER (2020): JAGGAER Optimizes Complex Sourcing for Global Manufacturer ITW to Achieve Millions of Savings Annually. – Available at: [https://www.jaggaer.com/app/uploads/2020/10/20Q4\\_CS\\_Illinois-Tool-Works.pdf](https://www.jaggaer.com/app/uploads/2020/10/20Q4_CS_Illinois-Tool-Works.pdf) [Accessed 25 November 2021].
- JAGGAER (2021): Supplier Management. – Available at: <https://www.jaggaer.com/solutions/> [Accessed 6 November 2021].
- JANSEN, M. B., HURST, G. C., NOTEHELPER, F. G., HIJINO, S., LATZ, G., MASAI, Y., MASAMOTO, K., SAKAMOTO, T., TOYODA, T., WATANABA, A. (2021): Encyclopedia Britannica: Japan. – Available at: <https://www.britannica.com/place/Japan> [Accessed 3 October 2021].
- JBIC – JAPAN BANK FOR INTERNATIONAL COOPERATION (2021): Export Loans. – Available at: <https://www.jbic.go.jp/en/support-menu/export.html> [Accessed 11 October 2021].
- JIMÉNEZ-RODRÍGUEZ, R. & MORALES-ZUMAQUERO, A., (2021): Commodity price pass-through along the pricing chain. – Review of World Economics, 3 July.
- JIYOUNG, K. (2017): Corporate financial structure of South Korea after Asian financial crisis: the chaebol experience. – Economic Structures, 6(24): 14 p.
- JOGMEC – JAPAN OIL, GAS AND METALS NATIONAL CORPORATION (2020): Integrated Report 2020. – Tokyo.
- JOGMEC – JAPAN OIL, GAS AND METALS NATIONAL CORPORATION (2021): Overview. – Available at: <http://www.jogmec.go.jp/english/about/about001.html> [Accessed 22 September 2021].
- JOVANOVIC, S. (2014): Hedging Commodities: A practical guide to hedging strategies with futures and options. – 454 p., Harriman House Publishing; Hampshire.
- KEXIM – EXPORT-IMPORT BANK OF KOREA (2021): Purpose of Establishment. – Available at: <https://www.koreaexim.go.kr/site/homepage/menu/viewMenu?menuid=002001001001> [Accessed 11 October 2021].
- KIGAM – KOREA INSTITUTE OF GEOSCIENCE AND MINERAL RESOURCES (2021): KIGAM Brochure. – Available at: [https://www.kigam.re.kr/board-Download.es?bid=ATT&list\\_no=46942&seq=1](https://www.kigam.re.kr/board-Download.es?bid=ATT&list_no=46942&seq=1) [Accessed 18 October 2021].

- KIM, I.-G. (2021): Race to produce high-nickel batteries accelerates. – Available at: <https://www.kedglobal.com/newsView/ked202110170001> [Accessed 11 November 2021].
- KINCH, D. (2021): Global aluminum needs up to \$1.5 trillion investment to decarbonize energy supplies: IAI. – Available at: <https://www.spglobal.com/platts/en/market-insights/latest-news/coal/031621-global-aluminum-needs-up-to-15-trillion-investment-to-decarbonize-energy-supplies-iai> [Accessed 30 June 2021].
- KOLMYKOVA, A. (2016): Supply Chain Integration. – 252 p., Springer Gabler; Wiesbaden.
- KORES – KOREA RESOURCES CORPORATION (2020): Korea Resources Corporation and Subsidiaries Consolidated Financial Statements December 31, 2019 (With Independent Auditors' Report Thereon). – 78 p., KPMG Samjong Accounting Corp.; Seoul.
- KOTRA – KOREA TRADE-INVESTMENT PROMOTION AGENCY (2021): Main Activities. – Available at: <https://www.kotra.or.kr/foreign/kotra/KHENKT030M.html> [Accessed 8 October 2021].
- K-SURE – KOREA TRADE INSURANCE CORP. (2021): Profile. – Available at: <https://www.ksure.or.kr/en/company/profile.do> [Accessed 11 October 2021].
- KUHANATHAN, A. (2021): Commodities: higher demand, supply bottlenecks, but no speculation (yet). – Allianz SE; Munich. – Available at: [https://www.allianz.com/en/economic\\_research/publications/specials\\_fmo/2021\\_03\\_11\\_Commodities.html](https://www.allianz.com/en/economic_research/publications/specials_fmo/2021_03_11_Commodities.html) [Accessed 14 October 2021].
- KULIK, J. (2019): Unter dem Radar: Die strategische Bedeutung Seltener Erden für die wirtschaftliche und militärische Sicherheit des Westens. – Arbeitspapier Sicherheitspolitik, Nr. 13/2019; Academy for Security Policy, Berlin. – Available at: <https://www.baks.bund.de/de/arbeitspapiere/2019/unter-dem-radar-die-strategische-bedeutung-seltener-erden-fuer-die> [Accessed 18 October 2021].
- KUMAR, A. (2021): Sigma Lithium, LG Energy strike supply deal over lithium for EV battery. – Reuters. – Available at: <https://www.reuters.com/business/autos-transportation/sigma-lithium-lg-energy-strike-supply-deal-over-lithium-ev-battery-2021-10-05/> [Accessed 5 November 2021].
- KUNITOMO, H. (2017): JOGMEC's strategical support systems for metal mining activities. – Available at: <https://www.mmta.co.uk/wp-content/uploads/2017/02/Japan-stockpile-JOGMEC.pdf> [Accessed 11 October 2021].
- KUTSCHKER, M. & SCHMID, S. (2010): Die japanischen Keiretsu. – In: Internationales Management. 7th ed. Munich(Germany): pp 794–798., Wissenschaftsverlag; Oldenbourg.
- LAB-MP (2019): La Proposita di una strategia italiana delle materie prime. – Ministry of Economic Development; Rimini.
- LEE, A. (2020): Iron Ore's Stunning Rally Faces Challenge as Supply Risks Fade. – Available at: <https://www.bloomberg.com/news/articles/2020-08-19/iron-ore-s-strength-faces-challenge-as-supply-risks-fade> [Accessed 30 June 2021].
- LEE, K. & CHA, J. (2021): Towards Improved Circular Economy and Resource Security in South Korea. – Sustainability, 13(1), 17: 14 p.; doi.org/10.3390/su13010017.
- LME (2020): Physical and financial hedging – a beginner's guide. – Available at: <https://www.lme.com/en/Education/Online-resources/LME-insight/Physical-and-financial-hedging-beginners-guide> [Accessed 12 November 2021].
- LME (2021): Electric vehicle batteries. – Available at: <https://www.lme.com/en/Trading/Initiatives/Electric-vehicle-battery-materials> [Accessed 11 November 2021].
- LME (2021a): Futures. – Available at: <https://www.lme.com/en/Trading/Contract-types/Futures> [Accessed 14 October 2021].
- LME (2021b): LMEminis. – Available at: <https://www.lme.com/Trading/Contract-types/LMEminis> [Accessed 2 December 2021].
- LUSTY, P. A. J. & MURTON, B. J. (2018): Deep-Ocean Mineral Deposits: Metal Resources and Windows into Earth Processes. – Elements, 14(5): pp 301–306; <https://doi.org/10.2138/gselements.14.5.301>.

