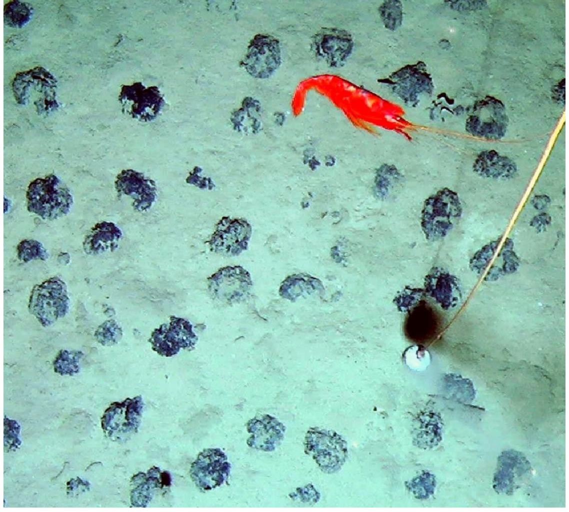

ISA TECHNICAL STUDY NO. 32

Study of the potential impact of polymetallic nodules production in the Area on the economies of developing land-based producers of those metals which are likely to be most seriously affected

INTERNATIONAL SEABED AUTHORITY

Study of the potential impact of polymetallic nodules production in the Area on the economies of developing land-based producers of those metals which are likely to be most seriously affected

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Contents

Abbreviations

1994 Agreement	Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea
BGS	British Geological Survey
DLBPS	developing land-based producer States
EMD	electrolytic manganese dioxide
EMM	electrolytic manganese metal
EU	European Union
EV	electric vehicle
GDP	gross domestic product
GNP	gross national product
Gt	billion tonnes
GVC	global value chain
HHI	Herfindahl-Hirschman Index
ICA	International Copper Association
ICSG	International Copper Study Group
IEA	International Energy Agency
IMF	International Monetary Fund
IMnI	International Manganese Institute
INSG	International Nickel Study Group
ISA	International Seabed Authority
ITC	International Trade Centre
LDC	least developed countries
LME	London Metal Exchange
MIT	Massachusetts Institute of Technology
Mt	million tonnes
NIC	newly industrialized country
NMC	nickel manganese cobalt
NPI	nickel pig iron
OECD	Organisation for Economic Co-operation and Development
ROW	rest of the world
SHFE	Shanghai Futures Exchange
SX-EW	solvent extraction-electrowinning
TMT	thousand metric tonnes
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
USGS	United States Geological Survey

Foreword

It gives me great pleasure to introduce this important study on the potential impact of polymetallic nodule production from the Area on the economies of developing land-based producers of the minerals derived from polymetallic nodules.

The United Nations Convention on the Law of the Sea (UNCLOS) provides that exploration for and exploitation of minerals in the Area shall be carried out in a way that fosters international cooperation, the balanced growth of global trade and the healthy development of the world economy, especially the economies of developing countries. In this context, it also contains provisions designed to protect developing States from adverse effects on their economies or on their export earnings resulting from a reduction in the price of minerals, or in the volume of exports of those minerals, to the extent that such reduction is caused by activities in the Area (UNCLOS, Articles 150 (h) and 1 (3)).

Understanding the potential economic impacts of seabed mineral production has long been an issue of the utmost concern to developing land-based producers of minerals. That is why the Agreement relating to the Implementation of Part XI of UNCLOS (1994 Agreement) provides that between the entry into force of UNCLOS and the approval of the first plan of work for exploitation, ISA shall concentrate on, among others, the study of the potential impact of mineral production from the Area on the economies of developing land-based producers of those minerals which are likely to be most seriously affected, to minimize their difficulties and assist them in their economic adjustment, taking into account the work done in this regard by the Preparatory Commission (Section 1, paragraph 5 (e), Annex to the 1994 Agreement).

It is in this context and fully in line with ISA's Strategic Directions 2 (Strengthening the regulatory framework for activities in the Area) and 6 (Ensuring integrated participation by developing States) of the ISA Strategic Plan for 2019-2023 that the Secretariat commissioned the present study. The objective of the study, which is designed according to the terms of references endorsed by the Legal and Technical Commission in 2019 (ISBA/25/C/19, para.14), is to help us better understand the potential magnitude of any impact of a price reduction or decrease in the export volume of affected metals, including copper, nickel, cobalt and manganese, on developing land-based producers.

The findings of this study will provide the Legal and Technical Commission, in performing the functions of the Economic Planning Commission, with a preliminary assessment of the potential nature of such impacts and the extent to which they could be caused by activities in the Area. It makes an important contribution to the discussion on developing an economic assistance policy in accordance with the principles established by the 1994 Agreement (Annex, Section 7). Finally, it recommends areas for further study or research.

Three of the findings of this study are of particular importance.

First, it highlights that statistics on current export levels allow only preliminary identification of developing land-based producer States which are likely to be seriously affected by the start of deep-seabed mining.

Second, it notes that it will only be possible to assess specific impacts once mining in the Area has commenced. It is interesting to note that, based on the research undertaken, a potential methodology for such an assessment could be a comparison of quantitative indicators (such as the value of exports of affected metals and their contribution to the value of total export earnings, physical volumes of production of affected metals, the value of export earnings relative to GDP, etc.) before and after the beginning of deep-seabed mining.

Third, the study notes that, depending on the state and specialization of the economies of specific developing land-based producers, the degree of negative impacts from deep-seabed mining may vary substantially. Furthermore, it is important to note that provisionally identifying certain developing land-based producers States as the States that may be most seriously affected does not mean that those same States will indeed be severely affected.

I wish to thank the consultants from the All-Russian Scientific-Research Institute of Mineral Resources named after N.M. Fedorovsky who led the work on this study and to express my appreciation to all who contributed to the study. I believe it represents another important step towards the effective implementation of the provisions of UNCLOS and the 1994 Agreement.

H.E. Mr. Michael W. Lodge
Secretary-General
International Seabed Authority

Executive summary

1. The Secretariat of the International Seabed Authority (ISA) commissioned the preparation of this report to study the potential impact of mineral production from the Area on the economies of developing land-based producers of those minerals which are likely to be most seriously affected, with a view to minimizing their difficulties and assisting them in their economic adjustment, taking into account the work done in this regard by the Preparatory Commission.

2. The purpose of the study is to provide a preliminary assessment of the impact of activities in the Area on developing land-based producer States (DLBPS). Activities in the Area may lead to serious adverse effects on the export earnings and economies of DLBPS, resulting from the decline in price or supply volumes of the affected metals. The need for such a study is determined by the provision of UNCLOS that developing States must be protected "from adverse effects on their economies or on their export earnings resulting from a reduction in price of an affected mineral, or in the volume of exports of that mineral, to the extent that such reduction is caused by activities in the Area…" (UNCLOS, Articles 150 (h) and 1 (3)). The Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982 (1994 Agreement) provides that between the entry into force of the UNCLOS and the approval of the first plan of work for exploitation, ISA shall concentrate on, among others, study of the potential impact of mineral production from the Area on the economies of developing land-based producers of those minerals which are likely to be most seriously affected, with a view to minimizing their difficulties and assisting them in their economic adjustment, taking into account the work done in this regard by the Preparatory Commission (Section 1, paragraph 5 (e), Annex to the 1994 Agreement).

3. The study considers the implications of metal production from the future exploitation of polymetallic nodules in the Area. Affected metals include copper, nickel, cobalt, and manganese.

4. Potential impacts of seabed mineral production (including polymetallic nodules) on DLBPS and the criteria of their assessment were considered by Special Commission 1 of the Preparatory Commission. Special Commission 1 has also identified areas of research that need to be undertaken in order to study the possible impacts of seabed mineral production on DLBPS. Conclusions and methodology of Special Commission 1 have been confirmed in the submitted report.

5. This study supports the conclusion of Special Commission 1 that an assessment of the relationship between mining in the Area and land-based mining should be made for each mineral separately. Assessment of the impacts of mining in the Area should also be carried out for each specific DLBPS that may be affected individually.

6. The members of the study group fully support the conclusion of Special Commission 1 that statistics on current export levels allow only preliminary identification of DLBPS which are likely to be seriously affected by the start of deep-sea mining. Specific impacts can only be assessed once mining in the Area has commenced. Such an assessment can be made by comparing certain quantitative indicators (such as the value of exports of affected metals' products and its contribution to the value of total export earnings, physical volumes of production of affected metals, the value of export earnings relative to GDP, etc.) before and after the beginning of seabed mining. It is important to understand, however, that provisionally identifying certain DLBPS as the States that may be most seriously affected does not mean that those same States will indeed be severely affected after the beginning of seabed mining.

7. Special Commission 1 emphasized that when assessing the impact of the start of seabed mining on DLBPS, it should be kept in mind that any change in the market situation affecting price dynamics is always determined by a set of diverse and/or multidirectional factors. It is very difficult to quantify the individual role of each of these factors. The members of the study group fully support this conclusion, while noting that, in addition to the obvious factors affecting mineral prices, there may also be hidden factors whose very existence is not obvious.

8. In assessing the potential impact of activities in the Area by the research group, the following factors have been taken into account:

i. the timing of the production of polymetallic nodules, its volume, and the number of affected metals (copper, nickel, cobalt, and manganese) which can be extracted from the mined nodules

ii. the demand/supply balance for each of the affected metals that may have developed by the time the mining of polymetallic nodules in the Area begins

iii. the place of any DLBPS in the markets of affected metals

iv. the role of the affected metals in the economy or export earnings of specific DLBPS.

9. In its work, the study group took into account assumptions from the economic model for polymetallic nodule exploitation developed by the Massachusetts Institute of Technology (MIT), as well as assumptions from the economic models proposed by the African Group, Germany, and China.

10. There is considerable uncertainty concerning the time frame of the commencement of mining, which is compounded by uncertainty concerning future processing of nodules. It is likely that individual contractors may start seabed mining in about 2027. It is also likely that the number of such contractors will increase in the following years and may reach 12 by 2035. If one contractor extracts 3 Mt of dry nodules per year, jointly they will produce 36 Mt of nodules. The processing of this amount of nodules could provide 356,400 tonnes of copper, 444,600 tonnes of nickel, 61,200 tonnes of cobalt, and 9.2 Mt of manganese. However, it is more realistic that only a few of the twelve contractors would be fully prepared to commence production on time. The remainder would continue working under exploration contracts, which will be extended under the 1994 Agreement.

11. At the average global market price over the past five years, the price of metals in 3 Mt of nodules would amount

to approximately USD173 million for copper, approximately USD436.5 million for nickel, and about USD220 million for cobalt. The nodules themselves are considered equivalent to manganese ores, meaning their price could amount to approximately USD425 million. The price of the manganese products that can be produced as a result of nodule processing will be several times higher. However, the specific composition of nodules (high phosphorous content) may have a negative impact on their demand as an equivalent to manganese ores and on their price.

12. The actual value of nodules and the products derived as a result of nodule processing will be determined by the market situation during the period of extraction.

13. In the analysis of trends and prospects for the development of affected metals markets (including supply and demand prospects), each market was considered separately. The selected retrospective level is 2008, and the selected forecast horizon is 2035. When estimating demand prospects for affected metals, consumption forecasts prepared by various consulting agencies and research groups were used. When assessing supply prospects for land-based producers, parameters of existing mines and expected indicators of projected mines were used.

14. Considering mining of polymetallic nodules and its potential impact on markets of affected metals, three scenarios were considered: minimum (two contractors), base (six contractors), and maximum (twelve contractors). All scenarios posit that the first contractor starts mining in 2027 and the second in 2030, while the remaining contractors (if applicable) join the process in 2031–2033. It is also assumed that a maximum aggregate production level of six or twelve contractors could be reached in 2035. Under these introductory conditions, three deep-sea mining scenarios for each of the metals in question were considered (Table E.1.).

15. **Copper:** There are a considerable number of world copper consumption forecasts. They are based on the expected growth rates of world GDP and population, the development of "green technologies", the transition to renewable energy sources, compliance with the Paris Agreement on the regulation of measures to reduce carbon dioxide in the atmosphere, and other factors. In this diversity of forecasts, the projected growth rate of copper consumption varies between 1.8–4 per cent per year.

16. Three cases of world copper consumption growth were chosen for the analysis: 2 per cent, 2.8 per cent, and 3.5 per cent.

17. It is expected that the bulk of land-based mine projects will be commissioned from 2025, and in 2035 they will be able to produce 10.3 Mt of copper (50 per cent of the current level). Production of secondary copper is also expected.

18. With global copper consumption growing by 2 per cent per year and the implementation of all land-based projects, the market will be saturated with copper until 2035, which will have a negative impact on price movements. Under such conditions, some of the land-based mine projects will be delayed or temporarily abandoned.

19. With copper consumption growth at 2.8 per cent per year, the threat of metal shortages may arise even if all projects are commissioned, but after 2032.

20. With global consumption growth at 3.5 per cent per year, metal shortages may occur after 2030, and if the commissioning of some of the projects is delayed for some reason, metal shortages may occur earlier.

Table E.1. Projected rates of mining of polymetallic nodules and production of affected metals with 2, 6 and 12 contractors mining

	2 contractors	6 contractors	12 contractors
Beginning of production, year	2027	2027	2027
Reaching full capacity, year	2032	2035	2035
Mining of polymetallic nodules at full capacity, tonnes	6,000,000	18,000,000	36,000,000
Production of affected metals with mining at full capacity, tonnes			
Cobalt	10,200	30,600	61,200
Nickel	74,100	222,300	444,600
Copper	59,400	178,200	356,400
Manganese	1,533,600	4,600,800	9,201,600

21. It can be expected that if the average annual growth rates of real consumption exceed 2–2.5 per cent, then from the mid-2020s, new land-based production projects will appear, including those based on the currently explored objects.

22. Mining of polymetallic nodules, with copper consumption increasing by 3.5 per cent per year alone, will not have any impact on the copper supply/demand balance; under such circumstances, even a maximum scenario would not have serious adverse effects on the market. However, there may still be some decline in copper prices, as possible supply tensions will be reduced. Under other consumption growth scenarios, a copper shortage may manifest itself either after 2032 or not at all, as all the world economy's copper needs may be met by land-based production and secondary metal. In this case, even small volumes of copper from polymetallic nodules may put additional pressure on the market.

23. **Nickel:** The main prospects for growth of nickel consumption are related to the electrification of motor vehicles and the production of high-capacity batteries. Estimates of nickel demand growth in this area vary greatly and range from four to 14 times increase by 2030.

24. Three cases of world nickel consumption growth were chosen for the analysis: 2.6 per cent, 4 per cent, and 5 per cent.

25. It is expected that the commissioning of new land-based mines will start in the next year or two. In 2035, they may provide about 750,000 tonnes of additional metal. As a result, nickel mine production may exceed the current level by one third.

26. Despite a significant increase in production with consumption growth of 2.6 per cent per year after 2029, the market may face a primary metal shortage. However, this forecast does not take into account stocks reserves (exchanges and companies) and secondary metal (there are prospects for growth of its production). Therefore, the shortage may turn out to be significantly lower.

27. In the other two scenarios, the market may experience a shortage over the whole period under consideration. This would create conditions for intensified preparations for the exploitation of known but inactive deposits. In addition, in recent years, there has been an increase in expenditures for nickel exploration, which may result in the identification of new deposits that can be put into operation quickly.

28. If production of polymetallic nodules starts in 2027 and increases with the intensity we expect, it will not cause overproduction of nickel even with the minimum expected growth rate of consumption, the commissioning of all currently known projects of new land-based mines, and offshore mining by twelve contractors. Only the first years of offshore mining couldbe an exception. The earlier appearance of nickel from polymetallic nodules on the market at the lowest expected growth rate of metal consumption may cause a significant surplus of the metal, which may persist for several years. Only if nickel consumption growth rates are higher than the low scenario of consumption growth, the beginning of offshore mining will not cause overproduction of the metal.

29. **Cobalt:** Almost all cobalt production is a by-product, mainly with copper (from sediment-hosted stratiform and stratabound copper deposits) or nickel (from magmatic nickel-copper-cobalt sulphide deposits and nickel laterites). As a result, the dynamics of cobalt mining and production are correlated with the production of copper and nickel from certain types of deposits. This determines the complexity of bringing the demand for cobalt and its production into a balanced state.

30. Prospects for cobalt consumption are linked to the lithium-ion batteries sector. At the same time, several factors (including price volatility and concerns about insufficient supplies) have led to changes in the chemical composition of lithium-ion batteries, which are aimed at complete replacement of cobalt or reduction of its content.

31. To date, there are quite a large number of forecasts for global cobalt consumption growth. Three cases were chosen for the analysis: 5.6 per cent, 7.2 per cent, and 8.8 per cent.

32. The commissioning of new land-based mines is expected to start in the next year or two. By 2035, they may provide 75,000 tonnes of additional metal. As a result, cobalt mine production may exceed the current level by one third even if some of the currently exploited fields are exhausted.

33. With an annual growth rate of 5.6 per cent in world cobalt consumption and the realization of all projects, a metal shortage may occur after 2028. Given the expected overproduction in previous years, the market may feel it with a delay.

34. If cobalt consumption grows by more than 7 per cent per year, the threat of a shortage will already occur in 2026–2027, even if all projects are commissioned.

35. The expansion of land-based production of cobalt is complicated by the by-product nature of its production. However, there is reason to believe that with the shortage approaching, the commissioning of projects based on cobalt-containing ore deposits, which are currently inactive or are in the early stages of exploration, will accelerate. The shortage of cobalt and the resulting price increase may also stimulate its fuller extraction from mined ores, primarily laterite ores.

36. If production of polymetallic nodules starts in 2027 and increases according to any of the scenarios we are considering, even with a minimum expected consumption growth rate (+5.6 per cent

per year) and the commissioning of all currently known new land-based mine projects, there will be no overproduction of cobalt. Only the first years of offshore mining could be an exception. However, significant overproduction of cobalt can be expected up to 2028 and is difficult to avoid. As a result, such large stocks of cobalt may accumulate in various warehouses that insufficient production would be compensated for by these stocks for a long time to come. Accordingly, the metal's prices will be at a low level. Then, the beginning of offshore mining will exacerbate the situation. At the same time, it is possible that the price level will be critical for offshore mining itself, making it low-profit or even unprofitable.

37. **Manganese:** The main factor determining the prospects of world manganese consumption is the dynamics of the steel industry's development, which, in turn, depends on the global economic situation as a whole.

38. Forecasts of manganese ore consumption made by various analysts are relatively close; it is expected to increase by 1–3 per cent per year. Three cases of manganese demand forecasts were chosen for the analysis: 1 per cent, 1.5 per cent, and 3 per cent.

39. Production of manganese ores in existing mines can increase by approximately 20 per cent by mid-2020s by expanding their capacity. In addition, in the next year or two, new land-based mines will be commissioned, which together could provide over 7 Mt of additional ore per year by 2035. As a result, production of manganese ore may exceed the current level by about a third by 2035.

40. If the consumption of manganese ores grows by 1 per cent per year (this scenario is possible with a decrease in steel output growth rates in China, which is forecasted by many analysts), demand for it will be provided by existing operations. At the same time, the production volumes of manganese ores may significantly exceed the consumption level, which will have a negative impact on prices. Market surpluses and low prices will force producers of manganese ore to reduce output or suspend operations, and most new mine projects will be frozen and exploration will be stopped.

41. If the consumption of manganese ores grows by 1.5 per cent per year, the capacity of the existing enterprises will be sufficient to provide manganese ores until 2030, and the shortage that may arise in the future will be covered by the existing projects.

42. At the growth of consumption of manganese ores by 3 per cent per year, the operating mines and ground projects can provide manganese ores only until 2025. Expectancies of shortages in the next years could cause intensification of development of new deposits, and also exploration works aimed at revealing new manganese ores deposits. Commissioning of new deposits may eliminate the potential shortage of raw materials.

43. A "niche" in the manganese market, which can be occupied by deep-sea mining, will emerge only if consumption of manganese ore grows by more than 2 per cent per year. At the same time, the volumes of "sea" manganese production, which the market will be able to absorb painlessly, will be determined by the consumption growth rate. If they are 3 per cent per year and production starts in 2027 at our anticipated rate, the manganese market is likely not to be adversely affected by the operation of no more than six contractors. With more contractors operating or at a lower rate of growth in consumption, the manganese market will be adversely affected, which may have a negative impact not only on land-based producers but also on the contractors themselves.

44. **Polymetallic nodules:** It is important to understand that the situation in the markets will also have an impact on the prospects for implementing seabed mining projects. A decrease in prices for one or more of the four affected metals, caused by any reason, automatically reduces the market value of polymetallic nodules as raw materials for the extraction of these metals. This decline may result in some or even all seabed mining projects becoming subeconomic or unprofitable. This transformation is possible both before and during seabed mining. At the same time, one should expect tougher competition between different market participants, which will include seabed mines; the survival of each of them will depend on the level of profitability at a certain level of prices for affected metals.

45. The market position of polymetallic nodules and, consequently, the profitability of their production projects will also be affected by the organization of their processing. At present, it is anticipated that nodules will first be processed to extract copper, nickel, and cobalt, and the remaining manganese-rich slag will then be sold to producers of manganese products (ferro-alloys or electrolytic manganese metal (EMM)). In this connection, the issue of interaction between different links of such an organizational and production chain remains unsolved.

46. **Assessment of potential impact on relevant DLBPS:** Offshore mining, under any scenario, will have a significant impact on the markets of affected metals, changing the direction and volume of supply of these metals. An additional factor of influence on affected metals markets and their participants will be a possible decline in prices for these metals. Both the change in the structure of markets and the decline in prices can have a negative impact on the economies and export earnings of DLBPS, with varying degrees of intensity. First of all, it may affect those DLBPS whose export deliveries are oriented to the markets of the contractor sponsoring countries.

47. DLBPS: Depending on the state and specialization of the economies of specific DLBPS, the degree of negative impacts of seabed mining may vary. Such an indicator as a share of export earnings from affected metals in export earnings of DLBPS as a whole is used as a criterion for estimation of the severity of negative effects. It is accepted that if at least 10 per cent of DLBPS export earnings are generated by affected metals, the economy of this DLBPS is dependent on the export of affected metals, and a decrease in income from it can lead to serious negative effects.

48. It has been determined that among the countries exporting affected metals which are likely to be most seriously affected by seabed mining, there are 13 DLBPS (Table E.2.).

49. It should be noted that this study identified DLBPS which are likely to be seriously affected by seabed mining, but did not offer any assistance or compensation to such DLBPS, since that issue is taken into account in the 1994 Agreement.

50. The 1994 Agreement establishes principles for the provision of economic assistance to developing countries which suffer serious adverse effects on their export earnings or economies resulting from a reduction in the price of an affected mineral or in the volume of exports of that mineral, to the extent that such reduction is caused by activities in the Area. According to the 1994 Agreement, ISA shall establish an economic assistance fund in the proportion of ISA's funds, which exceeds those necessary to cover the administrative expenses of ISA. For the establishment of such a fund, only those funds from royalty payments received by ISA from contractors, including the Enterprise, and voluntary contributions shall be used.

Table E.2. Copper, nickel, cobalt, and manganese products exporting countries which are likely to be most seriously affected by seabed production

	Products' share in export revenues (%)	*Products' share of GDP (%)*
Exporters of copper products		
Zambia	56.1	18.7
Democratic Republic of the Congo	55	11.1
Eritrea	50	5.6
Chile	48.9	12.8
Lao People's Democratic Republic	34.4	7.7
Mongolia	26	15.9
Peru	25.8	5.1
Exporters of nickel products		
Madagascar	20.3	3.7
Zimbabwe	15.6	3.1
Exporters of cobalt products		
Democratic Republic of the Congo	24.3	4.8
Exporters of manganese products		
Gabon	21.9	5
Cumulative effect of exports of all affected metals		
Mauritania	12	4.8
Namibia	11.4	4.9
Papua New Guinea	10.6	4.3

51. Thus, the first step for ISA is to determine the rates of royalty payments to be received from contractors in order to be able to pre-assess the possible extent of the economic assistance fund for the affected DLBPS. With the start of seabed mining, the amount and duration of economic assistance will be determined individually, taking into account the nature and magnitude of the problems faced by the affected DLBPS (1994 Agreement).

Introduction

52. For about half a century, humankind has been concerned that the rapidly increasing production of mineral resources could lead to the rapid depletion of the world's mineral resource base. The main reason for such anxiety is the fundamental importance of mineral resources both for the world economy and for existence of human civilization as a whole. Long-term provision of mineral resources to the economy is one of the guarantors of its sustainable development.

53. These fears are not quite groundless. Statistical data on production indicators of the world mining industry unequivocally show the increasing load on the Earth's mineral and raw material base. Thus, if we consider the basic metals contained in ocean polymetallic nodules, according to USGS estimates,[1] over the entire twentieth century, global copper production amounted to 396.4 Mt, and over the period from 2000 to 2015, to 251.2 Mt. For nickel, these figures were 34.8 and 28.6 Mt respectively; for cobalt, 1.34 and 1.31 Mt; and for manganese, 433.3 and 198.2 Mt. Therefore, it is natural to expect that at this rate of mining growth, there will be a moment when there will be no mineral resources available for humankind.

54. Indeed, increased mining has resulted in accelerated depletion of the resources of mined deposits, a reduction in the number of untapped deposits located in traditional mining areas or in easily accessible areas, and a decrease in the quality of mined ores. However, the vast majority of minerals are not experiencing quantitative reductions, as the data in Table 1.1 clearly demonstrate.[2,3,4] Among the metals presented in the table, the exception is manganese, but in 2016 its reserves increased to 690 Mt.[5]

55. The growth of resources against the background of increased production is based on two key factors. Firstly, there is active exploration with the involvement of new methods and techniques, including new areas, and secondly, the emergence of new and better known technologies in the field of ore processing, which transfers deposits unprofitable in the past into the category of profitable.

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1 USGS (2016). *Historical Statistics for Mineral and Material Commodities in the United States* (2016 version). National Minerals Information Center. https://www.usgs.gov/centers/nmic/historical-statistics-mineral-and-material-commodities-united-states.

2 Ibid.

3 USGS (1996). *Mineral Commodity Summaries 1996*. https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs-1996ocr.pdf.

4 USGS (2016). *Mineral Commodity Summaries 2016*. https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/mcs/mcs2016.pdf.

5 USGS (2017). *Mineral Commodity Summaries* 2017. https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/mcs/mcs2017.pdf.

56. Thus, the exhaustion of raw-material bases of industrial metals in general is a distant prospect. Nevertheless, active work is being done to identify potential and promising sources of minerals. These include the mineral resources of the world's ocean floor.

Table 1.1. Land-based resources of copper, nickel, cobalt and manganese in 1995 and 2015, and joint production of these metals in 1995–2015

Metal	Identified land-based resources		Total mine production for 1995–2015
	1995	2015	
Copper (Gt)	1.6	2.1	0.3
Nickel (Mt)	130*	130*	34
Cobalt (Mt)	11	25	1.5
Manganese (Mt)	680**	620**	235.6

* – resources containing at least 1% nickel
** – reserves; no resource estimate

57. The emergence of a major source of a new type of raw material and the beginning of the process of its development raise the question of what consequences it may provoke for the world market of raw materials in general and its individual participants in particular. This question is usually of a theoretical nature. However, in relation to the resources of the ocean floor, it is of fundamental importance. The reason for is that, according to the UNCLOS, "the area of the seabed and ocean floor and the subsoil thereof, beyond the limits of national jurisdiction, as well as its resources, are the common heritage of mankind, the exploration and exploitation of which shall be carried out for the benefit of mankind as a whole", while "[a]ctivities in the Area shall … be carried out in such a manner as to foster healthy development of the world economy and balanced growth of international trade, and to promote international cooperation for the over-all development of all countries, especially developing States, and with a view to ensuring: … f) the promotion of just and stable prices remunerative to producers and fair to consumers for minerals derived both from the Area and from other sources, and the promotion of long-term equilibrium between supply and demand; … h) the protection of developing countries from adverse effects on their economies or on their export earnings resulting from a reduction in the price of an affected mineral, or in the volume of exports of that mineral, to the extent that such reduction is caused by activities in the Area" (UNCLOS, Article 150 (f, h)).

58. Under the regime of the Area established by the UNCLOS and the 1994 Agreement, activities in the Area are organized and controlled by ISA. Among other, the functions of ISA include "study of the potential impact of mineral production from the Area on the economies of developing land-based producers of those minerals which are likely to be most seriously affected, with a view to minimizing their difficulties and assisting them in their economic adjustment, taking into account the work done in this regard by the Preparatory Commission".

59. A study has been carried out in line with the terms of the references endorsed by the Legal and Technical Commission at its meetings in March 2019.[6]

60. The purpose of the study is to inform the Legal and Technical Commission, in performing the function of the Economic Planning Commission, with a preliminary assessment[7] of the potential magnitude of any impact on developing land-based producers who may suffer serious adverse effects on their export earnings or economies as a result of a reduction in price or reduction in the volume of affected metals, and where such reduction

6 See paragraph 14 of ISBA/25/C/19.
7 At this stage, the study will be indicative of the potential magnitude of any impact, and consideration of how this is properly traced through the value chain at the later stage of exploitation activities.

could be caused by activities in the Area. The study is also expected to make an important contribution to the development of an economic assistance policy by ISA in accordance with the principles established by the 1994 Agreement (Annex, Section 7), and to recommend areas of further study or research.

61. The study concerns four metals contained in polymetallic nodules: copper, nickel, cobalt and manganese.

62. This report presents the results of the study.

Objectives and methodology

63. Potential seabed mineral production (including polymetallic nodules production) for DLBPS and their evaluation criteria were considered by Special Commission 1 of the Preparatory Commission. Areas for in-depth studies to be carried out to examine the possible impacts of seabed mineral production on DLBPS were also identified at that time. These included, in particular, the following areas:

i. projection and estimation of the production volume of each of the metals from mining in the Area

ii. assessment of the interaction between land-based mining in the Area and production in the context of the world supply and demand situation and the various world markets; such an assessment should indicate short-term (less than 5 years), medium-term (between 5 and 20 years) and long-term (more than 10 years) trends

iii. quantitative assessment of the impact on export and economy.

64. These directions were in line with the key tasks assigned to the research team by ISA.

65. The research team was also tasked with identifying and demonstrating development trends in copper, nickel, cobalt, and manganese markets.

66. In accordance with the recommendations of Special Commission 1, the year 2035 was chosen as the forecast horizon for the study.

Projection or estimation of the volume of production of each metal from mining in the Area

67. Owing to the uncertainties in the timing of the commencement of mining in the Area and its possible scale, the only possible approach to addressing this issue was a scenario-based approach. The start of the production scenarios considered were based on the completion dates of the current exploration contracts. Information in the public space regarding the status of exploration contracts, which expire in 2021, and the readiness of the processing industry to operate on new raw materials was also taken into account. This has made it possible not only to assess the possible timing of the commencement of production, but also the maximum number of contractors who may be ready to commence production during the period under review. The results, combined with the economic model of the MIT (2019), allowed identification of scenarios for deep-sea production development.

68. In order to estimate the production of each of the four metals considered (copper, nickel, cobalt, and manganese) by mining in the Area, data on the productivity of one polymetallic nodule mining contractor (including the rate of full productivity), the polymetallic nodule contents of those metals, and the recovery rates of those metals as shown in the economic model of the MIT (2019) were used. Production

volumes for different scenarios were proportional to the number of contractors producing in a given estimated year.

69. As a result, the study considered three possible scenarios for the development of deep-sea mining: a minimum scenario involving two contractors; a baseline scenario involving six contractors; and a maximum scenario involving 12 contractors. All of the scenarios assumed the following:

i. the first contractor starts production in 2027 and the second one in 2030; the remaining contractors (subject to their participation) join the process in 2031–2033

ii. a maximum aggregate production level of six or twelve contractors may be reached in 2035

iii. each contractor achieves full capacity progressively over three years: the first year, 33 per cent (1 Mt of dry nodules), the second year, 66 per cent (2 Mt of dry nodules), the third year and beyond, 100 per cent (3 Mt of dry nodules).

Assessment of the relationship between mining in the Area and land-based production in the context of the world supply and demand situation and the various markets around the world

70. This task required a comparison of the expected supply/demand balance in the copper, nickel, cobalt, and manganese markets over the period under review with the possible production of these metals in the Area.

71. To assess potential demand, current consumption projections of the affected metals made by various research groups and international organizations, as well as some interested companies, were used. Since these forecasts are multiple, we also used a scenario approach. For these purposes, we chose three cases: minimum, maximum, and basic (intermediate).

72. In order to assess the potential proposal, a possible land-based mining production was assessed for the period until 2035.

73. Possible future production consists of two components: production of currently operating mines and production that can be achieved through new deposit development projects.

74. The expected production from existing mines was determined based on actual production in 2018, taking into account planned expansion projects for existing capacity (if any). At the same time, the resource base of the enterprises was taken into account while maintaining production at the achieved or planned level. In this way, the operations that could drop out during the period under review due to the complete exhaustion of resources were identified. Prospects of expansion of resource base at the expense of geological exploration works and, accordingly, possible prolongation of term of existence of the operations, were not considered. The main source of information for this was mining companies' reports.

75. Due to the fact that data is not available for all the countries in operation, in order to get the most complete picture of the world mining industry, the missing production volumes were recorded based on official government statistics and/or industry statistics. This primarily concerned China, but also several other countries such as DR Congo and some in Latin America (Chile, Peru, etc.). Data for the country as a whole were also drawn from relatively small producing countries. Taking this part of production into account, it was assumed that it would remain at 2018 levels.

76. When assessing production at the fields currently under development, the expected (design) production and planned commissioning dates of the projects were taken into account. If the commissioning dates for a project are not defined by the company that implements the project, they have been evaluated on the basis of its implementation stage (preproduction, construction, feasibility study, prefeasibility study). The possible term of existence of the operations was also considered on the basis of design productivity and the size of the resource base.

77. As part of the scenario approach, all the projects under consideration were conditionally divided into "Proved" and "Possible" categories in terms of their potential involvement in operation.

78. Comparison of consumption growth scenarios with land-based production scenarios allowed estimation of possible balance of supply and demand in the period under review. Inclusion of the expected levels of metal production in the Area under different scenarios made it possible to assess possible interaction between land-based and offshore production depending on market developments.

Analysis of market trends for affected metals

79. The analysis of trends characterizing the markets of affected metals was carried out on the basis of data reflecting the dynamics of production of various products (primary, semi-finished, and end products), dynamics of their consumption and international trade, and world market prices.

80. The materials of British Geological Survey (BGS), International Copper Study Group (ICSG), International Nickel Study Group (INSG), Cobalt Institute, International Manganese Institute (IMnI), and United States Geological Survey (USGS) were the sources of production and consumption data. Websites of the International Trade Centre (ITC) and Chatham House, the Royal Institute of International Affairs were the sources of international trade data.

81. The period under consideration included 2008–2017.

Quantitative assessment of consequences for export and economy

82. Depending on the state and specialization of the economy of a particular DLBPS, the degree of adverse impacts from seabed mining may vary. Criteria for identifying DLBPS which may be most severely affected by seabed mining have been proposed by Special Commission 1. These criteria are called dependency thresholds. They make it possible to estimate how much the export earnings or the DLBPS economy depends on the four affected metals. It was assumed that States whose dependency levels exceeded the established values could be severely affected by seabed mining.

83. In this study we used such thresholds of dependence as absolute value of export revenue in total DLBPS export revenue and value of export revenue from four minerals in DLBPS economy. It is accepted that if at least 10 per cent of DLBPS export revenue is generated by the affected metals, the total export revenue of this DLBPS depends on the export of the affected metals. The second criterion used is the share of export earnings in DLBPS GDP: if at least 5 per cent of GDP is based on export earnings from the four affected metals, the economy of this DLBPS is dependent on exports of the affected metals. If a DLBPS met the criteria, the State was considered dependent on one or more of the four metals affected. The decrease in that State's income from the export of those metals, due to seabed mining, could then have serious negative consequences.

1. Overview of work done by the Preparatory Commission

84. While establishing an international régime for the newly-defined maritime zone, "the Area", i.e. "the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction" (UNCLOS, Article 1 (1)), the UNCLOS dealt with a number of related issues, one of them being "the protection of developing countries from adverse effects on their economies or on their export earnings resulting from a reduction in the price of an affected mineral, or in the volume of exports of that mineral, to the extent that such reduction is caused by activities in the Area, ..." i.e. "all activities of exploration for, and exploitation of, the resources of the Area" (UNCLOS, Articles 150 (h) and 1 (3)).

85. In the above context, pursuant to paragraphs 9 and 5 (i) of Resolution I of the Third United Nations Conference on the Law of the Sea, the Preparatory Commission for the ISA and for the International Tribunal for the Law of the Sea, during its resumed session in Summer 1983, established Special Commission 1.

86. Mandate of the Special Commission included "undertak(ing) studies on the problems which would be encountered by DLBPS likely to be most seriously affected by the production of minerals derived from the Area with a view to minimizing their difficulties and helping them to make the necessary economic adjustment, including studies on the establishment of a compensation fund, and submit(ting) recommendations on the [ISA] thereon" (Resolution 1, paragraph 5 (i)).

87. The Special Commission started its work in Spring 1984 during the second session of the Preparatory Commission. Understanding that "in studying the problems of DLBPS, it is necessary to know, first, which minerals would be produced from sea-bed sources; second, how the introduction of the minerals from this new source would affect the existing land-based producers; third, what would these effects be and which developing States would be affected; fourth, what problems or difficulties, in connection with these effects, these developing States would encounter; and finally, what could be done to minimize these difficulties" informed the programme of work of Special Commission 1. The programme included the following subject areas:

i. projection of future production from the international seabed Area
ii. relationship between production from the Area and existing land-based production
iii. identification, definition and measurement of effects of seabed production on DLBPS
iv. determination of the problems/ difficulties that would be encountered by the affected DLBPS

v. formulation of measures to minimize problems/difficulties of affected land-based producer States.

88. The discussions revealed the interrelationships between all these areas, especially between (ii), (iii) and (iv). Furthermore, the need for relevant data and information was recognized and discussed on several occasions by the Commission. In this regard, the discussions on the problematic areas have been conducted in an integrated manner. Nevertheless, four main areas of concern can be identified:

i. projection of future production from the international seabed Area

ii. relationship between production from the Area and existing land-based production; Identification, definition and measurement of effects of seabed production on DLBPS; Determination of the problems/difficulties that would be encountered by the affected DLBPS

iii. formulations of measures to minimize problems/difficulties of DLBPS

iv. data and information needs.

89. Regarding the necessary data and information, the Commission concluded that the following topics are of particular importance:

i. information about minerals, their markets, production, consumption, export, import, trade flows, prices, etc.

ii. information about DLBPS, their production, and importance of minerals for their economies

iii. information of the existing international or multilateral economic measures that can be related to the work of the Special Commission.

90. It should be noted that the mandate of Special Commission 1 was of a somewhat different nature from that of the other organs of the Preparatory Commission. It did not presuppose procedural preparation for the start of the functioning of various structures, but the conduct of studies, mainly aimed at determining the potential impact of future development of the seabed on the production of relevant minerals in developing States, and making recommendations on the basis of such studies. So, the work of the Special Commission was very difficult from a technical point of view; it provided for the use of data and information, research and analysis, studies and assessments. As a result of this work, it was recognized that its documentation, which is a report on its work, is an extremely useful source of material for ISA. In this regard, all the documentation of Special Commission 1 is fully presented in the Report of the Preparatory Commission for submission to the Assembly of ISA at its first session (document LOS/PCN/153). These documents were included in volumes VI–IX.

A. Analysis of work in connection with potential impacts

Minerals that were used as a basis for identification of potential impact

91. Special Commission 1 came to a conclusion that ISA should concentrate its work on polymetallic nodules, including the projected timing of commercial production from the Area. It was further decided to concentrate work on extraction of copper, nickel, cobalt, and manganese, which appeared to be more cost-effective, rather than consider all the minerals contained in polymetallic nodules. For other minerals, it was recommended by the Special Commission 1 to keep in view all the trends and developments regarding them.

Relationship between seabed mineral production and the price and the volume of export of the relevant mineral

92. Regarding the relationship between production in the Area and existing land-based production (identification, definition, and measurement of effects of seabed production on DLBPS; determination of the problems/difficulties that would be encountered by the affected DLBPS) Special Commission 1 came to the conclusion that, taking into account the fact that seabed mining will only occur in the future, the above matters cannot be studied with any reasonable degree of precision and accuracy. In this regard, ISA should concentrate on relevant data, information, and analysis, as well as on the expected time frame for the beginning of production from the Area, which requires projections regarding the demand for manganese, copper, nickel, and cobalt contained in polymetallic nodules to identify.

93. Based on this, the Commission came to the conclusion that it is more efficient to assess the relationship between the production from the Area and land-based production for each mineral separately. This assessment should be of a long-term nature.

94. A similar approach should be used to assess the effects of production from the Area. These should be considered separately for each state that could be affected.

95. The Commission identified that the adverse effects of seabed mineral production on the export earnings and economies of DLBPS are the possibility of excess supply of primary products extracted from the relevant minerals and resulting price reductions. In addition to that, there is an opportunity for consumer countries to supply the import demand with the seabed mineral production, which would lead to a reduction in export volume from DLBPS to these countries.

96. Price reduction for certain mineral or a reduction in its export volume may lead to reduction in export earnings or to adverse effects on the economies of DLBPS. These adverse effects may lead to:

i. direct reduction of earnings for DLBPS
ii. increase in unemployment
iii. lack of foreign currency
iv. reduction in state income and reduction in development investment funds
v. so-called side effects such as reduction in production of minor minerals
vi. multiplier effect which reflects the connections of affected mining sectors with other sectors of the economies of DLBPS.

97. Difficulties may also be encountered in terms of balance of payments, economic slowdown, social upheaval, and political implications.

98. At the same time, Special Commission noted that the main issue for DLBPS may be their limited ability to counter and control these effects and not the effects themselves, whereas the degree of limitations may be different for each state depending on a number of factors. This requires examination by ISA.

Isolation of the effects of seabed exploitation

99. Special Commission 1 noted that it is an issue to identify if the price reduction for a certain mineral or reduction in export volume from DLBPS was caused by seabed production of the mineral, because it could be the cumulative effect of seabed mineral production as well as other factors. Thus, if the seabed mineral production begins simultaneously with commissioning of a big new land-based mining operation, the resulting price will reflect the impact of the new mineral flow both produced from the seabed and from the new land-based mining operation. To identify the impact of flow of minerals produced from the seabed, it is necessary to separate it from the impact of the minerals produced from the new land-based mining operation.

100. Following this reasoning, a list of factors which can act simultaneously with seabed mineral production and impact the price or export volume of the relevant minerals, was composed. The effects of these factors must be isolated. The list included the following factors:

i. change of economic environment in relevant DLBPS

ii. changing situation of the market of relevant metals

iii. change in supply of relevant metals from other sources and change of production costs from other sources

iv. change of technology in exploitation, processing and use of relevant metals

v. substitution of one mineral for another

vi. natural disasters occurring in the relevant time frame

vii. strikes or riots occurring in the relevant time frame

viii. changing situation in DLBPS regarding reserves and resources of relevant metals

ix. change in the system of using of secondary resources (recycling)

x. cyclical fluctuations of economy

xi. fluctuations of exchange rates, etc.

101. It was noted that these factors should be taken into account in developing the methodology of identifying the price reduction for the affected mineral or the export reduction of the mineral caused by the seabed mineral production.

B. Criteria for or background to concept of serious adverse effects

102. Special Commission 1 noted that the characterization of adverse effects of seabed production on the export earnings or economies of DLBPS involves a combination of two aspects:

i. one or more of the four minerals concerned–copper, nickel, cobalt, and manganese–have an important or significant role in the total export earnings or economies of the individual DLBPS, that is, the individual DLBPS have to be dependent to a certain degree on these minerals

ii. there has to be a decrease to a somewhat substantial extent in the export earnings of individual DLBPS from the export of these minerals, or an unfavorable change to a somewhat substantial extent in the economies of individual DLBPS.

103. These two aspects of the dependency of a DLBPS on the export earnings of the four minerals concerned, and a somewhat substantial fall in export earnings, have been discussed by Special Commission 1. There have been attempts to characterize the dependency aspect in a quantifiable manner with the use of some figures. These are called "dependency levels". Likewise, there have been attempts to characterize the aspect of somewhat substantial unfavorable change after seabed production occurs in a quantifiable manner with the use of some figures. These are called "trigger levels", because they form the basis of triggering some action by the organization concerned.

104. Under agreements reached in Special Commission 1, a DLBPS can contact ISA if it considers that it is affected or is likely to be affected. ISA will examine the request of the State and will conduct an in-depth investigation with a view to identify common effects on the export earnings and economy of the State, to find out to what extent these effects were or will be a result of seabed mineral production, and to determine the remedial measures to be taken, if necessary.

Criteria for identification of DLBPS likely to be seriously affected as a result of seabed production of minerals

105. In conformity with the provisions of Articles 150 (h) and 151 (10) of the UNCLOS, Special Commission 1 agreed that the criteria by which DLBPS should be considered most seriously affected by seabed mining would be related to export earnings or economies of DLBPS. These criteria will be based on the extent to which individual States depend on the contribution of copper, nickel, cobalt, and manganese to their export earnings and their economies before the beginning of the seabed mining.

106. Special Commission 1 concluded that the following can be used as quantitative indicators reflecting the role of the metals in question in export earnings and the DLBPS economy:

i. absolute value of exports of the four minerals

ii. absolute value of export earnings in relation to total export earnings

iii. absolute amount of production

iv. value of production in relation to total gross national product (GNP) or total gross domestic product (GDP)

v. value of export earnings from the four minerals in relation to the economy

vi. some combination of various quantifiable yardsticks related to export earnings and those related to economies; the Special Commission, if it preferred such combination, should have expressed this quantitatively.

107. The Commission concluded that the most efficient implementation of these criteria lies in the use of relevant statistical data. Under this approach, the emphasis should be placed on statistically measurable indicators.

108. Members of Special Commission agreed that the effects on export earnings are more suitable for statistical assessment than the effects on economy. The clearest statistically measurable indicator of export earnings from one or more minerals concerned is their price. It was noted, however, that such an assessment is related to a number of issues, among them the need to consider the export on barter basis correctly. One direct economic indicator is the value of production of one or more of the four mineral commodities concerned. It was noted that the main issue to be considered with regard to the value of production is the availability of statistics on the valuation of the amounts of outputs in the mineral sectors concerned. For the purpose of measuring gross domestic or national product accountable to these sectors, double-counting of the values of secondary inputs has to be avoided. The prices at which the outputs are valued should be the prices the producers receive rather than any reported prices. This is considered a major issue in the present and was so in the past.

109. The criteria for identification of DLBPS likely to be seriously affected as a result of seabed mineral production will be the "critical" levels of certain indicators that require identification. It was noted by the Commission that the "critical" levels of numerical indicators can change depending on many factors, such as:

i. production capacity of certain States regarding one or more relevant minerals
ii. projected future production
iii. size of raw material base (resource) of relevant minerals
iv. GDP and per capita income
v. population size
vi. size of the State
vii. geographical position of the State.

110. Special Commission pointed out that statistical data on the current level of export can only allow preliminary identification of relevant developing states. It was emphasized that preliminary identification of various DLBPS as states likely to be seriously affected will not presume that these states will be identified as seriously affected after the seabed mining occurs. The final identification of DLBPS that will be seriously affected by seabed mining will only be possible by taking into account the actual effects of seabed mining on export earnings or the economy of relevant DLBPS.

111. During the work of Special Commi-ssion, the question of categorization of DLBPS based on the dependence of their economies and export earnings on the production and export of copper, nickel, cobalt, and manganese was actively discussed. It was originally suggested that three DLBPS categories should be distinguished based on their dependency: i) dependent, ii) highly dependent, and iii) very highly dependent. Accordingly, it was also suggested that three DLBPS groups should be distinguished by their level of probable negative impact: i) likely to be affected, ii) likely to be seriously affected, and iii) likely to be most seriously affected.

112. These proposals were subsequently revised, and as a result, Special Commission decided to designate only one category of DLBPS by degree of dependency: "dependent". This category

should include DLBPS which have received on average at least 10 per cent of their annual export earnings from exports of the metals in question over the 3 years preceding the application. Regarding the "least developed" DLBPS identified in the relevant United Nations documents, critical levels of dependency shall be reduced by 33 per cent. In certain cases, when DLBPS can demonstrate that they are likely to face, or are facing, certain issues as a result of seabed mineral production, ISA can consider them "dependent" even if the percentage of relevant metals in their export volume is lower than the established percentage.

Serious adverse effects of seabed mining

113. Special Commission 1 emphasized that it is essential to agree on criteria to be used by ISA to determine, when seabed mining occurs, whether or not the effects on the export earnings or economies of the DLBPS concerned are serious.

114. After seabed mining occurs, if the observed effects on the export earnings or economies of the DLBPS concerned are of an extent more than or equal to the established indicators, ISA shall carry out an in-depth study, which will include a thorough assessment of the effects of seabed production in the Area on the DLBPS concerned and associated problems. The study will be carried out on a case-by-case basis; the cases will pertain to particular DLBPS and particular minerals. In the course of the study, one of the most important matters that should be addressed is whether, and to what extent, the observed serious effects have been caused by seabed production. The conclusions made by ISA following the findings of the in-depth study will form the basis for the application of appropriate remedial measures.

115. The following formulations to categorize serious adverse effects were suggested:

A. The adverse effects on the export earnings of DLBPS could be considered to be serious if, in the year seabed production occurs:

i. the price of any of the four minerals concerned–copper, nickel, cobalt, and manganese–falls by an average of (X per cent) from the price of these minerals in the previous year; or

ii. the volume of exports of any of the four minerals from the DLBPS, provisionally identified previously, falls by (Y per cent); or

iii. the export earnings of the DLBPS, provisionally identified previously, from the four minerals falls by (Z per cent).

B. The adverse effects on the economies of DLBPS could be considered to be serious if, in the year seabed production occurs:

i. the national income of the DLBPS concerned falls by (N per cent) from the previous year; or

ii. the rate of economic growth of the DLBPS concerned falls by (M) percentage points; or

iii. the rate of unemployment in the DLBPS concerned increases by (P) percentage points; or

iv. the foreign exchange reserves of the DLBPS concerned fall by (R per cent).

116. Following the results of the discussion, Special Commission made a decision whereby the trigger threshold is the actual fall (if the applications are submitted after the commencement of commercial production from the Area) or the estimated fall (if the applications are

submitted before the commencement of commercial production from the Area) in the export earnings of a particular DLBPS from the export of one or more of the four metals concerned by at least 10 per cent in comparison with the situation where there is no seabed production. In the cases of the "least developed" among the DLBPS, identified in the relevant United Nations documents, the dependency thresholds and the trigger thresholds shall be reduced by 33 per cent. In the cases of DLBPS where the actual or estimated fall in export earnings from the export of one or more of the four metals concerned is less than 10 per cent, the trigger thresholds under which ISA should determine, on a case-by-case basis, necessary remedial measure or measures to help that particular DLBPS, were discussed but not fully coordinated.

C. In-depth investigation of potential effects of seabed mineral production on DLBPS

117. Following the results of the discussion, Special Commission 1 came to the conclusion that there are two main fields that require thorough investigation regarding the in-depth study of potential effects of seabed mineral production on DLBPS:

a) After the beginning of seabed exploitation, the resulting price of a certain mineral and the volume of export of this mineral from DLBPS can be affected by other factors aside from seabed mineral production. These factors can be of an internal nature as well as of an external nature to the DLBPS. It is necessary to take these factors into account to identify the effects of the seabed mineral production as such. This is a technically complex area.

b) The problems of DLBPS will be to a large extent associated with the limited abilities of these States to eliminate the effects of seabed mineral production on their export earnings or their economies and to control these effects. It is necessary to thoroughly assess these limitations, and any long-term remedial measures should take into account the elimination of these limitations.

118. The plan agreed on by the Special Commission 1 for an in-depth study of the potential impact of seabed production from the Area for DLBPS and related issues coordinated included the following positions:

a) Identification of exploited resources of the Area, and the metals extracted from these resources.

b) Forecast or estimation of volume of production of each metal from the Area.

c) Assessment of the relationship between production from the Area and land-based production, within the context of the world supply-demand situation and the different world markets as well as different trade practices; such assessment should indicate the short-term (less than 5 years), medium-term (5 to 20 years) and long-term (longer than 10 years) trends.

d) Formulation of methodology to establish to what extent effects on price or volume of exports of a metal of a DLBPS can potentially result from or are caused by production of the metal from the Area. Such a methodology shall take into account: world metal market situation; changes in consumption patterns; production from maritime zone under national jurisdiction; substitution; recycling; technological developments; and other relevant factors, such as the general economic conditions, government policies, and the exhaustion of deposits within the national jurisdiction of the DLBPS concerned.

e) Quantification of effects on exports.

f) Quantification of effects on economies, taking into account various factors.

such as:

i. Unemployment, to the extent that it is caused by or related to reduced production of the four metals.

ii. Lack of development as a result of reduced government revenues from the four metals.

iii. Side effects, such reduced production of accessory minerals as a result of the reduction in the production of the four metals.

iv. Multiplier effects on the economy as a whole.

g) Investigation of the problems directly linked with the effects, including assessment of capabilities and limitation of the affected State to counter or control the effect.

h) When applications are made simultaneously, a study should be made in order to determine in what way the adverse effects of seabed production would cause more problems to certain DLBPS as compared to other land-based producers, in order to establish priorities.

119. It was found that measurement of actual effects should be carried out only after seabed production occurs.

2. Overview of mineral production from activities in the Area

A. Types of mineral resources and affected metals for study purposes

120. The contracts for exploration currently cover all three mineral resources for which the ISA has adopted regulations on exploration. These are polymetallic nodules, polymetallic sulphides, and cobalt-rich ferro-manganese crusts. ISA has adopted regulations on prospecting and exploration of these minerals, and to date thirty contractors have concluded contracts with ISA for exploration of these mineral resources.

121. In this study, only polymetallic nodules are considered as minerals. This study will be focused on polymetallic nodules.

122. Polymetallic nodules consist of more than 50 metals, including precious, refractory, and rare earth elements (REE).[8] The Preparatory Commission recommended to concentrate only on four metals: copper, nickel, cobalt, and manganese, extraction of which seemed to be economically feasible. Economic models developed by the MIT, African Group, and China Central South University are also based on extraction of these four metals from nodules. However, according to MIT experts, thallium, rubidium, other rare earth elements & yttrium, titanium, and precious metals are also of economic interest. The model prepared by the German Federal Ministry for Economic Affairs and Energy Model (BMWi) provides only the extraction of copper, nickel, and cobalt.

123. In this study, four metals contained in polymetallic nodules were considered: copper, nickel, cobalt, and manganese. We do not allow for failure to extract manganese from nodules, as it contradicts the principle of rational management of the resources of the Area for the benefit of mankind as a whole (UNCLOS, Article 150 (b)). Failure to extract manganese will also principally lower the economic performance of nodule exploitation, which will result in reduction in derivative payments, including payments to ISA.

124. The assessment of resource potential of polymetallic nodules from the Clarion-Clipperton Zone and manganese, copper, nickel, and other metals contained in these nodules is provided in Table 3.1.

125. It is notable that the number of metals contained in polymetallic nodules exceeds the reserves and resources of land-based deposits or is consistent with them. This makes it necessary to consider

[8] Kuhn T., Wegorzewski A., Rühlemann C., and Vink (2017). A Composition, Formation, and Occurrence of Polymetallic Nodules. In R. Sharma (ed.), *Deep-Sea Mining: Resource Potential, Technical and Environmental Considerations*. Springer, pp 23–63.

Table 3.1. Amount of metals in manganese nodules from the Clarion-Clipperton Zone compared to land-based reserves and resources

Elements	Visbeck M, Gelpke N (2014) (Mt)	ISA (2012)* (Mt)	Global resources on land (both economically and sub-economic)[9] (Mt)	Global reserves on land[10] (Mt)
Nodules	21,100	21,100–30,700		
Manganese (Mn)	5,992	5,950–8,657	N/A	810
Copper (Cu)	226	234–341	2,100	870
Nickel (Ni)	274	270–393	130	89
Cobalt (Co)	44	46.4–67.5	25	7.0
Titanium (Ti)	67		1,200	491
Rare earth oxides	15		N/A	120
Molybdenum (Mo)	12		25	18
Lithium (Li)	2.8		80	17
Tungsten (W)	1.3		N/A	3.2
Niobium (Nb)	0.46		N/A	13.0
Arsenic (As)	1.4		N/A	N/A
Thorium (Th)	0.32		6.4	N/A
Bismuth (Bi)	0.18		N/A	N/A
Yttrium (Y_2O_3)	2		N/A	0.5
Platinum group metals	0.003		0.1	0.07
Tellurium (Te)	0.08		N/A	0.03
Thallium (Tl)	4.2		0.017	N/A

* – Inferred Resources

the technological, financial, economic, and market aspects of extraction of polymetallic nodules in further studies. It is obvious that economic indicators of deep-sea mining and all derivative payments will increase due to the processing capability of commercial extraction of additional metals. At the same time, it can negatively affect the wider range of raw material markets and widen the list of DLBPS likely to be affected as a result of exploitation in the Area, which needs to be addressed separately.

[9] USGS (2020). *Mineral Commodity Summaries 2020.* https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

[10] Ibid.

B. Assumptions for future mineral resource production in the Area

126. As of December 2019, 18 contracts for exploration of polymetallic nodules had entered into force. A complete list of the contracts, with details of the sponsoring State (States) and the dates of expiry of each contract, is provided in Figure 3.1.

127. In our assumptions for future mineral exploitation in the Area, we proceed from the following input conditions:

i. the regulations on exploitation of mineral resources in the Area are to be adopted in 2020

ii. applications for approval of a plan of work for exploitation of mineral resources in the Area in the form of contracts are to be submitted by the applicant after the expiry of its contract for exploration

iii. the duration of the design and build phase preceding the beginning of production is 2–4 years (Figure 3.2).

Figure 3.1. Timing of contracts for exploration for polymetallic nodules

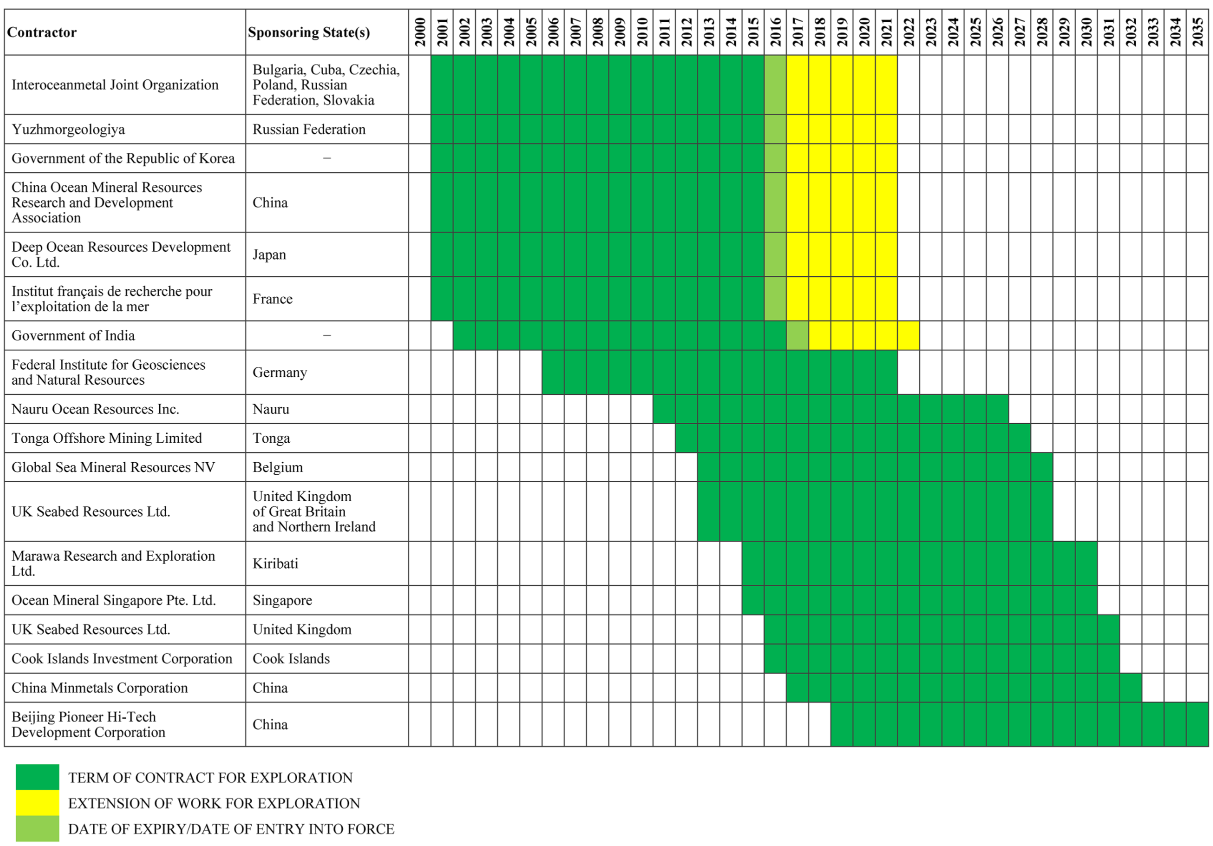
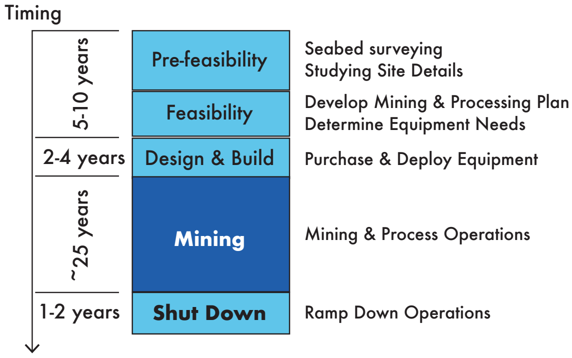


Figure 3.2. Modelled progression of seabed mining activities



Source: MIT, 2019.

128. Two scenarios were considered:

a. First applications for approval of a plan of work for exploitation of mineral resources in the Area are submitted in 2021, after the expiry of timing of the first extension of contracts for exploration works. In this case, the first contract for exploitation of polymetallic nodules can be signed in 2022. Then, considering the duration of the Design & Build phase, exploitation can begin already in 2025–2027 (Figure 3.3).

b. Contracts for exploration expiring in 2021 are extended for 5 years, until 2026. Then first applications for approval of a plan of work for exploitation of mineral resources in the Area can as well be submitted in 2026, and the first contact for exploitation of polymetallic nodules can be signed in 2027. In this case exploitation (considering the duration of the Design & Build phase) can begin in 2030–2032 (Figure 3.4).

129. It seems that, if the contractors with the contracts for exploration expiring in 2021 planned to proceed to exploitation, they would have already declared their intentions. Our confidence is based, above all, on the necessity to find investments for realization of projects for exploitation of polymetallic nodules. In the practice of land-based mining companies, this is preceded by open publication of feasibility study results. This information is currently absent from the public space. However, one of the contractors reported the completion of a preliminary economic assessment only in 2019, bearing in mind that it precedes pre-feasibility and feasibility studies. It is noted that the activities undertaken do not allow the contractor to make investment decisions. It is emphasized, however, that the results justify further analytical work and technological studies.[11] Another contractor stated that it plans to carry out a mining system test at a depth of 1,000 m,[12] in around 2020. It is obvious that such timing will not allow the contractor to prepare for the beginning of exploitation in time according to scenario A. Thus, we believe that probability of realization of scenario A is low, while scenario B appears more realistic.

130. In our assumptions for future exploitation, it is necessary to take into account the possibility of submitting an application before the expiration of the contract for exploration. To date, this applies to one of the contractors, which declared its intentions to begin commercial extraction by 2027.[13] It is quite possible, however, that its plans will change (specifically due to the unfavourable market situation in the market of affected metals). It is possible that other companies will follow the same path, but in the longer

[11] Interoceanmetal Joint Organization (2019). Preliminary Economic Assessment Technical Report IOM polymetallic nodules project in CCZ, Pacific Ocean. https://iom.gov.pl/wp-content/uploads/2019/05/pdf-23-Balaz-et-al-2019.pdf.

[12] Chinadialogueocean.net (2019). China's deep-sea mining, a view from the top. https://chinadialogueocean.net/10891-china-deep-sea-exploration-comra/.

[13] Nature.com (2019). Seabed mining is coming – bringing mineral riches and fears of epic extinctions. https://www.nature.com/articles/d41586-019-02242-y.

term. In such a scenario, the dates of signing the contracts for exploitation and, accordingly, the dates of the beginning of exploitation, cannot align with the limited time frame (such as the expiry of the contract for exploration).

131. Thus, there is still significant uncertainty in projecting the time frames for the beginning of exploitation of polymetallic nodules. This is compounded by uncertainty regarding future processing of nodules. Information on the existing processing companies ready to do that, or on projects to create specific companies, is absent. Without such companies, the beginning of exploitation is impossible. In theory, such companies can appear within five years, which argues in favour of scenario B or the intermediate option, with the beginning of production approximately in 2027. At the same time, it should be taken into account that not only the existence of specialized processing plants is necessary to start processing, but also the registration of all supply agreements between them and contractors, which requires additional time.

132. An important factor for assessment of potential effects of production in the Area on relevant metal prices is the volumes of production of these metals.

133. The fundamental proposition of all economic models is a production level of three million dry tonnes of nodules per year by each contractor.[14] The assessment of volumes of future production, however, requires additional assumption of the number of contractors.

134. In the MIT model,[15] the baseline scenario of exploitation in the Area by two contractors was considered. We, following MIT, base our assumptions on the fact that initially the exploitation can be started by two contractors with production levels of three million dry tonnes of nodules per year each. For the first one, the determined period of the beginning of exploitation would be 2027, and for the second one, 2030. Like MIT, we assume steady production increase by both contractors: 33 per cent productivity (one million dry tonnes of nodules) in the first year, 66 per cent (two million dry tonnes of nodules) in the second year, and 100 per cent (three million dry tonnes of nodules) in the third year.

135. At the same time, we cannot exclude the probability that all nine contractors, whose contracts for exploration (initial or extended) will expire in 2026, will begin exploitation in 2030–2032. The contracts of two more contractors expire in 2027, which allows them to begin exploitation approximately in the same period (see Figure 3.4). Thus, it is likely that the number of contractors who will start deep-water mining in the early 2030s may reach twelve. However, it is more realistic that only a few of the twelve contractors would be fully prepared to commence production on time. The remainder will continue work on exploration contracts, which will be extended under the 1994 Agreement.

136. In addition, an important factor affecting the number of contractors who have started mining will be the state of world markets and prices for these metals. The state of the markets means their ability to absorb additional quantities of metals without serious negative consequences for DLBPS. In terms of prices, they should be at a level that ensures the cost-effective exploitation and processing of polymetallic nodules.

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[14] "Financial Regimes for Polymetallic Nodule Mining: A Comparison of Four Economic Models", report submitted to the ISA by MIT on January 2019.

[15] "Report to the International Seabed Authority on the Development of an Economic Model and System of Payments for the Exploitation of Polymetallic Nodules in the Area", report submitted to the ISA by MIT on 3 June 2019.

Figure 3.3. Possible dates of the beginning of production (scenario A)

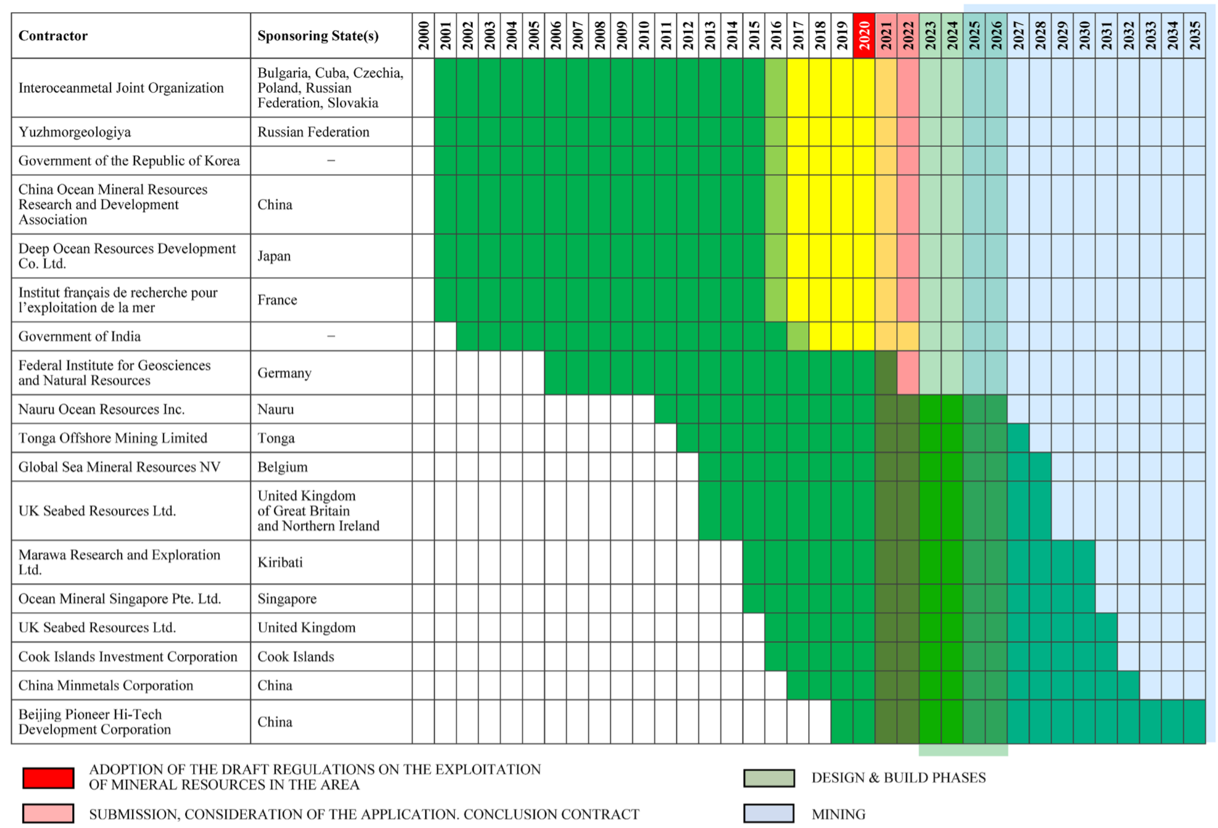


Figure 3.4. Possible dates of the beginning of production (scenario B)

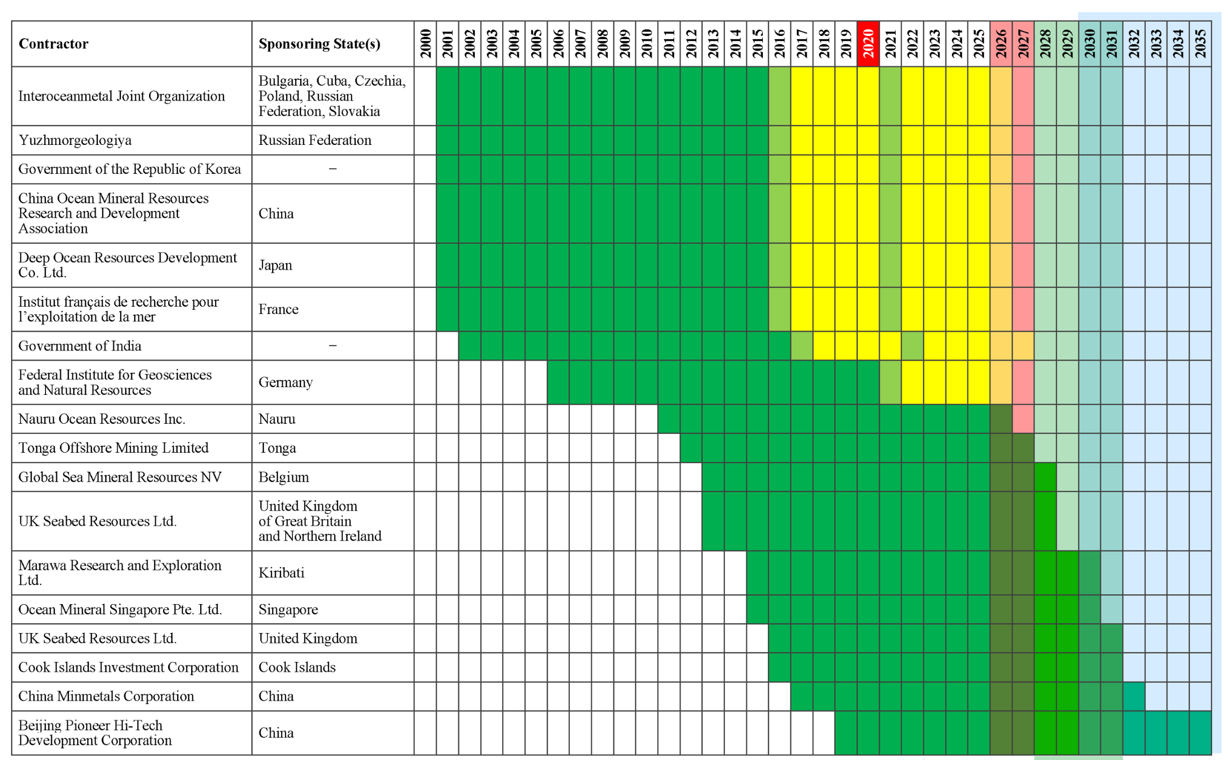
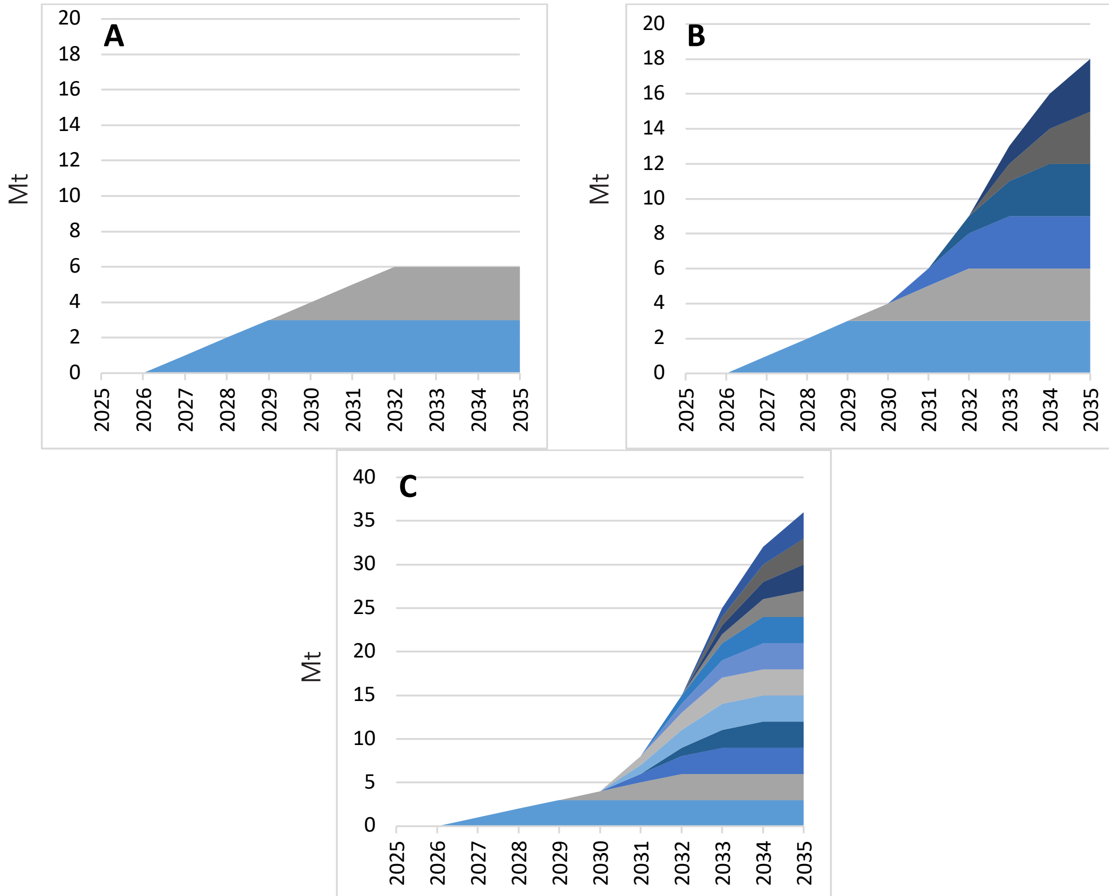


Figure 3.5. Possible scenarios for polymetallic nodules mining (in Mt): A) 2, B) 6 and C) 12 contractors



137. Figure 3.5 shows the possible scenarios for two, six and twelve contractors to increase nodule mining. The general condition is that the first contractor starts mining in 2027 and the second in 2030. The scenarios for six and twelve contractors assume that additional contractors whose exploration contracts expire between 2026 and 2027 will start between 2031 and 2033, and full capacity will be reached gradually over a period of three years.

138. The amount of produced and marketed metal is determined by its content in the ore (in our case, in nodules) and its extraction parameters in course of processing. Table 3.2 shows the annual amount of production for each of the relevant metals, provided full functioning of two, six, and twelve contractors, each producing three million dry tonnes of nodules per year. In the case of a different number of contractors, annual production rates will be proportional to their number and annual productivity. It should also be noted that actual metal content and recovery rates of nodules may differ from those estimated in the developed economic models, which will also have an impact on annual production rates.

Table 3.2. Rough estimate of metals recovered annually by 2, 6 or 12 contractors

	Composition (%)*	Recovery rate (%)*	Amount recoverable (tonnes per annum)		
			2 contractors	6 contractors	12 contractors
Cobalt	0.2	85	10,200	30,600	61,200
Nickel	1.3	95	74,100	222,300	444,600
Copper	1.1	90	59,400	178,200	356,400
Manganese	28.4	90	1,533,600	4,600,800	9,201,600

* Data from MIT (2019), "Report to the International Seabed Authority on the Development of an Economic Model and System of Payments for the Exploitation of Polymetallic Nodules in the Area".

139. On the basis of average prices over the past five years (this interval is chosen to smooth out short-term price fluctuations), the cost of metals encapsulated in 3 Mt of nodules would be about USD173 million for copper, approximately USD436.5 million for nickel, and approximately USD220 million for cobalt (taking into account the period of abnormally high prices in 2017–2018; the average price was approximately USD172 million in 2019).[16]

140. The nodules themselves are considered to be analogous to manganese ores. On the basis of a five-year average price of manganese ores with comparable manganese content, the value of manganese ores could be approximately USD425 million. The cost of manganese products that can be produced from nodule processing is known to be several times higher. However, the characteristics of the composition of the nodules, namely their high phosphorous content, may have a negative impact on their demand as analogues of manganese ores, and on the price.

141. The actual value of nodules and the products derived from their processing will be determined by the market situation during the period of extraction.

16 The prices (cash) of the LME are used for calculations.

3. World market conditions for the affected metals

A. Overview of the value chain of the affected metals

142. The structure of the value chain intrinsic to the metals industry is shown in Figure 4.1.[17] The end consumption of the metals industry is divided into industrial production and consumer end consumption. Industrial production purchases its raw materials through traders and metal exchanges, the main one of which is the London Metal Exchange (LME).

143. There are three models of interrelationships between the commodity links in the value chains of the metallurgical industry. These are presented in Figure 4.2.[18] The most common are traditional and resource-driven value chains. Metal producers, such as smelting plants, process the raw material coming from the mining industry. The traders' main function is selling and delivering various metals, but they can be bypassed in the value chain if the metal producer sells directly to an industrial end customer. The global metal community uses the LME to trade

Figure 4.1. Value chain in the metals industry

Figure 4.2. Vertical integration in mining

[17] Alajoutsijärvi K., Mainela T., Ulkuniemi P., and Montell E. (2012). Dynamic effects of business cycles on business relationships. *Management Decision* 50, no 2. pp. 291–304.

[18] The Business of Mining (2010). Vertical integration in mining: the trader's value chain. https://thebusinessofmining.com/2010/05/21/vertical-integration-in-mining-the-traders-value-chain/.

futures and options to hedge against adverse price movements, using prices which are discovered the market and used as the global reference. Participants can trade six different types of contract against 14 underlying metals (including copper, nickel, and cobalt) on three trade platforms. This is also called a market of "last resort", as it can be used to sell excess stock in periods of oversupply as well as a source of material in periods of extreme shortage.

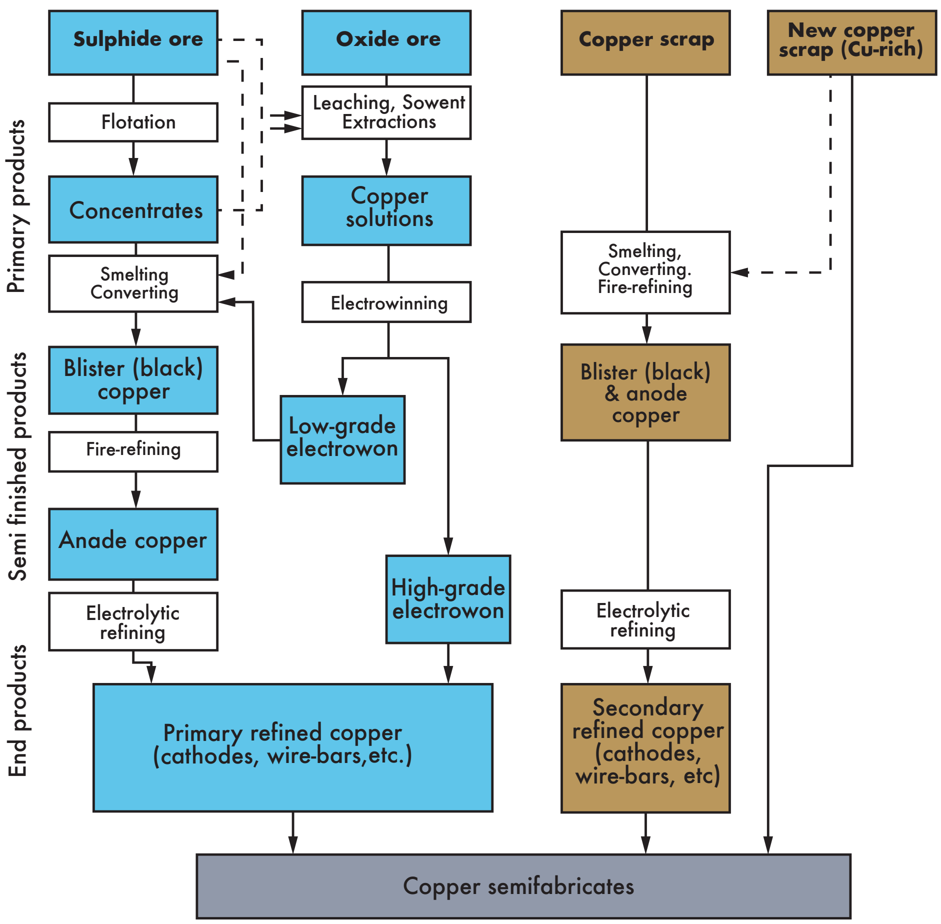
144. In this study we consider the value chain to the industrial end consumption level.

145. The value chain is shown in Figure 4.3 for copper, Figure 4.4 for nickel, Figure 4.5 for cobalt, and Figure 4.6 for manganese.[19]

B. Overview of the value chain of developing land-based producers of the affected metals

146. Currently, 126 UN Member States are classified as developing countries, which, despite being united into one category, are very heterogeneous in economic situation.

Figure 4.3. Copper value chain



[19] Van Zyl H. J., Bam W. G., and Steenkamp J. D. (2016). Identifying barriers faced by key role players in the South African manganese industry. Conference paper, SAIIE27 Proceedings, Stonehenge, South Africa. https://www.researchgate.net/publication/309556467_Identifying_barriers_faced_by_key_role_players_in_the_South_African_manganese_industry.

Figure 4.4. Nickel value chain

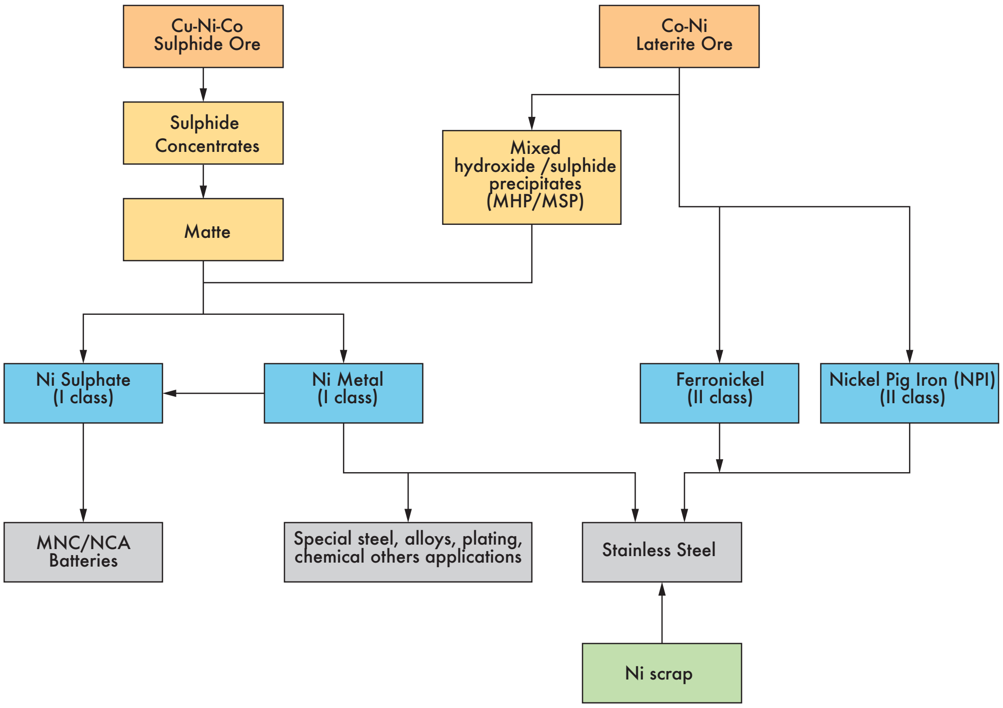


Figure 4.5. Cobalt value chain

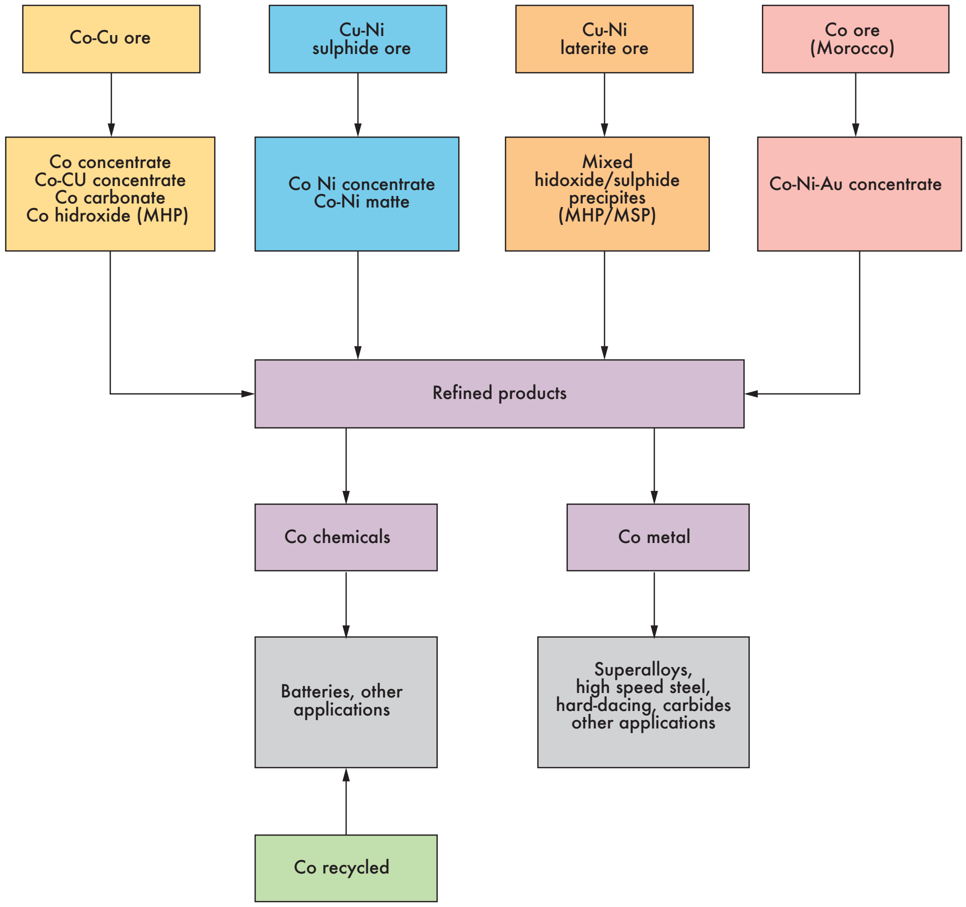
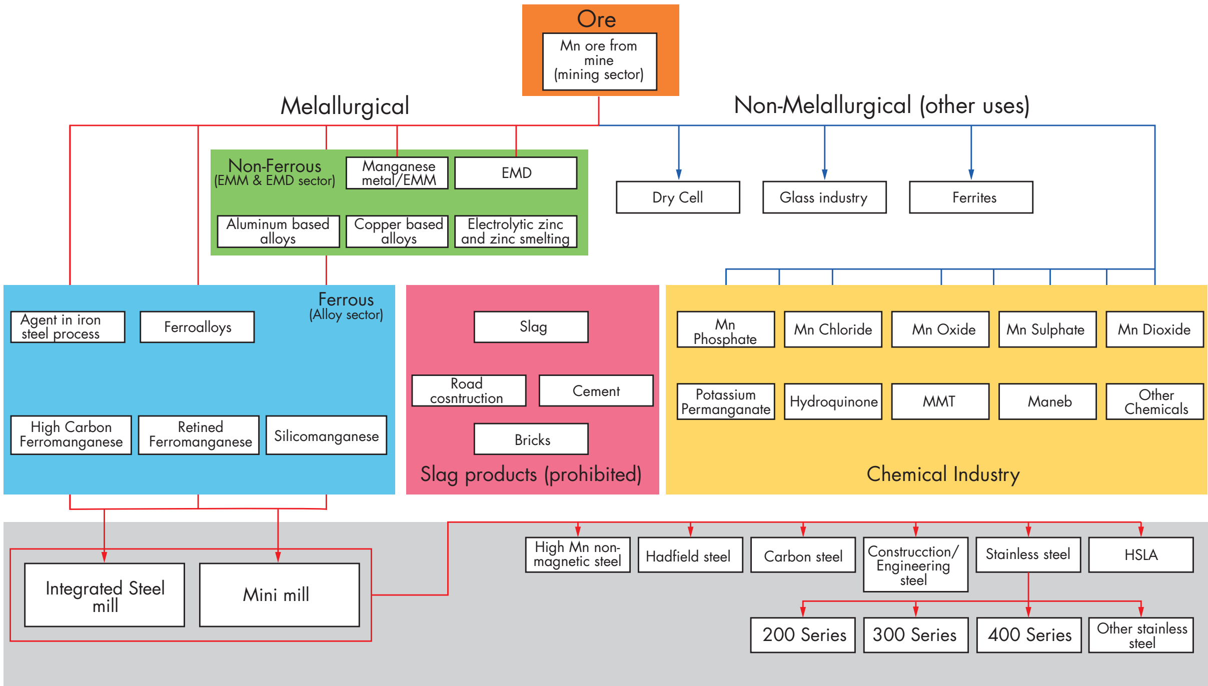


Figure 4.6. Manganese value chain



Legend: electrolytic manganese metal (EMM), electrolytic manganese dioxide (EMD), methylcyclopentadienyl manganese tricarbonyl (MMT), high-strength low alloy steel (HSLA).

Thus, they include high-income, upper-middle-income, lower-middle-income, lower-middle-income and low-income countries, measured by per capita gross national income (GNI). Among these, the least developed countries (LDCs), which included 47 countries in 2019, also stand out.[20] In addition, some political scientists and economists highlight the so-called newly industrialized countries (NIC) among developing countries. These include countries which, by their level of development, are between developing and developed countries. These countries have moved away from an agriculture-based economy and into a more industrialized, urban economy. The main feature of the NICs is a significant growth in GDP. The list of existing NICs is open to some debate among experts and economists, but the International Monetary Fund (IMF) includes NIC South Africa, Mexico, Brazil, China, India, Indonesia, Malaysia, Philippines, Thailand, and Turkey.[21]

147. The deepening international division of labour in the global economy has created and spread global value chains (GVCs), that account for a rising share of international trade, global GDP, and employment. Evolution of GVCs in various economic sectors, including commodities, has significant implications in terms of global trade, production, and employment, and how developing country firms, producers, and workers are integrated into the global economy. GVCs link firms, workers, and consumers around the world and often provide a stepping stone for firms and workers in developing countries to integrate into the global economy. For

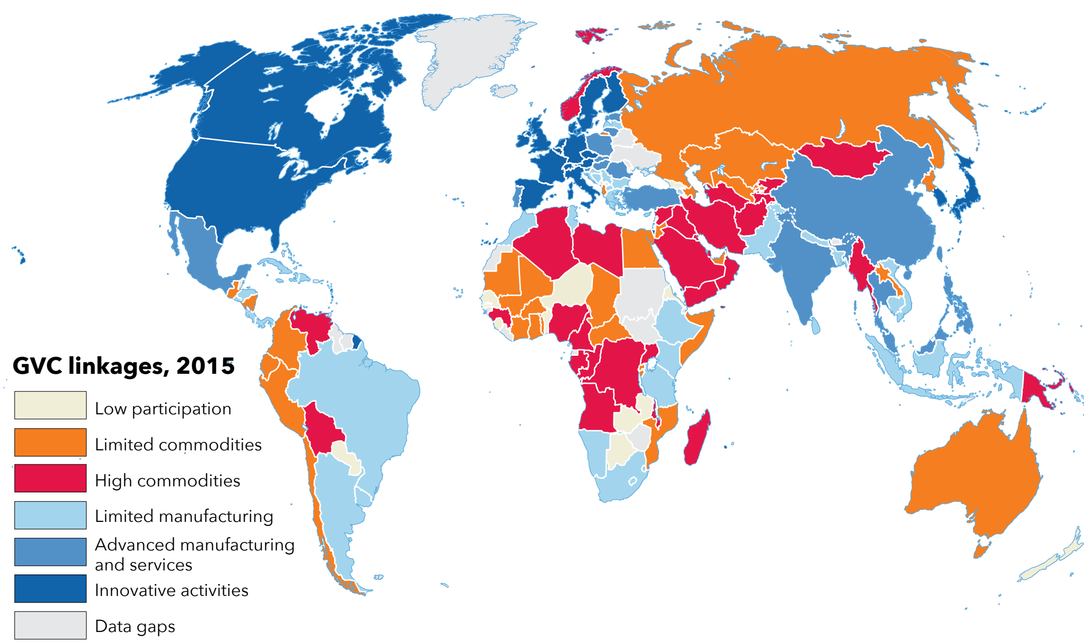
[20] UN (2020). *World Economic Situation Prospects 2020*.
[21] IMF (2016). The Role of Newly Industrialized Economies in Global Value Chains. IMF Working Paper. https://www.imf.org/external/pubs/ft/wp/2016/wp16207.pdf.

many countries, especially low-income countries, the ability to effectively insert themselves into GVCs is a vital condition for their development.

148. All countries, regardless of the state of their economy or domestic political situation, participate in GVCs, but in different ways. Developed and NICs participate in complex GVCs by producing advanced and innovative manufactured products and services. By contrast, many countries in Africa, Central Asia, and Latin America still produce commodities for further processing in other countries or engage in limited manufacturing (Figure 4.7).

149. As for value chains for the affected metals (copper, nickel, cobalt, and manganese) characteristic of DLBPS, they are generally limited to mining or metallurgical processing of mining products. Accordingly, such countries participate in GVCs at best as suppliers of metallurgical products, and at worst as sources of ores and/or concentrates. Often, exports contain both due to the lack of capacity of local metallurgy to fully process mining products. The exception is in the NICs that have developed industries consuming affected metals. These include, first of all, China.

Figure 4.7. Participation of various countries in GVCs



Source: World Bank Group.[22]

Note: The following four types of country participation in GVC are particularly notable: (1) commodities; (2) limited manufacturing; (3) advanced manufacturing and services; and (4) innovative activities. Commodity-related countries are divided into three categories: Low participation – primary goods' share of total domestic value added in exports is less than 20 per cent; Limited commodities – primary goods' share of total domestic value added in exports is equal to or greater than 20 per cent but less than 40 per cent; High commodities – primary goods' share of total domestic value added in exports is equal to or greater than 40 per cent.

[22] World Bank Group (2020). World Development Report 2020: Trading for Development in the Age of Global Value Chains. https://openknowledge.worldbank.org/handle/10986/32437.

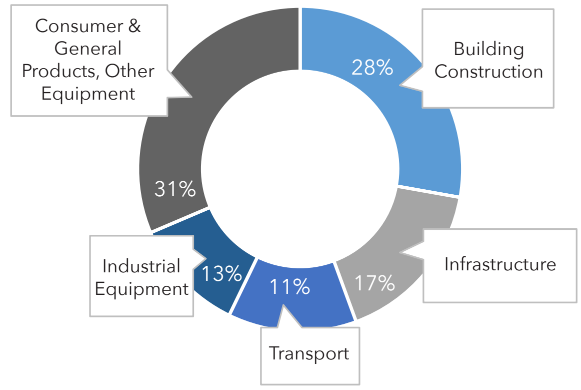
C. Analysis of trends and developments in the affected metals, including future supply and demand prospects, and potential effects of transfer pricing

Copper

Consumption

150. Copper is one of the most widely used metals in the world due to its high electrical and thermal conductivity, corrosive resistance, and plasticity. It is widely used in many fields of industry, among them building construction and infrastructure, production of consumer and general products, transport, and industrial and other equipment production (Figure 4.8; Table 4.1).

Figure 4.8. Copper end-use structure in 2017



Source: ICA.

Table 4.1. End-use of copper by product and sector in 2017 (copper content)

	Copper Wire* (kt)	Copper/Alloy (kt)			Copper foil (kt)	Mech. wire (kt)	Castings/ Powder (kt)
		Tube	RBS**	PSS**			
Building construction							
Electrical power	5 769	33/-	-/74	-	-	-	-
Communications	232	-	-	-	-	-	-
Plumbing	-	491/-	-/561	12/-	-	-	138/-
Architecture	-	4/18	-/78	129/-	-	10	58/-
Building plant (aircon tube)	-	213/-	-	-	-	-	-
Infrastructure							
Power utility	3 091	-/85	452/116	4/-	77	-	-
Telecom-munications	813	-	-	28/-	-	-	-
Transport							
Automotive electrical (harnesses, motors)	1 642	1/-	-	278/276	-	-	-
Automotive non-electrical (radiators, tubing)	-	2/7	1/67	-/42	66	24	-

	Copper Wire* (kt)	Copper/Alloy (kt)			Copper foil (kt)	Mech. wire (kt)	Castings/ Powder (kt)
		Tube	RBS**	PSS**			
Other transport (railroad, shipping and marine)	777	-/36	52/32	-	-	69	295/-
Industrial equipment							
Electrical (industrial transformers and motors)	1 257	-	87/35	228/83	-	-	-
Non-electrical (valves, fittings, instruments and in-plant equip.)	-	153/138	-/763	1/-	-	-	394/-
Consumer & general products; Other equipment							
Consumer & general products (appliances, instruments, tools, etc.)	1 779	1/-	1/123	163/279	-	117	-
Aircon and refrigeration	371	1 825/-	-/55	-	-	-	-
Electronics and PCs	474	3/-	4/-	44/280	526	-	-
Ammunition, clothing, coins, and other	550	8/70	19/168	703/762	-	207	202/104

Source: ICA.

*Copper wire includes: building wire, power cable, magnet wire, telecom cable, other communication cable, other LV energy, automotive wire and cable, bare conductor.

**Legend: rod bar section (RBS), plate sheet strip (PSS).

151. There are more than 50 saleable types of copper and copper-based alloys in structure of metal production and consumption. The main types are copper of different purity, brass, bronze, and copper-nickel alloys. Copper and copper alloys are used for production of wire rods and semi-finished products: plates, sheets, strips, foil, rods, bars, tubes, fittings, powders, and castings.

152. Pure copper is mainly used in the electrical and electronic industries. It is used for production of power cable and wire, which is further used for windings of motor controllers, electric motors, power accumulators, and transformers. In electronics, copper is used for production of computer and cellphone components, including microprocessors.