- LYNCH, D. J. & PALETTA, D. (2018): Trump announces steel and aluminum tariffs Thursday over objections from advisers and Republicans. – The Washington Post, March 1, 2018. – Available at: <https://www.washingtonpost.com/news/business/wp/2018/03/01/white-house-planning-major-announcement-thursday-on-steel-and-aluminum-imports/> [Accessed 20 November 2021].
- MANDL, C. & MINNER, S. (2017): Big Data in der Rohstoffbeschaffung. – Beschaffung aktuell, 4. April 2017. – Available at: <https://beschaffung-aktuell.industrie.de/einkauf/big-data-in-der-rohstoffbeschaffung/#> [Accessed 15 October 2021].
- MARINO, J. A., BERENGO, M., CLARK, M., DI PALMA, G., SIGNORETTA, P. E., KNIGHTS, M. F., FOOT, J., WICKHAM, C. J., KING, R. L., LARNER, J., LOVETT, C. M., POWELL, J. M., NANGERONI, G. (2021): Encyclopedia Britannica: Italy. – Available at: <https://www.britannica.com/place/Italy> [Accessed 21 September 2021].
- MARSCHIEDER-WEIDEMANN, F., LANGKAU, S., BAUR, S.-J., BILLAUD, M., DEUBZER, O.; EBERLING, E., ERDMANN, L., HAENDEL, M., KRAIL, M., LOIBL, A., MAISEL, F., MARWEDE, M., NEEF, C., NEUWIRTH, M., ROSTEK, L., RÜCKSCHLOSS, J., SHIRINZADEH, S., STIJEPIĆ, D., TERCERO ESPINOZA, L., TIPPNER, M. (2021): Rohstoffe für Zukunftstechnologien 2021. – DERA Rohstoffinformationen, 50: 366 p., Berlin.
- METI – JAPAN MINISTRY OF ECONOMY, TRADE AND INDUSTRY (2021): Indices of Industrial Production. – Available at: <https://www.meti.go.jp/english/statistics/tyo/iip/index.html> [Accessed 15 October 2021].
- MEZ, L., OKAMURA, L. & WEIDER, H. (eds.) (2019): The Ecological Modernization Capacity of Japan and Germany. – Springer VS; Wiesbaden.
- MINÉRALINFO (2020): Comité pour les métaux stratégiques. – Available at: <https://www.mineralinfo.fr/page/comite-metiaux-strategiques> [Accessed 13 October 2021].
- MISE – MINISTERO DELLO SVILUPPO ECONOMICO (2021a): Laboratorio materie prime. – Available at: <https://unmig.mise.gov.it/index.php/it/dati/materie-prime/laboratorio-materie-prime> [Accessed 21 September 2021].
- MISE – MINISTERO DELLO SVILUPPO ECONOMICO (2021b): Petrolio. – Available at: <https://www.mise.gov.it/index.php/it/component/content/article?id=2019785:petrolio-76274615> [Accessed 29 November 2021].
- MIT (2016): Rare Earth Elements. – Available at: <https://web.mit.edu/12.000/www/m2016/finalwebsite/elements/ree.html> [Accessed 1 July 2021].
- MOFA (2021): Economic Diplomacy. – Available at: <https://www.mofa.go.jp/policy/economy/index.html> [Accessed 18 October 2021].
- MOODY'S (2021): Korea Mine Rehabilitation & Mineral Res Corp – Moody's assigns first-time A1 ratings to KOMIR; outlook stable (Korean). – Available at: [https://www.moody's.com/research/documentcontentpage.aspx?docid=PR\\_454520](https://www.moody's.com/research/documentcontentpage.aspx?docid=PR_454520) [Accessed 17 October 2021].
- MOORE, J. F. (1996): The Death Of Competition – Leadership And Strategy In The Age Of Business Ecosystems. – 297 p., HarperBusiness; New York.
- MORRISON, W. M. & TANG, R. (2012): China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States. – 36 p.; Washington. – Available at: <https://sgp.fas.org/crs/row/R42510.pdf> [Accessed 11 October 2021].
- MOTIE – MINISTRY OF TRADE, INDUSTRY AND ENERGY (2021): Organizational Structure. – Available at: <https://english.motie.go.kr/en/am/organization/organization.jsp> [Accessed 20 September 2021].
- NATURE RESEARCH CUSTOM MEDIA (2021): The rich resources in Japan's deep-sea muds. – Available at: <https://www.nature.com/articles/d42473-020-00528-8> [Accessed 11 October 2021].
- NEXI – NIPPON EXPORT AND INVESTMENT INSURANCE (2021): Types of Insurance. – Available at: <https://www.nexi.go.jp/en/products/types/index.html> [Accessed 11 October 2021].
- NIPPON STEEL (2019): Nippon Steel Integrated Report 2019. – 132 p.; Tokyo. – Available at: [https://www.nipponsteel.com/en/ir/library/annual\\_report.html](https://www.nipponsteel.com/en/ir/library/annual_report.html) [Accessed 11 October 2021].

- NIPPON STEEL (2021): Financial Report for the year ended March 31, 2021. – 60 p.; Tokyo. – Available at: [https://www.nipponsteel.com/en/ir/library/pdf/financialreport\\_2020.pdf](https://www.nipponsteel.com/en/ir/library/pdf/financialreport_2020.pdf) [Accessed 11 October 2021].
- NOLLET, J. & BEAULIEU, M. (2005): Should an organisation join a purchasing group? – *Supply Chain Management*, 10(1): pp 11–17.
- NRCAN – DEPARTMENT OF NATURAL RESOURCES CANADA (2019): The Canadian Minerals And Metals Plan. – 46 p., Ottawa. – Available at: [https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP\\_The\\_Plan-EN.pdf](https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf) [Accessed 11 October 2021].
- NRCAN – DEPARTMENT OF NATURAL RESOURCES CANADA (2020): The Canadian Minerals and Metals Plan – Update to Action Plan 2020. – 9 p., Ottawa. – Available at: [https://www.minescanada.ca/sites/default/files/pictures/PDF/cmmp\\_action\\_plan2020\\_update\\_final-en.pdf](https://www.minescanada.ca/sites/default/files/pictures/PDF/cmmp_action_plan2020_update_final-en.pdf) [Accessed 11 October 2021].
- NRCAN – DEPARTMENT OF NATURAL RESOURCES CANADA (2021a): Critical Minerals. – Available at: <https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/critical-minerals/23414> [Accessed 21 September 2021].
- NRCAN – DEPARTMENT OF NATURAL RESOURCES CANADA (2021b): Canada Announces Critical Minerals List. – Available at: <https://www.canada.ca/en/natural-resources-canada/news/2021/03/canada-announces-critical-minerals-list.html> [Accessed 21 September 2021].
- NRCAN – DEPARTMENT OF NATURAL RESOURCES CANADA (2021c): Canadian Mineral Exploration. – Available at: <https://www.nrcan.gc.ca/mining-materials/mining/canadian-mineral-exploration/8290> [Accessed 21 September 2021].
- OEC (2021a): Japan. – Available at: <https://oec.world/en/profile/country/jpn> [Accessed 11 October 2021].
- OEC (2021b): Canada. – Available at: <https://oec.world/en/profile/country/can> [Accessed 11 October 2021].
- OEC (2021c): United States. – Available at: <https://oec.world/en/profile/country/usa> [Accessed 11 October 2021].
- OEC (2021d): France. – Available at: <https://oec.world/en/profile/country/fra> [Accessed 11 October 2021].
- OEC (2021e): Italy. – Available at: <https://oec.world/en/profile/country/ita> [Accessed 11 October 2021].
- OEC (2021f): Great Britain. – Available at: <https://oec.world/en/profile/country/gbr> [Accessed 11 October 2021].
- OECD (2019): Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences. – OECD Publishing; Paris.
- OECD (2020): Trade in raw materials. – Available at: <https://www.oecd.org/trade/topics/trade-in-raw-materials/> [Accessed 11 October 2021].
- OECD (2021a): Current account balance (indicator). – Available at: <https://data.oecd.org/trade/current-account-balance.htm> [Accessed 11 October 2021].
- OECD (2021b): Material resources. – Available at: [https://stats.oecd.org/Index.aspx?DataSetCode=MATERIAL\\_RESOURCES](https://stats.oecd.org/Index.aspx?DataSetCode=MATERIAL_RESOURCES) [Accessed 11 October 2021].
- OECD (2021c): Steel Market Developments: Q2 2021. – OECD Publishing; Paris. – Available at: <https://www.oecd.org/sti/ind/steel-market-developments.htm> [Accessed 11 October 2021].
- OMAR, Y., MINOUFEKR, M. & PLAPPER, P. (2019): Business analytics in manufacturing: Current trends, challenges and pathway to market leadership. – *Operations Research Perspectives*, Volume 6.
- PALM, R. (2011): Die große Angst am Rohstoffmarkt. – Available at: <https://www.handelsblatt.com/unternehmen/management/unternehmer-sorgen-fuer-das-hedging-fehlt-fachwissen/4503302-2.html> [Accessed 9 September 2021].
- POST – THE PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (2019): POSTnote 609:

Access to critical materials. – London. – Available at: <https://post.parliament.uk/research-briefings/post-pn-0609/> [Accessed 14 October 2021].