153. Due to its good thermal conductivity, copper is used in production of various heat exchangers, including cooling, conditioning, and heating radiators, PC cooling systems, and heat pipes. Copper pipes are widely used for liquids and gas transmission in water, gas supply, heating and air conditioning systems, refrigeration units, and chemical engineering

(production of vacuum apparatus and coil).

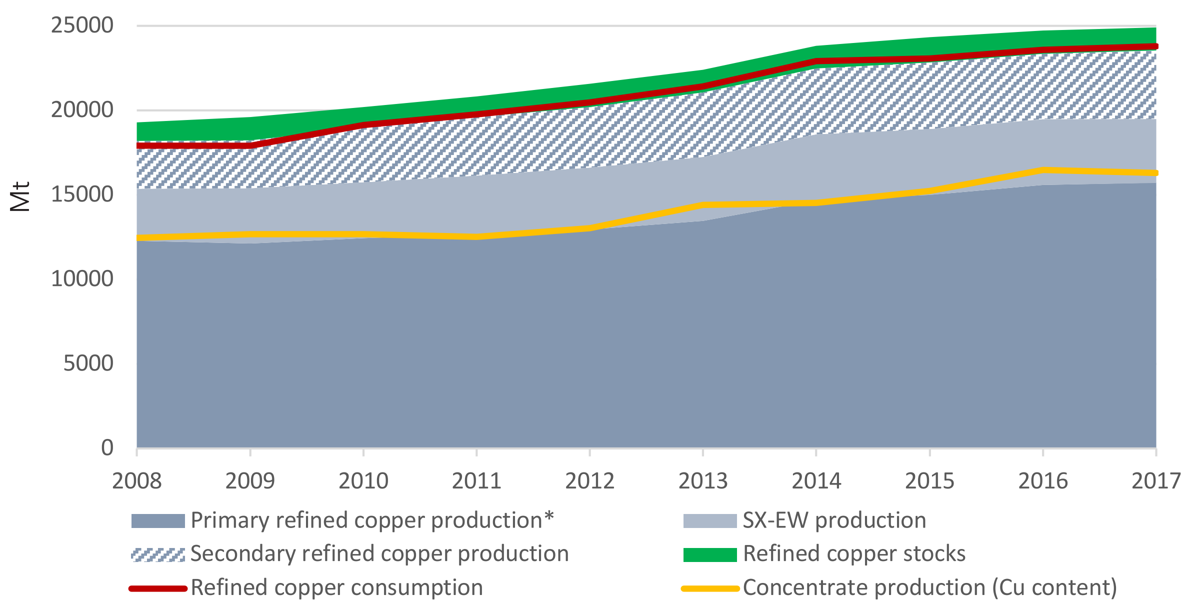
154. Due to its high corrosive resistance and resilience to wide range of climate variations, copper is used for roof coverings.

155. In other fields of industry, alloys of copper with various metals are mainly used, primarily with brass, bronze, and nickel (cupronickel, etc.).

156. According to the data of the International Copper Association (ICA), world copper semis consumption (inclusive of refined copper and direct melt copper scrap) was estimated at 28.1 Mt in 2017.[23] According to the ICSG, refined copper consumption in 2017 amounted to 23.7 Mt.[24] Thus, the amount of metal extracted by direct melting from high-quality scrap is estimated to be approximately 4.5 Mt. In further analysis, direct melt copper is not taken into account in the absence of such statistics.

157. In the period from 2008 to 2017, the world refined copper consumption in general increased by 33 per cent (Figure 4.9).[25] This increase was achieved almost entirely by China, which had more than doubled metal consumption due to the increase in the pace of construction and production of consumer goods. Meanwhile, in the States considered the largest copper consumers to the 2000s–USA, Japan, and Germany–consumption decreased by 11–16 per cent during the reporting period.

Figure 4.9. World refined copper production, consumption and stocks in 2008–2017



*Production from ores and concentrates, excluding SX-EW copper
Sources: ICSG, WBMS[25]

[23] ICA, Ltd. Data Set. Global 2018 Semis End Use Data. https://copperalliance.org/trends-and-innovations/data-set/.
[24] ICSG. Selected Data. World refined copper production and usage trends. https://www.icsg.org/index.php/component/jdownloads/finish/165/871.
[25] World Bureau of Metal Statistics. https://world-bureau.com/.

Production

158. In 2017, 23.5 Mt of refined copper was produced in the world. Approximately 67 per cent of it was extracted from ores and concentrates, 16 per cent was from low-metal content/oxide-bearing ore under Solvent Extraction-Electrowinning technology (SX-EW), and 17 percent was provided by metallurgical secondary raw material processing companies.[26]

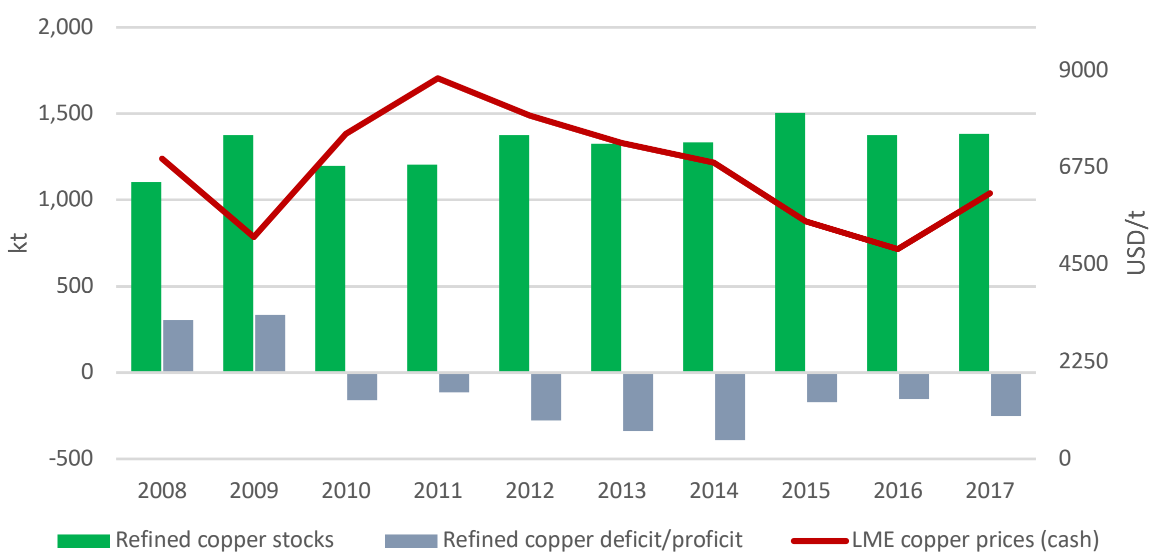
159. Metal production in the period from 2008 to 2017 increased in proportion to consumption simultaneously with an increase in its extraction both from primary and secondary sources (Figure 4.9). The increase in metal production was ensured by China, its main consumer. Aside from the exploitation capacity expansion, China actively purchased raw material overseas, primarily in Chile and Peru, the world's largest copper mine producers. Due to copper scrap imports, secondary copper production in the country doubled during the reported period, and in 2017 China provided for half of world production.

160. Although copper consumption levels are slightly above the output, copper eficit on the world market does not occur. The reason is copper stocks, the rate of which varies annually and is on average 5–7 per cent of total production volumes. Thus, the global copper market has overall surplus (Figures 4.9 and 4.10).

Prices

161. Copper is an exchange-traded metal. Copper prices are determined on trading platforms, the largest of them being the LME.[27] Having recovered from the 2008–2009 financial and economic crisis, copper prices started to grow actively and peaked in 2011, followed by a long period of decline (Figure 4.10). The growth trend in prices only began in 2016 and was established in 2017 and the beginning of 2018 against the background of a deficit threat caused by a prolonged strike at the world's largest copper mine, Escondida in Chile, and increase in demand from electrical industry. Nevertheless, prices started to

Figure 4.10. World refined copper production/consumption balance and stocks (left) and prices (right) in 2008–2017



Sources: ICSG, LME.

26 ICSG. *ICSG 2018 Statistical Yearbook.*

27 LME. Market Data. Reports and data. Monthly averages. https://www.lme.com/Market-Data/Reports-and-data/Monthly-averages.

decline already in the second half of 2018 and continued shrinking in 2019. The main reason is "the trade war" between China and the USA, which affects negatively the economies of both countries.

Forecast of demand and consumption

162. The main prospects for growth of copper consumption in the future are linked to development of so-called "green technologies", meaning electric vehicles (EV) and renewable energy (wind and solar power generation, etc.).

163. According to DBS Group Research estimates, copper consumption by EVs will increase by 19 per cent per year, exclusive, for chargers and infrastructure.[28] By 2020, metal consumption in this industry will already exceed the current level by nine times from 207,000 tonnes to 1.91 Mt, and by 2035, with sustained growth rate, by 22 times to 4.6 Mt. According to ICA estimates, copper consumption by EVs will increase at a higher rate and will reach 1.74 Mt already by 2027.[29]

164. While production of a passenger car with internal combustion engine requires approximately 23 kg copper, a hybrid EV requires 40 kg, a plug-in hybrid EV 60 kg, a battery EV 83 kg, a hybrid electric bus 89 kg, and a battery-powered electric bus 224–369 kg.

165. Besides the EVs themselves, copper is required for chargers and necessary infrastructure. Depending on capacity, one charger requires from 0.7 to 0.8 kg copper. For example, the American WiTricity Corporation developed a wireless charger for sedan-type EVs, which requires 4 kg copper to produce.[30]

166. It is obvious that the expected copper consumption growth in the electric transportation industry depends directly on its development rates. The proportion of sales of EVs in the world vehicle trade amounted to 2.2 per cent, with more than 2 million electric cars sold in total. At the same time, this is 64 per cent more than last year and hundreds of times more than in 2010, when only several thousands of cars were sold.[31] According to a Bloomberg forecast, sales of EVs will exceed 40 million by 2035, which will amount to 20 per cent of vehicle sales.[32] At present, the main consumer of EVs is China. According to the data of International Energy Agency (IEA), almost half (45 per cent) of the 5.1 million EVs in the world as of the end of 2018 are on the roads of China.[33] Taking into account the significant government support, the market of electric automobiles is expected to grow by 25 per cent annually,[34] and in the long run the main demand growth will be ensured by China. Besides electric motor vehicles, China is actively developing electric rail transport, including high-speed rail transport, demanding a significant amount of copper (377 kg per train and 12 tonnes per 1 km of railroad). According to an ICA forecast, by 2030 copper consumption

[28] DBS Group Research (May 2018). Copper and Its Electrifying Future. https://www.dbs.com/aics/templatedata/article/generic/data/en/GR/102018/181004_insights_copper_and_its_electrifying_future.xml.

[29] ICA, Ltd. Copper Alliance (June 2017). *The Electric Vehicle Market and Copper Demand*. https://copperalliance.org/wp-content/uploads/2017/06/2017.06-E-Mobility-Factsheet-1.pdf.

[30] ICA, Ltd. Copper Alliance. Copper in EV Charging – An Emerging Standard Around Wireless Charging. https://copperalliance.org/trends/copper-in-ev-charging-an-emerging-standard-around-wireless-charging/.

[31] EV-volumes.com. Global EV Sales for 2018 – Final Results. http://www.ev-volumes.com/news/global-ev-sales-for-2018/.

[32] Bloomberg Finance L.P. *Electric Vehicle Outlook 2019*. https://about.bnef.com/electric-vehicle-outlook/#toc-download.

[33] IEA (May 2019). *Global EV Outlook 2019*. https://www.iea.org/reports/global-ev-outlook-2019.

[34] DBS Group Research (May 2018). Copper and Its Electrifying Future. https://www.dbs.com/aics/templatedata/article/generic/data/en/GR/102018/181004_insights_copper_and_its_electrifying_future.xml.

in the Chinese transport industry will increase almost three times, by 3.3 Mt.[35]

167. The electric transport markets of European countries, the USA, Japan, India, etc. are developing at a slower pace. Chile is worth special mention, as it has the largest electric bus fleet after China and is planning to electrify all public transport by 2040 and 40 per cent of private vehicles by 2050.[36]

168. Construction of power plants functioning on renewable energy sources implies an increase in copper consumption, but to a lesser extent compared to the electric transportation industry. According to the data of DBS Search Group, in 2010–2016 construction of solar, wind, and other power generation took approximately 463,000 tonnes of copper, and in the period from 2017 to 2040 the amount of metal could increase to 635,000 tonnes per year. Wood Mackenzie analytics made a much broader forecast. According to their estimates, construction of wind power generations alone will take more than 5.5 Mt of copper—about 400,000 tonnes per year from 2018 to 2022 and 600,000 tonnes through 2028. On the other hand, there is a trend towards replacing copper wires with aluminum wires in wind turbines, which could weaken the demand for copper.[37]

169. Aluminum is the main alternative to copper, but its advantages (relative cheapness and lightness) are offset by disadvantages (low conductivity compared to copper and higher material consumption). Therefore, we cannot expect mass substitution of copper with aluminum in the foreseeable future.

170. To date, there are a large number of world copper consumption forecasts. They are based on expected growth rates of world GDP and population, "green technologies" development, shift to renewable energy sources, compliance with the Paris Agreement on the regulation of measures to reduce carbon dioxide in the atmosphere, and other factors.

171. In the course of the work, several options were considered for forecasting the growth in demand for copper from various sources. Due to the different approaches of researchers to the presentation of data (graphs, specific figures, annual growth rates in %), the authors of this report have developed a graph to visualise their interpretation (Figure 4.11).

172. The copper consumption forecasts offered by Roskill,[38] McKinsey Global Institute,[39] Fitch Solutions,[40] and DBS Group[41] are based on the growth prospects for copper demand associated with the development of "green technologies", meaning EVs and renewable energy sources. According to the abovementioned forecasts, the annual growth in demand for copper will amount to 2–3 per cent.

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35 ICA, Ltd. (November 2019). *Copper Alliance*. *Future China Transport*. https://copperalliance.org/wp-content/uploads/2019/11/04-Future-china-transport-v22.pdf.

36 IEA (2019). *Global EV Outlook 2019.* https://www.iea.org/reports/global-ev-outlook-2019.

37 Mining com (2019). *Global wind turbine fleet to consume over 5.5Mt of copper by 2028 – report.* https://www.mining.com/global-wind-turbine-fleet-to-consume-over-5-5mt-of-copper-by-2028-report/.

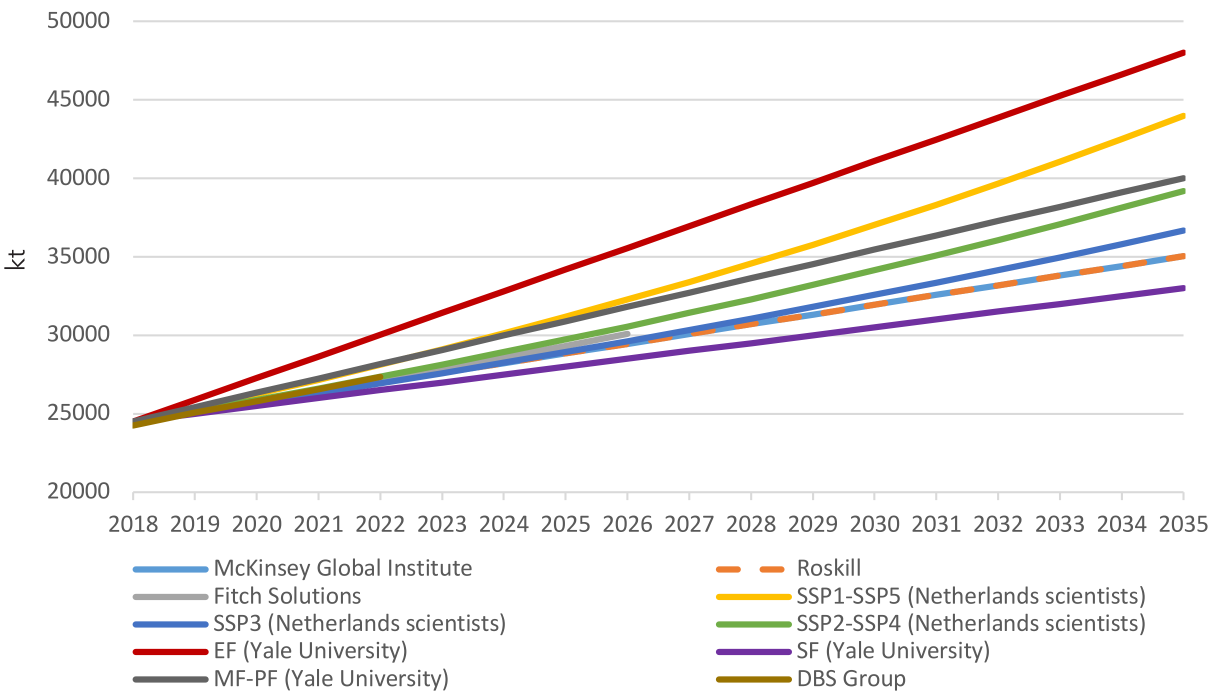
38 Roskill. Market Reports (2019). Copper. Demand to 2035, 1st Edition. Copper – The Electric Metal. https://roskill.com/market-report/copper-demand-to-2035/.

39 McKinsey Global Institute (February 2017). Beyond The Supercycle: How Technology Is Resharping Resources. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/How%20technology%20is%20reshaping%20supply%20and%20demand%20for%20natural%20resources/MGI-Beyond-the-Supercycle-Full-report.ashx.

40 Mining com (2019). *Global copper market under supplied, demand on the rise – report*. https://www.mining.com/global-copper-market-supplied-demand-rise-report/.

41 DBS Group Research (May 2018). Copper And Its Electrifying Future. https://www.dbs.com/aics/templatedata/article/generic/data/en/GR/102018/181004_insights_copper_and_its_electrifying_future.xml.

Figure 4.11. Copper consumption forecasts for 2018–2035



173. The work of Netherlands scientists[42] and researchers from Yale University[43] takes an integrated approach where many factors are taken into account.

174. The study by a group of scientists from the Netherlands examined options for growth in demand for copper up to 2100 based on five world development scenarios (SSP 1–5), taking into account "green technologies", population growth rates, and GDP in various combinations. In part, these scenarios correlate with the emission scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC Special Report on Emission Scenarios).[44] The SSP scenarios assume that the annual growth rate of global demand for copper up to 2035 will roughly range from 2.8–3.5 per cent. At the same time, the least optimistic scenario (SSP3) implies weak "green technologies" development with rapid population growth and slow GDP growth. The most optimistic (SSP1 and SSP5), which imply the growth of demand for copper at the same level (about 3.5 per cent) until 2060, imply diametrically opposite schemes of global socio-economic development: SSP1 assumes active development of "green technologies" with moderate population growth, and SSP5 assumes a course of continuation of use of carbon fuels with low level of investments in development of energy by renewable sources, but active economic development and growth of GDP, and low population growth.

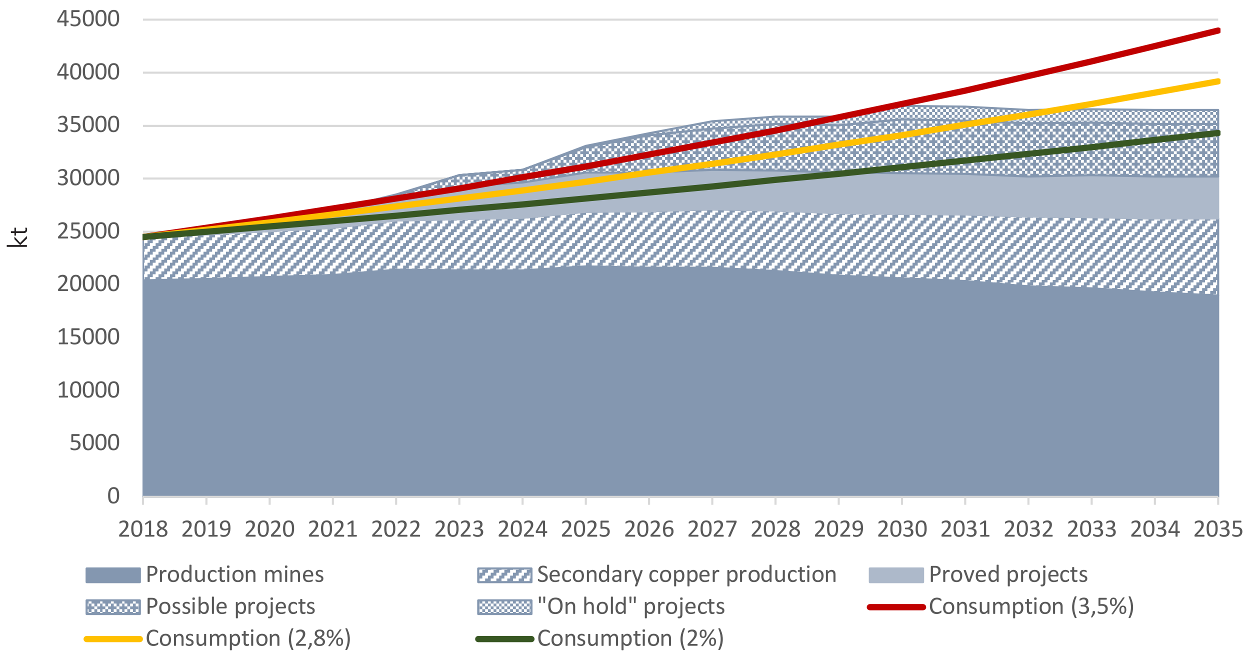
175. Scientists from Yale University did a copper demand growth forecast up to 2050 based on the UNEP Global Environment Outlook's four scenarios:

42 ScienceDirect (2018). Estimating global copper demand until 2100 with regression and stock dynamics. https://www.sciencedirect.com/science/article/pii/S0921344918300041.

43 ScienceDirect (2016). Copper demand, supply, and associated energy use to 2050. https://www.sciencedirect.com/science/article/pii/S0959378016300802.

44 Intergovernmental Panel on Climate Change (2000). *Emissions Scenarios*. https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf.

Figure 4.12. Copper land-based production and consumption forecast for 2018–2035



Market First, Policy First, Security First, and Equitability First.[45] The scenarios are based on dominance of market relations, politics, security or their harmonious combination in the world order. The most optimistic scenario in terms of annual growth in demand for copper is the Equitability First scenario, according to which it will reach 4 per cent by 2035. The Security First scenario, aimed at resolving a large number of different conflicts, is the most pessimistic (annual growth of 1.8 per cent). The Market First and Policy First scenarios assume that demand for copper will grow at the same pace until 2035, about 2.9 per cent per year.

176. Thus, despite the diversity of forecasts, the expected growth in consumption varies within rather narrow limits of 1.8–4 per cent.

177. Based on the analysis of the above options, and taking into account the average annual growth in demand for copper over the last decade, we chose three cases (Figure 4.12). These cases reflect the full picture of possible development of the situation although, like any long-term forecasts, they are to a high degree tentative.

178. Case 1 implies annual world copper consumption growth by 2 per cent and is proposed on the basis of forecast data by Roskill, McKinsey Global Institute, and Security First and SSP3 scenarios.

179. Case 2 is based on average copper consumption growth in 2007–2018, which amounted to 2.8 per cent. A similar annual growth is implied by the SSP2-SSP4 scenarios, while the Market First-Policy First scenarios and DBS Group and Fitch Solutions forecasts also have similar figures.

180. Case 3 implies the highest copper consumption at 3.5 per cent. It is based on SSP1-SSP5 and Equitability First scenarios.

[45] UNEP (2001). *Global Environment Outlook – environment for development (GEO-4)*. https://wedocs.unep.org/bitstream/handle/20.500.11822/7646/-Global%20Environment%20Outlook%20%204%20(GEO-4)-2007768.pdf?sequence=3&isAllowed=y.

181. Despite different paces of expected copper consumption growth, all analytics agree that China remains the primary consumer of metal. According to the data of the Antaike agency, copper consumption in the country will peak after 2027, exceeding 10 kg per person. Meanwhile, GDP growth is expected to reach USD16,000 per person, and energy consumption will amount to 7,534 kWh, which corresponds to the level of developed countries.[46]

182. India, whose economy is entering a phase of rapid growth, has significant potential for copper consumption growth. According to the data of DBS Group Research, in the short term (through 2022) the country is expecting very high growth rate of copper consumption at 6.2 per cent.

183. Thus, we can say that the main "engine" of copper consumption is economic growth, regardless of the course of further energy development, which is due to the wide range of applications of the metal.

Resources and reserves

184. According to the data of USGS, world copper reserves are estimated at 870 Mt, resources at 2.1 Gt, and undiscovered resources at 3.5 Gt.[47] At current rates of copper mining production (more than 20 Mt) given the loss in processing, reserves can provide mining operations for 40 years, and resources for more than 100 years.

Forecast of land-based mining

185. To assess the rates of world copper production through 2035, the data about reserves and identified resources (measured + indicated + inferred resources) of more than 300 world copper mines and projects was collated and analysed, while resources of prospected fields were not taken into account. The production forecast is based on measured + indicated + inferred resources, given the recovery loss. The expected copper production in existing mines is calculated on the basis of actual production in 2018, taking into account the planned projects for expansion of existing capacities. The main source of information was the reports of mining companies. Thus, information was obtained on enterprises that jointly provide more than 80 per cent of world production.

186. In view of the absence of data on all mines in most of the countries, the lacking production volumes are taken into account on the basis of data from national statistics and/or industrial statistics with a view to getting a full picture of the global copper-extracting industry. This particularly applies to China as well as DR Congo and countries of Latin America (Chile, Peru, etc.). In addition, data for the country as a whole was collected from relatively small copper producers (such as Armenia, Serbia, Uzbekistan, etc.).

187. Besides mine copper production (inclusive of concentrates and cathode copper by SX-EW), production from secondary sources was taken into account. At present, the end-of-life recycling rate for copper amounts to 50 per cent, and recycled content to 30 per cent.[48] This is expected to grow against rising copper consumption and the general trend towards increased recycling of resources.

188. Copper projects are conditionally divided into three groups based on the

[46] DBS Group Research (May 2018). Copper and Its Electrifying Future. https://www.dbs.com/aics/templatedata/article/generic/data/en/GR/102018/181004_insights_copper_and_its_electrifying_future.xml.

[47] USGS (2020). *Mineral Commodity Summaries 2020*. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

[48] OECD (2018). *Global Material Resources Outlook to 2060*. https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/OECD.pdf.

perspectivity of their involvement in production: Proved projects, Possible projects, and "On-hold" projects (Figure 4.12). The main criterion for assigning a project to a group was the current stage of its development (Preproduction, Construction, Feasibility Study, Prefeasibility Study). Their planned implementation dates and the difficulties arising therefrom were also taken into consideration. For example, the project of exploration of the Resolution copper-porphyry deposit in USA, implying the construction of the largest new copper production operation (600,000 tonnes per year) is technically at the Preproduction stage, but due to absence of necessary mining permits, its operation will not begin until 2030. Permits are difficult to obtain, because the deposit is located within the "sacred lands" of native North Americans. For that reason, the project is assigned to the second group (Possible projects).

189. The "On-hold" group includes projects whose implementation is suspended for various reasons: court proceedings (Reko Diq in Pakistan, Panguna in Papua New Guinea), mining ban (Kingking in Philippines), issues with obtaining permits from environmental agencies (Harper Creek in Canada), etc.

190. Meanwhile, assigning the project to the most promising Proved projects group does not imply its timely implementation, because the commissioning dates of deposits (especially those with large and enormous reserves) are often postponed for various reasons.

191. According to our analysis, copper production from existing mines will decrease by 7 per cent by 2035 due to the depletion of the fields on which they operate. At the same time, possible growth of secondary copper production (approximately by 1.8 times by 2035) can offset the capacity outage completely.

192. The main number of Proved and Possible projects is expected to be put into operation from 2025, and by 2035 they will provide 4 and 5 Mt of copper per year respectively. "On-hold" projects will only provide 1.3 Mt of copper per year by 2035.

193. Thus, with annual copper consumption growth of 2 per cent (case 1) and implementation of Proved and Possible projects, there are no prerequisites for deficit occurrence. In this case, the market will be oversaturated with copper, which can negatively affect the pricing trend. At the same time, if the majority of Possible projects will not be put into operation on time, difficulties with copper supply to industry can occur from 2030, even with moderate global consumption growth.

194. If the average annual copper consumption growth will amount to 2.8 per cent (case 2), the deficit threat can arise even if all the projects are launched, but in the long term, after 2032. In 2035, copper deficit could amount to from 3 up to 13 Mt, depending on the emergence and implementation of new projects.

195. With the highest prognosed global copper consumption growth rate of all at 3.5 per cent per year (case 3), copper deficit on the market can arise earlier—already after 2030 or even after 2025—if the commissioning of the majority of Possible projects will be suspended. By the end of the period under review, copper deficit could amount to 7.5–18 Mt, which is likely to boost metal prices on the world market. At the same time, expectations of such a deficit will become a powerful incentive to intensify preparations for the development of new copper deposits.

196. Besides supply and demand, copper prices are affected by a variety of factors, economic (dollar value change, Organisation for Economic Co-operation and Development (OECD), CLI, etc.) and socio-political (strikes, "trade wars", etc.),

and therefore any price change forecasts are conditional.

197. As shown in Figure 4.12, mine operations on the basis of existing mines will remain the main source of copper throughout the period under review. The most significant mines are located in Chile as well as in Peru, China, USA, Democratic Republic of the Congo, and Zambia. The main role in the planned increase in copper production, in addition to scrap processing operations, will be played by Proved and Possible projects, which can provide 6–9 Mt of metal in total annually after 2025. The majority of them are located in the aforementioned countries. Also, large projects are being implemented in Argentina, Mexico, Canada, Russia, and Papua New Guinea. "On-hold" projects will only be able to compensate partially for the copper deficit, which could theoretically arise after 2030.

Impact of nodule mining

198. With regard to the possible development of the nodules, we consider three options: a minimum (with two contractors; Figure 4.13), a base (with six contractors; Figure 4.14), and a maximum (with 12 contractors; Figure 4.15). All scenarios assume the first contractor starting production in 2027 and the second in 2030, with the remaining contractors (subject to their participation) joining the process in 2031–2033. It is assumed that the maximum aggregate production level of six or twelve contractors may be reached in 2035.

199. As can be seen from Figures 4.13–4.15, if deep-sea mining is carried out only by two or even six contractors, its volume will be practically invisible against the background of ground mining production.

200. Even under a maximum scenario of 12 contractors in 2035, only about 350,000 tonnes of copper per year could be produced altogether (Figure 4.15), which is the annual output of a very large enterprise (e.g. Los Pelambres in Chile). Formally, such an increase is not noticeable for world production; it corresponds to less

Figure 4.13. Forecast copper production and consumption, including polymetallic nodules mining, for 2018–2035 (2 contractors)

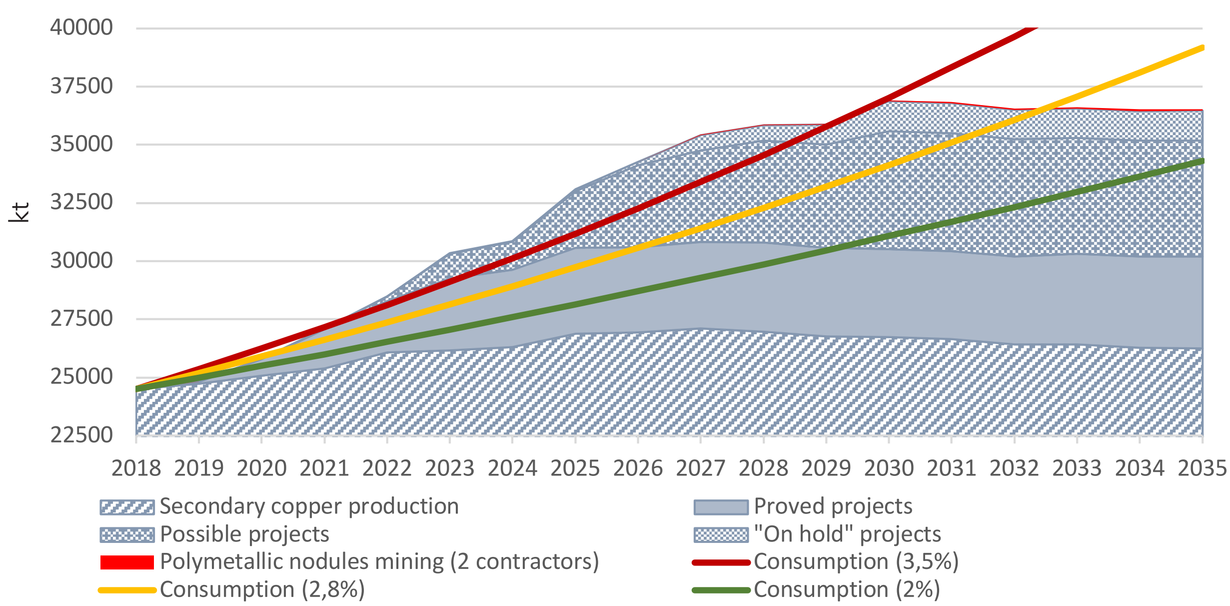


Figure 4.14. Forecast copper production and consumption, including polymetallic nodules mining, for 2018–2035 (6 contractors)

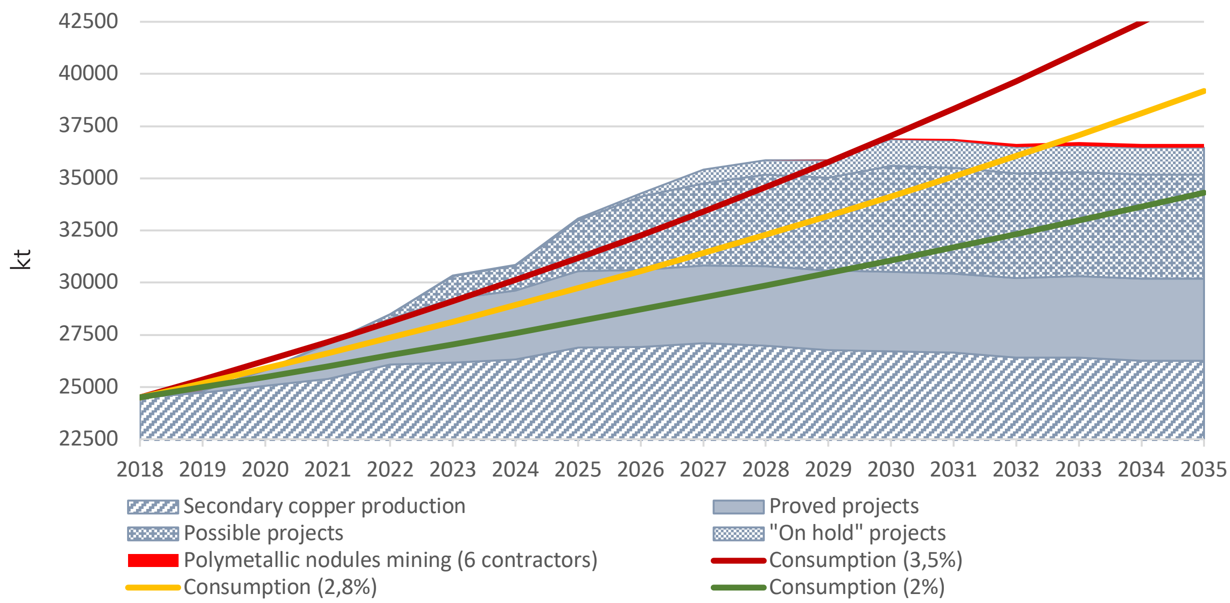
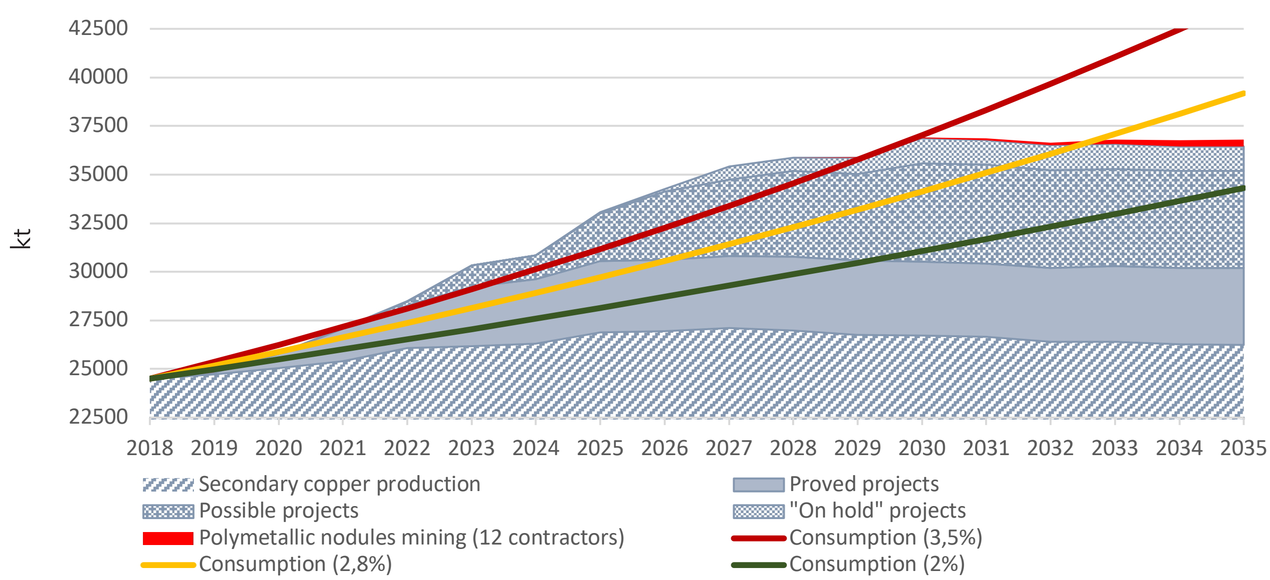


Figure 4.15. Forecast copper production and consumption, including polymetallic nodules mining, for 2018–2035 (12 contractors)



than 2 per cent of current world mining production. If at least part of the ground projects we are considering are put into operation, this share will be even smaller. However, the real effect from the start of production will depend on the demand/supply balance that will be formed in the market by that time.

201. According to the scenarios we are considering, if all of the new land-based mine projects currently in place are commissioned on time, it is only with annual consumption growth of 3.5 per

cent by the possible beginning of deep-sea mining (i.e. by 2027) that a copper shortage may emerge in the market by then. In this case, the start of polymetallic nodules mining even under the maximum scenario will not be able to negatively affect the copper supply/demand balance. However, it could still lead to some price reductions, as it would reduce possible supply tensions. With earlier start dates, seabed mining may increase the metal surplus, likely if all ongoing onshore projects are commissioned, increasing pressure on prices.

202. Under other scenarios of copper consumption growth (+2.8 per cent and +2 per cent per year), copper shortages may occur either after 2032 or not at all, and all the world economy's copper needs will be met by land-based production and secondary metals. With such development, even relatively small volumes of copper from polymetallic nodules will put additional pressure on the market. Besides, one cannot ignore the psychological pressure on market participants, which will be caused by the fact of the appearance of an additional source of metal with great potential for growth.

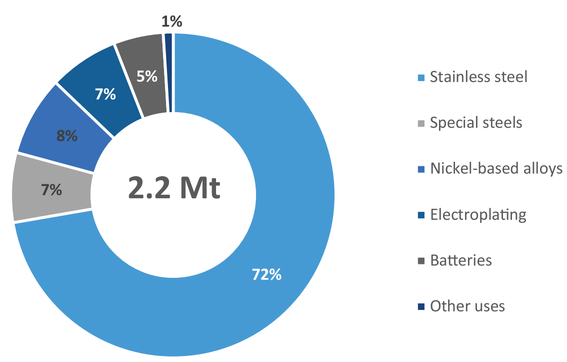
Nickel

Consumption

203. Primary nickel products are divided into two classes. The first includes high-grade nickel with 99 per cent or more metal content: electrolytic nickel, pellets, briquettes, granules, rondelles, powder, and flakes. The second is low-grade nickel: ferro-nickel, nickel pig iron (NPI), nickel oxide sinter, and utility. The production of a particular type of product depends on the type of raw material, and the type of product, in turn, determines its application in various fields.

204. The main field of application of nickel is the production of stainless and special steels, where the addition of nickel increases their strength and resistance to corrosion and aggressive environments. Steelmaking consistently accounts for more than two-thirds of the world's metal output. In 2017, the share of this industry in global consumption was 79 per cent, or 1,768 tonnes of nickel (Figure 4.16).[49] Both high-grade nickel and some class 2 products are used for steel production: ferro-nickel, and NPI. The steel quality does not depend on the type of product used.

Figure 4.16. Primary nickel consumption in 2017 by industry



Source: PJSC MMC Norilsk Nickel.

205. There are several stainless steel series. The biggest amount of nickel is used in AISI 304 300th series steels (8–12 per cent, up to 20 per cent of nickel in individual grades; 18–20 per cent chromium), which have a wide range of applications. The 300th series steels account for two-thirds of total stainless steels volume. The steels of the 200th and 400th series are produced in approximately equal volumes. The 200th series steel has a lower nickel content due to manganese alloying and is not a full replacement for grades with high nickel content. The 400th series steels mostly do not contain nickel.[50]

49 PJSC MMC Norilsk Nickel (2017). *Annual Report 2017*. https://ar2017.nornickel.com/download/full-reports/ar_en_annual-report_pages.pdf.

50 Ibid.

206. In other areas of application, only high-grade nickel can be used.

207. Another important area of application is the production of nickel alloys and superalloys, which are in demand primarily in the aerospace industry for engine manufacturing. In addition, alloys are used in the petrochemical and automotive sectors, where they can replace some stainless steel grades. In 2017, nickel consumption for their production amounted to 8 per cent of the world's total, or 153,000 tonnes (Figure 4.16).

208. Nickel is widely used for decorative and protective coatings with thickness of 1–100 micrometers, so-called galvanizing or nickel plating. Such coatings have high resistance to corrosion in air and water environments, high hardness, and good decorative properties. In 2017, galvanic plating accounted for 7 per cent of world consumption, or 131,000 tonnes (Figure 4.16).

209. The application of nickel in the production of batteries for electric transport is most actively developing. In 2017, 109,000 tonnes of metal were used for their production, which accounted for 5 per cent of world consumption (Figure 4.16). Nickel is one of the main components in the production of active cathode material for battery cells. Nickel is not contained in the most popular (primarily in China) lithium-ion batteries: lithium cobalt oxide, lithium iron phosphate, and lithium manganese oxide. The nickel-metal hydride accumulators, lithium nickel manganese cobalt oxide (NMC) and lithium nickel cobalt aluminum oxide, where the nickel content depending on the modification is from 30 to 80 per cent, are significantly less common nowadays.[51]

210. Other applications of nickel include foundry, coinage, its usage as a catalyst for chemical reactions, in the production of ferrite materials and as a pigment for glass, glazes, and ceramics, in the manufacture of various chemical equipment, in shipbuilding, in electrical engineering, and for many other purposes.

211. Global consumption of primary nickel extracted from the subsoil has almost doubled since the early 2000s, reaching 2.2 Mt in 2017 (Figure 4.17).[52] Practically the only reason for this was the rapid development of the steel industry in China. Metal consumption in the country during this period increased by more than ten times and in 2017 amounted to 1.17 Mt (54 per cent of the world total). The rest of the countries use less metal than China. Thus, the total share of former leaders (European Union (EU), USA, Japan, and South Korea) in nickel consumption is approximately a third of the world's total.

212. Changes in the geography of consumption did not affect its industry structure as a whole. Stainless steel production remained the main area where about two-thirds of the metal were used steadily.

213. The structure of metal usage within the main consumer countries corresponds to the world structure, with two-thirds directed to stainless steel production. The main growth of consumption by the EV industry is observed in China, where the production of nickel-cobalt-manganese compounds is developing, while the trend of partial replacement of cobalt with nickel persists. Production capacities of nickel-cobalt and aluminum compounds are being increased in Japan and South Korea.[53]

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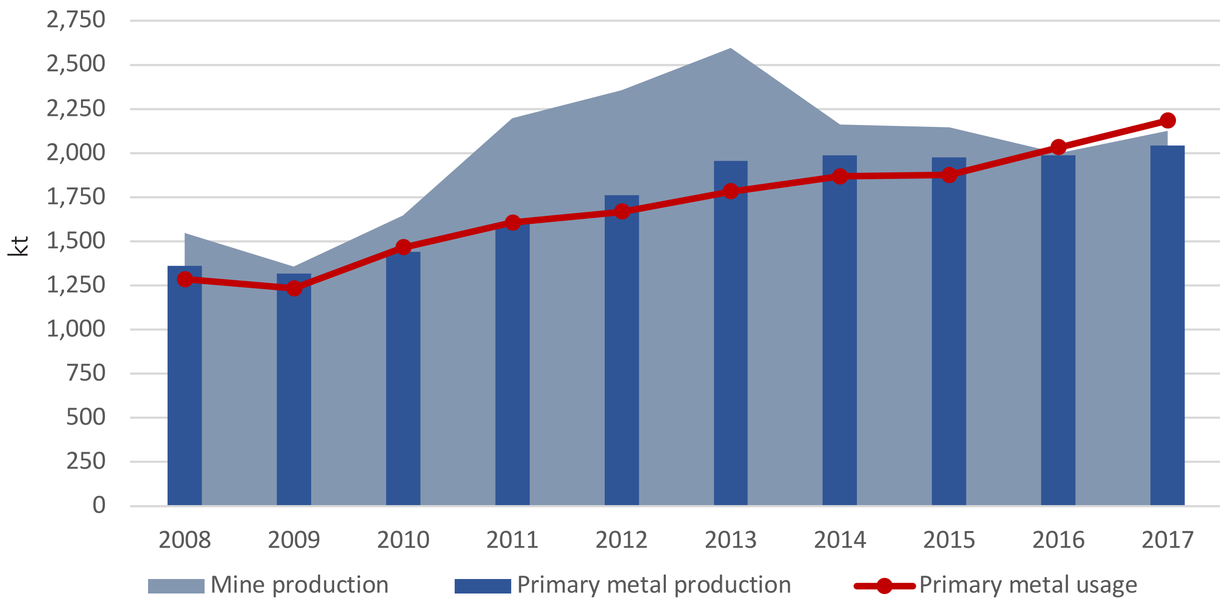
[51] Bloomberg News (2019). Nickel Ban Shows Indonesia's Ambition to Build EV Industry. https://www.bloomberg.com/news/articles/2019-10-28/indonesia-will-trade-nickel-riches-for-an-electric-car-industry?sref=AjlywoTi.

[52] INSG (2019). *World Nickel Statistics. Yearbook. Vol XXVIII. No. 12.*

[53] PJSC MMC Norilsk Nickel (2017). *Annual Report 2017*. p. 36.

Figure 4.17. World mine production, primary nickel production and usage



Source: INSG.

Production

214. The increase in world demand led to a corresponding growth in primary nickel production, which since the early 2000s has also doubled and exceeded 2 Mt in 2017 (Figure 4.17). The main growth in production also came from Chinese producers. However, the amount of nickel produced in the country does not fully meet the demand for it from domestic consumers.

215. The processing industry is developing most dynamically in Indonesia due to state policy in the spheres of subsoil use and industry. In 2014-2018, the country was banned from exporting nickel ore, which forced investors, mainly Chinese, to invest in the construction of processing operations. As a result, primary nickel output increased from 2 per cent of world nickel in 2015 to 10 pr cent in 2017. From 2020, the country's government will again impose an export ban, which is expected to lead to even greater production growth in Indonesia.[54,55]

216. As shown in section 4.A above, there is a differentiation between the production of high-grade and low-grade nickel depending on the type of raw material. The main nickel sources are two types of ores: sulphide and silicate ("laterite"). When processing sulfide ores, only refined nickel is obtained. Processing of laterite ores is possible by two methods, obtaining either ferro-nickel and NPI or refined metal. The second method requires significantly larger investments and is implemented at single sites.

217. Recycling of secondary nickel-containing raw materials is not developed properly and is applicable only for stainless steel production. It is known that the contribution of secondary raw materials to steel production is most significant in

[54] Reuters (2019). Miners welcome Indonesian export ore ban, plan smelting expansion. https://mobile.reuters.com/article/amp/idUSKCN1VW2AP.

[55] Bloomberg News (2019). Nickel Ban Shows Indonesia's Ambition to Build EV Industry. https://www.bloomberg.com/news/articles/2019-10-28/indonesia-will-trade-nickel-riches-for-an-electric-car-industry?sref=AjlywoTi.

China (there are no reliable estimates of the share of use) and in Japan (up to 40 per cent of production). According to INSG estimates, about 4–4.6 Mt of nickel-bearing scrap containing 350,000 tonnes of nickel are used annually for steel production.[56]

218. Until the early 2000s, sulphide ore deposits were the main source of nickel raw materials. Their main reserves are concentrated in traditional regions of the nickel industry: Russia, Canada, Australia, China, and South Africa. These countries specifically provided the bulk of nickel mining and primary nickel production. In the early 2000s, a new low-cost product was developed in China: NPI produced by processing laterite ores. The rapid growth in production that characterizes the 21st century became possible due to this. Indonesia, the Philippines, New Caledonia, Brazil, Colombia, Cuba, and a number of other countries have become sources of raw materials for Chinese producers. This is what ensured the main growth of nickel production. In 2009–2014, the growth rates of global nickel production increased sharply. This was due to the announcement of a ban on the export of nickel ore from Indonesia, and Chinese companies sought to stockpile raw materials to maintain production after the termination of Indonesian supplies. In 2014, global nickel production declined by 17 per cent due to a sharp drop in Indonesia, which could not be compensated for by growth in the Philippines and New Caledonia. In 2015, the decline in global production continued due to the suspension of nickel plants that did not meet environmental standards in China, primarily the NPI operations. Since 2016, the global nickel industry has stabilized, and there has been an increase in nickel production and primary nickel production.