PPS – PUBLIC PROCUREMENT SERVICE (2020): About PPS. – Available at: <https://www.pps.go.kr/eng/content.do;jsessionid=iw9zXlnVA-9T-2iQ1AK8EGMQo25XwJFAQM66FLrSH-VkBsRZBU9e!-27386891?key=01159> [Accessed 12 October 2021].

RAMKUMAR, A. (2021): Lithium Prices Soar, Turbocharged By Electric-Vehicle Demand and Scant Supply. – *The Wall Street Journal*, Dec. 13, 2021. – Available at: <https://www.wsj.com/articles/lithium-prices-soar-turbocharged-by-electric-vehicle-demand-and-scant-supply-11639334956> [Accessed 17 December 2021].

REGNÉR, P., AGWIN, D., JOHNSON, G. & SCHOLÉS, K. (2019): Corporate strategy. – In: Whittington, R. (ed.): *Exploring Strategy Text and Cases*. 12th ed. – pp 246–250, Pearson Higher Education & Professional Group; Harlow:

REUTERS STAFF (2021): China's CATL unveils sodium-ion battery – a first for a major car battery maker. – Reuters. – Available at: <https://www.reuters.com/article/toyota-results-idCNL1N2KG07D> [Accessed 14 October 2021].

RMO – THE RAW MATERIAL OUTLOOK (2021): Welcome to the Raw Material Outlook. – Available at: <https://www.rawmaterialoutlook.org/> [Accessed 5 November 2021].

ROSKILL (2021a): Tungsten – Outlook to 2030 15th Edition. – Roskill; London.

ROSKILL (2021b): Lithium-ion Batteries – Outlook to 2030 5th Edition. – Roskill; London.

ROSKILL (2021c): Rare Earths – Outlook to 2030 20th Edition. – Roskill; London.

ROSKILL (2021d): Nickel: Procurement race heats up as LG Chem signs offtake with Australian Mines. – Roskill; London. – Available at: <https://roskill.com/news/nickel-procurement-race-heats-up-as-lg-chem-signs-offtake-with-australian-mines/> [Accessed 5 November 2021].

SACE (2018): SACE SIMEST (CDP Group) brings Nexa Resources to Italy: \$ 62,50 million

of opportunities for Italian exports to Latin America. – Available at: [https://www.sace.it/en/media/sace-simest-\(cdp-group\)-brings-nexa-resources-to-italy-62-50-million-of-opportunities-for-italian-exports-to-latin-america](https://www.sace.it/en/media/sace-simest-(cdp-group)-brings-nexa-resources-to-italy-62-50-million-of-opportunities-for-italian-exports-to-latin-america) [Accessed 21 September 2021].

SAINT-AUBIN, P. (2019): Dependence on strategic metals: what solutions for the economy? – 2 p.; Paris. – Available at: [https://www.lecese.fr/sites/default/files/travaux\\_multilingue/FI03\\_2019\\_metaux\\_strategiques-GB.pdf](https://www.lecese.fr/sites/default/files/travaux_multilingue/FI03_2019_metaux_strategiques-GB.pdf) [Accessed 13 October 2021].

SAMSUNG SDI (2020): Cathode Materials, the Source of a Strong and Long-lasting Battery! – Available at: <https://www.samsungsdi.com/column/technology/detail/56458.html> [Accessed 5 November 2021].

SCHMID, M. (2020): Unternehmerische Rohstoffstrategien: Zum Umgang mit kritischen Versorgungssituationen. – 333 p., Springer Gabler; Wiesbaden. <https://doi.org/10.1007/978-3-658-29007-8>.

SCHUH, G., AGHASSI, S., BREMER, D. & GRAW, M. (2014): Einkaufsstrukturen. – In: Schuh, G. (ed.): *Einkaufsmanagement: Handbuch Produktion und Management* 7. – pp. 49–52., Springer, Berlin

SCREEN (2019): Substitution strategies guide for R&D&I. – French Alternative Energies and Atomic Energy Commission (CEA); Paris. – Available at: <http://screen.eu/wp-content/uploads/2019/06/SCREEN-D5.2-Substitution-strategies-guide-for-RDI-V2.pdf> [Accessed 5 November 2021].

SNOWDON, N., SHARP, D. & CURRIE, J. (2021): Green Metals: Copper is the new oil. – Goldman Sachs; New York.

STAUFEN (2016): Lean Purchasing 2016 – Im Einkauf liegt der Gewinn. – Available at: [https://www.staufen.ag/fileadmin/HQ/02-Company/05-Media/2-Studies/STAUFEN.-studie-lean-purchasing-2016-de\\_DE.pdf](https://www.staufen.ag/fileadmin/HQ/02-Company/05-Media/2-Studies/STAUFEN.-studie-lean-purchasing-2016-de_DE.pdf) [Accessed 26 November 2021].

STEVENS, P. (2021): The ship that blocked the Suez Canal may be free, but experts warn the supply chain impact could last months. – Available at: <https://www.cnn.com/2021/03/29/suez-canal->

is-moving-but-the-supply-chain-impact-could-last-months.html [Accessed 18 May 2021].

SWANSON, D. & SUZUKI, Y. (2020): COVID-19 Carves New Facets of Supply Chain Disruption. – *Transportation Journal*, 59(4): pp. 325–334.

SZURLIES, M. (2021): Rohstoffrisikobewertung – Nickel. – *DERA Rohstoffinformationen*, 48: 110 p., Berlin.