Prices

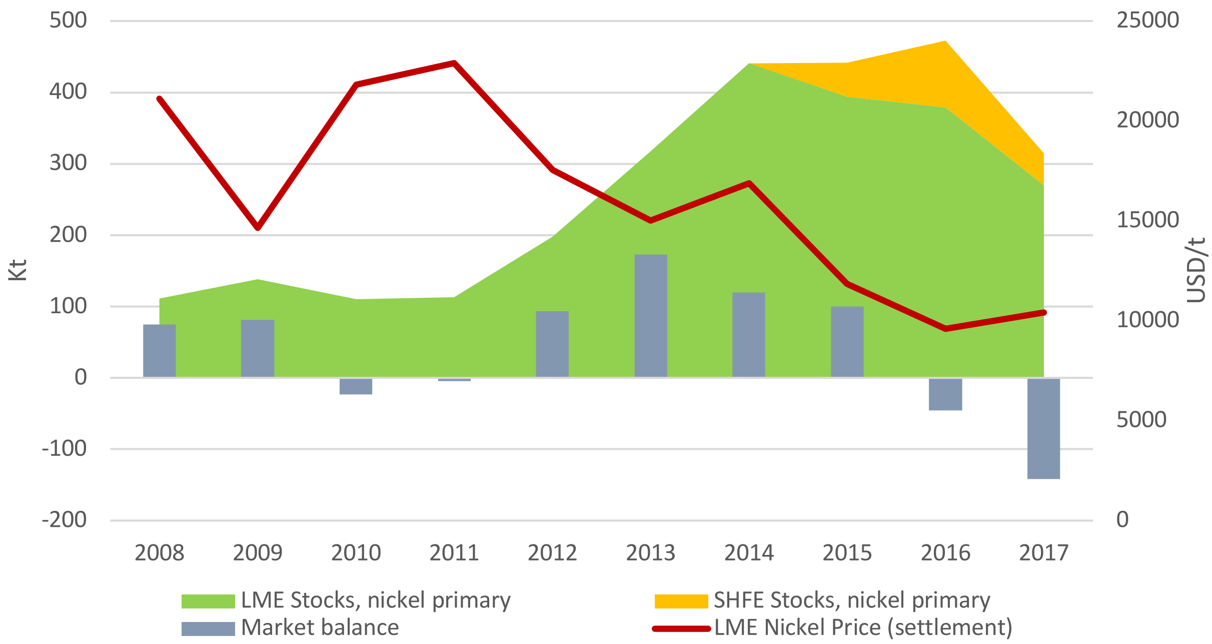
219. Nickel is an exchange-traded metal. Its prices are formed on trading platforms, the main one of which is the LME.

220. In 2005–2007, nickel prices demonstrated unprecedented growth due to increasing demand from Chinese producers and fears of a deficit, but more due to an inflow of speculative capital (Figure 4.18). The collapse of prices that followed from the middle of 2007 was related exclusively to the introduction of new rules for exchange trading that stopped speculation. The consequences of the global financial and economic crisis of 2008–2009 aggravated the price failure. Stable growth began only by mid-2009, facilitated by continued rapid development of the Chinese economy as a whole and increased demand for raw materials from stainless steel producers in that country. This led to the expansion of production capacities at existing enterprises and the emergence of a large number of nickel deposit development projects around the world. Some of these projects were successfully implemented, which resulted in increased production.

221. The continuous growth of metal mining and metallurgical production, however, stimulated by high prices, resulted in a shift of the market balance towards surplus since 2007 (Figure 4.18).[57,58] The unclaimed metal "settled" in LME warehouses, and its reserves reached a maximum of 466,000 tonnes in May 2015, which is comparable to a quarter of world production for the same year. At the same time, refined nickel trading started at SHFE, which partially reduced LME stocks but did not change the situation as a whole. As of the end of December 2018, LME stocks accounted

56 INSG. About Nickel. Recycle and Environment Issues https://insg.org/index.php/about-nickel/recycle-and-environment-issues/.
57 INSG (2019). *World Nickel Statistics. Yearbook. Vol XXVIII. No. 12.*
58 LME. https://www.lme.com/.

Figure 4.18. World primary nickel production/demand balance, stocks (left) and prices (right) in 2008–2017



Sources: INSG, LME.

for 206,400 tonnes of nickel, while SHFE stocks accounted for 93,900 tonnes, which corresponds to approximately 1.5 months of metal consumption.

222. Apart from a slight deficit in 2010–2011, the market was in surplus until 2015, which affected the drop in exchange prices for nickel. Short-term growth of quotations was observed in early 2014 under the threat of reduced supplies due to the beginning of the export ban in Indonesia. However, Filipino suppliers that closed the emerging shortage did not allow the nickel price to win back its positions, and it continued to fall (Figure 4.18).

223. Since 2016, the nickel market has been in a state of deficit, which affects the gradual increase in nickel quotations on the back of the recovery of demand both from the Chinese metallurgical industry and from alkaline battery producers, the production of which is one of the promising applications of the metal. According to the INSG, in 2018, the nickel deficit increased to 144,200 tonnes.[59] INSG also expects to reduce the deficit in 2019 and 2020 to 79,000 tonnes and 47,000 tonnes respectively. This could have a negative impact on the growth rate of the metal exchange value.

Forecast of demand and consumption

224. The main prospects for the growth of nickel consumption are associated with an increase in the share of electrification of motor vehicles and the production of high-capacity storage batteries. The key factors driving electrification of the transport system are incentives offered by the state, transformation of the consumer mindset, and improved technical specifications of batteries.

225. The electric car market growth is led by China. By 2020, it plans to increase NEV (electric cars and plug-in HEVs) sales

[59] INSG (2019). Press Release. INSG October 2019 Meetings, 22.10.2019.

to 2 million, and by 2025 up to 7 million vehicles.[60] The government has also introduced benefits and subsidies for the purchase and production of passenger electric transport. Similar measures have been taken by the governments of a number of European countries, including Belgium, Germany, the United Kingdom, France, and Norway.

226. Growth of electric car production is possible not only due to already established production clusters in China, European countries, and the USA, but also due to new regions. The Indonesian government has already announced plans to develop an EV industry in the country.[61]

227. Growing nickel consumption in Li-Ion batteries comes not only on the back of increasing share of nickel-containing types, but also higher average nickel content in the cathode material triggered by the need to substitute expensive cobalt units. While in 2016, NCM 1:1:1 (with nickel mass fraction of 20 per cent) accounted for the lion's share of nickel-magnesium compounds of the cathode material, in 2018, nickel-intensive compounds—NCM 6:2:2 (with nickel mass fraction of 36 per cent) and NCM 5:3:2 (30 per cent)—took the lead. Going forward, batteries are expected to switch to NCM 8:1:1 (with nickel mass fraction of 48 per cent), and some producers have announced plans to launch commercial production of LNO, a cathode material with nickel content of over 50 per cent. Further development of the automotive industry, the growing popularity of electric and hybrid cars, and the evolution of cathode technology towards nickel-intensive types lay the groundwork for major expansion of primary nickel consumption in this industry in the long run.[62]

228. Estimates of nickel demand growth in battery production by analytical agencies vary greatly and range from four to 14 times by 2030 (Figure 4.19). Such large differences are due to the inability to determine the most likely development of the situation in a number of key areas. The main factors, the impact of which is assessed differently by different experts, include, first of all, issues related to the prospects of using a particular type of battery and the prevailing type of EVs, on which the share of this or that metal depends. This raises questions about the speed with which the mining sector can respond to potential changes in the demand structure, the long-term availability of raw materials for expected growth in consumption, and the impact of these changes on traditional segments of metal demand.

229. The most optimistic forecast is given by the analytical group BloombergNEF, estimating the demand for nickel in batteries by 2030 at 1,800 tonnes of metal.[63] The agency estimates that, by 2030, global annual lithium-ion battery demand will reach 2,000 GWh, with passenger EVs accounting for more than 70 per cent.

230. Roskill anticipate an increase in nickel demand from EVs of 700,000 tonnes by 2030, with a slowdown already by 2028.[64]

231. McKinsey & Company and the Australian multinational independent investment bank and financial services company Macquarie Group Ltd. give

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[60] PJSC MMC Norilsk Nickel. *Annual Report 2018*, p. 43.

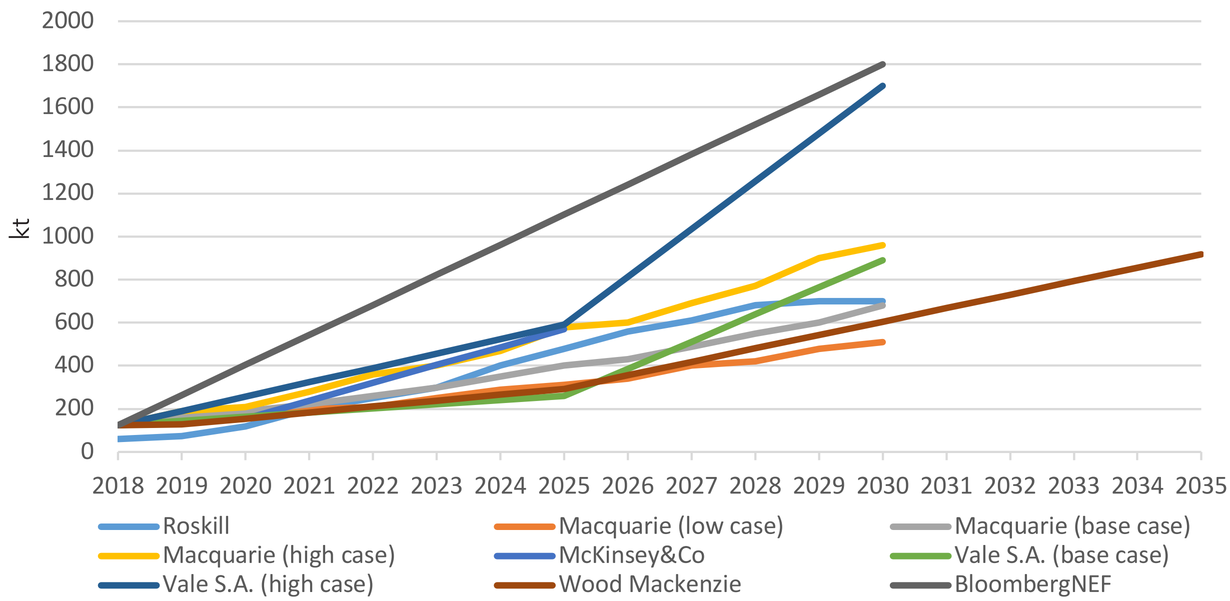
[61] Bloomberg News (2019). Nickel Ban Shows Indonesia's Ambition to Build EV Industry. https://www.bloomberg.com/news/articles/2019-10-28/indonesia-will-trade-nickel-riches-for-an-electric-car-industry.

[62] PJSC MMC Norilsk Nickel. Annual Report 2018, p. 43.

[63] Bloomberg News (2019). There's One Metal Worrying Tesla and EV Battery Suppliers. https://www.bloomberg.com/news/articles/2019-08-05/there-s-one-metal-worrying-tesla-and-the-ev-battery-supply-chain.

[64] Independence Group NL (2019). Austmine 2019. https://www.igo.com.au/site/PDF/2741_2/Austmine2019Presentation.

Figure 4.19. Forecast nickel consumption by EV-industry



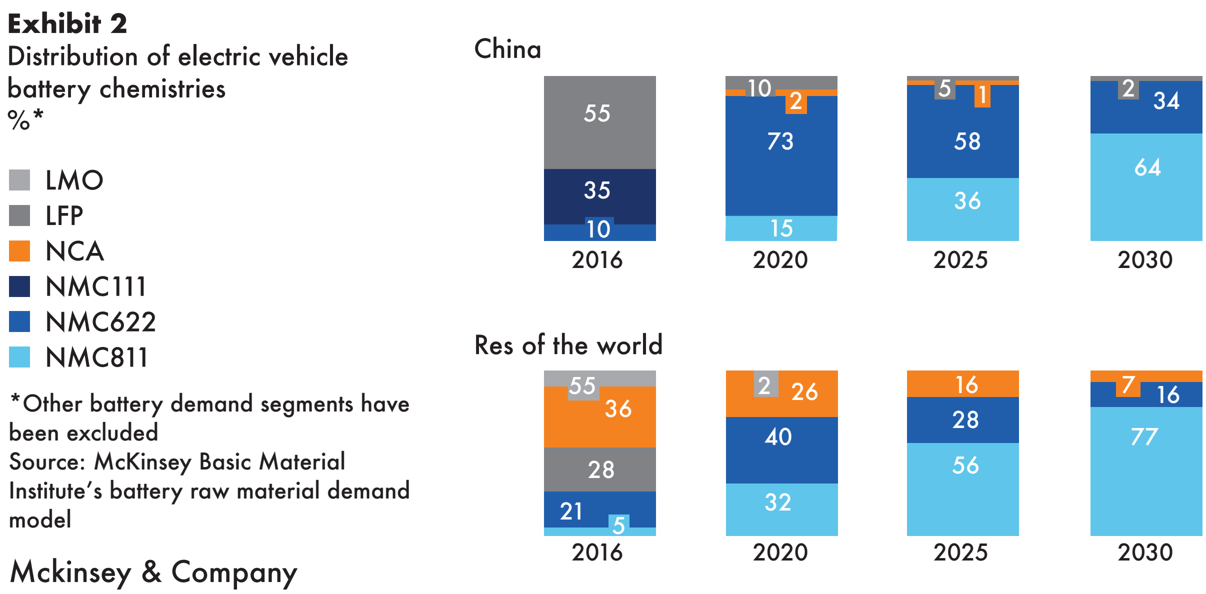
close estimates, given the other forecast horizon. According to their forecasts, the demand for high-grade nickel will increase 17-fold to 570–590,000 tonnes by 2025. At the same time, McKinsey estimates that, by 2030, the annual demand for electricity will increase to 2,300 GWh, while passenger EVs will account for no more than half. McKinsey sees changes in the types of batteries produced in China as the main reason. Whereas nowadays, Chinese preferences for battery chemistries clearly diverge from those in the rest of the world (ROW), with lithium iron phosphorus capturing 55 per cent of the Chinese market, analysts expect preferences to converge toward nickel manganese cobalt (NMC) chemistries, with NMC811 and NMC622 the winners capturing a combined market share of >90 per cent by 2025–2030. These chemistries are less cobalt-intensive—NMC811 contains ~25 per cent of the cobalt per kWh compared to NMC111—but also more nickel-intensive, with the nickel content in NMC811 a factor 1.75 higher per kWh (Figure 4.20).[65]

232. Vale S.A., one of the largest nickel producers, is considering two scenarios of consumption development. Under the maximum growth scenario, EV production will exceed 40 million units by 2030, and demand for nickel will reach 1,700 tonnes, which is in line with BloombergNEF estimates. According to the conservative scenario, the number of EVs would not exceed 20 million units, with nickel consumption falling within the range of most estimates (Figure 4.19). On the whole, the company expects a significant increase in the first-class nickel deficit by 2030, which cannot be covered by the formed stocks of refined metal (Figure 4.21).[66]

65 McKinsey & Company. Metal mining constraints on the electric mobility horizon. April 2018, https://www.mckinsey.com/industries/oil-and-gas/our-insights/metal-mining-constraints-on-the-electric-mobility-horizon.

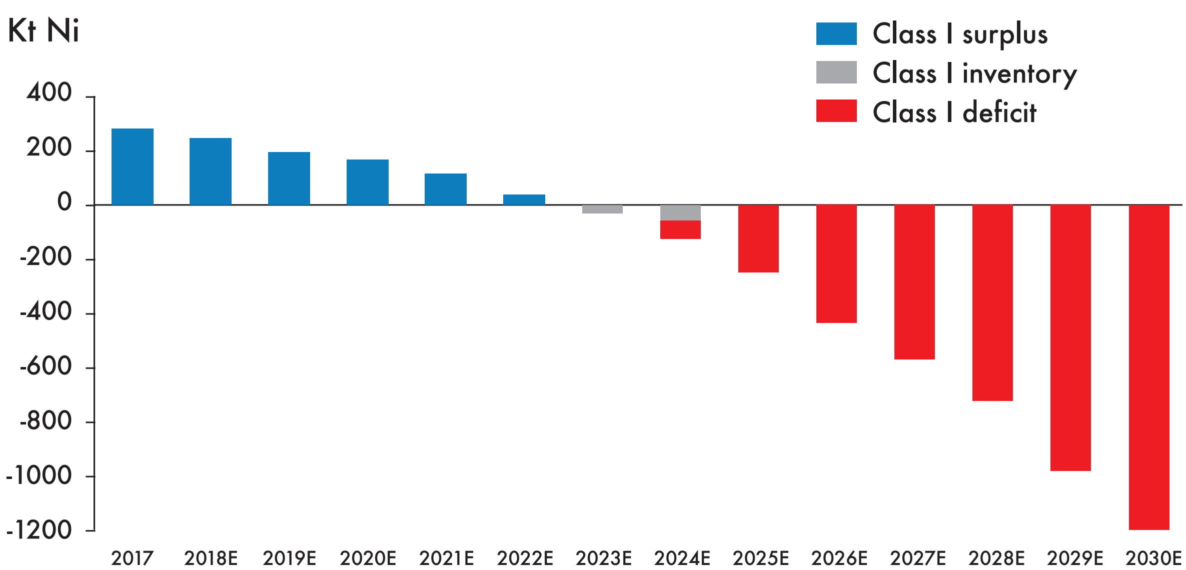
66 Vale S.A. Electric Vehicle Revolution and Implications for New Energy Metals. Mining and Steel Conference 2018, http://www.vale.com/EN/investors/information-market/presentations-webcast/PresentationsWebcastsDocs/BofA%20-%20May%202018%20-%20Bob%20Morris%20vFinal_i.pdf.

Figure 4.20. Distribution of EV battery chemistries



Source: McKinsey & Company.

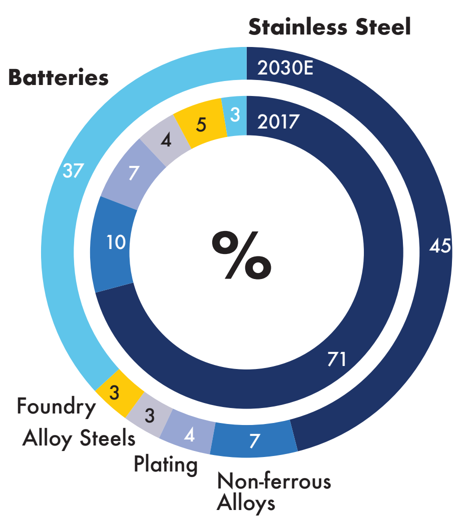
Figure 4.21. Class 1 (non-stainless) market balance



Source: Vale S.A.

233. Wood Mackenzie estimates strong demand from non-stainless applications, increasing by approximately 5 per cent per year. This is driven by nickel consumption in Li-ion batteries for EVs and energy storage.[67] With such growth dynamics, by 2030, the share of stainless steel in the consumption structure may significantly decrease in favor of the predominance of batteries (Figure 4.22). If this trend continues in the longer term, the share of the battery sector can be expected to equal that of stainless steel in the mid-2030s.

Figure 4.22. Nickel demand: 2017 vs. 2030



Source: Wood Mackenzie.

234. Regarding forecasts of future demand from stainless steel producers, all analysts agree that it will maintain stable growth. At the same time, estimates of its demand growth vary significantly: Roskill expects a 40 per cent increase by 2030, while Wood Mackenzie expects only a 20 per cent increase.[68,69]

235. We chose three cases of primary nickel demand forecast based on the abovementioned consumption growth options, reflecting both minimum and maximum growth rates of consumption dynamics (Figure 4.23). However, like all long-term forecasts, they are to a high degree tentative.

236. Case 1 (low) corresponds to the Wood Mackenzie forecast and expects annual growth of global demand by 2.6 per cent. These are the lowest growth rates from the examined forecasts.

237. Case 2 (base) corresponds to the Roskill forecast and expects average annual growth of global demand by 4 per cent. This generally corresponds to the average value of consumption growth rates projected by most analytical agencies.

238. Case 3 (high) corresponds to Bloomberg forecasts and expects the fastest average annual growth in demand by 5 per cent.

Resources and reserves

239. According to USGS,[70] world nickel reserves are estimated to be at least 89 Mt of nickel, while identified land-based resources averaging 1 per cent or greater of nickel contain at least 130 Mt of nickel. At the current level of production of nickel commercial ores and concentrates (about 2.1 Mt in 2017), taking into account losses during processing of raw materials, reserves availability at the achieved production level exceeds 40 years, and resources availability 60 years.

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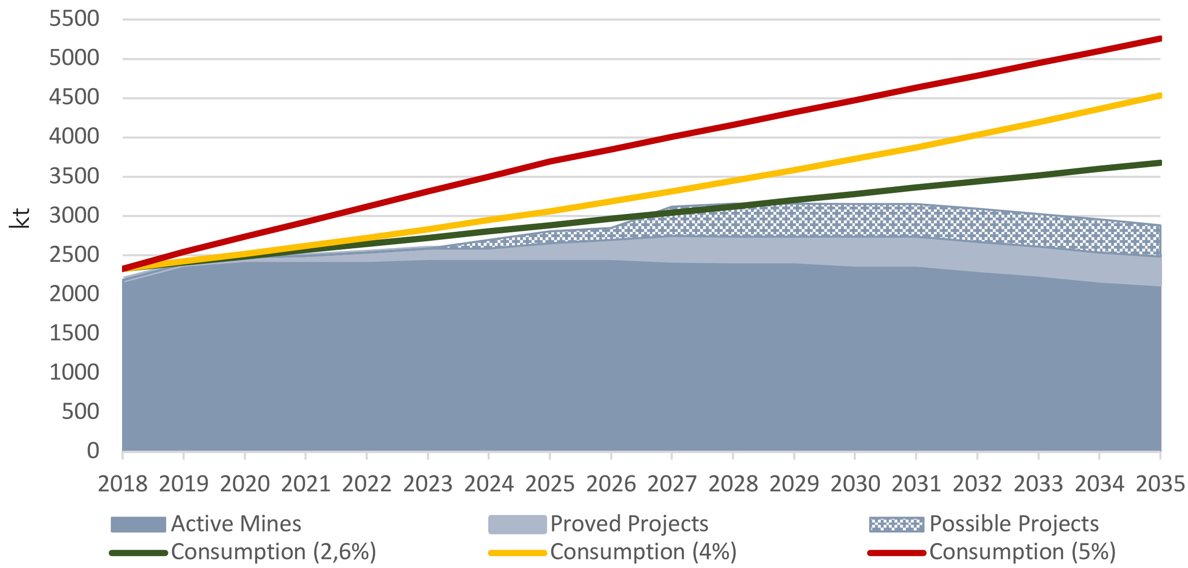
[67] Horizonte Minerals Plc. Investor Presentation Q4 2019 Nickel market. https://horizonteminerals.com/news/en_20191024-investor-presentation.pdf.

[68] Independence Group NL (2019). Austmine 2019. https://www.igo.com.au/site/PDF/2741_2/Austmine2019Presentation.

[69] Horizonte Minerals Plc. *Investor Presentation Q4 2019 Nickel market.* https://horizonteminerals.com/news/en_20191024-investor-presentation.pdf.

[70] USGS (2020). *Mineral Commodity Summaries 2020.* https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

Figure 4.23. Primary land-based nickel production and consumption forecasts until 2035



Forecast of land-based mining

240. In order to forecast the level of world production of primary nickel by 2035, data on reserves and identified resources (measured + indicated + inferred resources) of more than 150 nickel ore deposits of various degrees of development were compiled and analysed. Resources of prospected fields were not taken into account. The expected nickel production from existing mines is calculated based on actual production in 2018, taking into account the planned expansion projects of existing capacities. The main source of information was mining company reports. China and Indonesia were the exceptions; site-specific information on these countries is limited, and therefore production estimates for these countries as a whole are used.

241. Nickel projects are conditionally divided into two categories in terms of readiness for development: Proved and Possible projects. The main criterion for assigning a project to a group was its development stage (Preproduction, Construction, Feasibility Study, Prefeasibility Study). The timing of their implementation and the complexities involved were also taken into account. However, it should be noted that the stated deadlines are quite often postponed for various reasons.

242. It should be noted that the information on existing projects is obviously not complete. First of all, it is connected with inaccessibility of data on projects implemented in the territory of China. Also, there is no confidence in completeness of data from Indonesia and some other producers (such as Madagascar, New Caledonia, etc.).

243. According to the analysis, by 2035, the production at the existing operations may decrease by 2 per cent compared to the current level due to the complete depletion of the fields on which they operate (Figure 4.23).

244. Production at Proved projects may start already in 2020. By 2035, these projects will account for almost 350,000 tonnes of nickel. Possible projects may be put into operation from 2024. By the end of the period under review, they may jointly produce about 400,000 tonnes of nickel. Thus, the well-known projects will not only fully compensate for the retiring

production from the existing mines, but will also ensure its significant growth. As a result, nickel mine production may exceed the current level by one-third in 2035.

245. Despite a significant increase in production, even if consumption grows by 2.6 per cent per year (case 1, low), the market may experience a primary metal deficit after 2029 (in preceding years, the market will be close to a balanced state). At the same time, the possible deficit of metal will begin to exceed the current deficit only by 2032, so the value of metal may be very unstable practically until the end of the period under consideration. It should be noted that we do not take into account stocks of stock exchanges and private companies, as well as secondary metal, for the production of which there are prospects for growth (primarily due to used batteries). Therefore, the actual deficit may manifest itself later and/or be much lower.

246. In the other two scenarios of consumption growth (base and high), the market may experience a deficit over the whole period under consideration. This situation may lead to a significant increase in metal prices. This, in turn, will create conditions for the intensification of work on preparation for the exploitation of known, but so-far inactive, deposits, as was already the case in the first half of the 2000s. In this respect, laterite ore deposits are very promising, mainly concentrated on the territory of developing countries, development of which does not require much time and is relatively cheap. In addition, in recent years, there has already been a significant increase in nickel exploration costs. According to S&P Global, in 2019 alone, their costs increased to USD351.6 million, or by almost USD54 million, compared to the previous year.[71] Such work may result in the identification of new raw material facilities, which may also be put into operation promptly.

247. In addition to the balance of supply and demand, political sentiment regarding the development of the nickel consuming and producing sectors in Indonesia and China will continue to have a significant impact on the nickel market situation. The pace of global economic growth in general, and the pace of development of electric transport in particular, will also play a major role.

Impact of nodule mining

248. With regard to the possible development of polymetallic nodules, we are considering three scenarios: a minimum scenario (involving two contractors; Figure 4.24), a base scenario (involving six contractors; Figure 4.25) and a maximum scenario (involving 12 contractors; Figure 4.26). All scenarios assume the first contractor starting production in 2027 and the second in 2030; the remaining contractors (subject to their involvement) would join the process in 2031–2033. It is assumed that the maximum aggregate production level may be reached in 2035.

249. Provided that the minimum scenario is implemented and that two contractors are involved in deep-sea mining, their contribution to global nickel production will be negligible and will not exceed 3 per cent of the expected surface mining at that time, provided that all the projects under consideration are commissioned (Figure 4.24). However, with a maximum potential production level (about 74,000 tonnes of nickel per year), which is expected to be reached as early as 2032, deep-sea mining would be comparable to the production expected at that time in Finland or Papua New Guinea. This level may be enough to make deep-sea mining one of the top ten world metal producers. In terms of

[71] PR Newswire (2019). 2019 exploration budget recovery falters due to difficult market conditions and high-profile M&A activity. https://www.prnewswire.com/news-releases/2019-exploration-budget-recovery-falters-due-to-difficult-market-conditions-and-high-profile-ma-activity-300938552.html.

Figure 4.24. Forecast primary nickel production and consumption, including polymetallic nodule mining, for 2018–2035 (2 contractors)

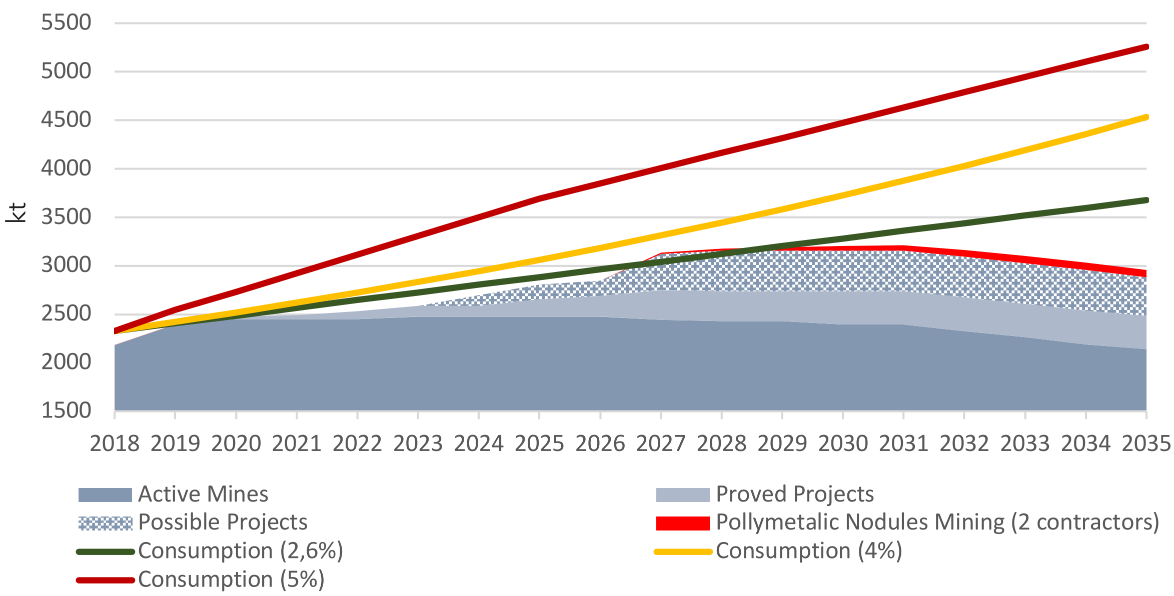
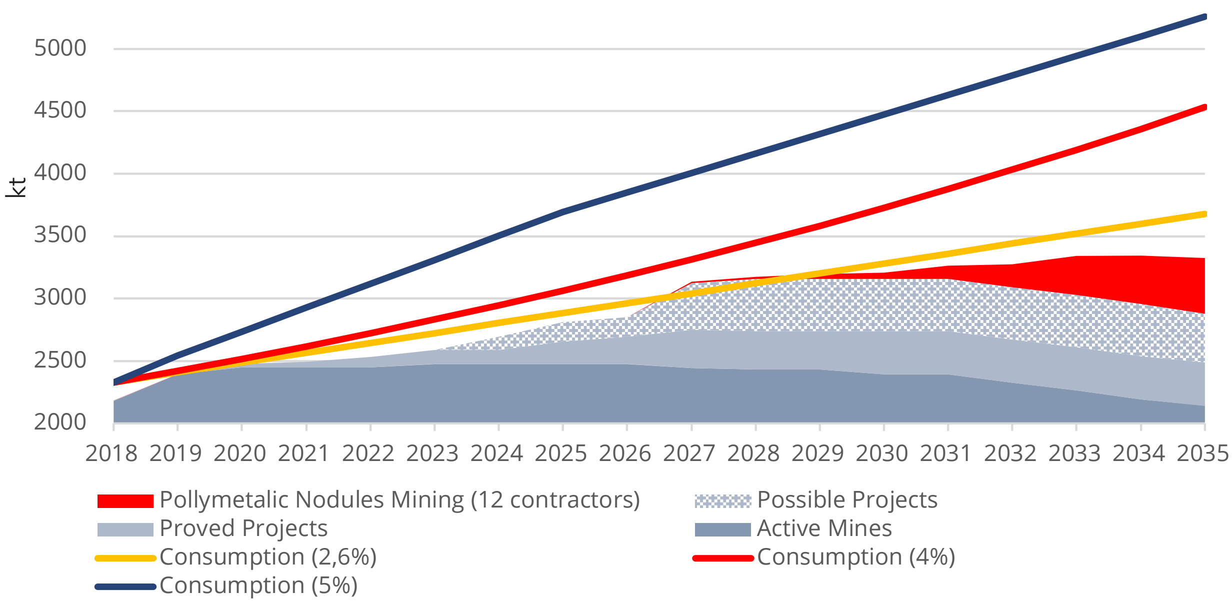


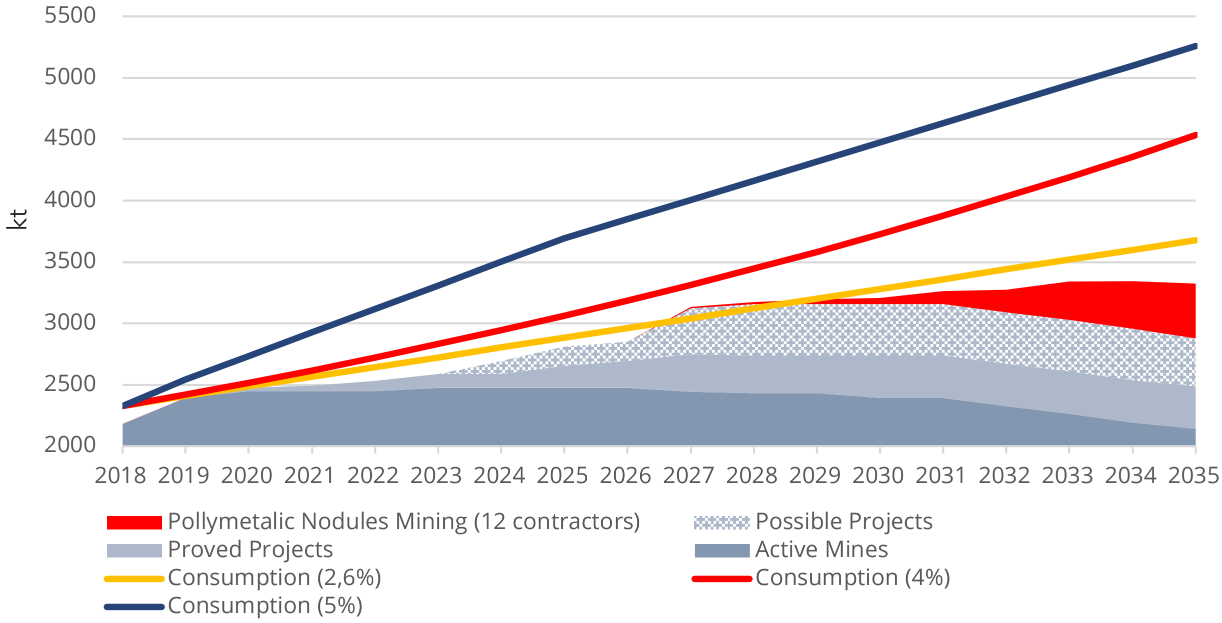
Figure 4.25. Forecast primary nickel production and consumption, including polymetallic nodule mining, for 2018–2035 (6 contractors)



potential production, one contractor is comparable to a medium-scale surface plant; these include Trident (Zambia), Cerro Matoso (Columbia), Biankouma-Sipilou (Cote-d'Ivoire), and others.

250. Under the implementation of base or maximum scenarios (involving six or twelve contractors), deep-sea nickel production volumes in 2035 may amount to approximately 222,000 tonnes or 445,000 tonnes respectively (see section 3.B). This would be 8 or 15 per cent of the surface mining expected at this point, provided that all the projects under consideration are commissioned (Figures 4.25 and 4.26).

Figure 4.26. Forecast primary nickel production and consumption, including polymetallic nodule mining, for 2018–2035 (12 contractors)



251. Thus, if production of polymetallic nodules starts in 2027 and increases with the intensity we expect, it will not cause overproduction of nickel even with the minimum expected growth rate of consumption, the commissioning of all currently known projects of new surface mines, and deep-sea mining by twelve contractors. Only the first years of deep-sea mining may be an exception. The earlier appearance of nickel from polymetallic nodules on the market at the lowest expected rate of growth in metal consumption may cause a significant surplus of metal that may persist for several years. Only if the growth rate of nickel consumption is higher than the low scenario of consumption growth, the start of deep-sea mining will not cause overproduction of the metal.

252. Even though the development of deep-sea mining in the scenarios we are considering will not have a negative impact on the nickel demand/supply balance, however, it may still lead to a slight decline in the previously established prices, as it will reduce possible supply tensions. Besides, as was mentioned above, one cannot ignore the psychological pressure on market participants, which will be caused by the fact of appearance of an additional source of metal with a great potential for growth.

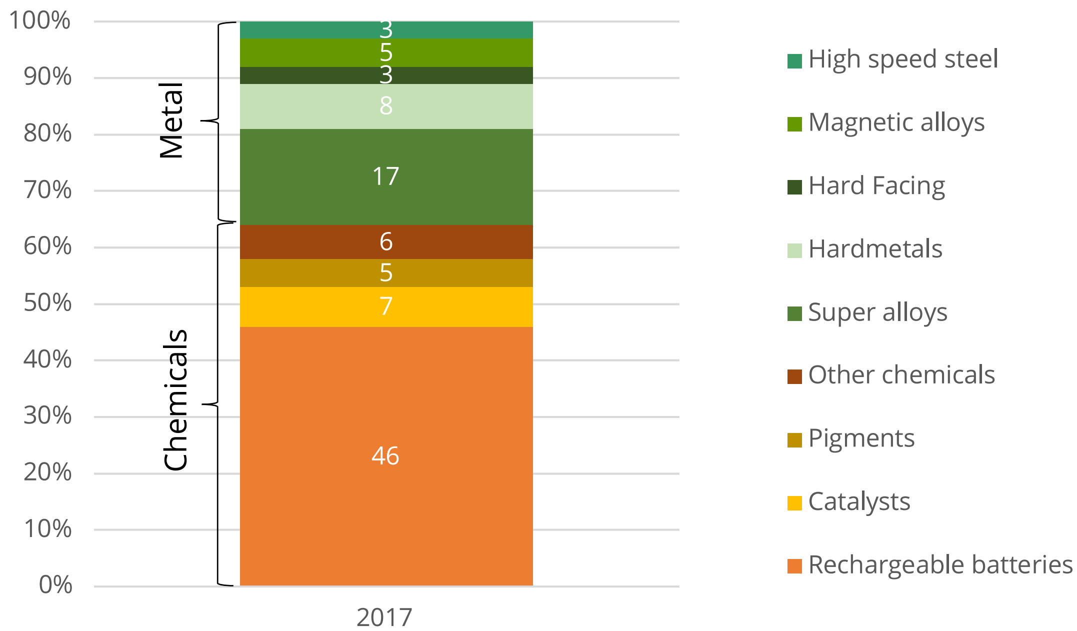
Cobalt

Consumption

253. Cobalt applications can be aggregated into two main areas: chemical compounds and metals (Figure 4.27). The main areas of use of cobalt are production of rechargeable batteries, various alloys, and catalysts. The structure of cobalt consumption has changed fundamentally over the last ten years, as due to the rapid growth of lithium-ion batteries production, metal cobalt has given way to chemical compounds.

254. The most frequently used types of cobalt batteries are lithium-ion batteries, such as NMC, lithium cobalt oxide, and lithium nickel cobalt aluminium oxide. Cobalt is also important in other types of batteries, such as nickel-cadmium and nickel-metal hydride. These batteries are

Figure 4.27. Cobalt end-use structure in 2017



Source: Cobalt Institute.

used in portable devices (smartphones, tablets), energy storage systems (solar panels), car electric motors, and household appliances. The unique properties of cobalt allow the thermal stability of lithium batteries and the integrity of the cathode to be maintained, which is a determining factor in their safe use.

255. Cobalt is widely used in various alloys in order to make them magnetic, heat-resistant, wear-resistant, and corrosion-resistant. Cobalt-containing alloys are divided into superalloys, alloys for prosthetics, magnetic, and wear-resistant alloys by their properties. Their areas of application are aerospace, cutting tools, automotive, industrial equipment, and prosthetics.

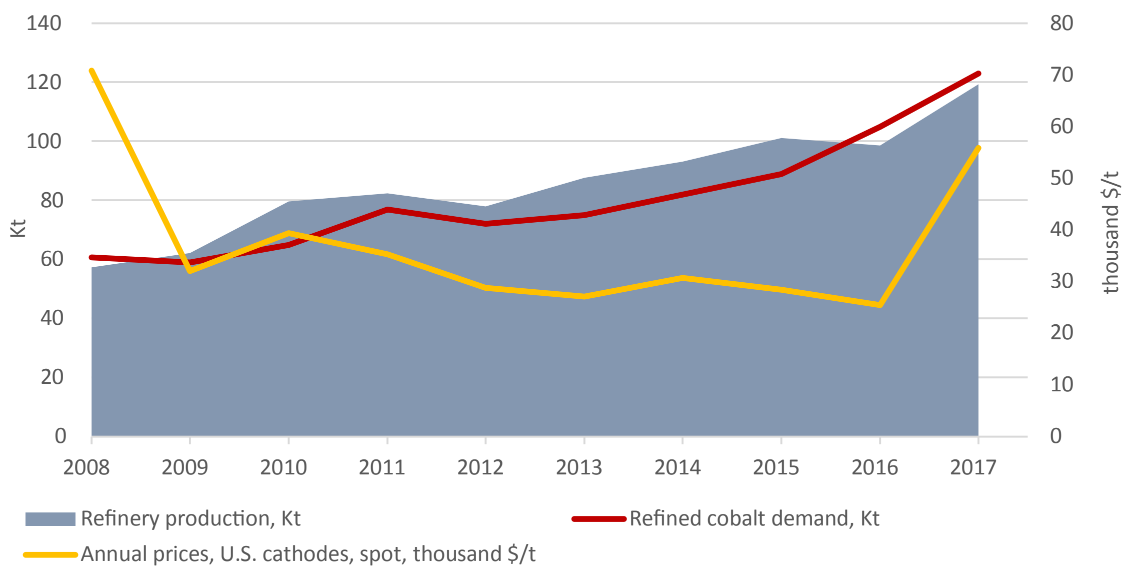
256. Cobalt and its compounds act as a catalyst in natural gas and oil product desulfurization reactions. Cobalt catalysts reduce the activation energy required for industrial processes such as the creation of recyclable plastics.

257. Cobalt oxide is used as a bright blue pigment in the manufacture of glass, porcelain, ceramics, enamels, paints and inks.

258. Among other areas of cobalt applications are electronics, medical diagnosis, cancer treatment, pharmaceuticals, etc.

259. Products made from cobalt metal and its alloys, as well as batteries, are suitable for recycling. Cobalt waste and scrap are recycled for economic (lower costs compared to extraction of cobalt from ores) and ecological reasons (to prevent damage caused by battery contents entering the soil). Cobalt waste and scrap are divided into new (generated during the manufacture of alloys and other cobalt-bearing materials and products) and old (collected after consumption). Collecting old scrap is more difficult because it is often mixed with other scrap that does not contain cobalt. The United Nations Environment Programme (UNEP) estimates end-of-life recycling rate at 32

Figure 4.28. World refined cobalt consumption, production and annual prices in 2008–2017



Sources: Cobalt Institute, BGS, IMF.

per cent, and recycled content at 68 per cent.[72] Difficulties in recycling of batteries are due to the variety of their forms and composition. In areas such as pigments, glass, paint, etc. recycling is not possible due to the low cobalt content in waste. The estimates of current secondary cobalt production vary greatly and range from 6 to 15 tonnes.[73]

260. In 2008–2017, cobalt consumption increased by more than two times, and in 2017, according to the Cobalt Institute, reached 123,000 tonnes (Figure 4.28).[74] The main reason for this was its use in lithium-ion batteries, the production of which was expanding rapidly in those years.

Production

261. Refined cobalt production was expanding as well (including cobalt contained in chemical compounds). However, it did not match the demand from consumers at certain periods. In such cases, the shortage of metal was compensated by various warehouse stocks (producers, traders, or stock exchanges) accumulated in periods of overproduction.

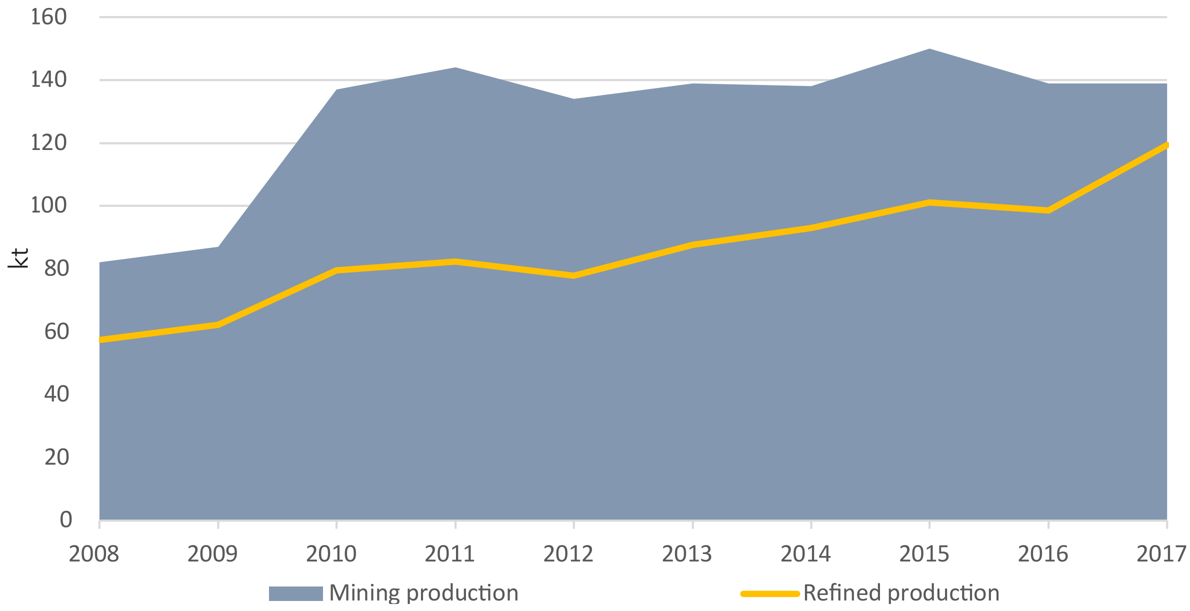
262. The difficulty in bringing the demand for cobalt and its production into a balanced state is that cobalt mining is mainly carried out along with copper (from sediment-hosted stratiform and stratabound copper deposits) and nickel (from magmatic nickel-copper-cobalt sulphide deposits and nickel laterites). The only cobalt deposit in the world where its commercial extraction is carried out is Bou Azzer deposit in Morocco. According to the estimates of CRU, in 2016, approximately 61 per cent of produced cobalt was extracted as a by-product of copper mining, and 37 per cent

[72] UNEP (2011). *Recycling Rates of Metals: a status report, International Resource Panel.* http://wedocs.unep.org/bitstream/handle/20.500.11822/8702/-Recycling%20rates%20of%20metals%3a%20A%20status%20report-2011Recycling_Rates.pdf?sequence=3&isAllowed=y.

[73] Al Barazi, S. (2018). *Rohstoffrisikobewertung – Kobalt, DERA Rohstoffinformationen 36, Berlin, 120 S.* https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-36.pdf.

[74] Cobalt Institute. Production and Supply. https://www.cobaltinstitute.org/statistics.html.

Figure 4.29. World mine and refinery cobalt production in 2008–2017 (in kt)



Source: BGS.

as a by-product of nickel mining.[75] As a result, the dynamics of cobalt mining and, consequently, refined cobalt production, correlate with copper and nickel mining from certain types of deposits rather than with the metal demand dynamics. Nevertheless, in 2008–2017, copper production was growing. According to the BGS,[76,77] during this period mine production increased by 1.7 times to 139,000 tonnes (Figure 4.29), and world production of refined cobalt increased by 2.1 times to 119,400 tonnes. According to the Cobalt Institute,[78] refined cobalt production in 2017 was slightly lower at 117,000 tonnes, having increased by 2.2 times over 10 years.

263. The main center of cobalt mine production is the Democratic Republic of the Congo (DR Congo), which accounts for approximately 60 per cent of the world production. Approximately 15–20 per cent of production in this country comes from artisanal-based operations, where child labor is widespread.[79] Wide distribution of artisanal mining makes it difficult to keep records of mine production in the country, and some artisanal mines carry out illegal mining. This might be the reason the statistical data on cobalt mine production in DR Congo differ greatly across various sources (USGS, BGS, and S&P Global).

264. The world leader in the production of refined cobalt and its compounds is China, whose production is mainly based on imported raw materials. As of 2016, USGS estimated cobalt refinery capacities

75 Al Barazi, S. (2018). *Rohstoffrisikobewertung – Kobalt, DERA Rohstoffinformationen 36, Berlin, 120 S.* https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-36.pdf.

76 BGS (2014). *World Mineral Production 2008–2012*. Keyworth, Nottingham: British Geological Survey, p. 100. https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html.

77 BGS (2019). *World Mineral Production 2013–2017*. Keyworth, Nottingham: British Geological Survey, p. 100. https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html.

78 Cobalt Institute. Production and Supply. https://www.cobaltinstitute.org/statistics.html.

79 JRC (2018). *Cobalt: demand-supply balances in the transition to electric mobility.* European Commission Technical Report. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf.

of China at 65,000 tonnes of cobalt per year, which accounted for approximately 44 per cent of the world's capacity.[80]

Prices

265. Cobalt prices are largely controlled by the political and economic situation in DR Congo (the major supplier of cobalt to the world market) and the economic situation in China (its main consumer).

266. At the moment, cobalt is an exchange-traded metal, and it has traded on the LME since 2010. Transactions with it and its compounds are also conducted on the so-called free market, including the US market.

267. In 2007, and especially in 2008, prices for cobalt showed rapid growth. This was stimulated by the rapid growth in demand, especially from China, with insufficient supply. As a result, in March 2008, the monthly average price reached a record high. On the US market (spot) it exceeded USD95,000 per tonne, and at the end of the year it was almost USD71,000 per tonne.[81] The global financial and economic crisis of 2008–2009 caused a sharp drop in demand for cobalt, while its production increased significantly (Figure 4.28). This led to an excess of metal on the market, which led to a sharp drop in price. On the US market, the average of 2009 was 2.2 times lower than the previous year's average, amounting to USD32,000 per tonne. Since mid-2009, prices started to recover, but a year later their decline resumed. From mid-2010 to early 2016, prices demonstrated volatility with a general downward trend. In 2016, there was an increase, but it was so small that the annual average was still lower than in 2015. The situation changed drastically in the beginning of 2017, when there was a rush on the market caused by the so-called "EV-boom". Cobalt prices started to grow rapidly, and the annual average exceeded the average of 2016 by 2.2 times on the US market, and by 2.3 times on the LME. This growth resumed until spring 2018, when the metal's price reached USD90,800 per tonne on the US market and exceeded USD93,500 per tonne on the LME. Thus, the minimum level at the beginning of 2016 was exceeded by more than four times. This spike in metal prices caused a significant increase in supplies from DR Congo. However, expectations of a metal deficit turned out to be overstated. China has announced changes in the policy to stimulate new-energy vehicles to cut subsidies by an average of 50 per cent from July 2019.[82] As a result, the prices collapsed as rapidly as they had previously grown. Already in January–February 2019, they had returned to the approximate level of USD30,000 per tonne. Obviously, this drop has had a negative impact on producers, causing production cuts or suspensions.