TAKAYA, Y., YASUKAWA, K., KAWASAKI, T. & FUJINAGA, K. (2018): The tremendous potential of deepsea mud as a source of rare-earth elements. – *Scientific Reports*, 8(5763). – Available at: <https://www.nature.com/articles/s41598-018-23948-5> [Accessed 7 October 2021].

TAYLOR, J. C. & WISE, E. M. (2013): *Encyclopedia Britannica: Nickel processing*. – Available at: <https://www.britannica.com/technology/nickel-processing> [Accessed 30 June 2021].

THE HERITAGE FOUNDATION (2021a): 2021 Index of Economic Freedom: South Korea. – Available at: [https://www.heritage.org/index/pdf/2021/countries/2021\\_IndexofEconomicFreedom-South-Korea.pdf](https://www.heritage.org/index/pdf/2021/countries/2021_IndexofEconomicFreedom-South-Korea.pdf) [Accessed 8 October 2021].

THE HERITAGE FOUNDATION (2021b): 2021 Index of Economic Freedom: Canada. – Available at: [https://www.heritage.org/index/pdf/2021/countries/2021\\_IndexofEconomicFreedom-Canada.pdf](https://www.heritage.org/index/pdf/2021/countries/2021_IndexofEconomicFreedom-Canada.pdf) [Accessed 8 October 2021].

THE WHITE HOUSE (2021a): Building Resilient Supply chains, revitalizing american manufacturing, and fostering broad based growth. – The White House; Washington. – Available at: <https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf> [Accessed 12 October 2021].

THE WHITE HOUSE (2021b): FACT SHEET: Biden-Harris Administration Announces Supply Chain Disruptions Task Force to Address Short-Term Supply Chain Discontinuities. – The White House; Washington. – Available at: <https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/08/fact-sheet-biden-harris-administration-announces-supply-chain-disruptions-task-force-to-address-short-term-supply-chain-discontinuities/> [Accessed 12 October 2021].

TOYOTA TSUSHO (2021): Stories of our projects. – Available at: <https://www.toyota-tsusho.com/english/about/project/04/> [Accessed 5 November 2021].

U.S. CENSUS BUREAU (2019): Annual Survey of Manufactures: Summary Statistics for Industry Groups and Industries in the U.S. – Available at: <https://data.census.gov/cedsci/table?q=United%20States&g=0100000US&tid=ASMAREA2017.AM1831BASIC01> [Accessed 19 November 2021].

UKEF – UK EXPORT FINANCE (2021): Annual Report and Accounts 2020 to 2021. – UK Government; London. – Available at: <https://www.gov.uk/government/publications/ukef-annual-report-and-accounts-2020-to-2021-by-section> [Accessed 21 November 2021].

UMBACH, F. (2019): Versorgungssicherheit bei kritischen Rohstoffen. – *Akademie für Politik und Zeitgeschehen: Aktuelle Analysen*, 73: 63 p., Hanns-Seidel-Stiftung e.V.; Munich.

UN – UNITED NATIONS (2011): Guiding Principles on Business and Human Rights. – United Nations, New York, Geneva. – Available at: [https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr\\_en.pdf](https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf) [Accessed 2 September 2021].

UN – UNITED NATIONS (2015): Paris Agreement. – United Nations; Paris.

USGS – U.S. GEOLOGICAL SURVEY (2018): The Mineral Industry of the Republic of Korea in 2015. – *USGS Minerals Yearbook 2015, volume III, Area I*: pp 16.1–16.4, Reston. – Available at: <https://www.usgs.gov/media/files/mineral-industry-republic-korea-2015-0> [Accessed 22 September 2021].

USGS – U.S. GEOLOGICAL SURVEY (2021): Mission Areas. – Available at: <https://www.usgs.gov/mission-areas/energy-and-minerals> [Accessed 22 September 2021].

VAN WEELE, A. J. & EISSIG, M. (2017): Strategische Beschaffung – Grundlagen, Planung und Umsetzung eines integrierten Supply Management. – 631 p., Springer Gabler; Wiesbaden.

VDI – VEREIN DEUTSCHER INGENIEURE (2017): Ressourceneffizienz durch Industrie 4.0 – Potenzi-

- ale für kleine und mittlere Unternehmen (KMU) des verarbeitenden Gewerbes. – 271 p., VDI Zentrum Ressourceneffizienz GmbH; Berlin. – Available at: [https://www.ressource-deutschland.de/fileadmin/Redaktion/Bilder/Newsroom/Studie\\_Ressourcen\\_effizienz\\_durch\\_Industrie\\_4.0.pdf](https://www.ressource-deutschland.de/fileadmin/Redaktion/Bilder/Newsroom/Studie_Ressourcen_effizienz_durch_Industrie_4.0.pdf) [Accessed 22 September 2021].
- VETTER, P. (2020): Jetzt soll Deutschlands Wirtschaft Rohstoffe „hamstern“. – *Welt*, 13.07.2020. – Available at: <https://www.welt.de/wirtschaft/article211509387/Wirtschaftsrat-der-CDU-Unternehmen-sollen-Rohstoffe-hamstern.html> [Accessed 19 October 2021].
- VILPE (2021): Raw material shortage causes delivery problems and price increase. – Available at: <https://www.vilpe.com/en/2021/06/17/raw-material-shortage-causes-delivery-problems-and-price-increase/> [Accessed 26 October 2021].
- WANNENWETSCH, H. (2021): Integrierte Materialwirtschaft, Logistik, Beschaffung und Produktion – Supply Chain im Zeitalter der Digitalisierung. 6th ed. – 909 p., Springer Verlag; Berlin.
- WASSENBERG, F., 2013. FRANKREICH. – IN: HILPERT H. G. & MILDNER S. (eds): *Nationale Alleingänge oder internationale Kooperation? Analyse und Vergleich der Rohstoffstrategien der G20-Staaten.* – pp 79–85; SWP; BGR; Berlin.
- WELLMER, F.-W., BUCHHOLZ, P., GUTZMER, J., HAGELÜCKEN, C., HERZIG, P., LITKE, R., THAUER, R. K. (2019): *Raw Materials for Future Energy Supply.* – 225 p., Springer International Publishing.
- WEISBERGER, B. A., ROLLINS, R. C., ROBINSON, E. E., LEWIS, P. F., FREIDEL, F., GOPNIK, A., OEHSER, P. H., HANDLIN, O., DONALD, D. H., ECONOMIST INTELLIGENCE UNIT, FLAUM, T. K., O'NEILL, W. L., WALLACE, W. M., NAISBITT, J., WINTHER, O. O., OWEN, W., SCHMIDT, K. P., PESSER, E., POLE, J., BEEMAN, R. R., LINK, A. S., HARRIS, J. T., HASSLER, W. W., BRADLEY, H. W., ZELINSKY, W. (2021): *Encyclopedia Britannica: United States.* – Available at: <https://www.britannica.com/place/United-States> [Accessed 13 October 2021].
- WERNER, H. (2017): *Supply Chain Management – Grundlagen, Strategien, Instrumente und Controlling.* 6th ed. – 548 p., Springer Gabler; Wiesbaden.
- WILDEMANN, H. (2009): Hedging im Globalen Einkauf. – In: Mieke, C. (ed.): *Entwicklungen in Produktionswissenschaft Und Technologieforschung: Festschrift für Prof. Dieter Specht.* – pp. 481–189, Behrens; Berlin.
- WILKE, J. (2012): *Supply Chain Koordination durch Lieferverträge mit rollierender Mengenflexibilität.* – 384 p., Springer Gabler; Wiesbaden.
- WITS – WORLD INTEGRATED TRADE SOLUTION (2020): *Trade statistics by Country/Region.* – Available at: <https://wits.worldbank.org/countrystats.aspx?lang=en> [Accessed 11 October 2021].
- WOODHOUSE, A. (2018): Toyota unit takes stake in Australian lithium producer. – *Financial Times.* – Available at: <https://www.ft.com/content/ad942564-30c5-3a4c-86e5-2a78a5fda78a> [Accessed 14 October 2021].
- WORLD BANK (2021a): GDP (current US\$). – Available at: <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD> [Accessed 11 October 2021].
- WORLD BANK (2021b): Industry (including construction), value added (% of GDP). – Available at: <https://data.worldbank.org/indicator/NV.IND.TOTL.ZS> [Accessed 11 October 2021].
- WORLD BANK (2021c): Services, value added (% of GDP). – Available at: <https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS> [Accessed 14 October 2021].
- YANG, H. & PARK, J.-M. (2019): LG Display aims to diversify suppliers due to South Korea-Japan spat. – *Reuters.* – Available at: <https://www.reuters.com/article/cbusiness-us-lg-display-results-idCAKC-N1UI0M5-OCABS> [Accessed 21 October 2021].
- YAN, G. & ZHONGXUE, L. (2019): *Global political economy of rare earths: changing positions of major market actors including China, European Union, Japan and United States.* – IOP Conference Series: Earth and Environmental Science; Beijing.

## Appendix

---

Online survey questionnaire	166
Expert interview guideline questions	169
Expert interviewees	170

## Online survey questionnaire

### Question 1: Strategies to secure raw material supply

(a) To what extent have the following strategies been implemented in your company to secure raw materials and prices?

(b) To what extent do you estimate they will be used in the next 3–5 years by your company?

	Current use				Planned use			
	n.a.	low	medium	high	n.a.	low	medium	high
Commodity price hedging	<input type="checkbox"/>							
Passing on increased raw material prices to customers	<input type="checkbox"/>							
Stockpiling	<input type="checkbox"/>							
Supplier diversification	<input type="checkbox"/>							
Long-term contracts	<input type="checkbox"/>							
Purchasing groups	<input type="checkbox"/>							
Increased material efficiency	<input type="checkbox"/>							
Recycling	<input type="checkbox"/>							
Material substitution	<input type="checkbox"/>							
Vertical integration	<input type="checkbox"/>							
Business tools (e.g. forecasting, supplier mapping)	<input type="checkbox"/>							
Others: _____	<input type="checkbox"/>							

### Question 2: Assessment of effectiveness

How effective were the strategies in securing raw materials and prices?

	n.a.	low	medium	high
Commodity price hedging	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Passing on increased raw material prices to customers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stockpiling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Supplier diversification	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Long-term contracts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Purchasing groups	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increased material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recycling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material substitution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vertical integration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Business tools (e.g. forecasting, supplier mapping)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Question 3: Vertical integration**

(a) To what extent have the following forms of vertical integration been used in your company?

(b) To what extent do you estimate they will be used in the next 3–5 years by your company?

	Current use				Planned use			
	n.a.	low	medium	high	n.a.	low	medium	high
Investment in suppliers (manufacturers)	<input type="checkbox"/>							
Investment in recycling plants	<input type="checkbox"/>							
Investment in exploration projects	<input type="checkbox"/>							
Investment in mine development projects	<input type="checkbox"/>							
Investment in existing mines	<input type="checkbox"/>							
Investment in raw material processing plants	<input type="checkbox"/>							
Others: _____	<input type="checkbox"/>							

**Question 4: Increased material efficiency**

(a) Does your company use digital manufacturing (e.g. smart manufacturing, Industry 4.0, internet of things)?