Forecast of demand and consumption

268. Prospects for future cobalt consumption are linked to the sector of lithium-ion batteries, primarily for electric transport as well as electronic devices and stationary batteries. At the same time, a number of risk factors, including price volatility and concerns about insufficient supplies, have led to changes in the chemical composition of lithium-ion batteries, which are aimed at complete substitution of cobalt or reduction of its content. Thus, lithium cobalt oxide used in electronics and containing 60 per cent cobalt are being gradually replaced by NMC containing 10–30 per cent cobalt, lithium nickel cobalt aluminum oxide

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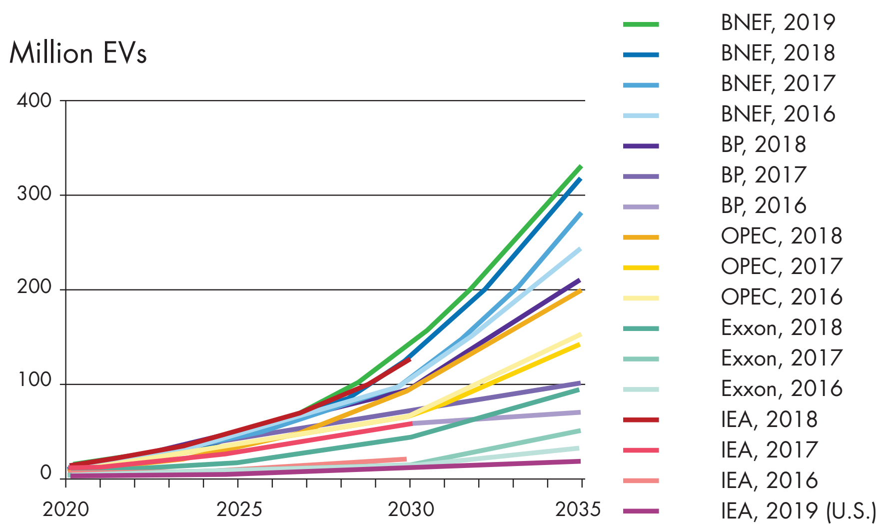
80 USGS (2019). *Cobalt (advance release), 2016 Minerals Yearbook*. https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2016-cobal.pdf.

81 IMF (2019). Primary Commodity Price System. http://data.imf.org/?sk=471DDDF8-D8A7-499A-81BA-5B332C01F8B9&sId=1547558078595.

82 Mining Review Africa (2020). Battery metals: Long term demand remains strong. https://miningreview.com/battery-metals/battery-metals-long-term-demand-remains-strong-despite-price-woes/.

Figure 4.30. Some forecasts of EV fleet dynamics, including commercial, until 2035



Source: BloombergNEF.

Note: BNEF's 2019 outlook includes passenger and commercial EVs. Some values for other outlooks are BNEF estimates based on organization charts, reports and/or data (estimates assume linear growth between known data points). Outlook assumptions and methodologies vary. See organization publications for more.

containing 14 per cent cobalt, and lithium iron phosphate that do not contain cobalt. At the same time, in EVs, abandonment of cobalt in lithium-ion batteries has not yet been observed, because it ensures optimal battery performance. Batteries with lower cobalt content and higher nickel and aluminum content are expected to be more widely used after 2020.[83]

269. To date, all of the forecasts of global cobalt consumption growth are largely based on the development of electric transport, but have different target levels for the growth of the electric car fleet. It was the diversity of these target levels (Figure 4.30) that determined the diversity of forecasts concerning the prospects of cobalt consumption.[84] According to different experts, cobalt consumption in 2030 may amount to 320 to 535,000 tonnes.[85,86]

270. As an example, let us present the scenarios of the IEA:[87]

i. Reference Technology Scenario (RTS): reflects projections that respond to policies on energy efficiency, energy diversification, air quality, and decarbonisation that have been announced or are under consideration. This forecast is quite conservative, as it suggests in 2030 the fleet of electric cars will amount to 56 million units, and global cobalt demand in 2030 will not exceed 241,500 tonnes, i.e. the

83 JRC (2018). *Cobalt: demand-supply balances in the transition to electric mobility*. European Commission Technical Report. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf.

84 BloombergNEF (2019). Electric Vehicle Outlook 2019. https://about.bnef.com/electric-vehicle-outlook/.

85 Fu, X., D.N. Beatty, G.G. Gaustad, et al. (2020). Perspectives on Cobalt Supply through 2030 in the Face of Changing Demand. *Environmental Science and Technology*, 54 (5), 2985–2993.

86 JRC (2018). *Cobalt: demand-supply balances in the transition to electric mobility*. European Commission Technical Report. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf.

87 Ibid.

average annual growth rate after 2018 should be 5.6 per cent.

ii. Deep Decarbonisation Scenario (IEA 2DS): reflects the ambition for 160 million electric cars in 2030 in a context consistent with a 50 per cent probability of limiting the expected global average temperature increase to 2°C. The forecast assumes that in this case the global cobalt demand in 2030 will reach 438,500 tonnes, i.e. the average annual growth rate after 2018 should be 11 per cent.

iii. Deep Decarbonisation Scenario (IEA B2DS): projects around 200 million electric cars in 2030, targeting the achievement of net-zero GHG emissions from the energy sector shortly after 2060. The forecast assumes that the potential demand for cobalt in 2030 will grow to 534,500 tonnes, i.e. the average annual growth rate after 2018 should be 12.9 per cent.

iv. Paris Declaration Scenario: provides the indicators necessary to achieve the objectives of the Paris Agreement on the regulation of measures to reduce carbon dioxide in the atmosphere. One of the main goals of this agreement is to limit the increase in the average temperature on the planet to 2˚C compared to the pre-industrial period, and to reduce it to 1.5˚C if possible. To this end, it is essential to expand the global fleet of EVs to 20 per cent of the total fleet of vehicles used by 2030. This means that 110 million electric cars and 400 million electric two-wheelers will be used in 2030. In this regard, the forecast assumes an increase in world cobalt consumption to 344,000 tonnes in 2030, i.e. the average annual growth rate after 2018 should be 8.8 per cent.

271. The BloombergNEF scripts are highly respected as they are the ones that are based on UNCTAD.[88] According to the current BloombergNEF model, sales of electric cars will increase from 2 million in 2018 to 10 million in 2025, 28 million in 2030, and 56 million in 2040. As a result, in 2040, about 550 million EVs, including commercial vehicles, will be moved on the roads.[89] Based on these parameters, cobalt consumption is projected to reach 327,000 tonnes in 2030.[90] To reach this level, the average annual growth in consumption after 2018 should be 8.3 per cent.

272. CRU agency gives a close forecast of cobalt consumption in 2030: according to its estimates it will be at the level of 300,000 tonnes, of which 70 per cent or more will come from batteries of all types.[91]

273. Little attention is paid to the prospects of cobalt consumption in non-battery areas. Nevertheless, significant growth is also expected there. Thus, according to CRU estimates, it will increase by 45 per cent. However, in physical terms, this increase will only be around 26,000 tonnes, from about 59,000 tonnes to over 85,000 tonnes.[92]

[88] UNCTAD (2019). Commodities and Development Report 2019. https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2499.

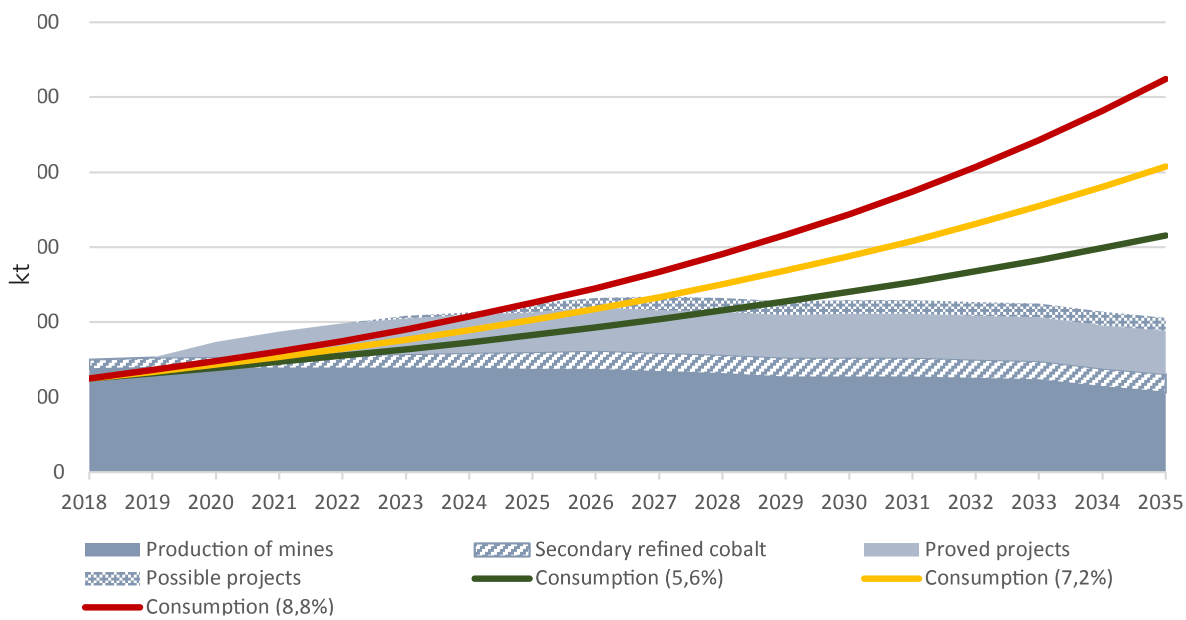
[89] BloombergNEF (2019). Electric Vehicle Outlook 2019. https://about.bnef.com/electric-vehicle-outlook/.

[90] Petersen J. (2019). The Cobalt Cliff Could Eradicate Non-Chinese EV Manufacturing Before 2030. *Seeking Alpha*. https://seekingalpha.com/article/4273346-cobalt-cliff-eradicate-non-chinese-ev-manufacturing-2030?app=1&isDirectRoadblock=false.

[91] JOGMEC (2019). "Securing critical materials for Japanese industry". JOGMEC Presentation, Tokyo, June 2019, http://mric.jogmec.go.jp/wp-content/uploads/2019/06/mrseminar2019_03_03.pdf.

[92] Ibid.

Figure 4.31. Forecast land-based cobalt production and consumption for 2018–2035



274. We have selected three cases for analysis, two of which were prepared by the IEA and reflect minimum and maximum fleet growth estimates for EVs (Figure 4.31). All available forecasts are limited to 2030. As part of our study, they are extended until 2035, while maintaining the trends that characterized the previous period of time.

275. Case 1 (low) corresponds to the IEA RTS scenario (considered the most optimal by IEA) and assumes an increase in world cobalt consumption to 5.6 per cent per year.

276. For case 2 (base), the average value between case 1 and case 3 of the selected IEA projections is taken and amounts to 7.2 per cent per year.

277. Case 3 (high) corresponds to the IEA Paris declaration scenario, to achieve which the consumption growth should be 8.8 per cent per year.

278. However, we are not sure that these scenarios take into account the prospect of reducing the use of cobalt in batteries.

Resources and reserves

279. According to USGS,[93] world cobalt reserves are estimated at 7 Mt, and identified world terrestrial cobalt resources at approximately 25 Mt. At the current level of mining production of cobalt (about 140,000 tonnes), taking into account losses during processing, reserves can provide mining operations for about 50 years, and resources for more than 100 years.

Forecast of land-based mining

280. In order to estimate the level of world cobalt production up to 2035, the data on reserves and identified resources of more than 90 cobalt-containing fields under development and being prepared for operation in the world were compiled and analyzed. Exploration resources have not been taken into account. Production forecast is based on measured + indicated + inferred resources, taking

[93] USGS (2020). *Mineral Commodity Summaries 2020*. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

into account extraction losses. Expected cobalt production at the fields under development is calculated on the basis of actual production in 2018, taking into account planned projects for expansion of existing capacities. The main sources of information were mining company reports.

281. Due to the lack of data on all fields under development, to obtain the most complete picture of the world cobalt mining industry, the missing production volumes have been taken into account based on official government statistics and/or industry statistical compilations. This concerns primarily DR Congo.

282. In addition to mining cobalt production, secondary cobalt production was also taken into account. Against the backdrop of increasing cobalt consumption and the general trend towards increased recycling of resources, it will definitely grow.

283. The fields to be prepared for operation are conditionally divided into two groups according to the prospects of their involvement in operation: Proved projects, and Possible projects (see Figure 4.31). The main criterion for assigning a project to a group was the stage of its development (Preproduction, Construction, Feasibility Study, Prefeasibility Study). Planned implementation dates and difficulties were also taken into account. However, inclusion of a project in the most promising group of Proved projects does not mean its timely implementation, as commissioning dates of fields (especially large and gigantic in terms of reserves) are very often postponed for various reasons.

284. According to our analysis, production of cobalt from existing mines could decline by 23 per cent by 2035 due to exhaustion of their resource base. At the same time, the possible increase in the production of secondary cobalt (by about two times by 2035) may make this reduction less sharp.

285. The main number of Proved and Possible projects is expected to be put into operation from 2021. By 2035 they can provide 58 and 17,000 tonnes of cobalt per year respectively.

286. As shown in Figure 4.31, the expected increase in cobalt production will not be able to provide the projected consumption level over the whole period under consideration.

287. With an annual growth of 5.6 per cent in world cobalt consumption (case 1; +5.6 per cent per year) and the implementation of all Proved and Possible projects, metal deficit may occur after 2028. However, given the possible overproduction in previous years, the market may feel it with some delay. At the same time, it is possible that some of the Proved and Possible projects will not be put into operation in time (their commissioning may be adversely affected by unfavorable prices both for cobalt itself and for the main components of developed deposits—copper and nickel). In that case, the difficulties with providing copper to industry may occur earlier.

288. If the average annual growth rate of cobalt consumption is 8.8 per cent (case 3), the threat of a deficit may occur already in 2026, even if all the Proved and Possible projects are launched.

289. Depending on which of the scenarios of consumption growth under review we have chosen, in 2035 the metal deficit may amount to 110–320,000 tonnes, even if all the currently available projects are implemented.

290. As already emphasized, growth of cobalt production is complicated by the absence of cobalt deposits proper

and by the presence of metal as a by-product in complex ores—nickel laterites, nickel-copper-cobalt sulphide, and others. Cobalt mining at such deposits is determined by interest in the basic metals—nickel and copper. However, there is reason to believe that as the deficit approaches, the commissioning of projects based on cobalt-containing ore deposits, which are not currently active or are in the early stages of exploration, will accelerate. In addition, a number of new projects may emerge. Such expectations are based on the rapid growth of cobalt exploration costs. According to S&P Global,[94] in 2018 95 companies were working for it, investing about USD111 million in exploration. A year earlier, such works were carried out by 52 companies, whose costs amounted to about USD36 million.

291. The deficit of cobalt and the price increase caused by it may become an incentive for its full extraction from mined ores, primarily laterite ores. Currently, only part of the mined ores of this type is used as a source of cobalt.

292. Lack of cobalt may give rise to an active growth in its prices. However, as shown in Figure 4.31, it is unlikely that they will grow in the short term. On the contrary, there is reason to believe that overproduction, which could continue until the mid-2020s, would lead to an even greater reduction in cobalt prices. It should be taken into account that cobalt prices are influenced not only by the balance of supply and demand, but also by a number of other factors. Above all, it concerns the situation in and around DR Congo. As mentioned above, this country is the largest supplier of cobalt raw materials in the world. At the same time, about 15–20 per cent of this cobalt is produced by artisanal operations, where child labour is used on a large scale. This is an outrage to the world community, and measures have already been taken to combat the use of such cobalt in the products of major Western companies. An additional risk factor is the unstable political situation in DR Congo. All of this threatens the stability of cobalt supplies from DR Congo and makes investments in its mining industry highly risky. Positive changes in the country may attract new major investors, which will have a positive impact on the entire global cobalt industry.

Impact of nodules mining

293. As for possible polymetallic nodule extraction projects, we consider three options for its development: minimum (involving two contractors; Figure 4.32), base (involving six contractors; Figure 4.33), and maximum (involving 12 contractors; Figure 4.34). All scenarios imply that production will start by the first contractor in 2027 and by the second in 2030; the remaining contractors (subject to their involvement) will join the process in 2031–2033. It is assumed that the maximum cumulative level of production by six or twelve contractors may be reached in 2035.

294. As can be seen from Figures 4.32–4.34, even if deep-sea mining is carried out under the maximum scenario (with the participation of 12 contractors) and provides about 61,000 tonnes of additional cobalt in 2035, it will not be able to cover even the deficit that is formed at the minimum expected rate of consumption growth.

295. However, the absence of formal overproduction does not mean that production of polymetallic nodules will not affect the cobalt market in any way. It is enough to compare its potential volumes with the current production. According to the scenarios we are considering:

[94] S&P Global (2019). World Exploration Trends 2018. PDAC Special Edition. http://www.egcsouthafrica.com/wp-content/uploads/2018/07/20190425_2018-World-Exploration-Trends.pdf.

Figure 4.32. Forecast cobalt production and consumption, including polymetallic nodule mining, for 2018–2035 (2 contractors)

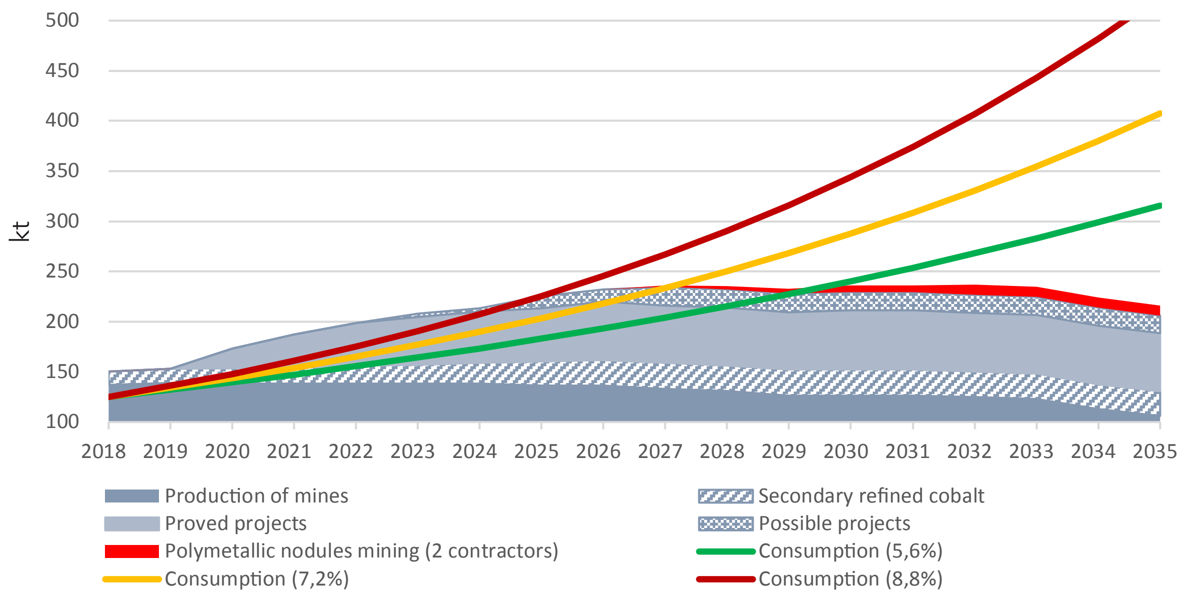


Figure 4.33. Forecast cobalt production and consumption, including polymetallic nodule mining, for 2018–2035 (6 contractors)

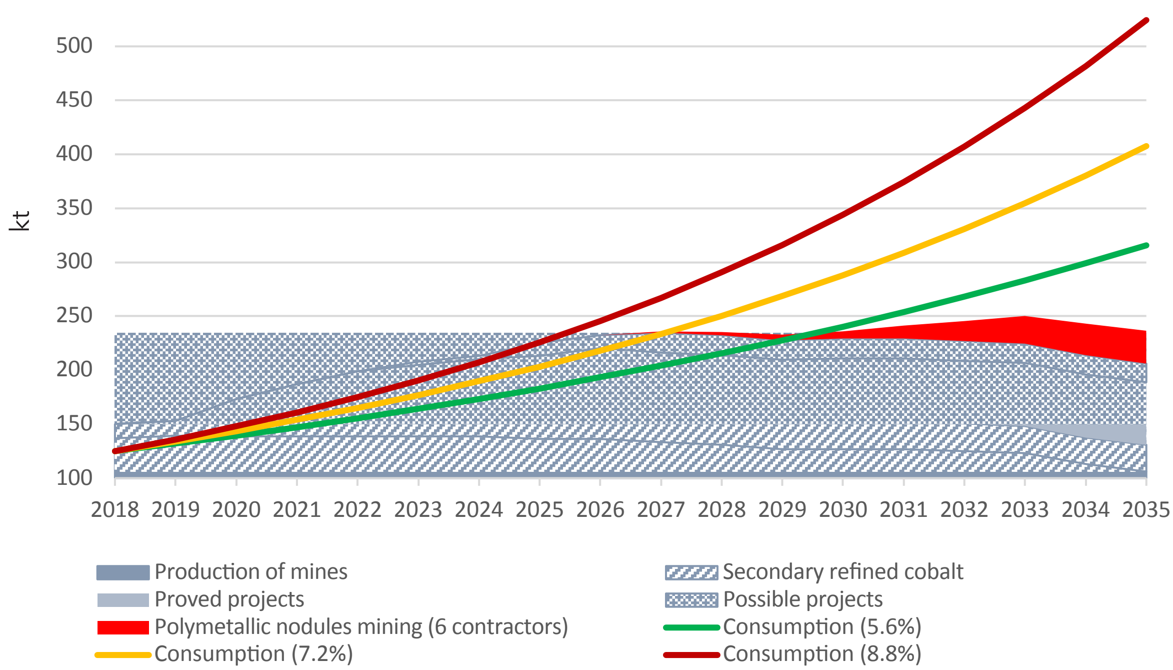
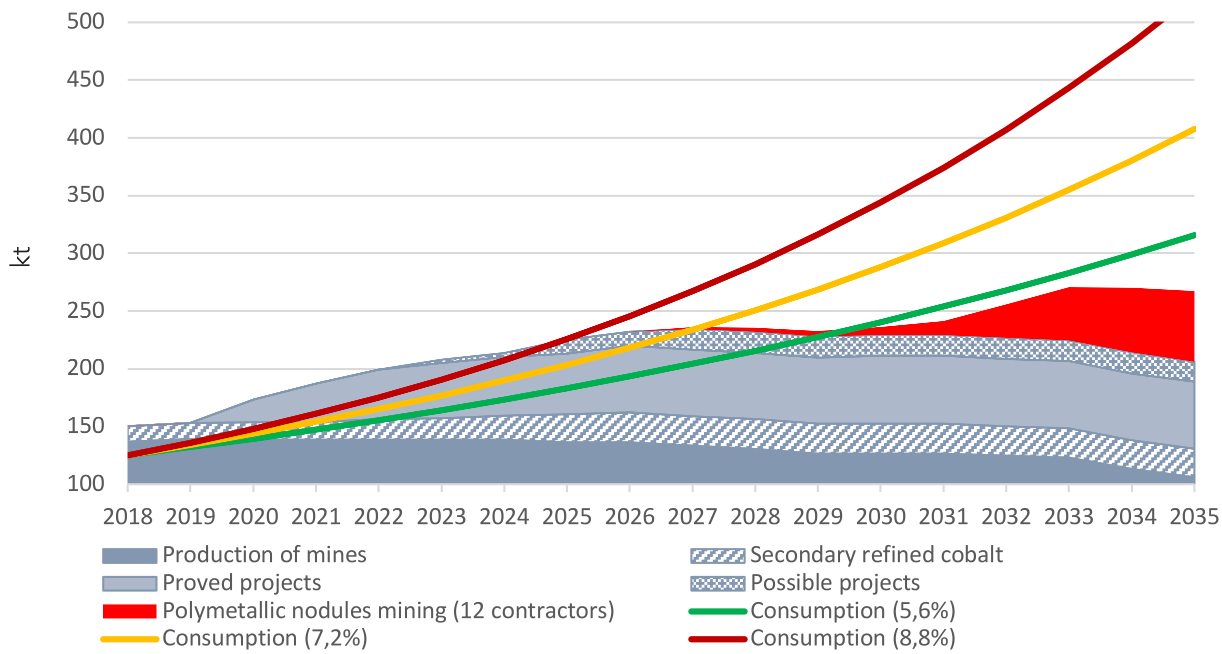


Figure 4.34. Forecast cobalt production and consumption, including polymetallic nodule mining, for 2018–2035 (12 contractors)



- Two contractors, having reached their maximum production, will ensure the market entry of more than 10,000 tonnes of additional cobalt per year from 2032, which will correspond to about 5 per cent of the expected ground production by that time (about 7.5 per cent compared to current production).

- Six contractors, achieving a maximum cumulative production in 2035, will provide an additional 30,600 tonnes of cobalt, which will correspond to approximately 15 per cent of the expected surface production by that time (over 22 per cent of current production).

- Twelve contractors, reaching a maximum cumulative production in 2035, will provide an additional over 61,000 tonnes of cobalt, which will correspond to approximately 30 per cent of the expected ground production (about 45 per cent of current production).

296. Even if there is an uncompensated shortage of metal in the market, the appearance of such additional metal portions (this even applies to metal from two contractors) will lead to a reduction in prices that had been formed by that time. In this case, there will be two factors that will work: reduction of supply tension; and psychological impact on the market participants by the very fact of appearance of an additional stable source of metal, which, moreover, has a potential for growth.

297. If deep-sea mining starts earlier or develops faster than we anticipate, with consumption growth in line with case 1, "marine" cobalt will exacerbate the expected significant metal surplus in the market. In this case, acute competition is expected with surface mines (including new ones), most of which are located in DR Congo. If consumption grows according to case 2 or case 3, the threat of such confrontation will be less (especially with case 3), but it also cannot be excluded.

298. The result of the competitive struggle may be the displacement of the least efficient cobalt mining enterprises from the market, but this will depend not only on the situation in the cobalt market, but also on the situation in the adjacent copper and nickel markets, with which cobalt is mined. In addition, the resulting price level for cobalt may be such that offshore mining itself is not economically viable and its start is not economically feasible.

299. Thus, if extraction of polymetallic nodules starts in 2027 and increases according to any of the scenarios we are considering, even with the minimum expected growth rate of consumption (+5.6 per cent per year) and the commissioning of all currently known projects of new surface mines, there will be no formal overproduction of cobalt. Only the first years of offshore mining can be an exception. However, significant overproduction of cobalt can be expected up to 2028 and is difficult to avoid. The reason for this is that cobalt is mainly mined as a by-product, as has already been repeatedly mentioned. That is, the emergence of new mines producing cobalt is practically not controlled by the situation in the market for this metal. As a result, such large reserves of cobalt may accumulate in various warehouses that the lack of extraction will be compensated by these reserves for a long time. Accordingly, the metal prices will be at a low level. Then, the beginning of offshore mining will exacerbate the situation. At the same time, it is not ruled out that the price level will be critical for offshore mining itself, making it low-profit or even unprofitable.

Manganese

Consumption

300. Over 90 per cent of the world's manganese is used in ferrous metallurgy. Manganese is used in the form of manganese ferro-alloys or metallic manganese as an alloying element to improve hardness, abrasion resistance of steel and, to a lesser extent, foundry pig iron, also for deoxidation and desulphurisation during theirs production.[95]

301. Manganese ores are mainly processed into manganese ferro-alloys. There are two groups of manganese ferro-alloys: ferro-manganese (FeMn), and silico-manganese (SiMn). Ferro-manganese is divided into high carbon (HC FeMn) and refined (Ref FeMn). HC FeMn contains 65–80 per cent manganese and 6–8 per cent carbon, Ref FeMn (medium- and low-carbon ferro-manganese) contains more than 85 per cent manganese and 0.5–2 per cent carbon. SiMn contains 60–75 per cent manganese and 10–35 per cent silicon.

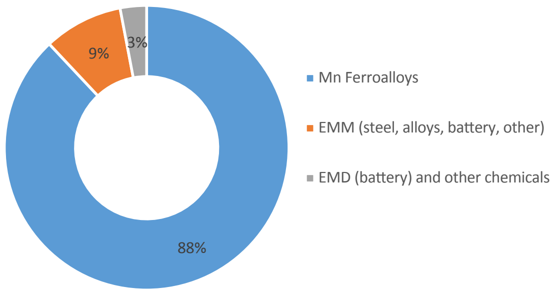
302. Also, manganese ore, including low-grade, is used for the production of manganese metal, mainly EMM. EMM is an extremely pure manganese product, containing over 99 per cent manganese content. One of the areas of use of manganese metal is the production of various alloys with non-ferrous metals, primarily with copper, copper-nickel, aluminum, and many others.

303. Figure 4.35 shows the structure of use of manganese ore.[96]

[95] Eramet S. A. (2019). 2018 Registration document. https://www.eramet.com/sites/default/files/2019-05/DRF_Eramet_2018_AMF_UK.pdf.

[96] Benchmark Minerals Intelligence. https://www.element25.com.au/site/PDF/1771_0/BenchmarkMineralIntelligenceManganeseTheBlackArt.

Figure 4.35. Structure of consumption of manganese ores in 2017

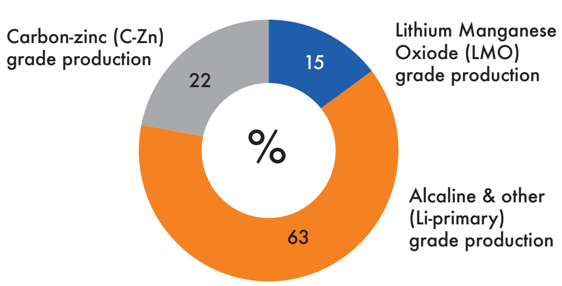


Source: Benchmark minerals.

304. Important non-metallurgical uses of manganese include battery cathodes. For their production electrolytic manganese dioxide (EMD) and, to a lesser extent, EMM are used.

305. There are several types of EMD produced in the world. The bulk of EMD production comes from alkaline and other (Li-primary) grades, followed by carbon-zinc (C-Zn) grade (Figure 4.36). In recent years, lithium manganese oxide grade EMD has demonstrated the most intensive growth in production, by 47 per cent in 2017 and 2018 compared to 2016 and 2017 respectively, although its share in total EMD production does not yet exceed 15 per cent.

Figure 4.36. Global EMD production in 2018, by grade



Source: IMnI.

306. According to Benchmark Minerals, it is estimated that about 250,000 tonnes of manganese were used in all types of batteries in 2017 and about 22 per cent was used in lithium-ion batteries. The structure of a lithium-ion battery consists of three main functional components: an anode (made of carbon), a cathode (which is a metal oxide), and an electrolyte between them (which is a lithium salt in an organic solvent). In lithium-ion batteries containing manganese, the cathode is represented by lithium manganese oxide.[97]

307. The chemical industry also produces other manganese compounds used in agriculture (as an ingredient for fertilizers and animal feed), medicine (potassium permanganate), electronics (for the production of soft manganese ferrites), as a dye in the production of glass, textiles, ceramics, and more.

308. The main factor determining the level of global consumption of manganese is the state and dynamics of the steel industry, which, in turn, depends largely on the situation in such industries as housing, infrastructure construction, automotive industry, and shipbuilding. In 2008–2017 global steel production grew by 26 per cent, leading to a significant increase in demand for manganese. As a result, during this period production of manganese ores in terms of metal and manganese alloys in physical terms increased by approximately 32 per cent (Figure 4.37).[98,99]

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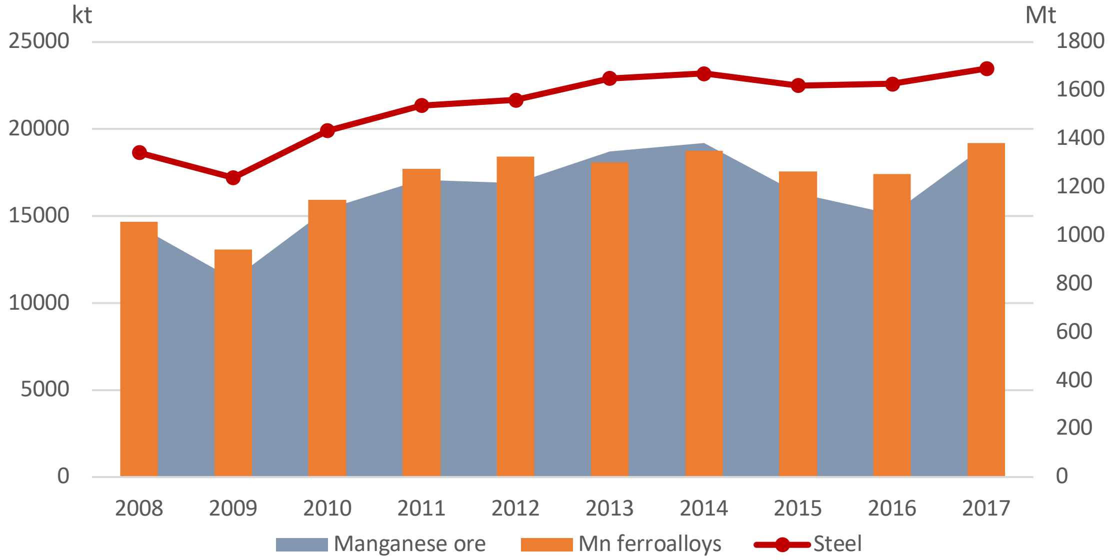
[97] The Assay (2019). Manganese: No Longer Just an Input on Steel. https://www.theassay.com/technology-metals-edition-insight/manganese-no-longer-just-an-input-on-steel/.

[98] IMnI (2019). Statistics 2019. https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

[99] IMnI (2016). 2013 *Public Annual Market Research Report*. https://www.manganese.org/files/publications/PUBLIC%20RESEARCH%20REPORTS/2013_IMnI_Public_Report.pdf.

Figure 4.37. Dynamics of manganese ore production in terms of metal and manganese ferro-alloys (left) and steel (right) in 2008–2017



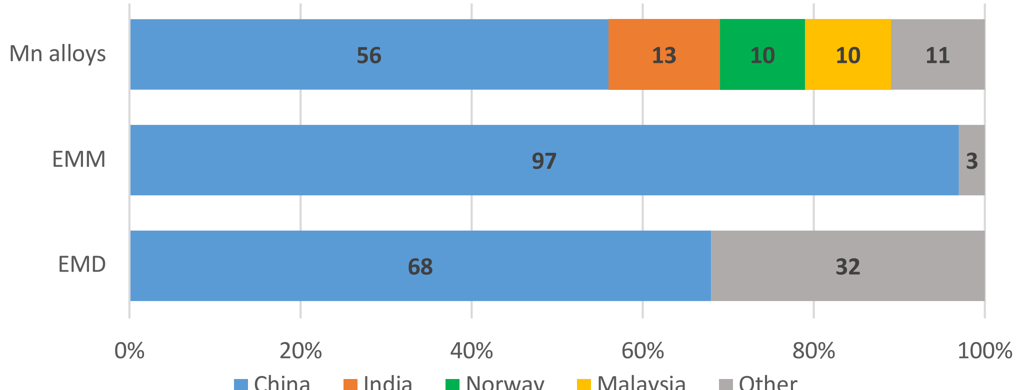
Sources: USGS, BGS, IMnI.

Production

309. The engine of the world steel industry is China. The economic take-off of China, which has experienced rapid urbanization with growing demands on its infrastructure, has contributed significantly to the strong period of growth in steel production and demand for manganese. As a result, since the early 2000s, China has become the world's main manganese ore consumer, while also acting as its largest producer. Despite increasing its own mining capacity, China imports manganese ore in large volumes, primarily from South Africa, Gabon, and Australia, which are among the top three world manganese ore producers (in terms of manganese content). Ores from Australia and Gabon are of high quality, while those from South Africa are of medium quality. When producing manganese products, they are added to mainly low quality (<30% Mn) Chinese ores.

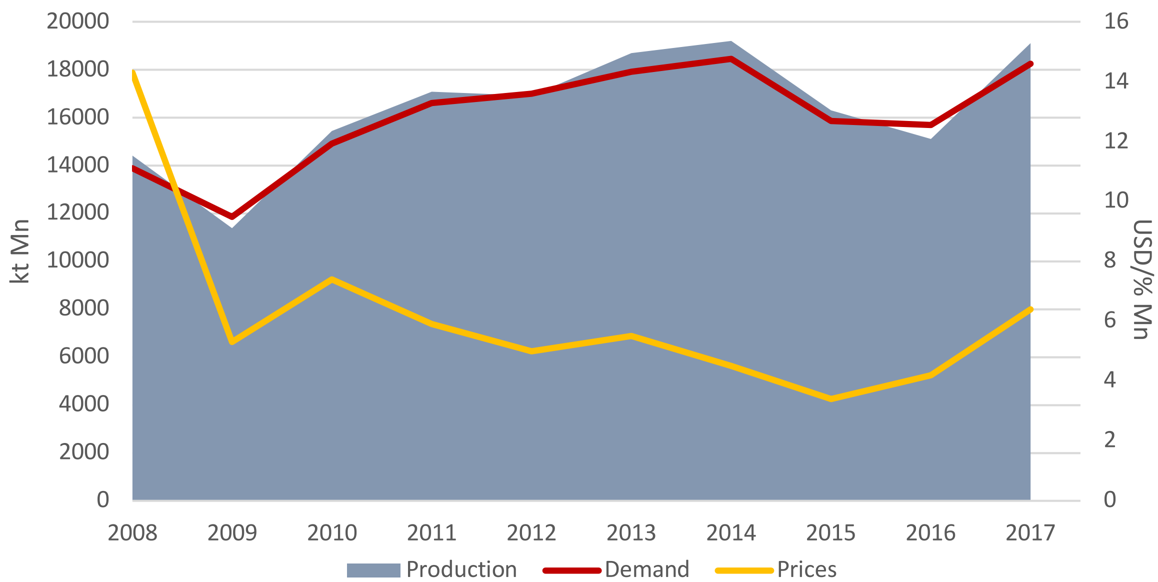
310. China is also the world's largest producer and consumer of manganese products (Figure 4.38), including manganese ferro-alloys, EMM, and EMD.

Figure 4.38. Production distribution of manganese products among main producing countries in 2017



Source: IMnI.

Figure 4.39. Dynamics of manganese ore production and demand (left) and average annual contract prices for Australian lump ore with Mn content of 46% for shipments to China (right)



Sources: IMnI, The Tex Report Ltd.

Prices

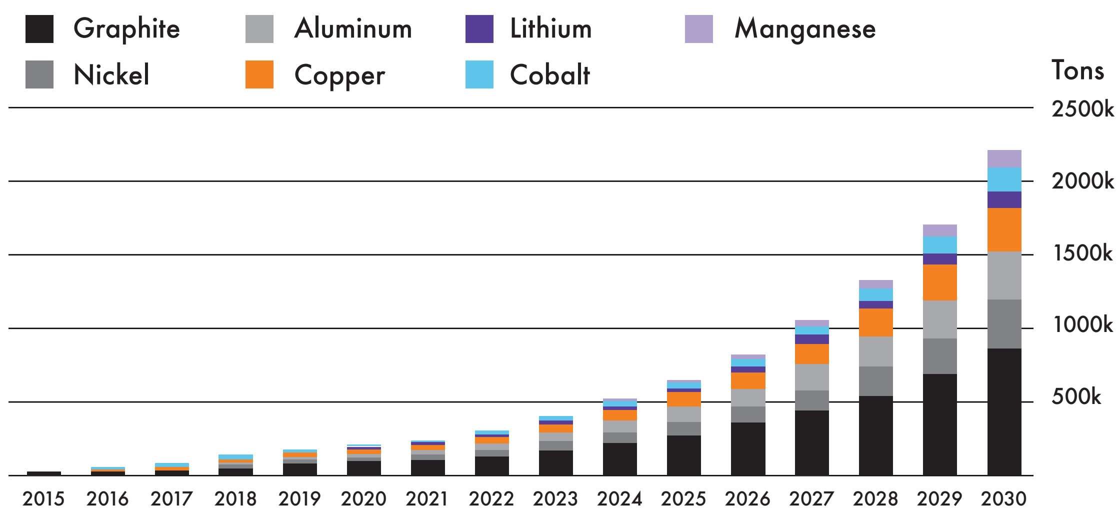
311. Prices for manganese ore are mainly formed on a contract basis and depend on a large number of factors, including market conditions (balance of supply and demand), the volume of stocks in Chinese ports, the economic situation in the world as a whole, and others.

312. Between 2009 and 2014, manganese ore production volumes exceeded steel producers' demand for them (Figure 4.39). The reason for this was a significant increase in manganese ore production in China[100] and the commissioning of about a dozen new deposits, primarily in South Africa, Gabon, and Côte d'Ivoire, which has led to market oversaturation. The response to this was a rapid fall in manganese prices. Thus, the average annual price of *South32* Australian lumpy commercial manganese ore for shipments to China in 2015 was 2.2 times lower than in 2011. As a result, some mining operations reduced or completely stopped production, which created conditions for reducing excess supply on the market. However, the global economic recession that followed the global financial and economic crisis of 2008–2009 excluded opportunities for price increases.

313. The world manganese market improved only by the autumn of 2016, when in conditions of revival of demand and shortage of supplies prices for manganese ore began to grow steadily. Thus, the average price in 2018 for Australian lumpy manganese ore supplied by South32 to China exceeded the average annual price in 2017 by 17 per cent and more than doubled since 2015. However, in 2019, due to the new imbalance of the manganese ore market, prices for manganese ore once again showed a decline.

[100] It should be noted that statistics on manganese ore production in China are controversial. Data from different sources may differ almost by a factor of two.

Figure 4.40. Global metals and materials demand from EV lithium-ion batteries



Source: BloombergNEF.

Forecast of demand and consumption

314. In the future, the steel industry will remain the main consumer of manganese products. Demand for manganese from battery manufacturers, including some lithium-ion batteries, is also expected to grow rapidly over the next decade. Globally, the demand for EMD, and to a lesser extent for EMM, is increasing worldwide with the increased production of batteries, in particular due to the growing introduction of EVs.

315. The automotive sector is expected to be one of the major end-user segments for lithium-ion batteries in the near future. The penetration of EVs is anticipated to provide a massive impetus for lithium-ion battery industry growth. There is much uncertainty about how fast manganese consumption growth will be in batteries, but production of lithium manganese oxide grade EMD used in lithium-ion batteries containing manganese is already increasing rapidly, by 47 per cent per year in 2017–2018.

316. To date, there are a number of forecasts of manganese use in batteries. One of them is for manganese demand growth for use in lithium-ion batteries, made by Bloomberg.[101] According to this forecast, demand will reach approximately 0.2 Mt of metal by 2030 (Figure 4.40). However, such volumes will not have a significant impact on the global manganese market due to their relative insignificance.

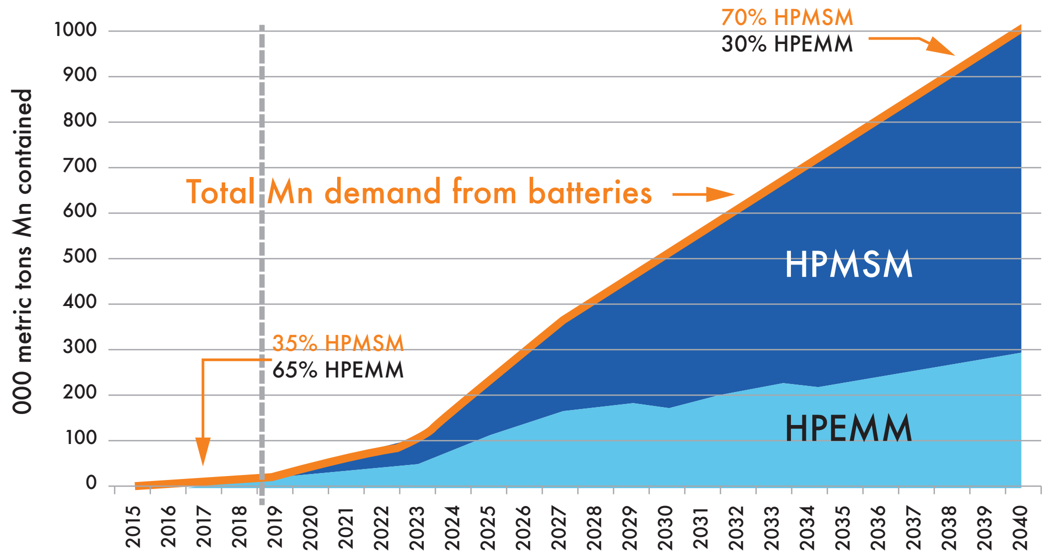
317. Cairn ERA and CPM give a more optimistic scenario, according to which, in 2030, the consumption of manganese in batteries will reach 500,000 tonnes, and in 2040 it will reach 1 Mt (Figure 4.41).[102,103] This level of additional demand may already affect the demand for the metal as a whole. If we compare it with current production, it corresponds to about 5 per cent.

[101] Djukanovic G. (2019). Manganese, copper and aluminium: The role of these metals in global battery demand. *Battery Materials Europe 2019. https://www.metalbulletin.com/events/download.ashx/document/speaker/E001854/a0I1t00000I5R1mEAF/Presentation.*

[102] Euro Manganese Inc. (2019). Manganese. https://www.mn25.ca/manganese.

[103] Ibid.

Figure 4.41. Manganese demand from Li-ion batteries (nickel-cobalt-manganese and lithium-nickel-manganese oxide battery chemistries only)



Source: Cairn ERA, CPM.

Legend: High-Purity Electrolytic Manganese Metal (HPEMM), High-Purity Manganese Sulphate Monohydrate (HPMSM).

318. Other forecasts are relatively close and expect annual growth of 1–3 per cent per year.[104,105,106] The largest contribution to the demand growth is expected from China and, to a lesser extent, from other developing countries, especially India.

319. One of the factors for the projected growth of manganese consumption in China is the tightening of the rebar standards introduced by the government in 2018, which suggests an increase in manganese consumption for melting 1 tonne of steel. This was a surprise, as a few years before this index was, on the contrary, reduced.[107]

320. As part of this work, we chose three cases of manganese demand forecast, reflecting both maximum and minimum growth in consumption dynamics (Figure 4.42).

321. Case 1 (low) expects growth of 1 per cent per year, which is in line with Eramet S.A.'s forecast.[108]

322. Case 2 (base) expects annual growth of 1.5 per cent and is an intermediate evaluation indicator. A moderate increase in steel production is expected due to the global economic slowdown, modernization of Chinese enterprises to meet environmental requirements, and uncertainty about trade policy. A

104 World Steel Associated (2019).

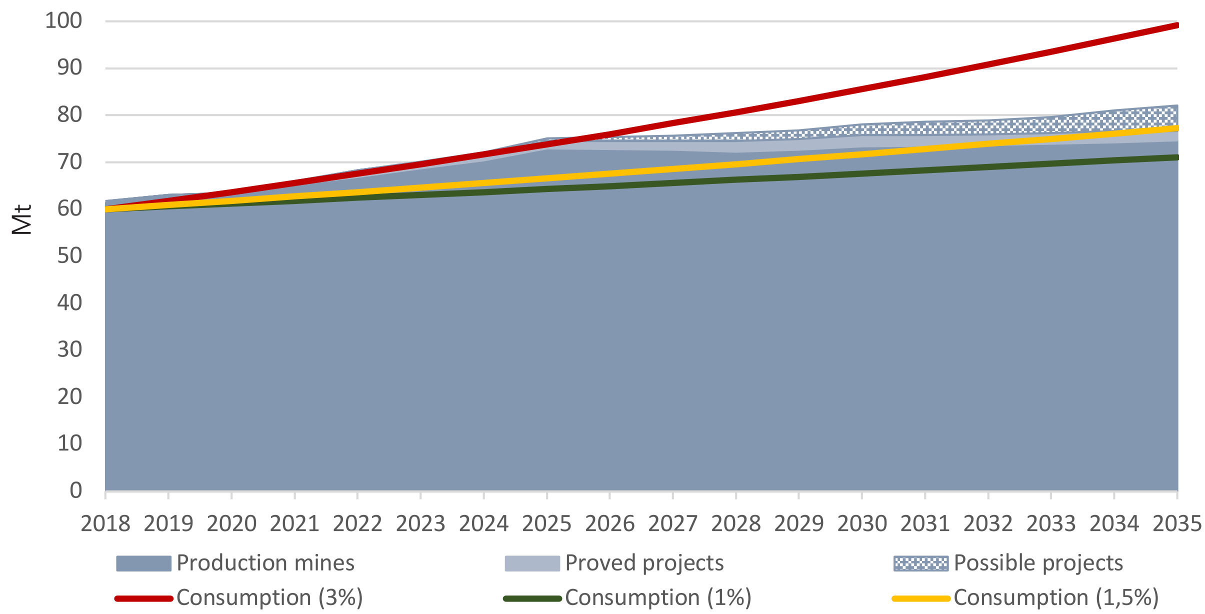
105 Chalabyan A., Mori L., and Vercammen S. (2018). The current capacity shake-up in steel and how the industry is adapting. *McKinsey & Company*. https://www.mckinsey.com/~/media/McKinsey/Industries/Metals%20and%20Mining/Our%20Insights/The%20current%20capacity%20shake%20up%20in%20steel%20and%20how%20the%20industry%20is%20adapting/The-current-capacity-shake-up-in-steel-and-how-the-industry-is-adapting.ashx.

106 OECD. https://www.oecd.org/industry/ind/Item_4b_Accenture_Timothy_van_Audenaerde.pdf.

107 Roskill. Manganese Outlook to 2029. 30.09.2019 https://roskill.com/market-report/manganese/.

108 Eramet S. A. (2019). 2018 Registration document. https://www.eramet.com/sites/default/files/2019-05/DRF_Eramet_2018_AMF_UK.pdf.

Figure 4.42. Forecast manganese ore land-based production and consumption for 2018–2035



close growth rate (1.4 per cent per year before 2035) is considered in the OECD forecast.[109]

323. Case 3 (high) expects demand for manganese to grow by 3 per cent per year, which corresponds to the average annual growth rate of steel production in the world in 2008–2017.