(b) To what extent has digital manufacturing increased material efficiency in your company?

(a)		(b) Extent of increase in material efficiency					
Yes	No	0 %	1 %–5 %	6 %–10 %	11 %–15 %	16 %–20 %	> 20 %
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Question 5: Long-term contracts**

How has the duration of raw material contracts changed over the past five years?

Much shorter	Shorter	Unchanged	Longer	Much longer	n.a.
<input type="checkbox"/>					

**Question 6: Market-specific factors**

How would you rate the impact of the following factors on your raw material securement strategy over the next years?

	n.a.	low	medium	high
Increases in tariffs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Short-term supply chain disruption due to external factors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Long-term supply chain disruption due to external factors (e.g. trade restrictions)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dependence on individual countries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dependence on individual suppliers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Decreasing quality of critical raw materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Decreasing availability of critical raw materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing demand for critical raw materials (e.g. lithium for batteries)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Question 7: Country-specific factors**

How do the following country-specific factors play a role in your company's strategy for securing raw materials?

	n.a.	low	medium	high
Government support for mining investments				
Government support for research (substitution, recycling, material efficiency)				
Government initiatives to promote joint ventures and collaboration between domestic companies				
Government-led stockpiling				
Bilateral trade agreements				
Government environmental protection standards				
State infrastructure for recycling systems				
Domestic availability of raw materials				
Others: _____				

**Question 8: Company-specific factors**

How do you rank your company's standing in terms of the following factors?

	n.a.	low	medium	high
Importance of sustainability/environmental criteria	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Predictability of own raw material needs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Degree of digitalisation in your company	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Geographical distribution of production sites	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proportion of critical raw materials in your end products	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Competitive pressure on the sales markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Importance of research and development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Question 9: Critical raw materials**

Please indicate your company's five most important non-fuel raw materials. How do you assess the risk of price increases and supply shortages for these raw materials? (Examples listed below)

	Price risk			Supply risk		
	low	medium	high	low	medium	high
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					

**Examples:**

Base metals: copper, zinc, tin

Battery materials: lithium, cobalt, graphite

Minor metals: germanium, gallium, cadmium, silicon, indium

Iron and steel alloys: iron, nickel, chromium, tungsten

Precious metals: gold, silver, platinum, palladium

Lightweight metals: magnesium, aluminium, titanium

Rare earth elements: neodymium, praseodymium, cerium, lanthanum

Industrial minerals: fluorspar, baryte, silica

## Expert interview guideline questions

The interview guidelines served as a semi-standardised, flexible means of structuring the expert interviews. The order and the focus of the blocks differed between interviews. The three strategies that were considered most important were assessed in

more detail in Block E, making variable use of the questions listed. The structure and focus for interviews of company representatives was slightly different from investor interviews, with a greater focus on either Block E or Block F as appropriate.

Block	Questions
<b>A: Intro</b>	<ul style="list-style-type: none"> <li>– Brief introduction of the interviewers</li> <li>– Obtaining consent to record the interview</li> <li>– Asking whether the respondent and his or her company may be named in the study or in the study's appendix</li> </ul>
<b>B: Icebreaker</b>	
<b>C: Status quo of the company regarding raw material procurement</b>	<ol style="list-style-type: none"> <li>1. What are your company's core <b>products</b>?</li> <li>2. Which are the most important non-fuel raw <b>materials</b> for your company (non-fuel raw materials include metal raw materials (ores), industrial minerals, stone and earths (such as gravel, stones, earths and hard/natural stones))?</li> <li>3. What <b>challenges</b> or risks does your country and company face with regard to raw material procurement (e.g. shortages, counteracting price shocks)?</li> </ol>
<b>D: Implemented strategies to secure raw material supply</b>	<p>Which of the following are <b>the three most important strategies</b> your company uses to secure raw material supplies?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> (1) Commodity price hedging</li> <li><input type="checkbox"/> (2) Passing on increased raw material prices to customers</li> <li><input type="checkbox"/> (3) Stockpiling</li> <li><input type="checkbox"/> (4) Supplier diversification</li> <li><input type="checkbox"/> (5) Long-term contracts</li> <li><input type="checkbox"/> (6) Purchasing groups</li> <li><input type="checkbox"/> (7) Increased material efficiency (provide brief explanation of what is meant by this – e.g. reduction of scrap is included but recycling is not)</li> <li><input type="checkbox"/> (8) Recycling</li> <li><input type="checkbox"/> (9) Material substitution</li> <li><input type="checkbox"/> (10) Vertical integration (e.g. investment in the extraction of raw materials)</li> <li><input type="checkbox"/> (11) Business tools (e.g. forecast tools, supplier mapping tools)</li> </ul> <p>Which three of these strategies are <b>least important</b> to your company in the context of securing raw material supplies and why?</p> <ol style="list-style-type: none"> <li>1. _____</li> <li>2. _____</li> <li>3. _____</li> </ol>
<b>E: Detailed information on the implemented strategies</b>	<p>Strategy _____</p> <ol style="list-style-type: none"> <li>1. <b>Which</b> non-fuel raw <b>materials</b> do you secure with this strategy?</li> <li>2. With respect to the previously mentioned raw materials, is this strategy of low, medium, or high <b>importance</b> in the context of securing your raw material needs and why?</li> <li>3. What <b>opportunities</b> and what <b>challenges</b> are associated with the use of this strategy?</li> <li>4. How do you estimate the relevance of this strategy for your company in <b>three to five years</b> and why?</li> <li>5. In your opinion, what <b>conditions</b> must be met at the company and country level for this strategy to be suitable and effective for securing raw material supplies? Under what circumstances does use of this strategy make sense? And which of them is the most relevant?</li> </ol>
<b>F: Mining and raw material procurement risk</b>	<p>Does your company invest in <b>mines</b>?</p> <ul style="list-style-type: none"> <li>– If yes, what are the <b>strategic reasons</b> for this investment?</li> <li>– If no, why not (e.g. risk too high, capital intensity too high)?</li> </ul>
<b>G: Outro</b>	<b>Timeline</b> for publication of the study results (publication at the turn of the year 2021/2022)