Resources and reserves

324. According to USGS, manganese reserves are estimated at 810 Mt (manganese content), while resource assessment is not provided.[110] At the current level of mining production of manganese ore (about 20 Mt of manganese content) reserves can provide mining operations for approximately 40 years. If we take into account the total physical volumes of reserves and resources of manganese ore contained in specific known deposits (both developed and explored), the reserves will amount to more than 5 Gt of ore, and the resources to more than 12 Gt of ore. Then the availability of manganese ores to the industry, depending on their production level, can be estimated in 70–90 years on the basis of reserves and 150–200 years on the basis of resources in kind.

Forecast of land-based mining

325. In order to estimate manganese ore production until 2035, data on reserves and identified resources (measured + indicated + inferred resources) of about 90 manganese ore mines or groups of mines and projects have been compiled and analysed. The production forecast is based on measured + indicated + inferred resources. The expected production of manganese ore at existing mines is calculated on the basis of actual production in 2018, taking into account planned expansion projects of existing capacities. The main sources of information were mining company reports.

326. Due to the lack of open data for some countries (primarily China), to get the most

[109] OECD (2017). Steel Demand Beyond 2030. http://www.oecd.org/industry/ind/Item_4b_Accenture_Timothy_van_Audenaerde.pdf.
[110] USGS (2020). Mineral Commodity Summaries 2020. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

complete picture of the world manganese mining industry, the missing production volumes are accounted for based on official government statistics and/or industry statistics.

327. We did not take into account the use of steel scrap by the steel industry, which is gradually growing. As steel scrap already contains manganese, its use in steelmaking reduces the need for manganese products.

328. Due to the rather inactive market in recent years, projects to expand the capacity of existing mines and develop new deposits are not proceeding as actively as they could under other market conditions. However, expansion is envisaged at a number of deposits under development, primarily in South Africa and Gabon.

329. Manganese ore projects are conditionally divided into two groups based on their involvement in operation: Proved projects and Possible projects. The main criterion for classifying a project in a group was the stage of its development (Preproduction, Construction, Feasibility Study, Prefeasibility Study), as well as the planned terms of their implementation and the difficulties encountered in this process.

330. Major Proved projects are being implemented in Guyana, Togo, Australia, Kazakhstan, and Russia. The possible projects include those that are currently in conservation. Such projects are known in Chile, Australia, Burkina Faso, and Russia.

331. At the same time, inclusion of the project in the most promising group of Proved projects does not mean its timely implementation, as the terms of deposit commissioning are very often postponed for various reasons, primarily economic.

332. According to our analysis, the production of manganese ore from existing mines could increase by about 20 per cent by the mid-2020s through the expansion of their capacity. In the future, it will be virtually unchanged throughout the period under review.

333. The first of the Proved projects under consideration may come into operation in the very near future. By 2035, they can provide additional production of about 2.3 Mt. Possible projects, if commissioned, could add up to 5 Mt of ore per year (Figure 4.42). Thus, as a result of increasing the capacity of currently operating mines and commissioning of all existing and possible projects in 2035, the annual capacity of manganese ore may reach 82 Mt, which is one-third higher than the current level.

334. It should be noted that China is conducting intensive geological exploration for manganese ores. In 2016–2017 alone, the country's manganese ore reserves and resources grew by 454 Mt.[111] In the subsequent period, several other facilities were opened, which provided an additional increase of 660 Mt of manganese ore.[112] It can be expected that at least some of the discovered deposits will be put into operation in the period under review, which will significantly increase the production of manganese ores.

335. If the average annual growth rate of manganese consumption will be at 1 per cent, the demand for manganese will be fully satisfied by the existing enterprises. Such a scenario will be implemented if the Chinese metallurgical industry significantly reduces the growth rate of steel output, trends to which are predicted by many analysts. At the same time, the production volume of manganese ores will exceed the level of consumption, which on the

[111] China Mineral Resources (2018). Ministry of Natural Resources. PRC. https://www.gov.cn/xinwen/2018-10/22/5333589/files/01d0517b9d6c430bbb927ea5e48641b4.pdf.

[112] SMM News (2019). China's 1st large manganese-rich mine uncovered in Guizhou. https://news.metal.com/newscontent/100939677/Report:-China%27s-1st-large-manganese-rich-mine-uncovered-in-Guizhou/.

one hand will inevitably reduce prices, but on the other hand will increase the warehouse stock, primarily of China. The market surplus and low prices will force the producers of manganese ores to reduce their output, while the small ones, who have the most difficulty to survive in such conditions, will have to close down or suspend their work. Most development projects will also be frozen and exploration will be phased out, especially in areas with low-quality mineralization.

336. If the average annual growth rate of manganese consumption is 1.5 per cent, operating mines will be able to provide it until 2030. In the coming years, there may be a shortage of raw materials, but this could be fully compensated by the Proved projects. At the same time, it is possible that the missing ore volumes will be replenished with stocks accumulated during the years of surplus. In that case, the real need for implementation of proved projects (if they are not yet operational by then) will be delayed.

337. If the average annual growth rate of manganese consumption will be at the level of 3 per cent, from 2020 there may be an insignificant shortage of products coming from the objects under development, but it can be compensated by the proved projects. However, from 2026 onwards, the market may face a deficit even if all the existing projects, both proved and possible, are implemented. This situation may stimulate price growth and intensify the process of involvement in the development of new deposits, as well as the expansion of geological exploration aimed at identifying new manganese ore deposits, primarily of high quality. Exploration for high-grade ores in Indonesia and Brazil and for low-grade ores in China and Australia has already increased. Commissioning of new facilities in the period under review may eliminate potential shortage of raw materials.

Impact of nodules mining

338. With regard to the possible exploration of polymetallic nodules, we are considering three scenarios: a minimum scenario (involving two contractors; Figure 4.43), a base scenario (involving six contractors; Figure 4.44), and a maximum scenario (involving twelve contractors; Figure 4.45). All scenarios imply that first contractor starts production in 2027 and the second in 2030; the remaining contractors (subject to their involvement) will join the process in 2031–2033. It is assumed that the maximum aggregate production level of six or twelve contractors may be reached in 2035.

339. As shown above, only with annual consumption growth of more than 1.5 per cent at the end of the period under review will the currently operating mines be unable to fully meet potential demand. However, the potential deficit will be fully covered by the projects currently under way. Only if consumption grows by more than 2 per cent per year, the operating mines, together with possible manganese projects, will not be able to fully meet the expected demand, but such a situation may occur only after 2032. Accordingly, it is only if manganese consumption grows by more than 2 per cent per year after 2030 that a niche may emerge on the market that deep-sea mining may occupy (Figure 4.43). At the same time, as it was already noted when considering the prospects of the copper, nickel, and cobalt markets, the emergence of a new supplier in almost any case may cause a price decline. It is determined not by the imbalance of supply/demand, but by the stabilization of supply.

Figure 4.43. Forecast manganese ore production and consumption, including polymetallic nodule mining, for 2018–2035 (2 contractors)

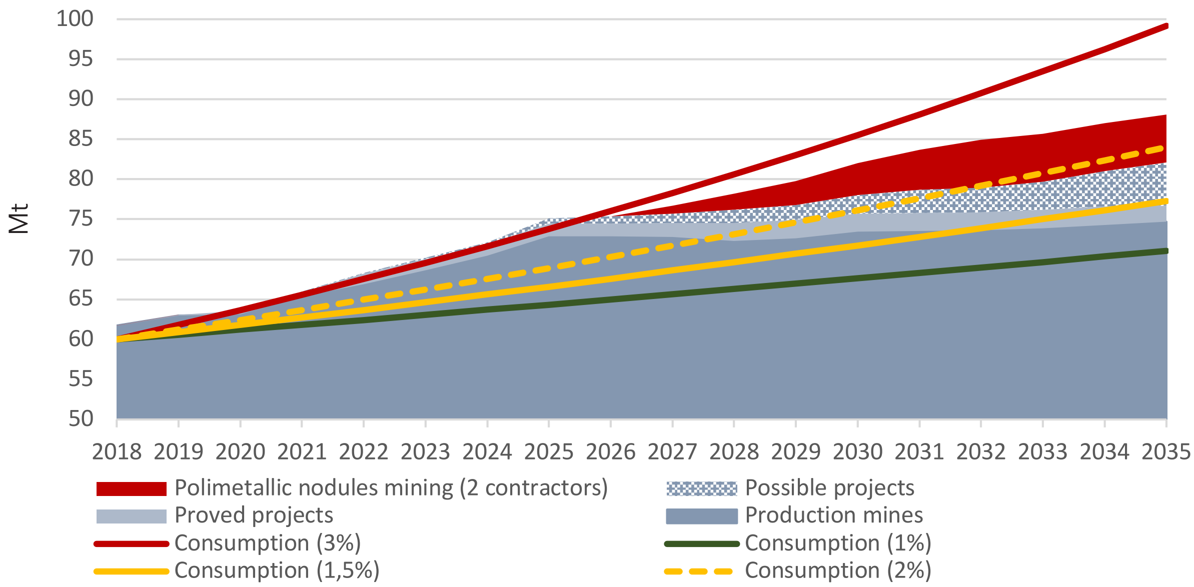


Figure 4.44. Forecast manganese ore production and consumption, including polymetallic nodule mining, for 2018–2035 (6 contractors)

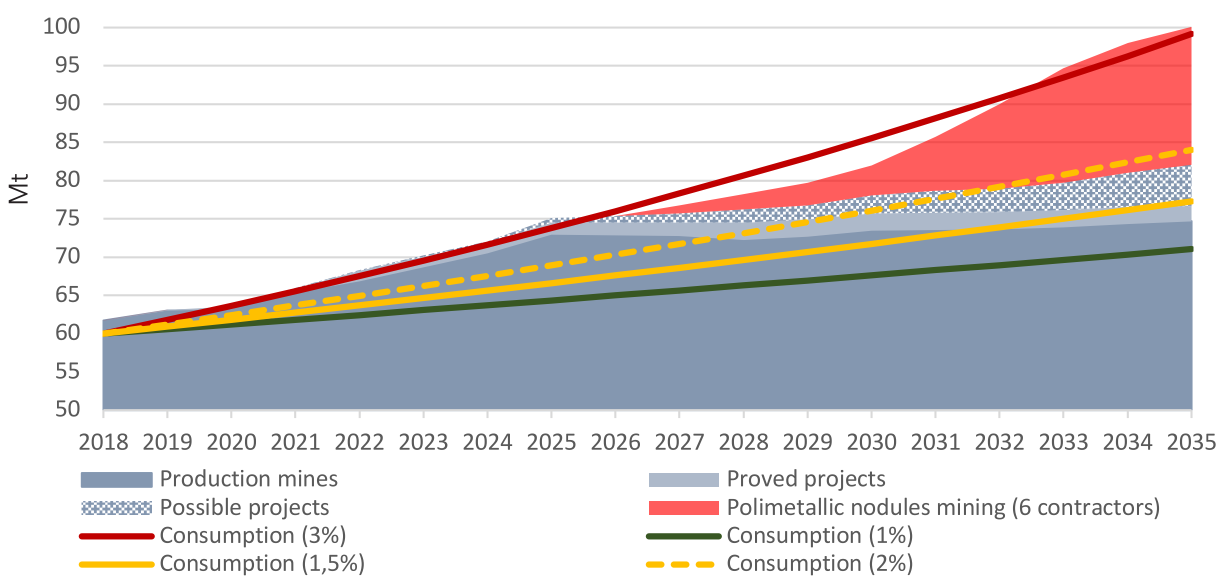
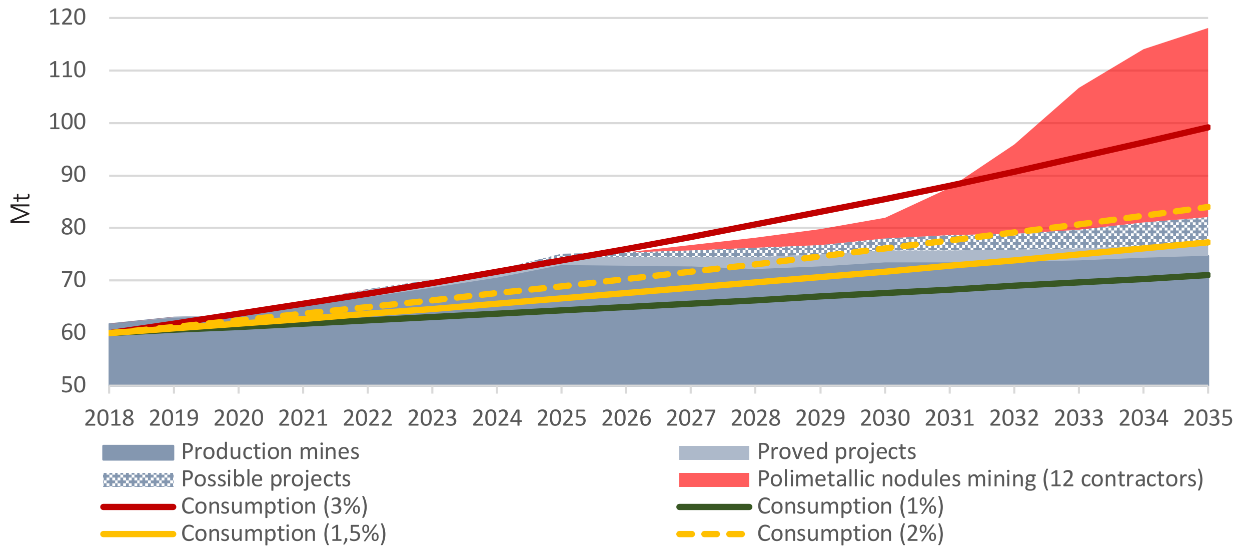


Figure 4.45. Forecast manganese ore production and consumption, including polymetallic nodule mining, for 2018–2035 (12 contractors)



340. Let's consider the prospects of the situation in the manganese market after the beginning of offshore mining under conditions of consumption growth by 3 per cent per year.

341. As Figure 4.43 shows, under the minimum scenario (two contractors entering the market, which from 2032 will jointly produce 6 Mt of ore containing about 1.5 Mt of manganese per year), there are no prerequisites for overproduction even if all land mine projects are put into operation.

342. Under the base scenario involving six contractors (from 2035, they will be able to produce 18 Mt of ore per year containing 4.6 Mt of manganese), in the last years of the period under review, there will be prerequisites for excess supply on the market (Figure 4.44). If some of the six contractors start production earlier than the scenario assumes, the excess supply will appear earlier and will be more significant.

343. Under the maximum scenario of twelve contractors (from 2035, 36 Mt of ore per year containing 9.2 Mt of manganese could be produced, corresponding to about half of current production) overproduction could occur from 2032 and as contractors reach full capacity, this would increase dramatically (Figure 4.45). This will inevitably lead to a price collapse, which will affect not only land producers, but also contractors themselves.

344. Thus, only if consumption of manganese ores grows by more than 2 per cent per year will there be a niche in the market that can be occupied by deep-sea mining. At the same time, the volume of "sea" manganese production, which the market will be able to absorb painlessly, will be determined by consumption growth rates. If they are in line with case 3 (+3 per cent per year) we are considering, and production starts in 2027 and increases at the rates we expect, then only if no more than six contractors are operating, the manganese market is likely to be unaffected. If more contractors enter the market or if consumption increases at a lower rate, the manganese market will experience adverse effects that may affect not only land-based producers but also contractors themselves.

D. Primary sector products of the affected metals

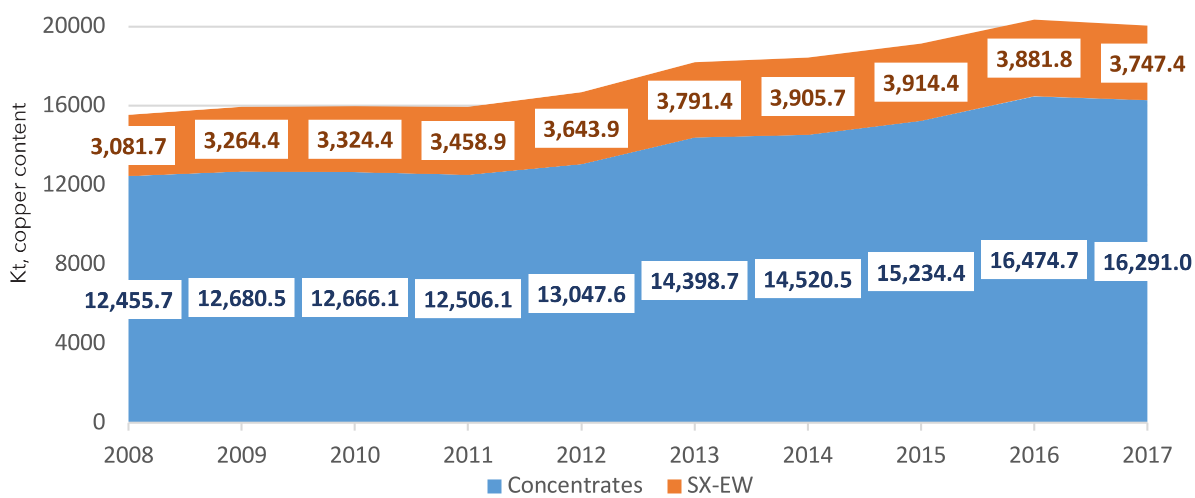
Copper

345. The main primary sector products of copper are concentrates derived from the benefication of sulphide ores (as shown in section 4.A). Intermediate products from oxide-ore hydrometallurgical processing using the solvent-extraction/ electrowinning (SX-EW) method are copper solutions, but they do not participate in the copper project trade chain. Copper produced by the SX-EW method accounts for approximately a fifth of the world's mining production. According to the ICSG data,[113] its contribution to the world index in 2008–2017 varied between 18.7 and 21.2 per cent (Figure 4.46).

346. As of 2017, a significant number of copper ores were mined and processed in 53 countries worldwide. Mining production volumes in particular countries vary from 5.5 Mt (Chile) to 100 tonnes (Albania).[114]

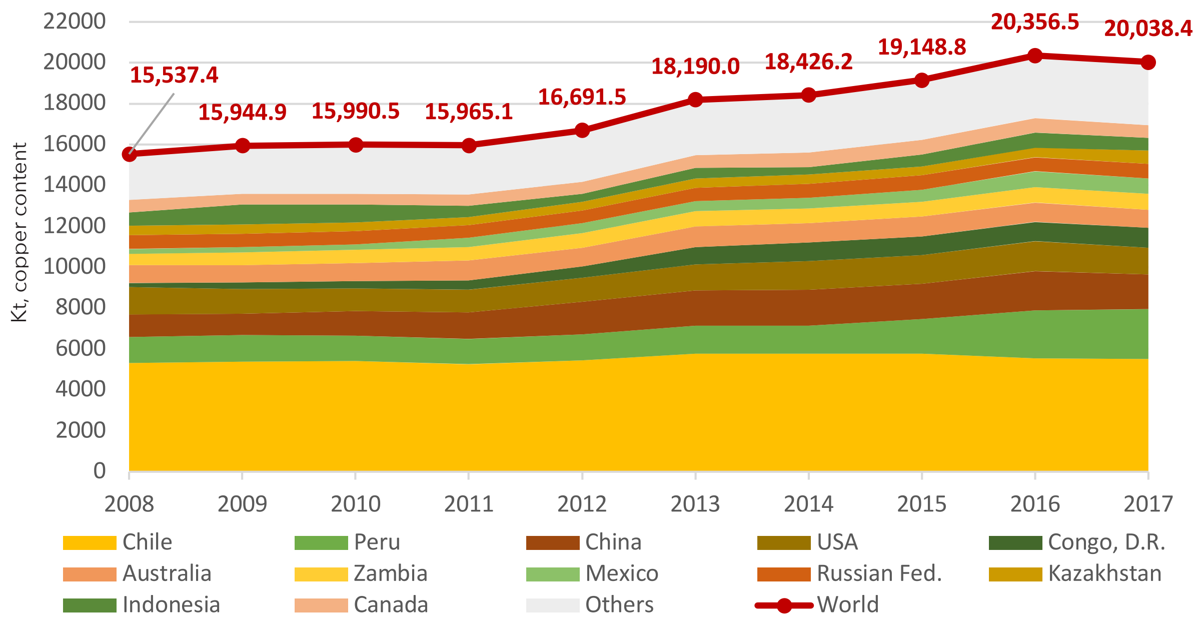
347. According to the ICSG, global copper mining production in 2017 exceeded 20 Mt, having increased by 29 per cent, or 4.5 Mt, in 10 years (Figure 4.47). Simultaneously, world mine capacity in conversion to copper equivalent increased by approximately 5.3 Mt, up to 23.9 Mt per year (+28.4 per cent). Mine capacity utilization in 2017 amounted to 83.9 per cent, whereas it was 83.6 per cent in 2008. The world's 20 largest mining operations account for approximately 37 per cent of capacity.

Figure 4.46. World copper production dynamics by process in 2008–2017



[113] ICSG (2018). *Annual Publication. Vol. 15.*
[114] Ibid.

Figure 4.47. World copper mining dynamics by major producing and other countries in 2008–2017



Source: ICSG.

348. The increase in copper mining was provided primarily by Peru (+1,178 tonnes), DR Congo (+789,000 tonnes), China (+614,000 tonnes), Mexico (+495,000 tonnes), Zambia (+261,000 tonnes), and Kazakhstan (+192,000 tonnes), which are in the world's top ten largest mine copper producers. Significant increases in production were shown by Spain (+188,000 tonnes against 7,000 tonnes in 2008) and Mongolia (+182,000 tonnes).

349. DR Congo has benefited the most from the expansion of copper mining production: in 10 years, it has risen from rank 15 to 5. After the civil war (1998–2003) the country started to develop its mining industry, and between 2007 and 2011, several large copper mines were put into operation, where primarily SX-EW technology was used, which accounted for approximately 72 per cent of the country's performance in 2017 (718 out of 1,002 tonnes). In 2008, this copper accounted for less than 25 per cent of the country's mining production (approximately 53 out of 213,000 tonnes).

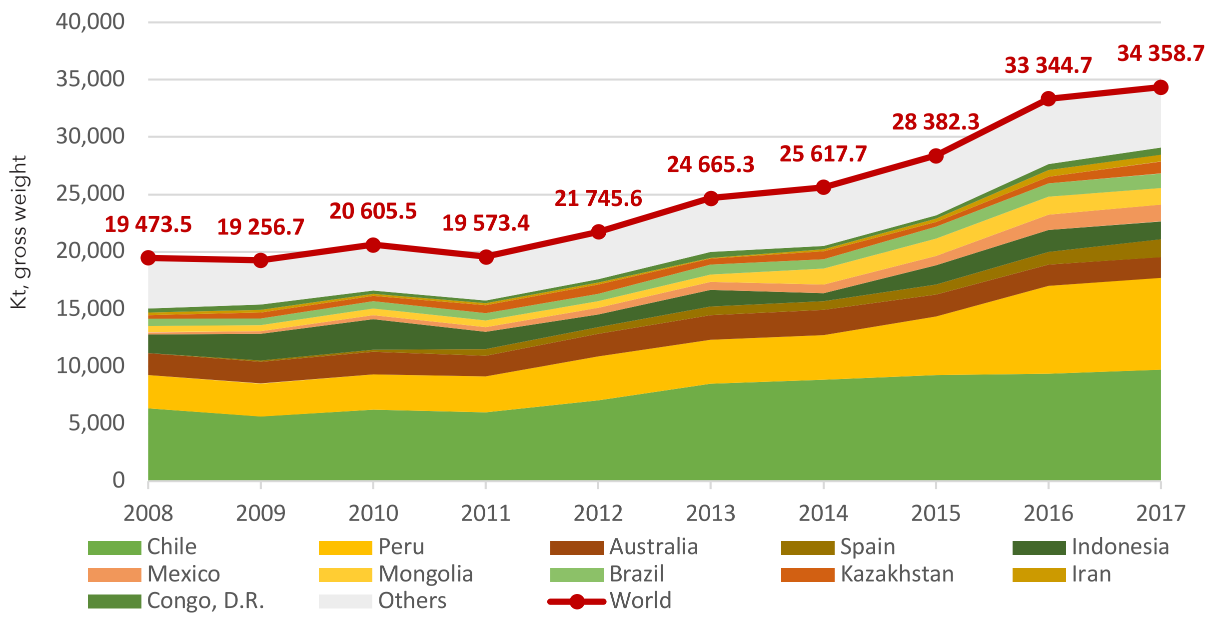
350. The rankings of Peru (from rank 3 to 2), China (from rank 4 to 3), Zambia (from rank 9 to 7) and Mexico (from rank 11 to 8) also went up.

351. Despite the past shifts in the global copper producer ranking, Chile, where both sulphide and poor oxide ores are being extracted and processed, remains the world leader in the industry (Figure 4.32). However, its share in the global index decreased from 34.3 per cent in 2008 to 27.5 per cent in 2017. In 2017, 5,503.5 tonnes of copper was produced in the country, which only exceeded the 2008 index by 176,000 tonnes (3.3 per cent).

352. The products of mining production, depending on its type, are either smelted and refined (concentrates) or are immediately ready for further use in various fields of industry (cathode copper produced by SX-EW technology).

353. The consumers of copper concentrates are copper smelters, located not only in countries where copper ores

Figure 4.48. World copper ores and concentrates export dynamics in 2008–2017



Source: ITC.

are mined and processed, but also in countries that do not have their own mine production, or where it is insufficient to meet the raw material needs of the copper smelter. This led to large-scale global trade in copper concentrates.

354. More than 60 per cent of copper concentrates produced worldwide are involved in global trade. According to the estimates of Chatham House, the Royal Institute of International Affairs,[115] in 2017, copper concentrates accounted for 59 per cent of world trade in copper products in terms of weight and 30 per cent in economic terms.

355. In 2008–2017, the volume of global trade in copper concentrates (HS code 2603) increased by approximately 1.8 times.

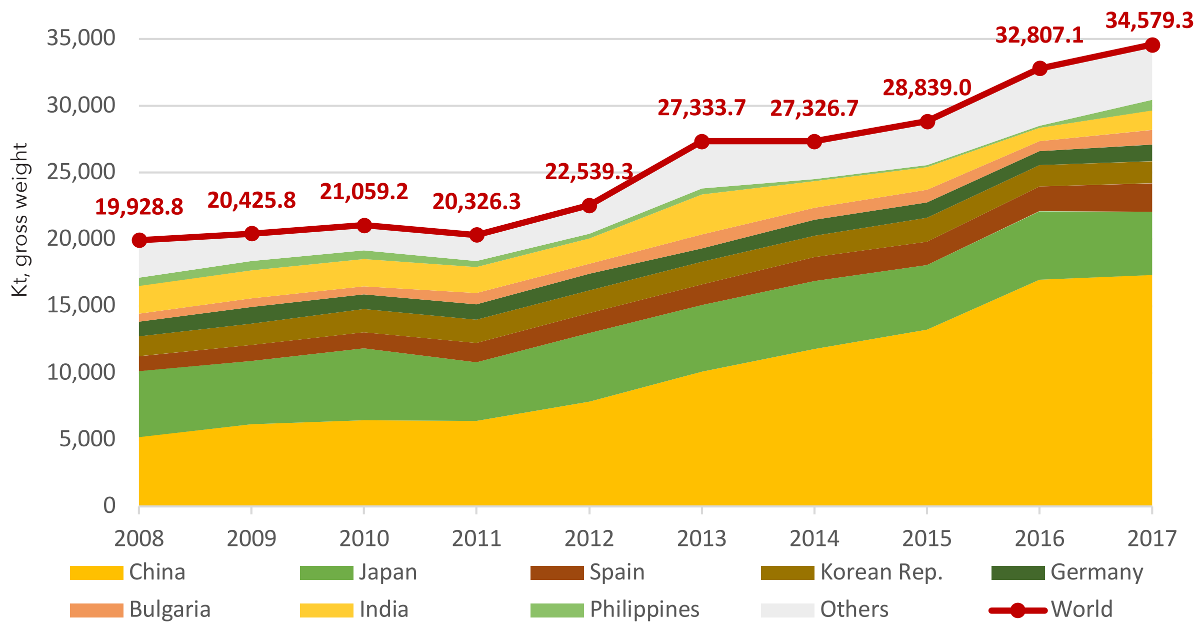
356. The increase in exports of copper concentrates over 10 years amounted to about 14.9 Mt (Figure 4.33). It was provided primarily by expanding supplies from Peru (+5.1 Mt), Chile (+3.4 Mt), Spain (+1.5 Mt), Mexico (+1.3 Mt), Mongolia (+0.9 Mt), Kazakhstan (+0.7 Mt), and Brazil (+0.6 Mt). Nevertheless, in 2017, Chile remained the largest copper exporter, accounting for approximately 28 per cent of world exports. As a result of Peru's strong export growth between 2015 and 2017, its share in the world total exceeded 23 per cent.

357. The import growth of copper concentrates was primarily obtained by China (+12.1 Mt) (Figure 4.48). While in 2008 China imported about the same amount of concentrate as Japan, in 2017 it exceeded Japan's index by more than 3.5 times. In 2017, a total of 17.3 Mt of copper concentrates were imported into China. The main suppliers were Peru (4.9 Mt), Chile (4.6 Mt), Mongolia (1.4 Mt), Mexico (0.9 Mt), Australia (0.85 Mt), Kazakhstan (0.7 Mt), and Spain (0.7 Mt) (Figures 4.49, 4.50).

358. Copper mattes are also an object of international trade. However, their trade volumes are negligibly small (in 2017, 268,400 tons, or less than 1 per cent of trade in concentrates).

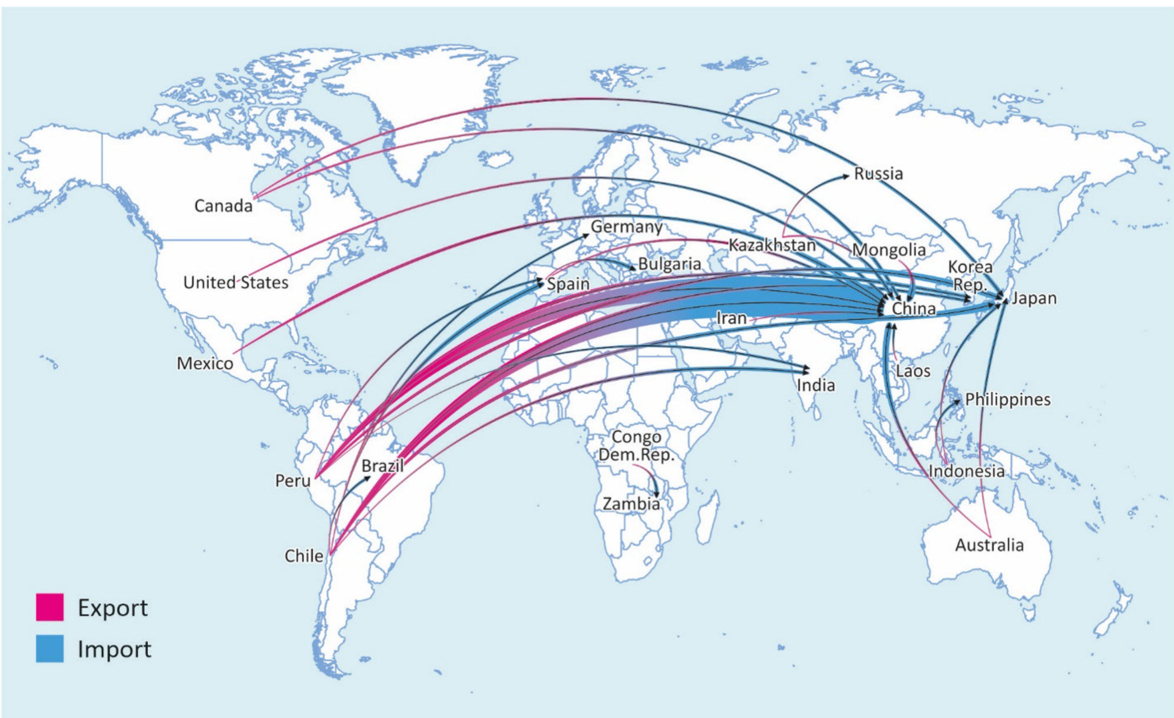
[115] Chatham House, the Royal Institute of International Affairs.

Figure 4.49. World copper ores and concentrates import dynamics in 2008–2017



Source: ITC.

Figure 4.50. Major international trade flows of copper ores and concentrates in 2017



Source: https://resourcetrade.earth/.

Nickel

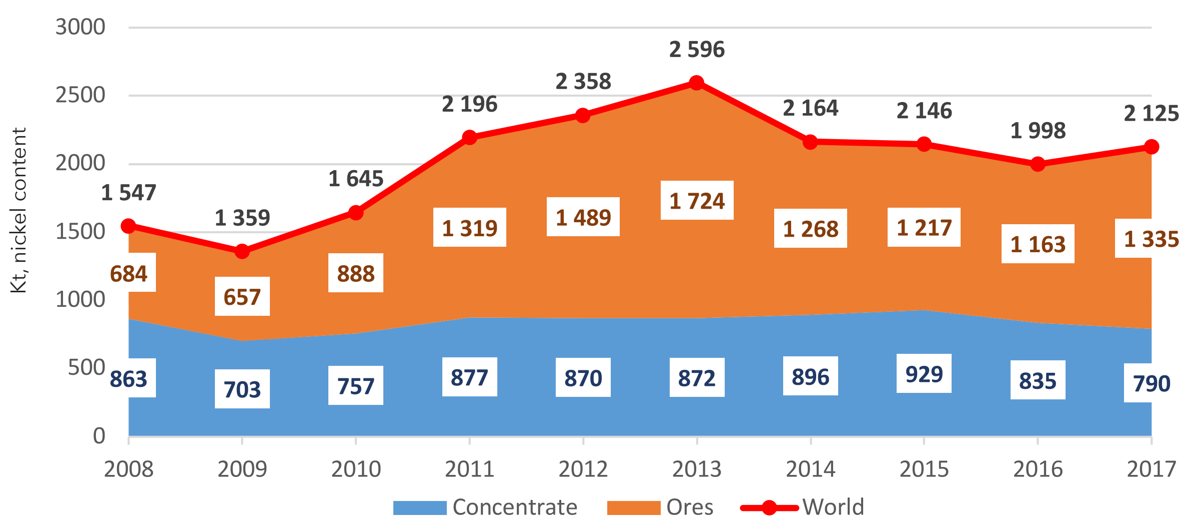
359. Depending on the type of mined and processed raw materials, primary-sector nickel products include ores with a high nickel content (a product primarily produced from laterite ores) or concentrates (a product primarily produced from the extraction and processing of sulphide ores). In 2008–2017, the production volumes of concentrates in general remained at approximately the same level, however, due to a significant increase in the production of laterite ores, their contribution to the global index decreased from 52 to 37 per cent (Figure 4.51).

360. As of 2017, nickel-containing ores were mined and processed in 33 countries worldwide. Country-specific mining production volumes ranged from 355,000 tonnes (Indonesia) to 200 tonnes (Norway).[116]

361. According to INSG, world nickel mine production in 2017 exceeded 2.1 Mt, having increased by 37 per cent or 579,000 tonnes over 10 years (Figure 4.52). At the same time, the maximum mine production level of 2.6 Mt was reached in 2013. This was ensured by the rapid expansion of laterite ore mining in Indonesia, while the subsequent sharp (almost 17 per cent) decline in the global index was a consequence of the restriction on nickel ore exports imposed by the Indonesian government in 2014.

362. The main production increase was provided by the Philippines (+260,000 tonnes), Indonesia (+136,000 tonnes), and New Caledonia (+109,000 tonnes). Significant increases were also seen in Guatemala (+54,000 tonnes), Madagascar (+38,000 tonnes), Brazil (+38,000 tonnes), and Papua New Guinea (+35,000 tonnes). In Madagascar, Guatemala, and Papua New Guinea, production only started in

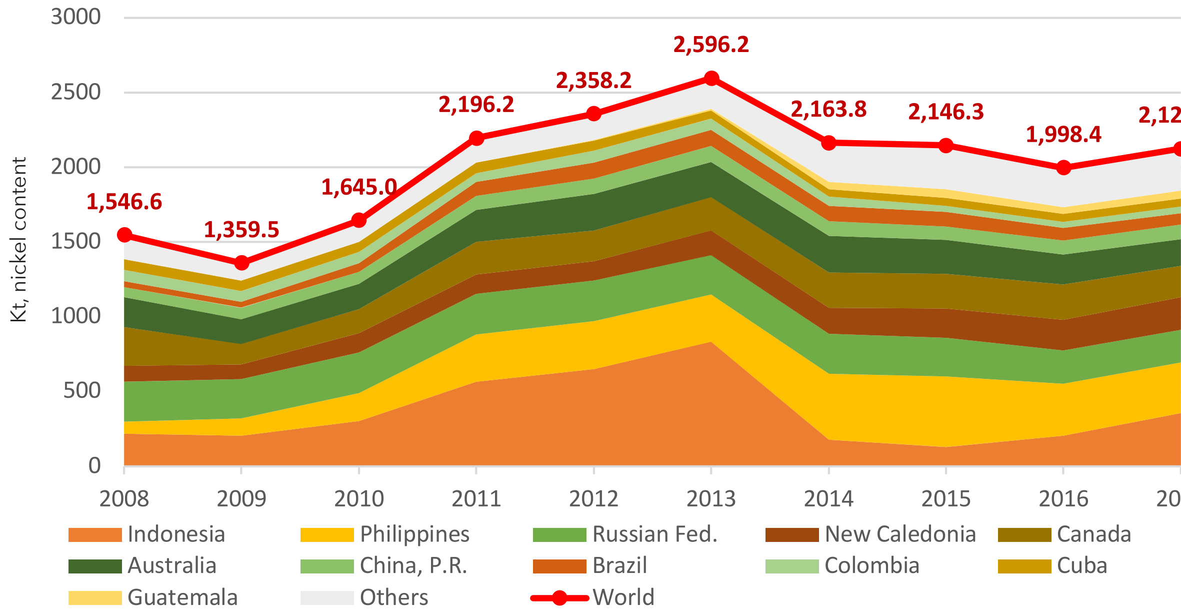
Figure 4.51. World nickel mine production by type in 2008-2017



Source: INSG.

[116] INSG (2019). *World Nickel Statistics Yearbook*. Vol XXVIII. No. 12.

Figure 4.52. World nickel mine production by countries in 2008–2017



Source: INSG.

2012. The ROW's leading nickel producers, including Russia (-47,000 tonnes), Canada (-48,000 tonnes) and Australia (-21,000 tonnes), have reduced production.

363. The geographical structure of world nickel production in 2008–2017 underwent significant changes. Until 2011, Russia, Canada, and Australia remained the main producing regions, which provided about 40–45 per cent of the world annual production. In 2011-2013, the leading supplier of commercial ores and concentrates was Indonesia, which increased production volumes from 280 to 834,000 tonnes of nickel and accounted for almost 32 per cent of global production in 2013. At the same time, the nickel industry in the Philippines started to develop, and by 2011 it already accounted for 12 per cent of world mine production.

364. This rate of production growth in Indonesia was driven by strong demand for ore, triggered by the expectation of a ban on ore exports from the country. The ban, which entered into force in January 2014, was adopted by the government with the aim of developing the country's domestic processing sector. As a result, nickel production in Indonesia fell by almost five times, to 177,100 tonnes, in 2014 compared to 2013. This threw Indonesia into the sixth position in the ranking of the world's leading nickel producers. As a result, the Philippines took the lead, providing 444,000 tonnes of nickel. New Caledonia, the third major supplier and producer of laterite ores, increased its production. In the traditional nickel regions–Russia, Canada, and Australia–by contrast, production declined slightly during this period.

365. In mid-2016, the change of the head of government in the Philippines affected the country's raw material policy. A powerful campaign was launched against open-pit mining because of the significant environmental damage to the tourism industry, which makes a major contribution to the country's GDP. More than half of the country's operating mines have been shut down, including one-third of the nickel

mines. In addition, almost all recently issued mining permits have been revoked. As a result, production in the Philippines decreased by 20 per cent in 2016, but the country remained the world's leading producer in this year. This did not lead to a significant reduction in nickel production as a whole. Discontinued capacity was offset by increased production in New Caledonia (oriented towards China) and Indonesia, where several new metallurgical plants started operating.

366. In 2017, after a three-year hiatus, Indonesia again became the mining leader, increasing production volumes to 355,000 tonnes nickel mine production. The situation with the mining industry in the Philippines has not changed; production at the closed mines has not been resumed, but the country remains the world’s second-largest producer of nickel raw materials.

367. Other major nickel suppliers with commercial ore and concentrate production volumes consistently exceeding 70,000 tonnes of nickel include Russia (221,000 tonnes in 2017), New Caledonia (215,000 tonnes), Canada (211,000 tonnes), Australia (179,000 tonnes), China (95,000 tonnes), and Brazil (77,000 tonnes).

368. As shown in section 4.A above, depending on the initial type of nickel ores, the type of products produced differs: sulfide ores are used to produce refined metal, and laterite ores are mainly ferro-nickel and NPI with low nickel content.

369. Consumers of nickel raw materials are metallurgical and hydrometallurgical operations located not only in countries where nickel ore is mined, but also in countries where there is no own mine production or it is not sufficient to meet the needs of the processing plants. This has led to large-scale global trade in raw nickel products.

370. Estimating the amount of metal contained in nickel ores and concentrates involved in global trade is problematic due to the variability in their metal content. Chatham House, the Royal Institute of International Affairs,[117] estimates that, in 2017, nickel ores and concentrates accounted for 92 per cent of world trade in nickel products in terms of weight and 9 per cent in economic terms. The main type of nickel raw material products is nickel ore. This has been ensured by the fact that for ten years the majority of deliveries have been from Indonesia, the Philippines, and New Caledonia.

371. In 2008–2017, the volume of world trade in nickel ores and concentrates (HS code 2604) on the whole increased by approximately 2.5 times, or by 31.5 Mt. The peak value was reached in 2013 and amounted to 119 Mt, which is two times more than in 2017 (Figure 4.53).

372. It should be noted that, according to the available data, in 2018, ore exports from Indonesia increased by four times and amounted to about 19.8 Mt against 4.9 Mt in 2017. Data for 2019 are not yet available. However, in 2020, supplies from Indonesia should stop again. From January 2020, the country once again started banning the export of nickel ore as a measure to stimulate the development of both the processing industry and the domestic consumption sector.[118]

373. It should also be noted that exports from the Philippines fell sharply in 2018, the decline amounting to 13.5 Mt.

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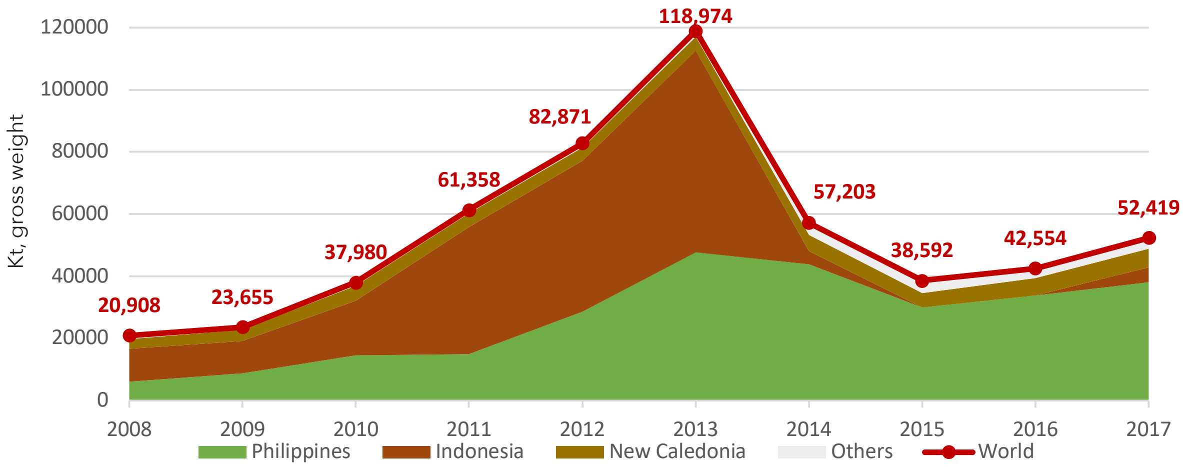
[117] Chatham House, the Royal Institute of International Affairs.

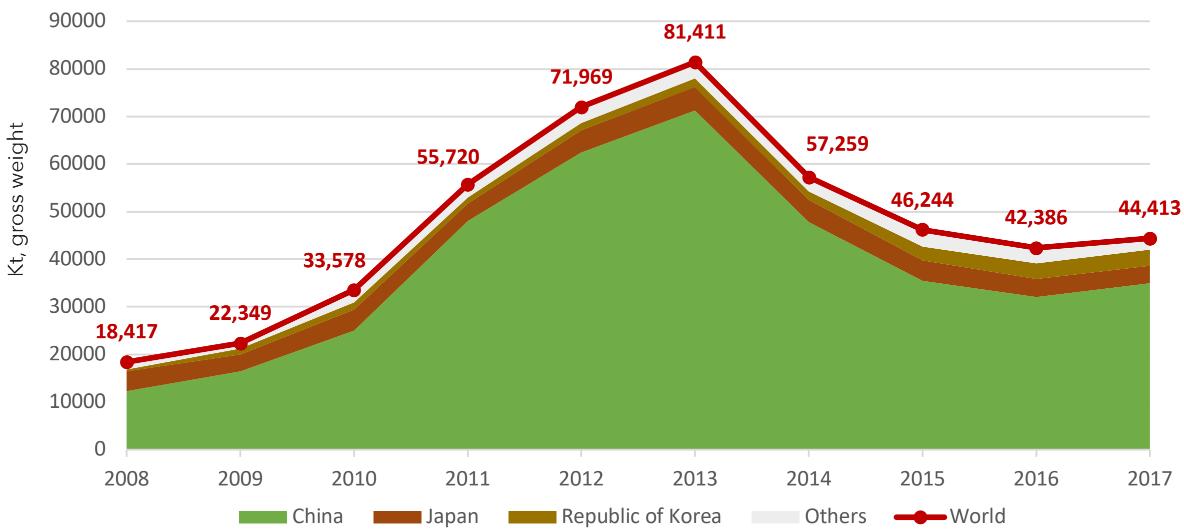
[118] Bloomberg News (2019). Nickel Ban Shows Indonesia’s Ambition to Build EV Industry. https://www.bloomberg.com/news/articles/2019-10-28/indonesia-will-trade-nickel-riches-for-an-electric-car-industry?sref=AjlywoTi.

Figure 4.53. World nickel ores and concentrates export in 2008–2017



Source: ITC.

Figure 4.54. World nickel ores and concentrates import in 2008–2017



Source: ITC.

374. The vast majority of nickel raw materials is shipped to China (Figures 4.54, 4.55). More than 95 per cent of these supplies are laterite commercial ores from Indonesia, the Philippines, and New Caledonia. Imports of nickel concentrates are insignificant. Japan (mainly purchases nickel ores from the same suppliers) and the Republic of Korea are also among the top three world importers.

Figure 4.55. Major international trade flows of nickel ores and concentrates in 2017

Source: https://resourcetrade.earth/.

Cobalt

375. Primary-sector products of cobalt include mining products. As shown above (section 4.C), almost all cobalt mining is done along with copper and nickel. Depending on the type of mined ore, mining products are: ore and concentrates, cobalt-rich solution in integrated plants; a cobalt-rich sulphide, hydroxide, or carbonate if further refining is done elsewhere; or a cobalt-rich alloy.

376. According to BGS, as of 2017, mining and processing of cobalt-containing ores in significant quantities was carried out in 18 countries worldwide. Only one of them, Morocco, extracts cobalt as a major component of the ores. Mine production volumes ranged from 82,500 tonnes (DR Congo) to approximately 700 tonnes (USA).[119]

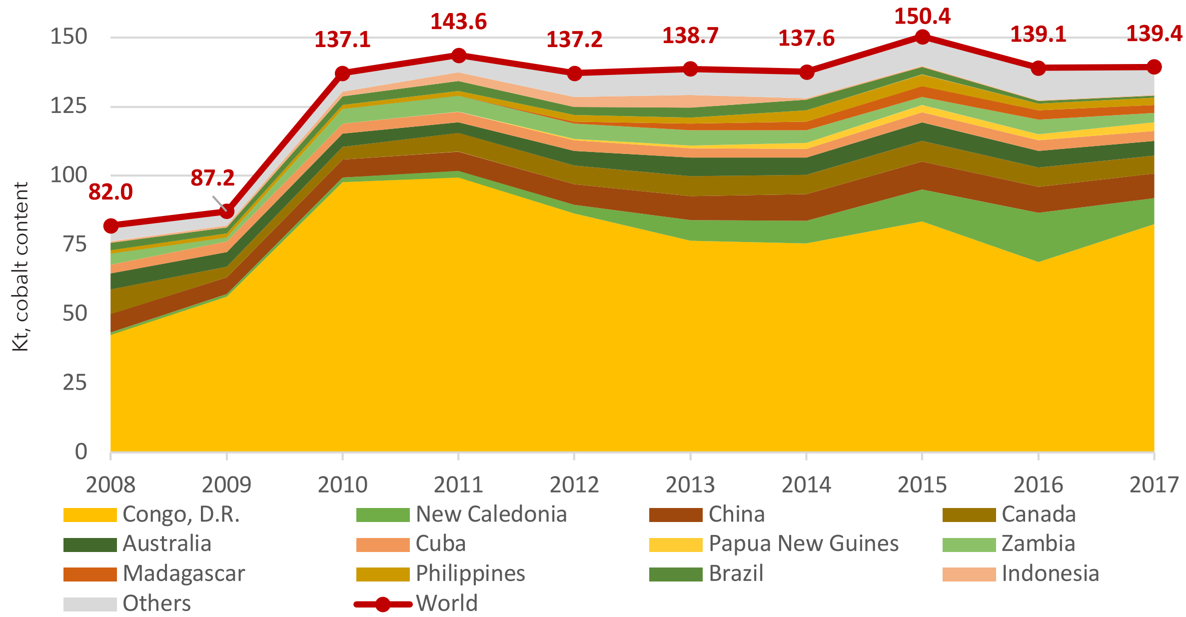
377. Mine production of cobalt in 2017 amounted to approximately 139,000 tonnes, having increased by approximately 70 per cent, or by almost 57,000 tonnes, over 10 years (Figure 4.56).[120],[121]

378. Production growth was provided by DR Congo (+40,000 tonnes or by almost two times), New Caledonia (+8,500 tonnes or by 11 times), Papua New Guinea (production started in 2012 and amounted to 3,300 tonnes in 2017), Madagascar (production started also in 2012 and amounted to 2,800 tonnes in 2017), and the Philippines (+1,500 tonnes or by 2.2 times). At the same time, mine production reached its maximum level in 2015, which was mainly due to a surge in DR Congo.

379. As noted above, the main cobalt mining center is DR Congo. Its share in world production in 2008–2017 ranged

[119] BGS (2019). World Mineral Production 2013–2017. Keyworth, Nottingham: British Geological Survey, pp. 100. https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html.
[120] Ibid.
[121] Ibid.

Figure 4.56. World cobalt mining dynamics by major producing and other countries in 2008–2017



Source: BGS.

from approximately 50 per cent to more than 70 per cent. In physical terms, production volumes varied between 42.5 (in 2008) and 99,500 tonnes (in 2011). DR Congo also contains the main cobalt deposits (according to USGS, almost half of the world's deposits, or 3.6 Mt).[122] They are enclosed in cobalt stratiform and stratabound copper deposits (the same type of deposits as the source of cobalt in Zambia).

380. Approximately 15-20 per cent of cobalt mine production in DR Congo comes from small-scale mining, also called "artisanal mining". According to Amnesty International estimates, 110–150,000 people are involved in cobalt mining practices.[123] The exact figure cannot be determined due to the lack of statistical studies and high rates of staff turnover and migration. Trade in artisanal raw materials is also not fully controlled and accounted for. Often there are conflicts between artisanal mining and large-scale mining. If large companies want to start mining in an area that was previously mined artisanally, it leads to displacement of many people and other problems such as the absence of compensation for loss of their livelihood. With the growing global demand for cobalt, conflicts between artisanal miners and industrial mining companies increase. There are consistent conflicts about mining rights and missing space/areas authorized for artisanal miners. Small-scale miners invade concession areas assigned to large-scale mining companies for the purpose of digging for minerals and thereby securing their survival.

381. Due to the peculiarities of the cobalt mining industry in DR Congo and the political instability in the country, the

122 USGS (2020). *Mineral Commodity Summaries 2020*. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

123 ÖNZ (2018). *Cobalt Critical*. https://oenz.de/sites/default/files/oenz_inkota_factsheet_cobalt.critical3.pdf.

supply of cobalt from the country to the world market is assessed as high risk. This determined the inclusion of cobalt as a critical material in the US[124] and EU[125] countries.

382. Consumers of cobalt mining products are refineries located both in countries where cobalt is mined and in countries that do not have their own mine production. There is an overall imbalance in the distribution of major cobalt mining and refining centers worldwide. This has led to large-scale global trade in cobalt raw materials.

383. Estimating the amount of metal contained in ores and cobalt concentrates involved in global trade as a whole is problematic because of the variability in their metal content. According to the available data, in concentrates obtained from the enrichment of sulphide copper-nickel ores, the cobalt content is usually 1–1.5 per cent and 2.5–3 per cent in those obtained from the enrichment of copper-cobalt ores.[126] According to estimates based on international trade data, in 2017, cobalt ores and concentrates accounted for about 33 per cent of world trade in cobalt products in terms of weight and about 10 per cent in economic terms.

384. Based on the data on export supplies, in 2008–2017 the volume of world trade in ores and cobalt concentrates (HS code 2605) decreased by almost a third. DR Congo, where refining production was destroyed by wars and crises and has hardly recovered so far, remains practically the only supplier of cobalt raw materials to the world market (Figure 4.57). The recipients of this raw material are China and Zambia (Figures 4.58, 4.59).

385. In 2013, it was announced that DR Congo intends to ban exports of copper and cobalt concentrates to encourage domestic processing. To date, the process has been suspended and no implementation is expected in the near future. The importance of the export of raw materials for national GDP and the lack of necessary electricity for an energy-intensive sector such as refining were cited as the main reasons (according to USGS,[127] electricity requirements for the recovery of cobalt cathode from intermediate products by electrowinning in chloride and sulfate media are on average 3,100 KWh/tonne and 6,500 KWh/tonne for operations in China, Japan, Norway, Zambia, DR Congo, and Canada. In DR Congo, these requirements are said to vary between 5,000 and 6,000 KWh/tonne). Nevertheless, according to OECD data, in 2010–2014 the country introduced export duties of up to 25 per cent on cobalt ores and concentrates.[128]

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[124] USGS (2017). Cobalt. Chapter F of *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*. https://pubs.usgs.gov/pp/1802/f/pp1802f.pdf.

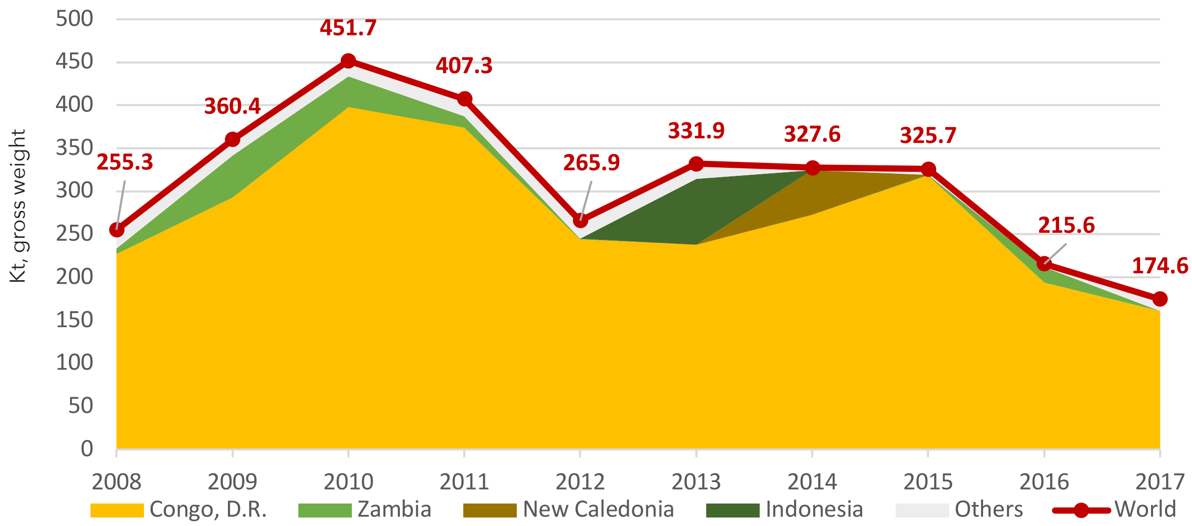
[125] EC (2017). *Critical raw materials*. https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en.

[126] Al Barazi, S. (2018). Rohstoffrisikobewertung – *Kobalt, DERA Rohstoffinformationen 36, Berlin, 120 S*. https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-36.pdf.

[127] USGS (2011). *Estimates of Electricity Requirements for the Recovery of Mineral Commodities, with Examples Applied to Sub-Saharan Africa*. https://pubs.usgs.gov/of/2011/1253/report/OF11-1253.pdf

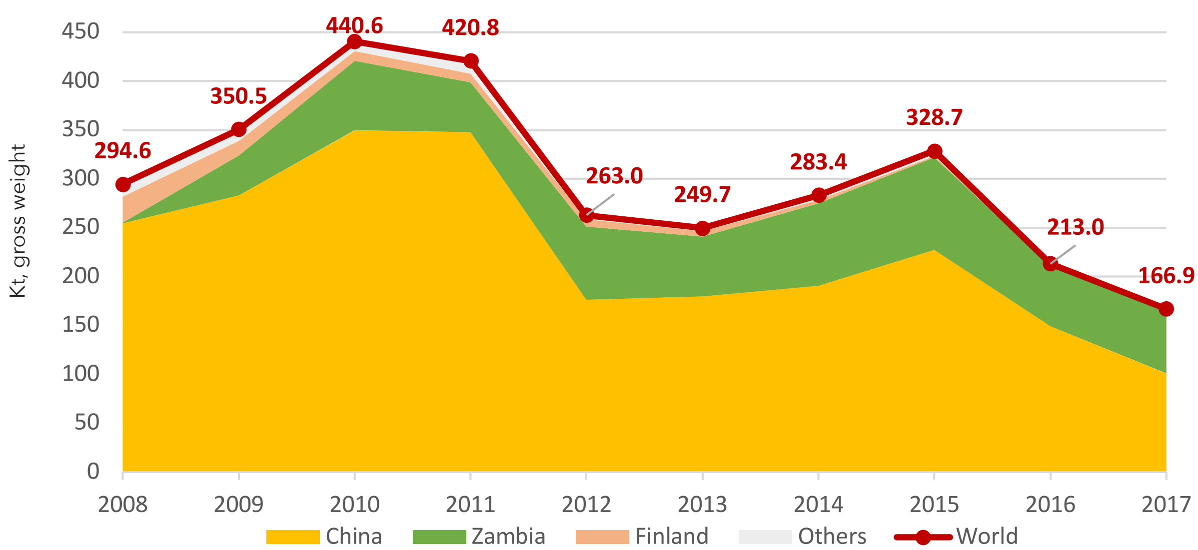
[128] JRC (2018). *Cobalt: demand-supply balances in the transition to electric mobility.* European Commission Technical Report. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf.

Figure 4.57. World cobalt ores and concentrates export dynamics in 2008–2017



Source: ITC.

Figure 4.58. World cobalt ores and concentrates import dynamics in 2008–2017



Source: ITC.

Figure 4.59. Major international trade flows of cobalt ores and concentrates in 2017

Source: https://resourcetrade.earth/.

Manganese

386. Primary-sector products of manganese include manganese ore. The ores produced are divided into three categories depending on their manganese content: high-grade (≥44 per cent Mn), mid-grade (≥30 per cent and <44 per cent Mn) and low-grade (<30per cent Mn). According to the IMnI, high-grade (approximately 41 per cent in metal terms in 2017) and mid-grade (approximately 43 per cent in metal terms in 2017) ores account for the main production.[129] High-grade ores are produced mainly in Australia, Gabon, Brazil, and South Africa, but also (in significantly lower quantities) in Indonesia, India, Côte d'Ivoire, Morocco, Namibia, and Vietnam. Mid-grade ores are produced mainly in South Africa, India, Kazakhstan, Malaysia, Australia, and Ukraine. Low-grade ores are produced mainly in China, as well as in Georgia, Ghana, and several other countries.[130] However, two or all three categories of ores may be produced in the same country. In different years, the proportions of ores of different categories in the production of specific countries and, as a consequence, in the world, have changed (Figure 4.60).

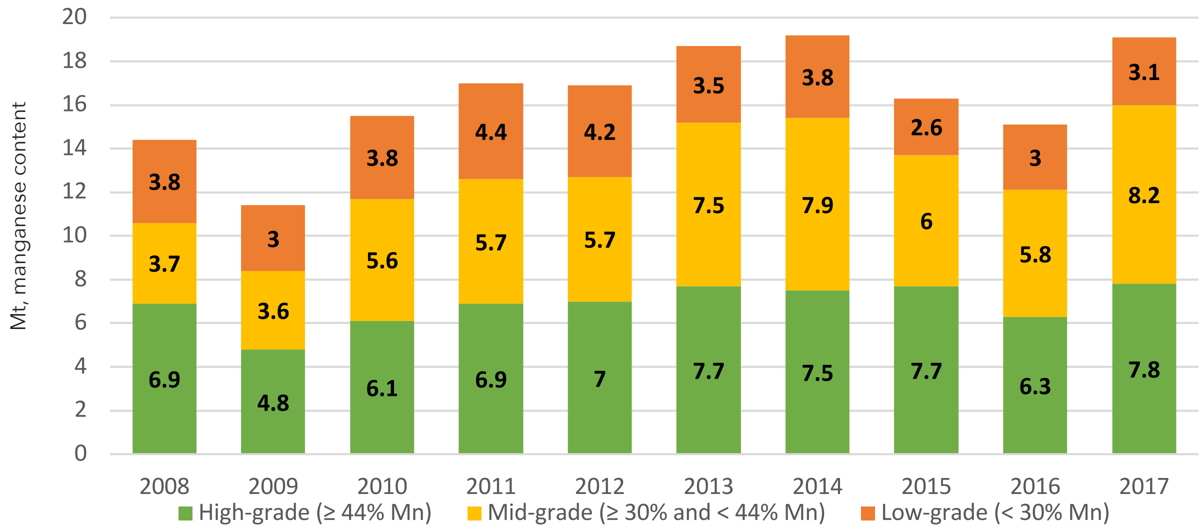
387. According to available data, production of manganese ores in 2017 in significant quantities was conducted in 29 countries. Mine production volumes in specific countries ranged from around 14 Mt (South Africa) to 1.1 Mt (Egypt).

388. According to BGS data available as of the beginning of 2020, which we adjusted based on national statistics of Kazakhstan, the volume of manganese ore production in 2017 amounted to about 51 Mt, having increased by more than 34 per

[129] IMnI (2019). *Statistics 2019*. https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

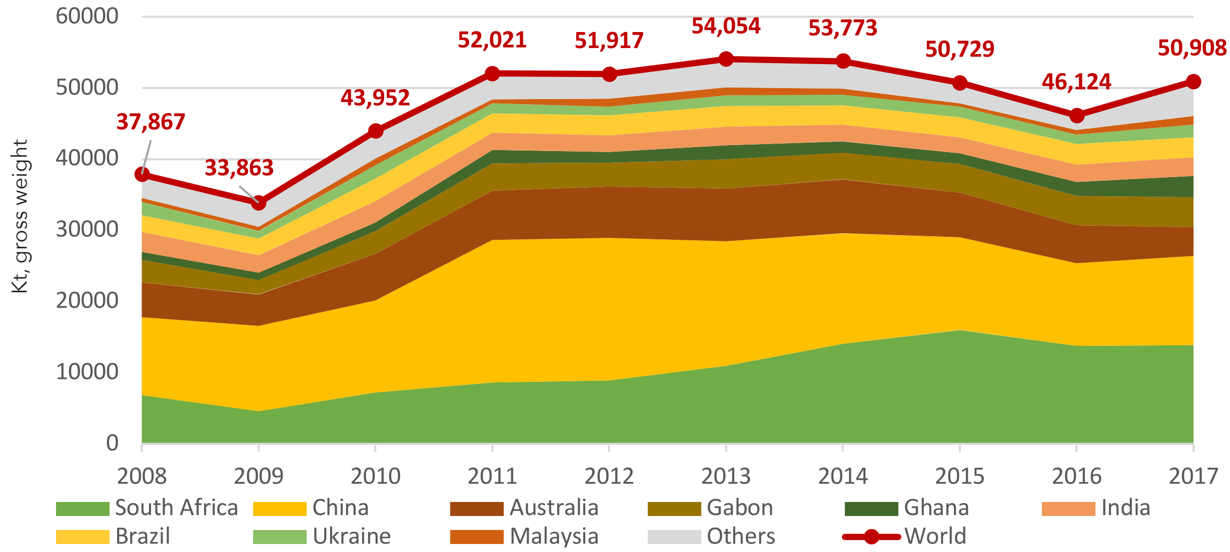
[130] IMnI (2016). *2013 Public Annual Market Research Report. https://www.manganese.org/files/publications/PUBLIC%20RESEARCH%20REPORTS/2013_IMnI_Public_Report.pdf.*

Figure 4.60. Distribution of manganese ore production by ore type



Source: IMnI.

Figure 4.61. World manganese ore production dynamics by major producing and other countries in 2008–2017



Sources: BGS and national statistic of Kazakhstan.

cent or 13 Mt over 10 years (Figure 4.61). According to IMnI estimates, production in 2017 amounted to 19.1 Mt Mn content, an increase of approximately 32.5 per cent, or 4.7 Mt, over 10 years.[131,132]

389. Production growth was mainly provided by South Africa, where it increased by more than two times, or by 7.6 Mt. Smaller but significant growth was also provided by Ghana (+1.9 Mt, or by

[131] IMnI (2019). *Statistics 2019.* https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

[132] IMnI (2016). *2013 Public Annual Market Research Report.* https://www.manganese.org/files/publications/PUBLIC%20RESEARCH%20REPORTS/2013_IMnI_Public_Report.pdf.

2.8 times), China (+1.5 Mt, or by 14 per cent), Gabon (+0.9 Mt, or by 28 per cent), Malaysia (+0.7 Mt, or by 2.3 times), and Brazil (+0.5 Mt, or by 20 per cent). In this period, production decreased only in Australia (-0.8 Mt in 2017, or by almost 16 per cent), although in 2014 production in the country was at the maximum level (+2.8 Mt, or 57 per cent compared to 2008), India (-0.2 Mt), and Ukraine.

390. South Africa is currently the world's largest producer of manganese ores. In 2017 it accounted for more than 27 per cent of gross production weight (18 per cent in 2008), and in terms of metal 36 per cent (21 per cent in 2008). In terms of gross weight of ore extraction, South Africa was inferior to China until 2014. However, in terms of metal contained in ore, it was at the top of the world ranking of manganese raw material producers due to the higher quality of the ores in some years up to 2012. After 2012, South Africa's leadership on this indicator has again become steady. In 2005–2014, the country's manganese ore production capacities were increased through both the commissioning of new mines and the expansion of existing ones' capacities. At the same time, depending on the situation on the market, capacity utilization was changing. Thus, according to IMnI in 2009 (under conditions of the global financial and economic crisis), capacity utilization was only 52 per cent, whereas in 2008 and 2010 it was 86 per cent and 88 per cent respectively, and in 2012 it reached 96 per cent.[133]

391. In 2017, China accounted for about 25 per cent of the gross weight of manganese ore production (29 per cent in 2008), but metal accounted for only 9 per cent (24 per cent in 2008). The problem of the country's manganese mining industry is the low quality of the raw material base, as the average manganese content in mined ores currently does not exceed 30 per cent. For comparison, in South Africa it is 35–38 per cent, in Australia it is close to 40 per cent, and in Gabon it exceeds 45 per cent.[134]

392. The main consumers of manganese ores are producers of manganese ferro-alloys. There is a pronounced disproportion in the distribution of manganese ore and ferro-alloy production centers (Figure 4.62). This has determined a large-scale ore trade.

393. Approximately 60 per cent of manganese ores produced in the world are involved in world trade. According to Chatham House, the Royal Institute of International Affairs,[135] in 2017 they accounted for 85 per cent of world trade in manganese products in terms of weight and 45 per cent in economic terms.

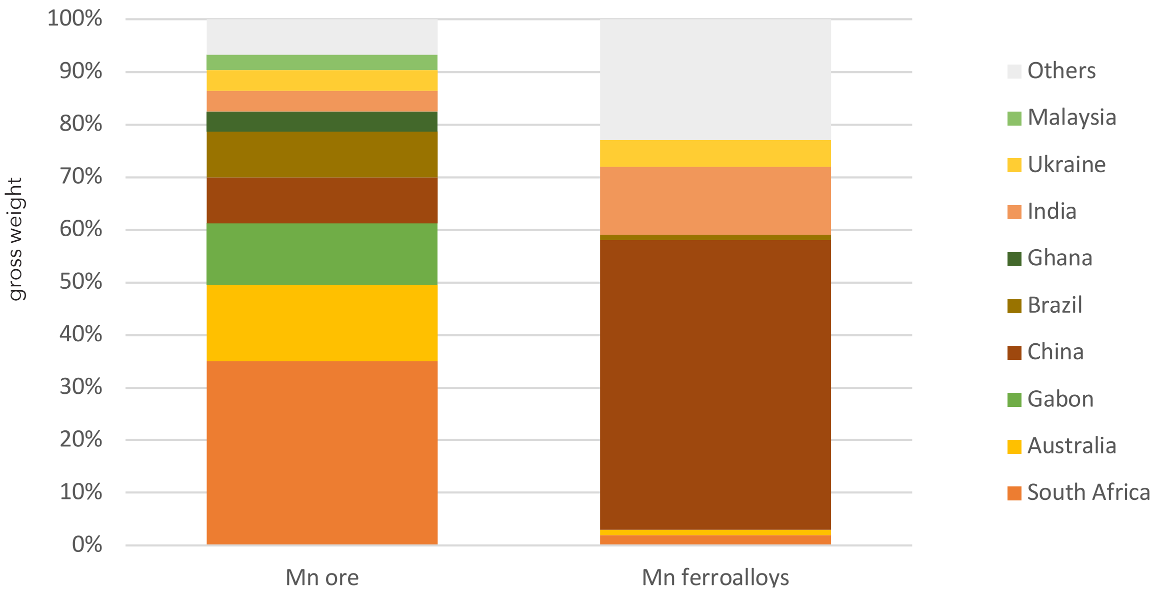
394. In 2008–2017, the volume of world trade in manganese ores (HS code 2602) increased by approximately 1.7 times.

395. Export growth of manganese ores in 10 years amounted to 13.3 Mt (Figure 4.63). It was mainly ensured by expansion of supplies from South Africa (+9.8 Mt, or by 2.7 times). Significant growth was demonstrated by Australia (+1.6 Mt, or by 1.4 times) and Gabon (+1.3 Mt, or by 1.4 times), as well as Brazil (+0.65 Mt, or by 1.3 times) and Côte d'Ivoire (+0.6 Mt, or by 13 times).

396. It should be noted that Côte d'Ivoire entered the top five largest exporters of manganese ores only in 2017. The rapid development of manganese mining and export in this country was largely facilitated by the arrival of a large Chinese business

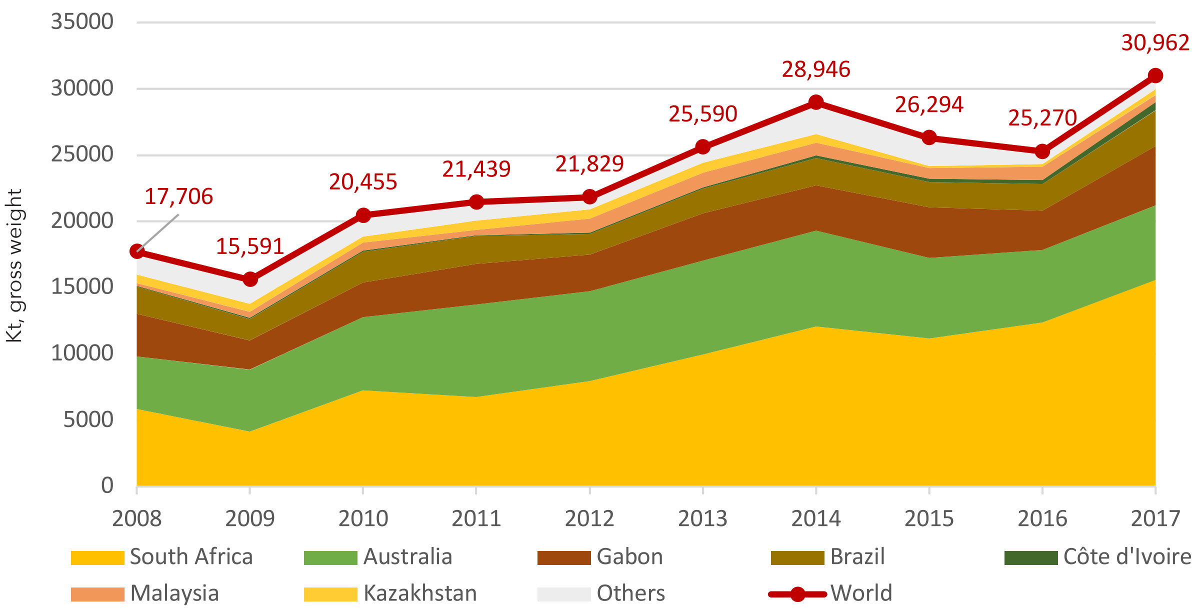
[133] Ibid.
[134] USGS (2019). Manganese [advance release]. In *2015 Minerals Yearbook*. https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2015-manga.pdf.
[135] Chatham House, the Royal Institute of International Affairs.

Figure 4.62. Distribution of production of manganese ore by content of manganese and ferro-alloys among major countries in 2017



Source: IMnI.

Figure 4.63. World manganese ore export dynamics in 2008–2017



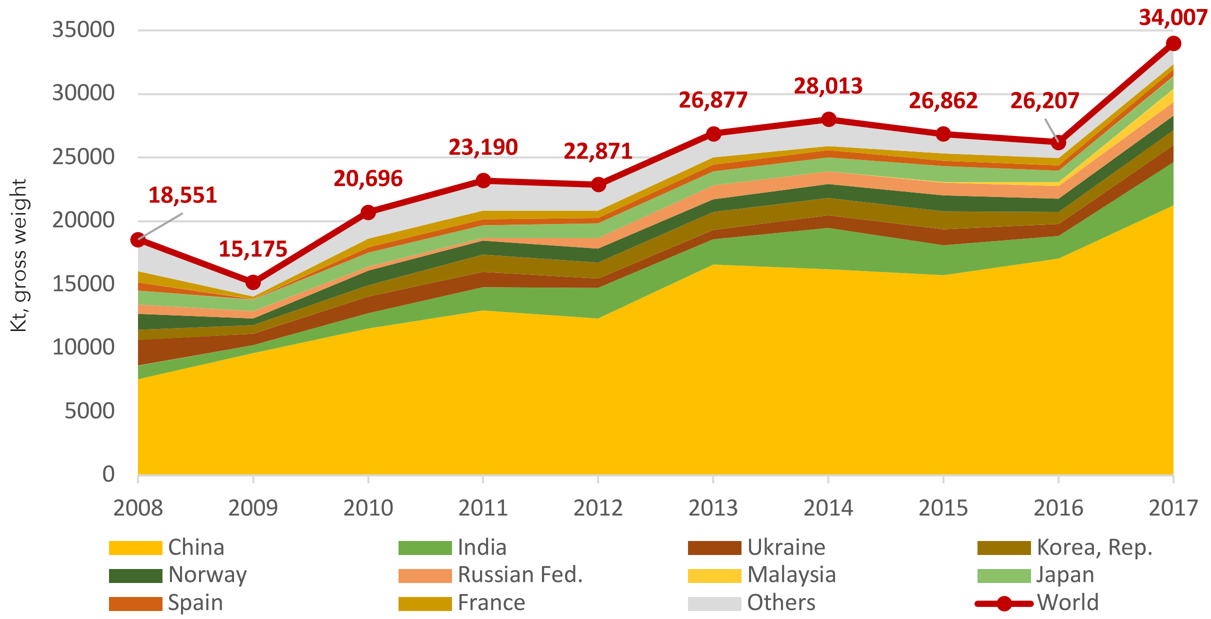
Source: ITC.

in 2009.[136] Côte d'Ivoire has very ambitious plans to develop the mining sector in general and manganese ore mining in particular. The aim is to diversify the country's economy, which is traditionally based on cocoa production.

397. The main importer of manganese ores is China, whose purchases in 2008–

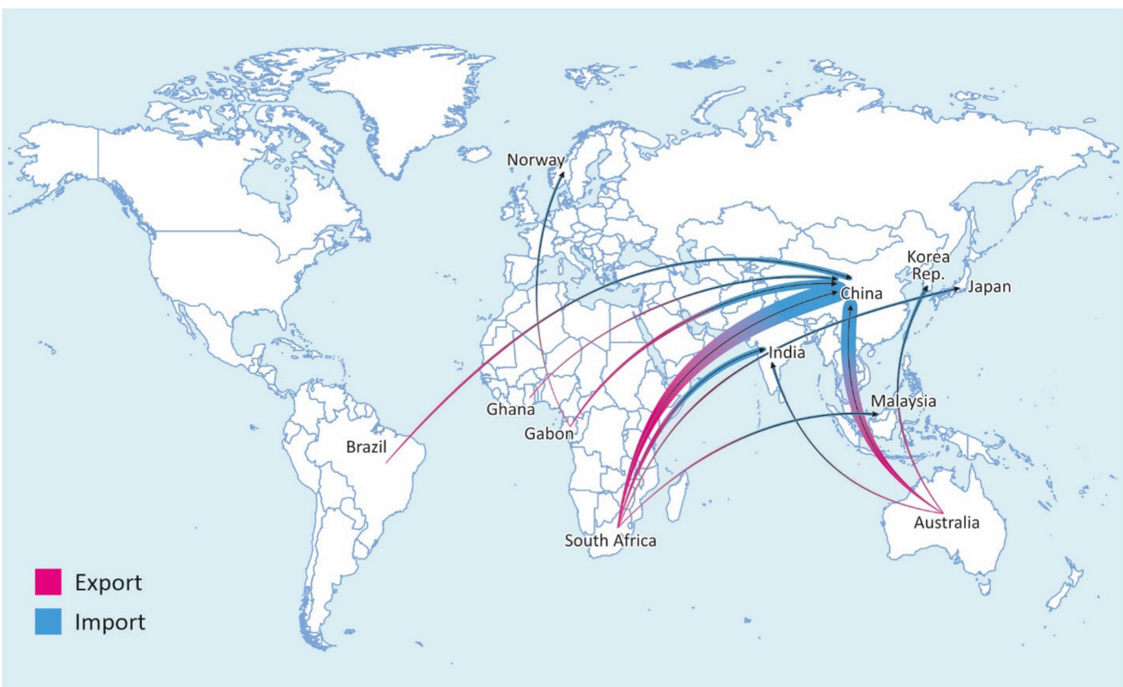
[136] RTI. La production globale de manganese en Côte d'Ivoire atteindra le million de tonne en 2017, https://www.rti.ci/info/economie/5423/la-production-globale-de-manganese-en-cote-divoire-atteindra-le-million-de-tonne-en-2017.

Figure 4.64. World manganese ore import dynamics in 2008–2017



Source: ITC.

Figure 4.65. Major international trade flows of manganese ore in 2017



Source: https://resourcetrade.earth/.

2017 increased by 13.7 Mt, or by 2.8 times (Figure 4.64). Manganese ore in the country is supplied by South Africa, Australia, Ghana, Gabon, Brazil, Malaysia, and many other countries. China, being the main producer of manganese ores of low quality, however, imports higher-grade ores and mixes them with its own for further production of ferro-alloys. Major importers also include India (its imports during the period under review increased by 2.3 Mt, or 3.2 times), Ukraine, South Korea, Norway, Russia, Malaysia, Japan, Spain, and France (Figure 4.65). It is noteworthy that India and Ukraine, which are major producers, import manganese ore in significant quantities. The reason for this in India is that the country's ferro-alloys production facilities are underutilized, while Ukraine, like China, mixes imported ores with its manganese ores of insufficient quality.

E. Semi-finished products sector of the affected metals

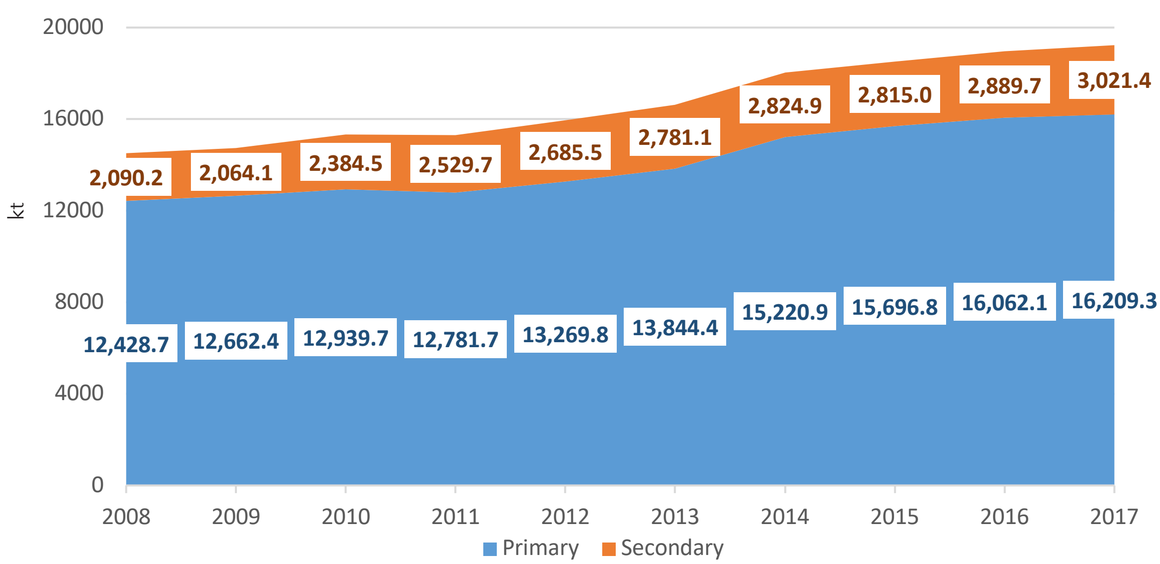
Copper

398. Semi-finished copper products include copper mattes, cement copper (precipitates), and smelter production. Smelter production is divided into three groups based on the source of material used in producing blister, anode and other smelter-level products. The three categories are: primary, from concentrates; low-grade electrowon from SX-EW and RLE (roast-leach-electrowon) plants; and secondary, from scrap materials. According to ICSG,[137] secondary copper currently accounts for approximately 16 per cent of blister copper production, compared to 14.4 per cent in 2008. In 2011–2013, its share exceeded 16.5 per cent (Figure 4.66).

399. This review focuses on copper extracted from natural ores. In doing so, primary and electrowon production is considered jointly.

400. According to ICSG (2018), primary blister copper production in 2017 exceeded 16 Mt, an increase of more than 30 per cent, or approximately 3.8 Mt, over 10 years (Figure 4.67). Almost all of this increase was provided by China (+3.6 Mt). Zambia has also shown significant growth (+0.5 Mt).

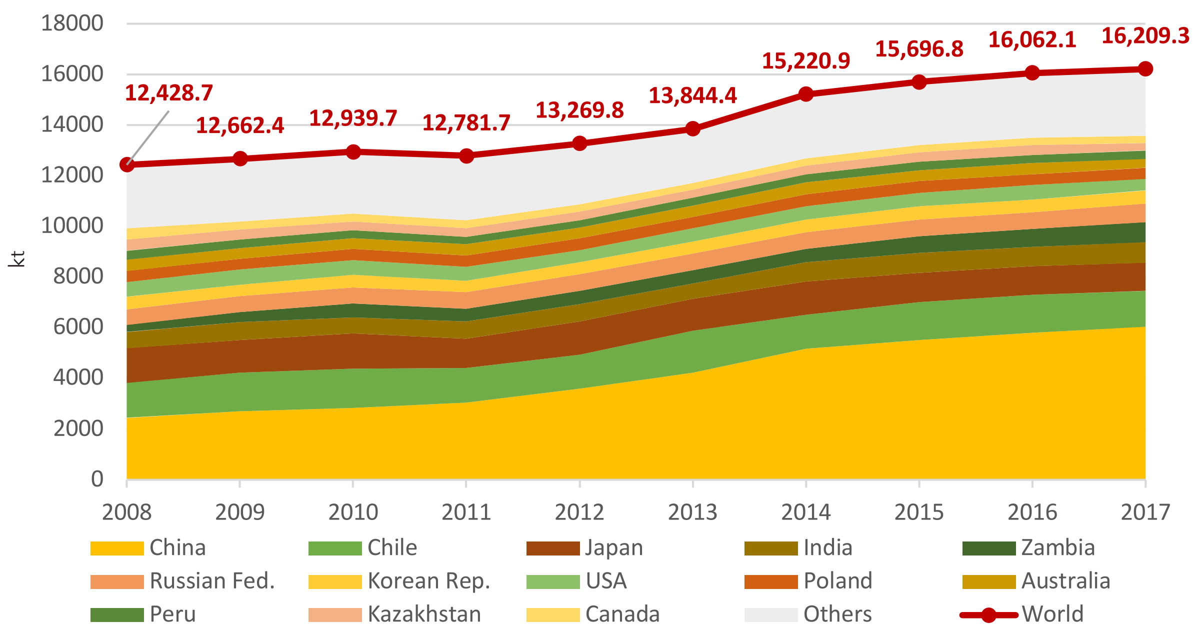
Figure 4.66. World primary and secondary copper smelter production dynamics in 2008–2017



Source: ICSG.

[137] ICSG (2018). Annual Publication. Vol. 15.

Figure 4.67. World primary copper smelter production dynamics in 2008–2017 by major producing and other countries



Source: ICSG.

401. Since 2005, China has been the world's largest primary blister copper producer. This was facilitated by the possibility of the large-scale import of copper concentrates, which exceeded the volumes of domestic mine production for more than 20 years. In 2017, more than 70 per cent of blister copper was produced from imported raw materials.

402. The statistics of international trade do not allow for separation of primary and secondary metal transactions, and they are considered jointly.

403. Blister copper is mainly refined at its production sites. As a result, less than 8 per cent of the world's primary and secondary blister copper production is involved in world trade. According to the estimates of Chatham House, the Royal Institute of International Affairs,[138] in 2017 it accounted for 3.1 per cent of world trade in copper products in terms of weight and 6 per cent in economic terms.

404. In 2008–2017, the volume of blister copper (HS code 7402) world trade increased by approximately 1.5 times (Figure 4.53).

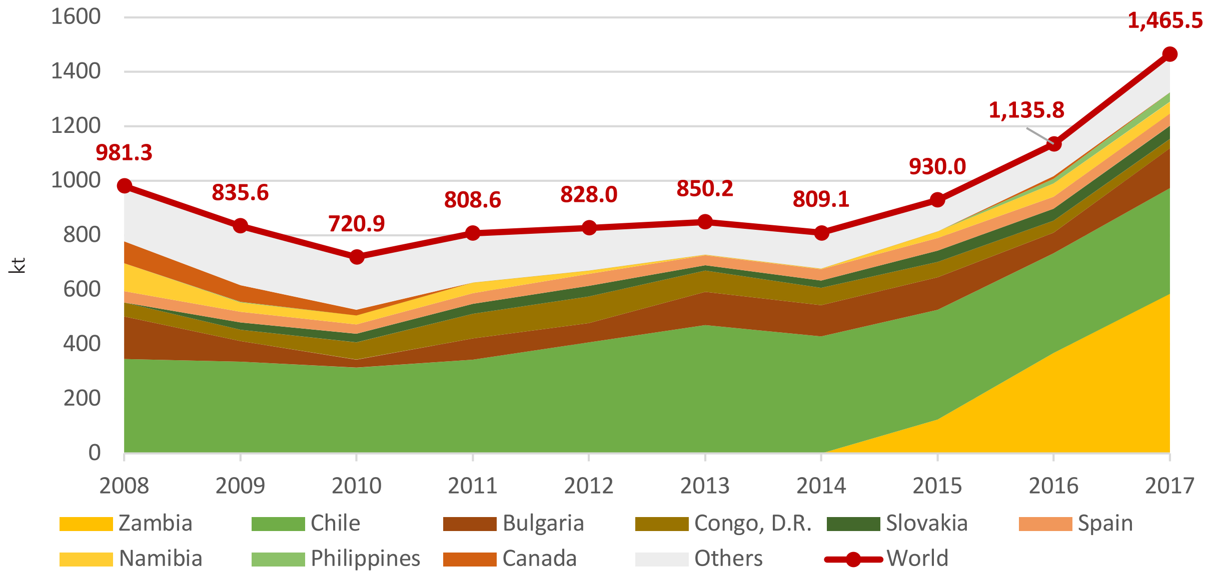
405. The increase in blister copper export amounted to approximately 0.5 Mt over 10 years (Figure 4.68), provided by Zambia (+0.6 Mt). The rapid expansion of blister copper production in this country allowed it to become the largest supplier of metal to the world market within three years. In 2017, it accounted for 40 per cent of the world total.

406. Chile, the main metal exporter for many years, has shifted to second place among blister copper exporters. In 2008–2017, its export volumes in physical terms remained unchanged, while its share in the world decreased from 35 per cent in 2008 to approximately 26.5 per cent.

407. The main export directions are China and Western European countries, primarily Belgium and Germany (Figures 4.69, 4.70).

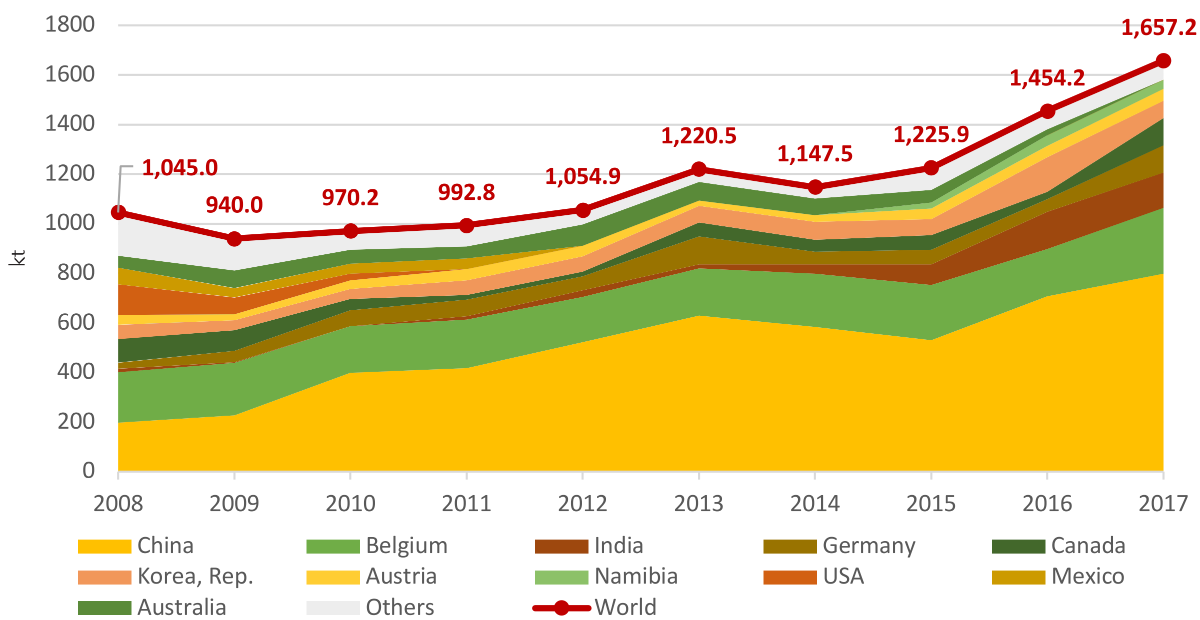
[138] Chatham House, the Royal Institute of International Affairs.

Figure 4.68. World unrefined copper export dynamics in 2008–2017



Source: ITC.

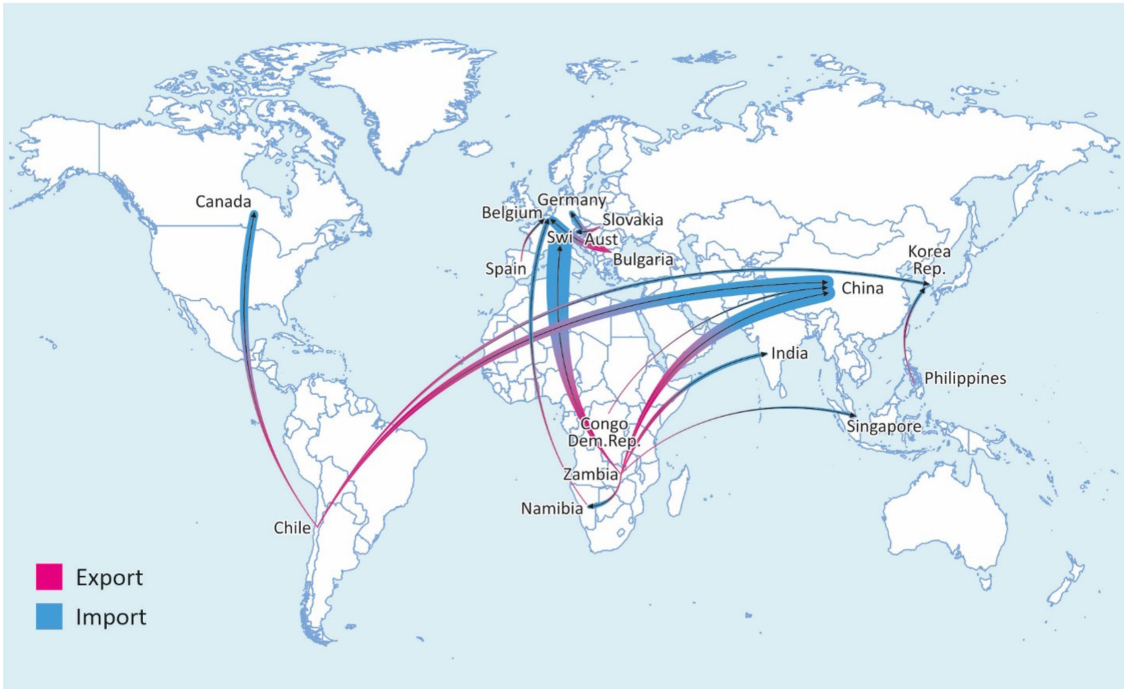
Figure 4.69. World unrefined copper import dynamics in 2008–2017



Source: ITC.

In 2008-2017 blister copper import to China increased by 0.6 Mt, or by four times. As a result, China's share of the world import increased from approximately 19 per cent to more than 48 per cent over 10 years.

Figure 4.70. Major international trade flows of unrefined copper in 2017



Source: https://resourcetrade.earth/.

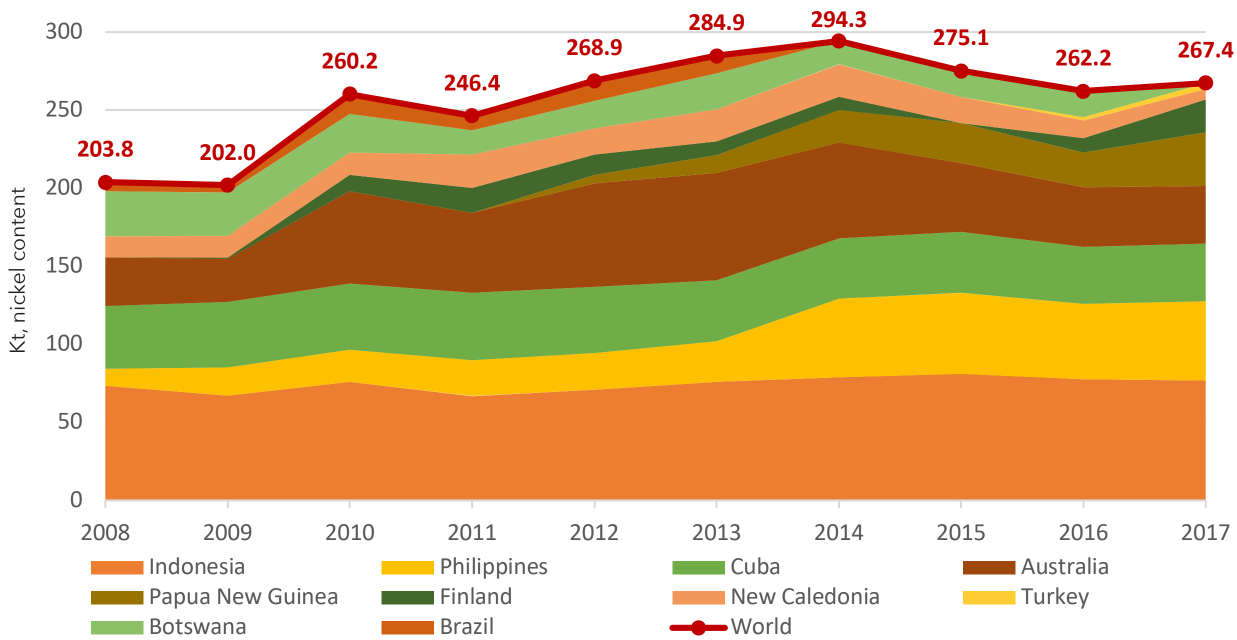
Nickel

408. Semi-finished nickel products include nickel-containing mattes, mixed sulphide concentrates (containing more than 35 per cent combined nickel and cobalt), and other intermediate products of nickel metallurgy, including salts and oxides for further refining.

409. The market for semi-finished products is significantly inferior to other nickel products in terms of volume and has a limited number of participants. According to INSG, in 2017, only 8 countries were producing them (Figure 4.71). At the same time, the available statistics do not allow identification of production indicators for specific types of products. In addition, these statistics are clearly incomplete, as indicated by the fact that they do not take into account a number of countries (such as Russia and Canada) that supply semi-finished products to the world market. It can be argued that the production of semi-finished nickel products by these countries is taken into account in mine production. In our view, the indicators of semi-finished nickel products production are important, first of all, for countries with underdeveloped nickel metallurgy. Russia and Canada are the largest producers of metallic nickel, so the lack of data on their production of semi-finished nickel products as such does not affect the assessment of the industry.

410. In 2008–2017, the production of semi-finished nickel products increased by 31 per cent, or almost 64,000 tonnes, in the countries included in the production statistics (Figure 4.71). It peaked in 2014, and the previous growth was mainly due to increased production in Australia in 2010–2014. In these years, it was 51–69,000 tonnes, compared to about 30,000 tonnes in previous years and about 40,000 tonnes in subsequent years. In addition, production started in Papua New Guinea in 2012 and doubled in the Philippines in 2014. It should be noted that throughout the

Figure 4.71. World nickel intermediate production by countries in 2008–2017



Source: INSG.

period under consideration, production in Indonesia remained constant and was supplied by several operations producing semi-finished nickel products.

411. Consumers of semi-finished ni- ckel products are metallurgical and hydrometallurgical operations that purchase them along with mining products.