## Expert interviewees

**Abdullah, Junaid**

Buyer  
Renault-Nissan-Mitsubishi

**Aranjo, Timo (III)**

Planning Manager  
Infrastructure company

**Baghaei, Daria**

Procurement Specialist  
Hercules SLR

**Bain, Caroline**

Chief Commodities Economist  
Capital Economics

**Becker, Marcus**

Vice President and Chief Procurement Officer  
Constellium

**Bouret, Eric**

Global Chief Procurement Officer  
Bouygues Construction

**Buso, Alberto**

Global Senior Purchasing Manager  
Carraro Drive Tech Spa

**Chowdhury, Sahidur Rahman**

Procurement Specialist  
Japan Tobacco International

**De Massis, Camillo**

Growth and Innovation Director  
Feralpi Group

**DeLaRosa, Paul**

Chief Procurement Officer  
Teledyne Technologies

**Ducrocq Sammarcelli, Jean-Baptiste**

Purchasing Buyer  
Saint-Gobain UK and Ireland

**Ecclestone, Christopher**

Strategist and Principal  
Hallgarten & Company

**Ellmann, Holger**

Senior Metal Trader  
Kyen Resources

**Eriksen, Petter**

Managing Director and Base Metal Trader  
Echo Metal Services LLC

**Henderson, David R**

Founder and President  
Rittenhouse International Resources

**Inbody, Paul**

Founder and President  
Key Business Solutions (KBS)

**Jallah, Sumo**

International Procurement Specialist  
United Nations

**Karayannopoulos, Constantine**

Chief Executive Officer  
Neo Performance Materials

**King, Prof. Alex**

Professor Emeritus of Materials Science  
and Engineering  
Iowa State University

**Koller, Ulf**

Consultant  
Pedersen & Partners

**Lifton, Jack**

Co-founding Principal  
Technology Metals Research

**Longiave, Pietro**

Group Commodity VP Base Metals  
Prysmian Group

**Merlini, Luca**

Head of Sales  
Steelgroup

**Miranda-Guasti, Francisco**

Senior Consultant in Logistics, Distribution,  
Transportation and Foreign Trade  
YellowFlow Solutions

**Morrison, Tim**

Manager Supply Chain Management  
TransAlta

**Mosca, Giovanni**

Chief Planning, Budgeting and Control Officer  
C.M.D. Costruzioni Motori Diesel

**Ottavis, Pietro**

Chief Technology Officer  
Comau

**Percario, Stefano (MCIPS)**

Head of Commodities Management  
Comau

**Ricca, Domenico Carolei**

Strategic Sourcing Specialist  
Plusprime LLC

**Rietveld, Elmer**

Senior Advisor and Researcher on critical raw materials  
TNO

**Rosset, Pier**

Procurement, Operational Excellence  
and Transformation Advisor  
Frachen Global Solutions

**Rota Sperti, Paolo**

Procurement Senior Director  
Contract Manager

**Salatini, Stefano**

Head of Purchasing  
Carraro Spa – Div. Agritalia

**Teissié-Solier, Anne**

Director GSM EMEA & Asia Operations and  
Global Category Director  
Corning

**Tremblay, Han-Li**

Senior Supply Chain Professional  
AvalonCSC

**Tsirigotis, Nicholas**

Energy Trading Professional  
Albioma

**Veggetti, Elisabetta**

Group Purchasing Director  
Coesia

**Valmori, Gabriele**

Purchasing Manager  
Aetna Group

**Weisberger, Marc**

Commodities Partner  
gunnercooke

**Wixey, Michael**

Private Consultant

**Wojszczyk, Dr Bartosz**

Chief Executive Officer  
Decision Point Global

**Anonymised interviewee 1**

Supply Chain Specialist  
International manufacturing company

**Anonymised interviewee 2**

Senior Procurement Manager  
International manufacturing company

**Anonymised interviewee 3**

Equity Researcher with focus on steel  
Financial services company

## Disclaimer

This publication has been prepared for general guidance on matters of interest only and does not constitute professional advice. No representation or warranty (express or implied) is given as to the accuracy or completeness of the information contained in this publication, and, to the extent permitted by law, PwC does not accept or assume any liability, responsibility or duty of care for any consequences of you or anyone else acting, or refraining to act, in reliance on the information contained in this publication or for any decision based on it.

© 2022 PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft.

All rights reserved. In this document "PwC" refers to PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft, which is a member firm of PricewaterhouseCoopers International Limited (PwCIL). Each member firm of PwCIL is a separate and independent legal entity.

**Deutsche Rohstoffagentur (DERA) in der  
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)**

Wilhelmstr. 25–30  
13593 Berlin  
Phone: +49 30 36993 226  
dera@bgr.de  
www.dera.bund.de

ISBN: 978-3-948532-59-8 (print version)  
ISBN: 978-3-948532-60-4 (PDF)  
ISSN: 2193-5319