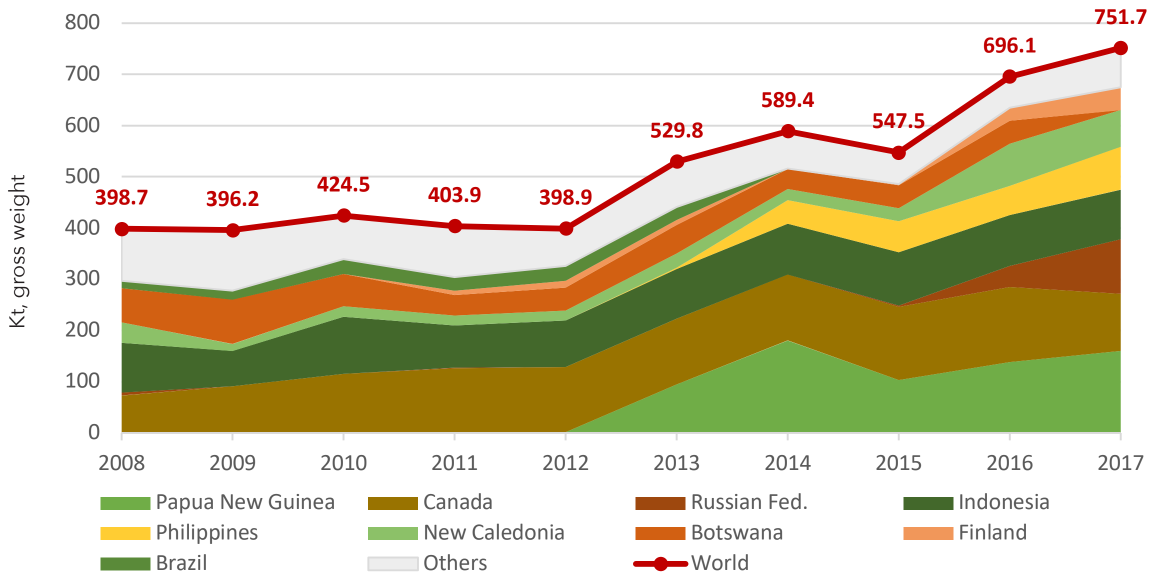
412. Chatham House, the Royal Institute of International Affairs,[139] estimates that in 2017 semi-finished nickel products (HS code 7501) accounted for 2 per cent of world trade in nickel products in terms of weight and 18 per cent in economic terms. The largest suppliers of semi-finished nickel products to the market are currently Papua New Guinea, Canada, Russia, Indonesia, the Philippines, and New Caledonia (Figure 4.72). At the same time, Russia, Canada, Indonesia, Finland, and Botswana are the main suppliers of nickel matte. Papua New Guinea, the Philippines, and New Caledonia are the main suppliers of nickel oxide sinters and other intermediate products of nickel metallurgy (excluding nickel mattes).

413. In 2008-2017, exports of semi-finished nickel products increased by almost two times, or by 353,000 tonnes (Figure 4.72). All the growth took place in 2013–2017. It was ensured, first of all, by Papua New Guinea entering the market (+160,000 tonnes), where nickel production began in 2012, as well as by a sharp increase in exports by Russia (+107,000 tonnes).

414. The main consumers of semi-finished nickel products are the largest producers of stainless steel: China, Japan, and Norway (Figure 4.73). At the same time, nickel oxide sinters and other intermediate products prevail in the import structure of China. Japan and Norway import mostly nickel matte.

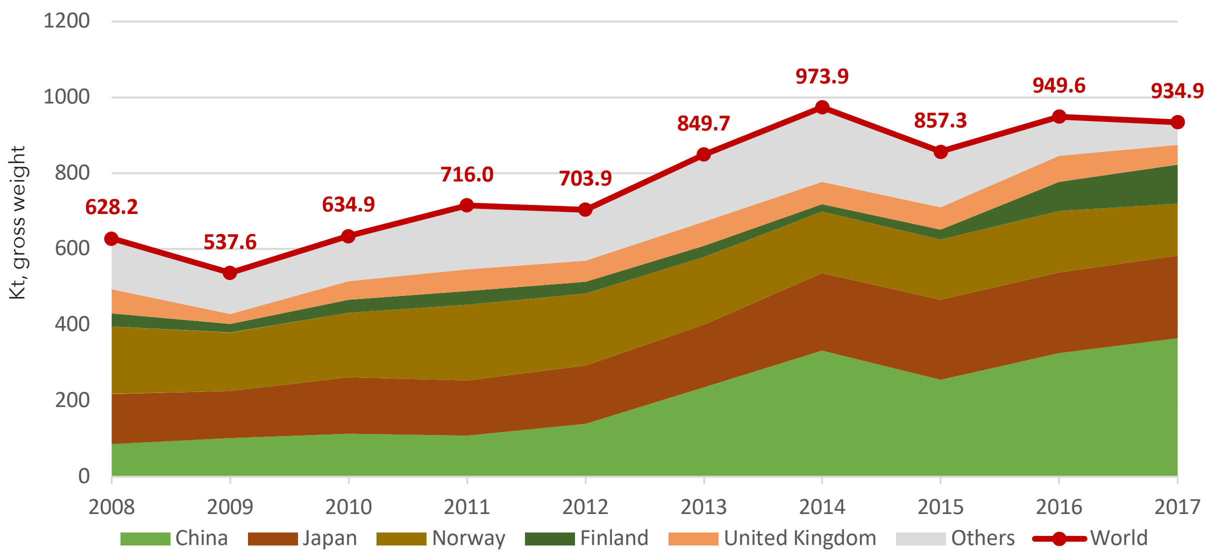
[139] Ibid.

Figure 4.72. World nickel intermediate production export in 2008–2017



Source: ITC.

Figure 4.73. World nickel intermediate production import in 2008–2017



Source: ITC.

Cobalt

415. Prior to refining, cobalt ores and concentrates are further processed into intermediate products. The majority of mining producers undertake processing to intermediate products domestically to lower the high costs of shipping bulky, low-value ores and concentrates. Intermediate cobalt products include cobalt salts (hydroxide, carbonate, and sulphate), accounting for 56 per cent of capacity and production, crude cobalt oxide, alliage blanc cobalt, and cobalt containing mattes. Their production volumes are not explicitly recorded, but are included in statistical data

of mine production. As far as international trade statistics are concerned, they also do not take into account intermediate products as separate products, but together with refined cobalt products. Therefore, their trade will be considered in section 4.F below.

Manganese

416. The products of manganese ore processing are manganese ferro-alloys, manganese metal, manganese dioxide, and other manganese chemicals. Almost all of these products are obtained directly from enriched ores. The exception is refined ferro-manganese, which can be produced either directly from ore or by refining high-carbon ferro-manganese or silico-manganese. Since it is not possible to determine which part of the silico-manganese and high-carbon ferro-manganese produced in the world as a whole and in individual countries are forwarded to production of refined ferro-manganese and which part to steelmaking. We consider them as end manganese products in section 4.F below.

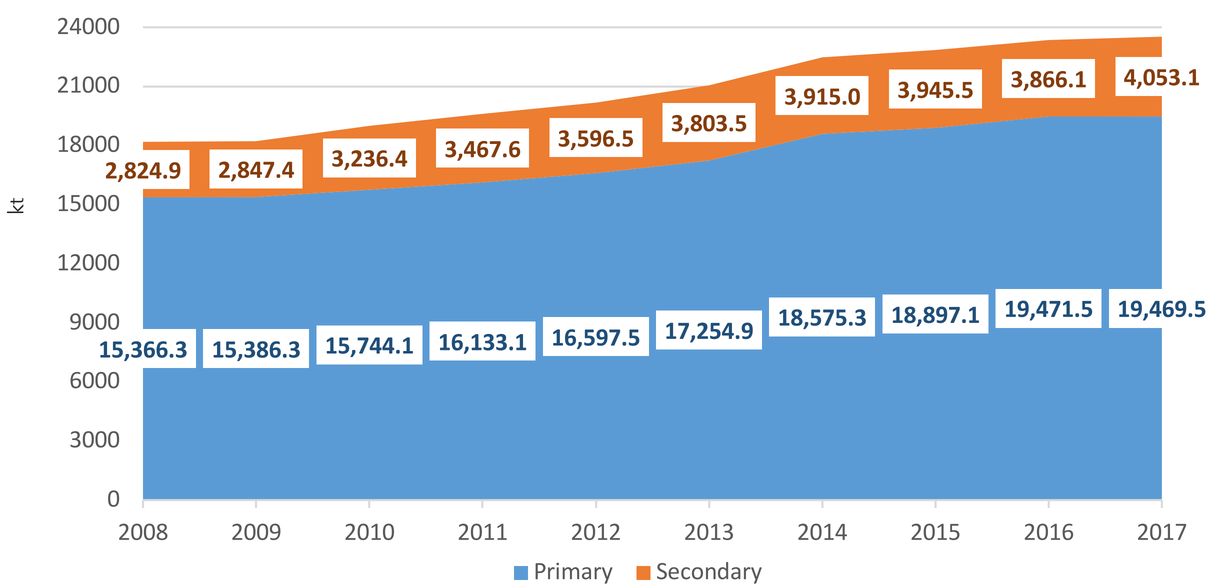
F. End products sector of the affected metals

Copper

417. End products include refined metal. Refinery production is broken into three statistical source categories: primary (electrolytic and fire-refined); secondary (electrolytic and fire-refined); and electrowon (High-grade SX-EW) refined production. According to the ICSG,[140] secondary copper accounts for more than 17 per cent of refined copper production against 15.5 per cent in 2008. In doing so, in 2011–2013 its share was at 17.7–18 per cent (Figure 4.74).

418. According to ICSG (2018), in 2017 refined copper production (secondary included) exceeded 23.5 Mt, having increased by more than 29 per cent, or by 5.3 Mt, over 10 years. At the same time, world refinery capacity increased by 5.2 Mt to 27.4 Mt (+23.5 per cent). Refineries capacity utilization in 2017 amounted to 85.9 per cent, while in

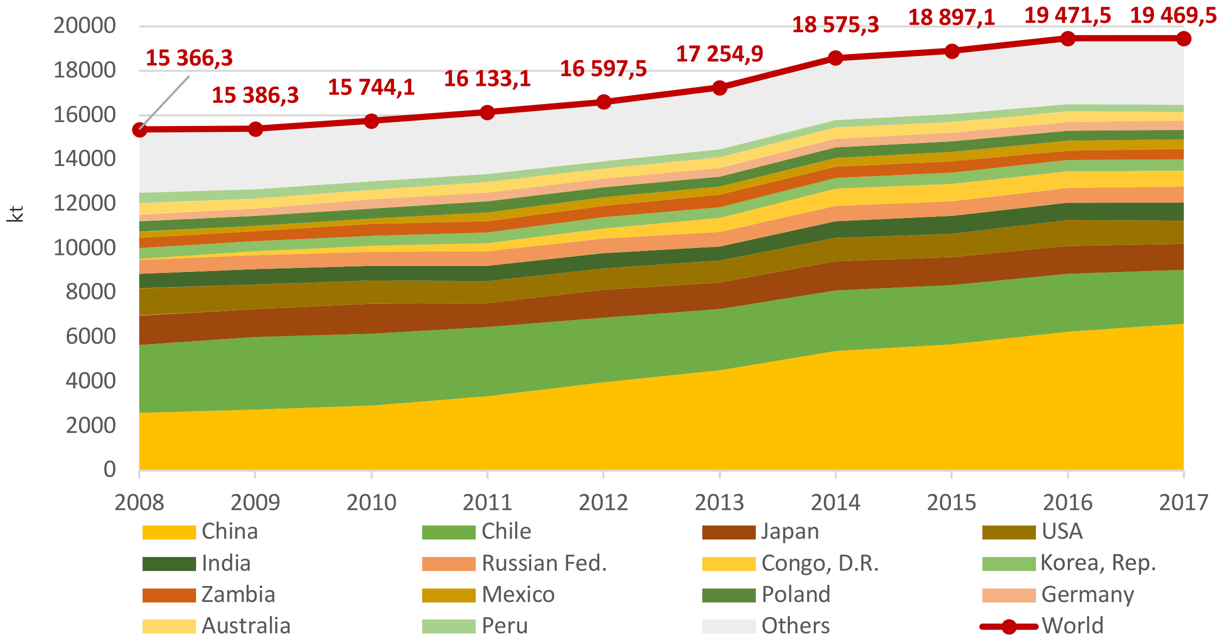
Figure 4.74. World primary and secondary copper refinery production dynamics in 2008–2017



Source: ICSG.

[140] ICSG (2018). *Annual Publication. Vol. 15.*

Figure 4.75. World primary copper refinery production dynamics in 2008–2017 by major producing and other countries



Source: ICSG.

2008 it was 82.1 per cent. The 20 largest refining operations in the world account for approximately 40 per cent of capacity.

419. This review focuses on copper extracted from natural ores. In doing so, primary and electrowon production is considered jointly.

420. The volume of primary refined copper production in 2017 amounted to 19.5 Mt, having increased by approximately 27 per cent, or by 4.1 Mt, over 10 years (Figure 4.75).

421. This increase was mainly provided by China (+4 Mt) and DR Congo (+0.7 Mt). At the same time, a number of countries that are among the largest exporters of metal have reduced their supplies, primarily Chile (-0.6 Mt).

422. Since 2011, China has been the world's largest refined copper producer. In 2017, its share of the world metal production amounted at almost 34 per cent against 17 per cent in 2008. Approximately 90 per cent of production was provided by domestic production of primary blister copper, and the rest was provided by its import. The bulk of refined copper produced in China is consumed domestically.

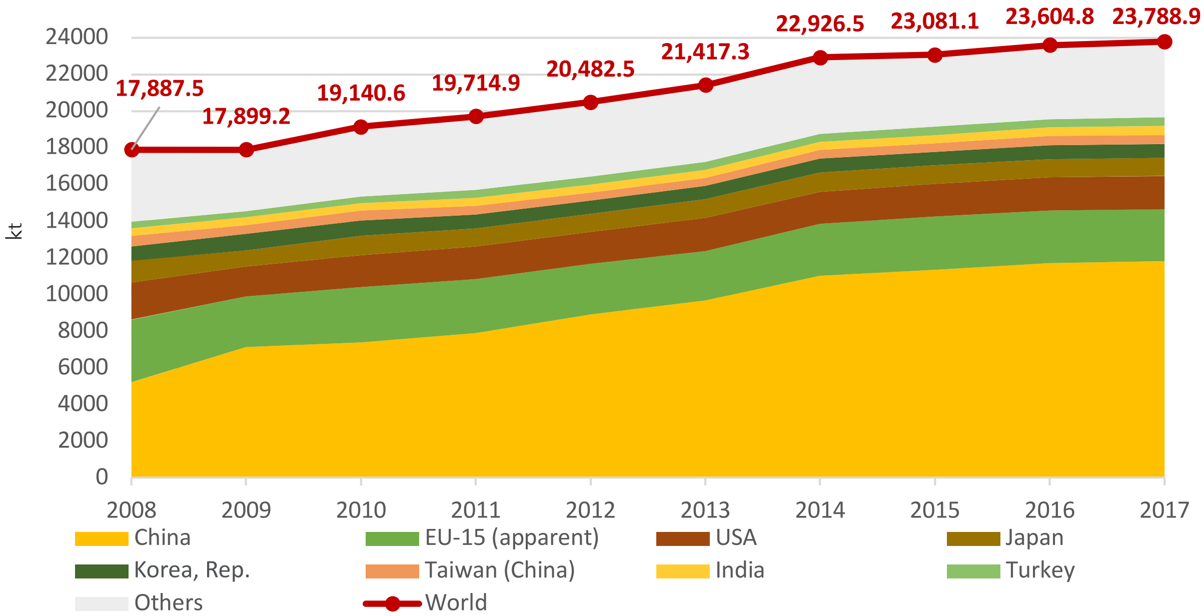
423. The share of Chile in domestic production of refined copper in 2017 amounted to 12.5 per cent against 20 per cent in 2008. The decline in the country's role was due not only to the growth of production in China, but also to the decline in domestic production. Almost all metal is exported.

424. Since 2013, DR Congo has been among the top ten refined copper producer states. This was due to the rapid expansion of SX-EW copper production. In 2017, the country accounted for approximately 4 per cent of the world production of primary refined copper. All metal is exported.

425. According to the ICSG,[141] in 2008–2017, the use of primary and secondary

[141] Ibid.

Figure 4.76. World refined copper (primary + secondary) usage dynamics in 2008–2017 by major and other countries and regions



Source: ICSG.

refined copper in industry increased by 33 per cent, or by 5.9 Mt, and amounted to 23.8 Mt (Figure 4.76). This increase was provided by China, as the consumption of refined copper by its industry increased by 6.6 Mt (+127 per cent) over 10 years. In 2017, the industry of China provided almost 50 per cent of the world metal consumption, against 29 per cent in 2008.

426. In economically developed countries, the use of refined copper in industry declined during this period. In EU-15, this decline amounted to 0.6 Mt (-17 per cent), and in the USA and Japan, 0.2 Mt (-11 and -16 per cent, respectively). Nevertheless, the industry of economically developed countries in 2017 provided 26 per cent of world metal consumption in total.

427. A comparison of the main centers of production and consumption of refined copper shows that they are largely fragmented (Figure 4.77). Despite the fact that the main metal consumers usually have their own refining operations, often their capacity is insufficient to meet their needs. This also applies to China. This situation has determined the large-scale international refined metal trade.

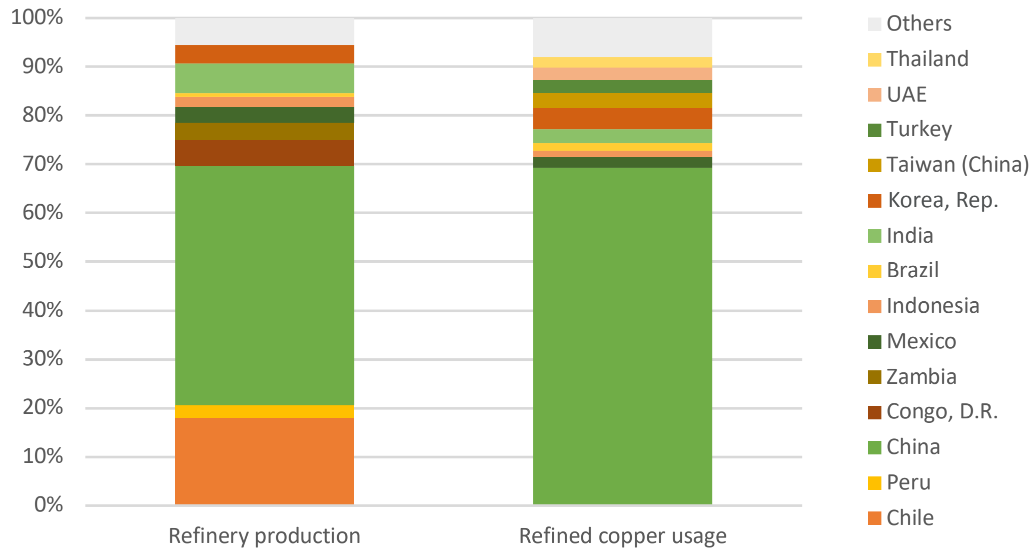
428. The statistics of international trade do not allow for separation of primary and secondary metal transactions, and they are considered jointly.

429. Refined copper in cathodes, billets for wire manufacturing, and billets for rolling (HS code 740311) is a key product in the copper market. Approximately 40 per cent of produced refined copper (secondary included) is involved in international trade. According to the estimates of Chatham House, the Royal Institute of International Affairs,[142] in 2017 it accounted for 16 per cent of world copper product trade in terms of weight and approximately 30 per cent in economic terms.

430. The dynamics of international refined copper trade differed from those of other copper products. This primarily applies

[142] Chatham House, the Royal Institute of International Affairs.

Figure 4.77. Distribution of refined copper production and usage among major countries and regions in 2017



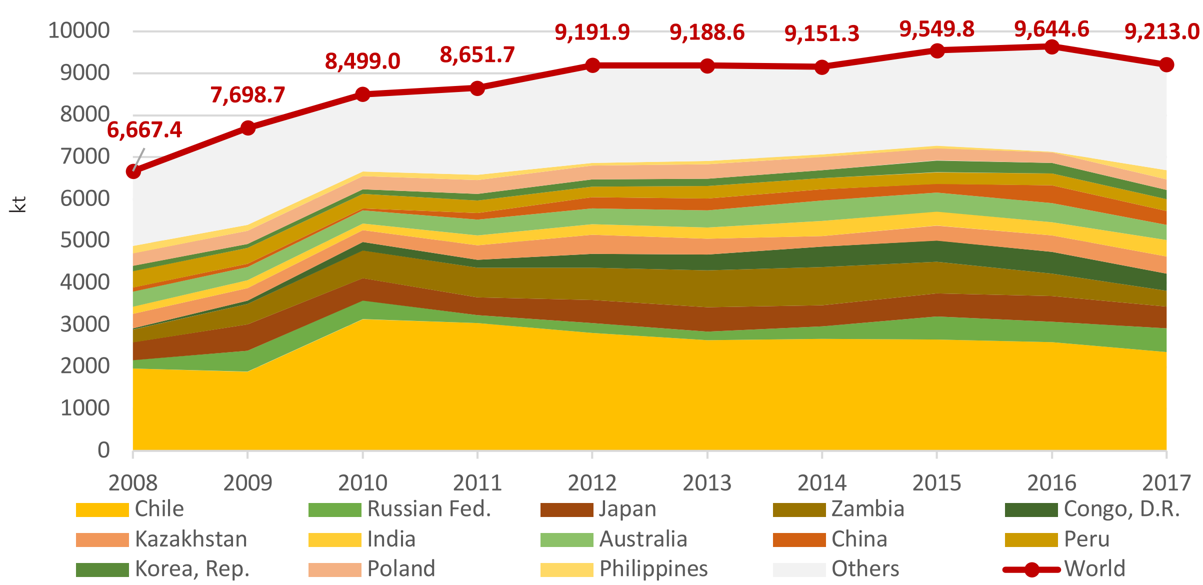
Source: ICSG.

to its decrease in 2017, while operations with concentrates and blister copper were expanding.

431. In 2007–2018, the export of refined copper increased by 38 per cent (+2.5 Mt) (Figure 4.78). However, compared to 2016 it decreased by 4.5 per cent (0.4 Mt). The largest increase in export over 10 years was demonstrated by Chile, DR Congo, and Russia. The supplies of each country expanded by approximately 0.4 Mt.

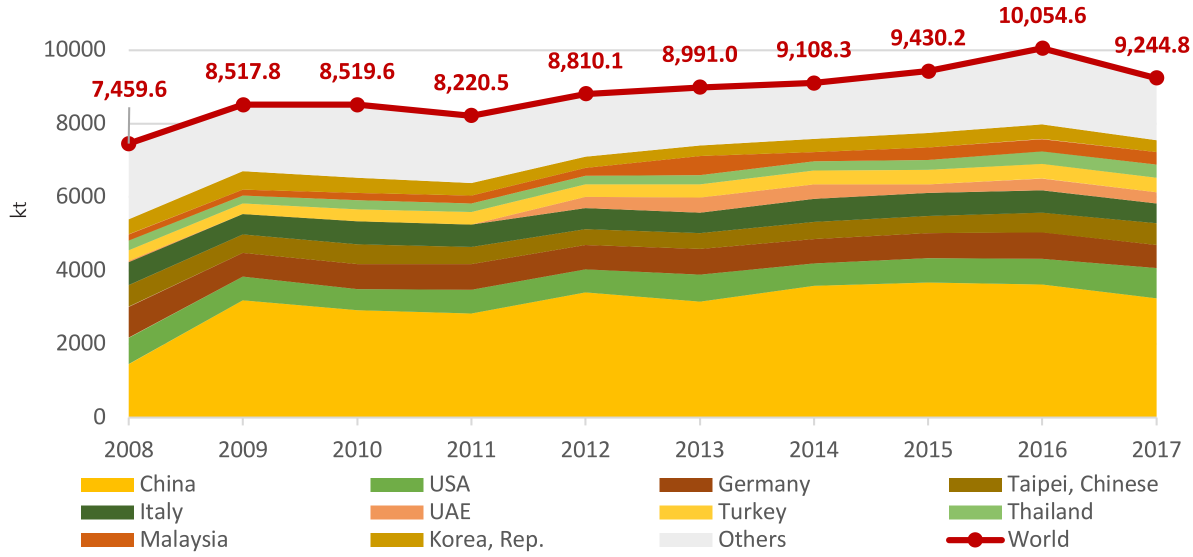
432. Chile remained the largest exporter of refined copper in 2008–2017. However, its share in the world index decreased from 29.4 to 25.6 per cent. This is largely due to the increased contribution of small suppliers.

Figure 4.78. World refined copper export dynamics in 2008–2017



Source: ITC.

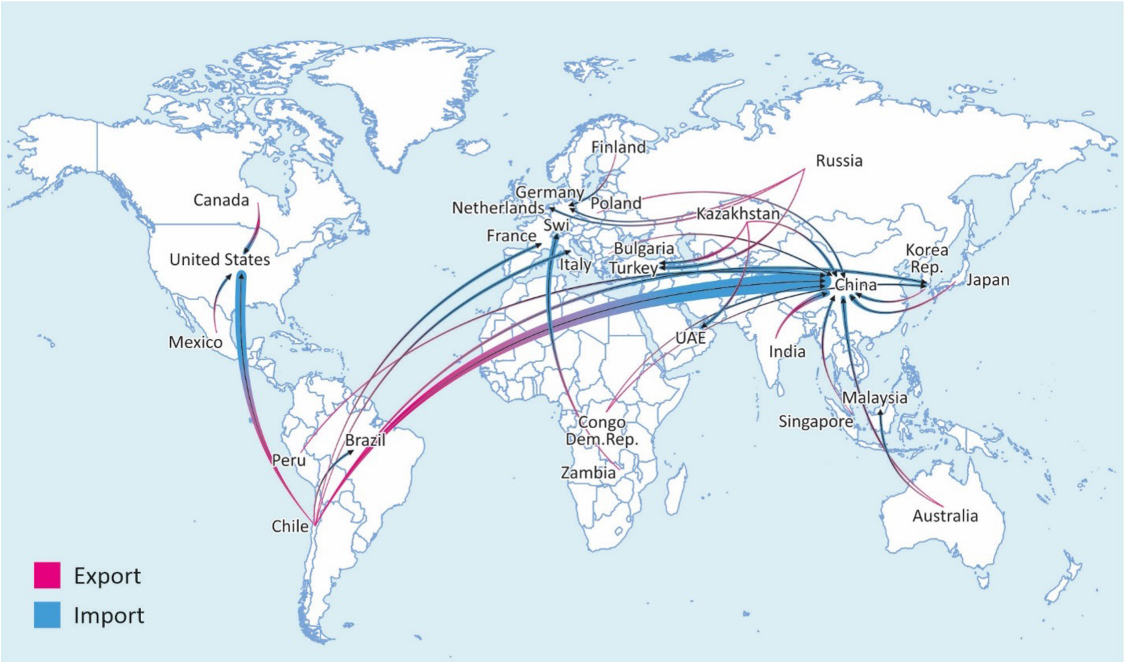
Figure 4.79. World refined copper import dynamics in 2008–2017



Source: ITC.

433. China remains the main export destination (Figures 4.79, 4.80). In 2008–2017, its import of refined copper increased by 2.2 times, and this increase occurred in 2009. As a result, the share of China in the world import increased from 19.5 to 37.4 per cent. In the following years, China's imports varied within a fairly narrow range, and its share in the world index was 34.3–39.4 per cent.

Figure 4.80. Major international trade flows of refined copper in 2017



Source: https://resourcetrade.earth/.

Nickel

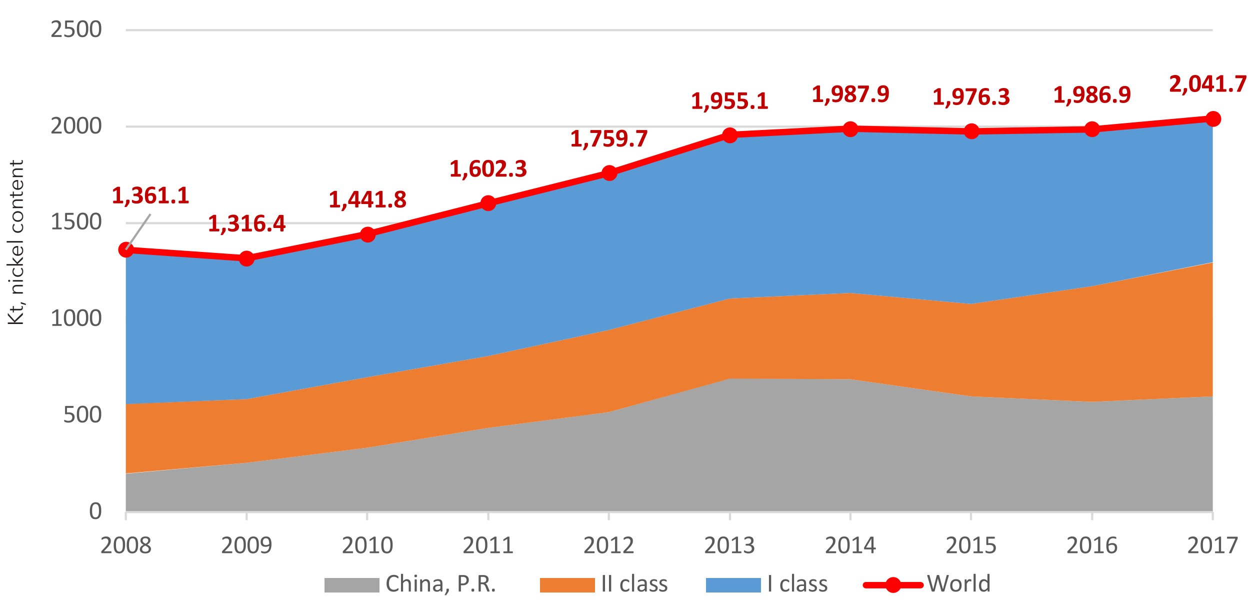
434. End products include unwrought nickel and ferro-nickel, including NPI. Secondary nickel-containing products in significant quantities are only used for the production of stainless steel and often go into production without being pre-processed to metal.[143]

435. According to the INSG,[144] in 2017 primary nickel production exceeded 2 Mt, having increased by 1.5 times, or by 0.7 Mt, over 10 years (Figure 4.81). Unlike the mining industry, primary nickel production did not fluctuate sharply during the same period. After a brief decline in 2009 due to the consequences of the global financial crisis, there was a steady increase in production. In 2009–2013, the growth dynamics were characterized by high rates of 10 per cent annually. However, since 2014, the development has stabilized and production growth rates have averaged 2 per cent a year.

436. The available statistics do not allow for a complete division of primary nickel production into product classes, as there is no such information on China, which is the largest producer. At the same time, there are reasons to believe that more than 90 per cent of Chinese production falls on products of class 2, including NPI and ferro-nickel, with a predominance of the former. Therefore, all production in China can be conditionally attributed to the share of class 2 products, meaning that, since 2011, low-grade nickel products have been dominating world primary nickel production (Figure 4.81).

437. Primary nickel production in 2008–2017 was carried out in 29 countries. Since 2015, 26 countries have been consistently producing it. At the same time, 75 per cent of production is provided by 10 countries. The industry leaders producing over 100,000 tonnes of nickel annually include China, Indonesia, Japan, Russia, Canada, Australia, and New Caledonia (Figure 4.82).

Figure 4.81. World nickel primary production by class in 2008–2017

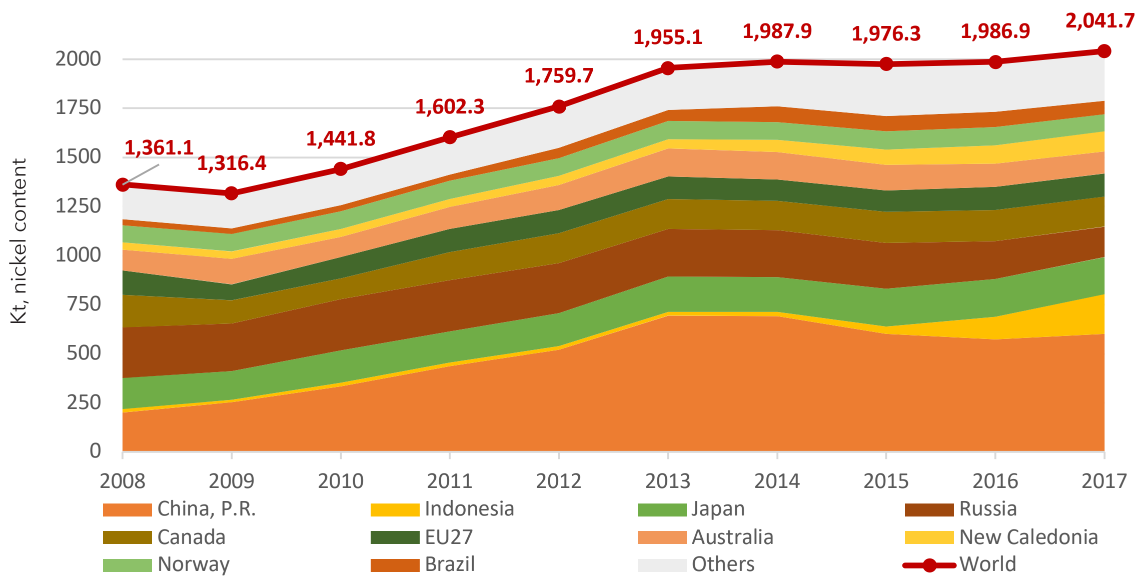


Source: INSG.

143 INSG. About Nickel. Recycle and Environment Issues. https://insg.org/index.php/about-nickel/recycle-and-environment-issues/.

144 INSG (2019). *World Nickel Statistics. Yearbook.* Vol XXVIII. No. 12.

Figure 4.82. World nickel primary production by countries in 2008–2017



Source: INSG.

438. The main increase in nickel production was provided by Chinese operations, which increased production by three times, or by 400,000 tonnes. The decrease in nickel production observed in 2014-2016 in the country was caused by the state environmental policy aimed at tightening control over harmful emissions into the atmosphere in large industrial regions where most NPI production facilities are located.

439. Russia, Japan, Canada, and Australia, which have long been leaders of nickel metallurgy, are now three to five times inferior to China.

440. Ferro-nickel and NPI are produced in 17 other countries. Besides China, Indonesia, Japan, and New Caledonia are also major producers. Production in each of these countries exceeds 100,000 tonnes of nickel. In addition, Brazil, the Republic of Korea, and Colombia have significant production (over 40,000 tonnes of nickel per year).

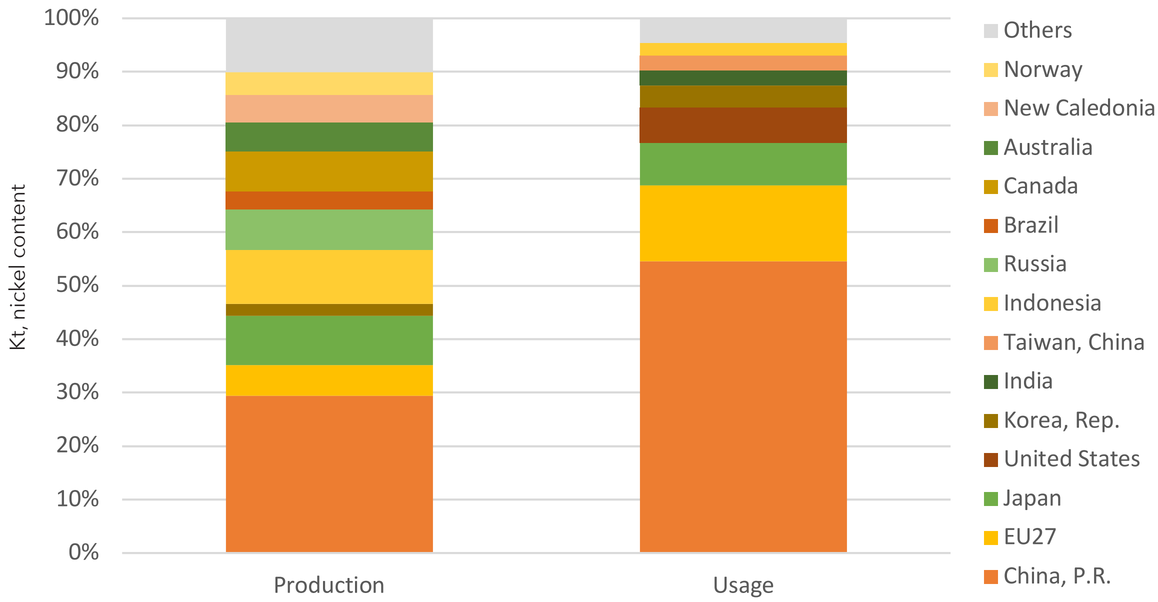
441. The main nickel producers of class 1 are Russia, Canada, and Australia. Annual production in each of these countries exceeds 100,000 tonnes of metal, and together they provide more than half of the world's production of high-grade metal. Norway, Finland, Japan, United Kingdom, South Africa, and Madagascar are also major producers, with annual production of over 30,000 tonnes.

442. A comparison of major primary nickel production and consumption centers shows that they are largely disjointed (Figure 4.83). Most major consumer countries of primary nickel are unable to meet the demand for metal from their own production. This is particularly true for China. Most consumer countries do not have their own production at all, for example the US and some EU countries. This situation has determined a large-scale international trade in primary nickel.

443. Chatham House, the Royal Institute of International Affairs,[145] estimates that ferro-nickel (including NPI) accounted for 4 per

[145] Chatham House, the Royal Institute of International Affairs.

Figure 4.83. Primary nickel production and usage by countries and regions in 2017



Source: INSG.

cent of world trade in nickel products in 2017 in terms of weight and 15 per cent in economic terms.

444. World trade in ferro-nickel and NPI (HS code 720260) in 2008–2017 was characterized by positive dynamics. The volume of export operations increased by three times, or by almost 1,400 tonnes (Figure 4.84). The main growth was provided by Indonesia (+960,000 tonnes), where the country's own processing industry started to develop. Supplies from New Caledonia and Japan remained consistently high.

445. The main importer of ferro-nickel since 2009 is China (Figures 4.85, 4.86). In 2015–2017, its foreign purchases of ferro-nickel demonstrated abnormally high growth rates, having increased by almost five times in three years, from 283 to 1,365 tonnes. As a result, in 2008–2017, ferro-nickel imports to China increased by more than 20 times in physical terms, and its share in the global index rose from 8 to 64 per cent.

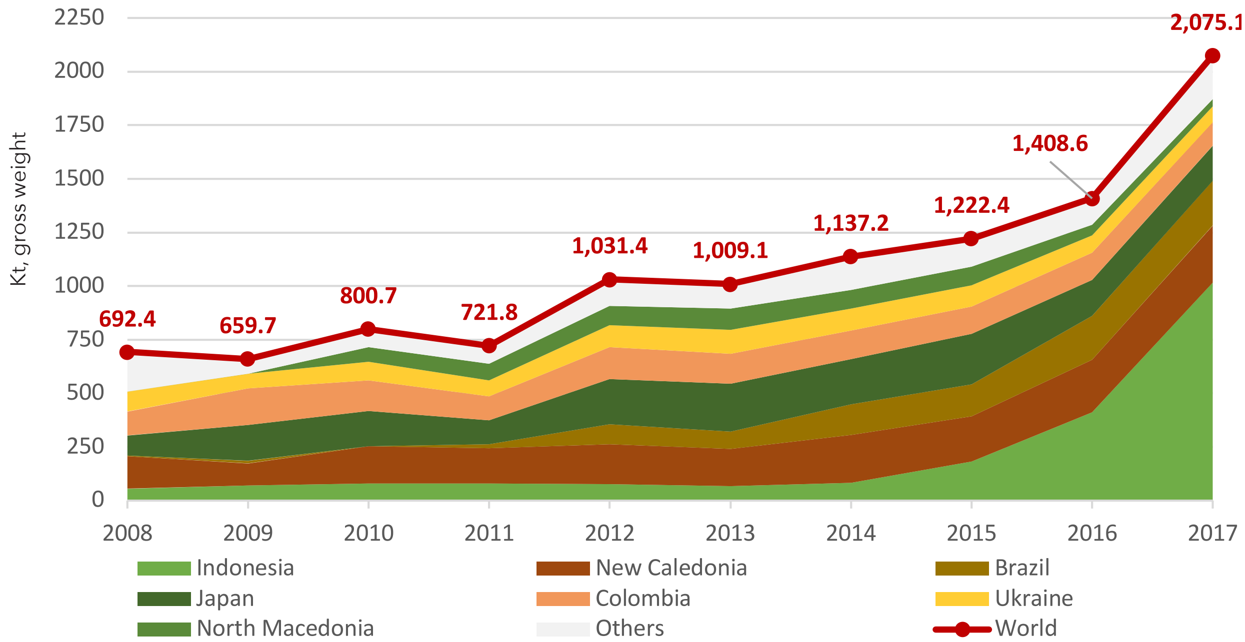
446. The main product in the nickel market is refined unwrought nickel (HS code 750201). Over 90 per cent of the metal produced is involved in international trade. However, according to Chatham House, the Royal Institute of International Affairs estimates,[146] its share in world trade in nickel products in 2017 was only 2 per cent in terms of weight and 34 per cent in economic terms.

447. Unwrought nickel is an exchange-traded commodity that the LME and SHFE trade in. Therefore, the geography of metal supplies is affected by the location of exchange warehouses. For example, LME warehouses are mainly located in the the following countries: Netherlands, Belgium, Germany, the United Kingdom, Spain, the US, the Republic of Korea, Malaysia, Singapore, and the United Arab Emirates. SHFE warehouses are located in China.

448. In 2008–2017, exports of unwrought nickel increased by about 34 per cent, or by 216,000 tonnes. In so doing, it reached its

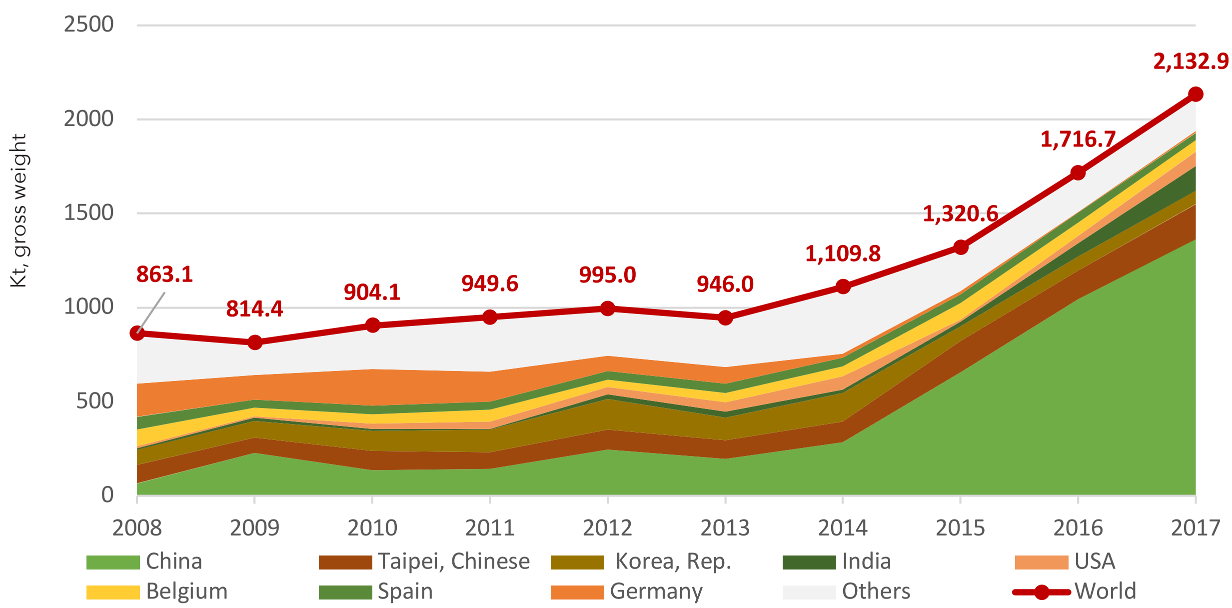
[146] Ibid.

Figure 4.84. World ferro-nickel export, including NPI, by countries in 2008–2017



Source: ITC.

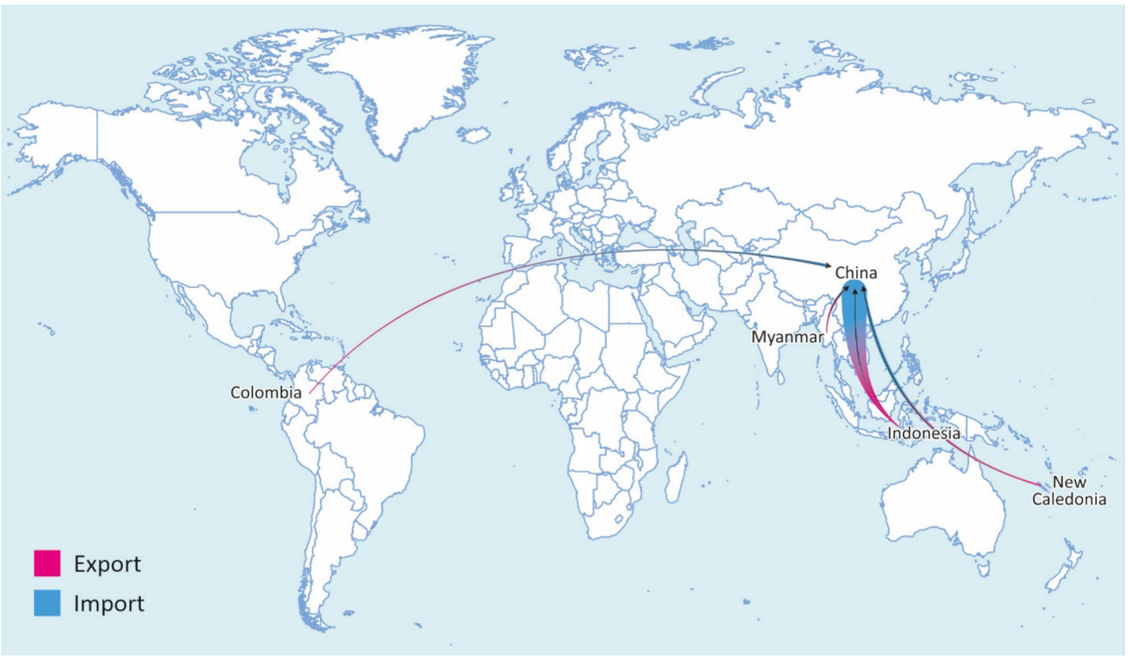
Figure 4.85. World ferro-nickel import, including NPI, by countries and regions in 2008–2017



Source: ITC.

maximum in 2015 after abnormal growth in 2013–2015 (Figure 4.87). The reason for this spike was mainly the increase in metal deliveries from Malaysia and Singapore, where LME warehouses are located. It is important to understand, though, that metal exported by countries with large trading floors can be counted twice in export statistics: first by the country of manufacture (importer, or the country

Figure 4.86. Major international trade flows of ferro-nickel, including NPI, in 2017



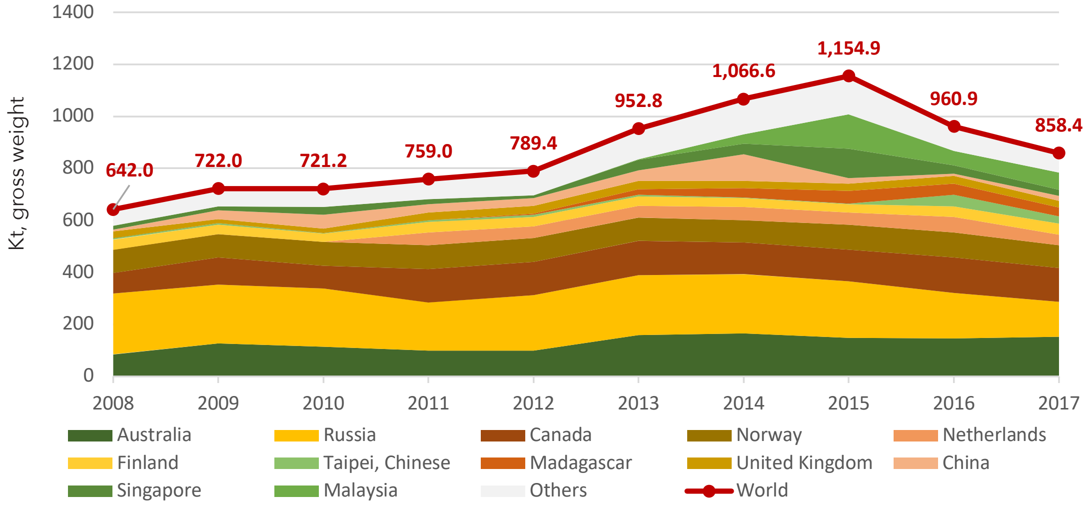
Source: https://resourcetrade.earth/.

where the trading floor is located), and then by the country where it was stored before reaching the consumer.

449. The main exporters of unwrought nickel are major metal producers: Russia, Australia, Canada, and Norway.

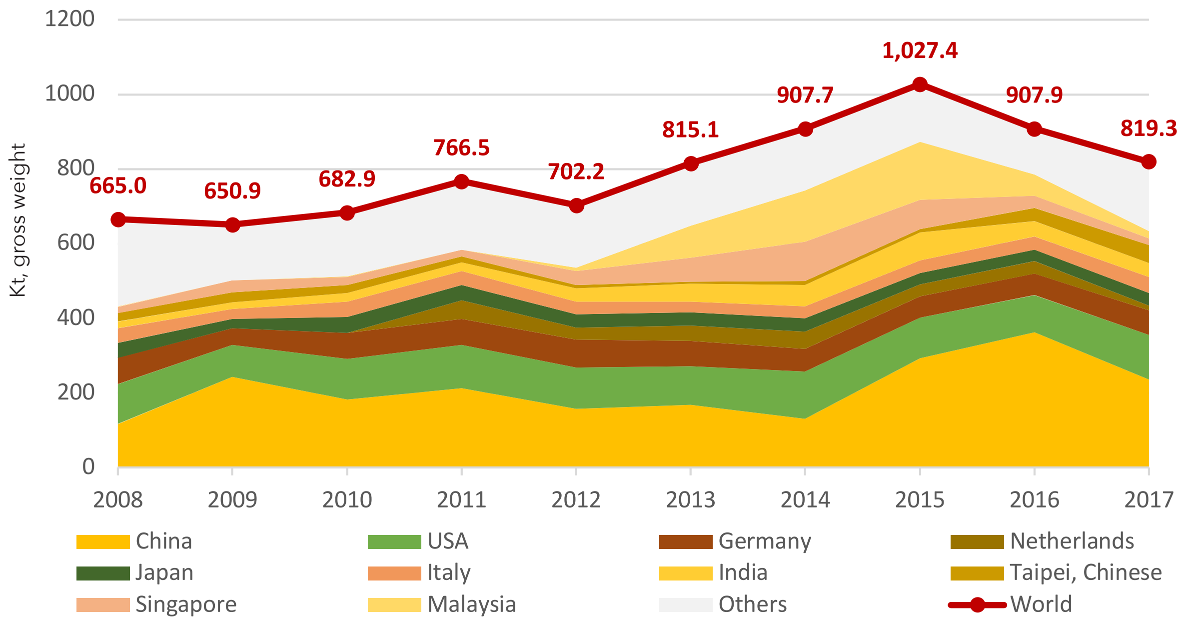
450. China has been the main destination of unwrought nickel supplies since 2007. Despite the wave-like dynamics, in 2008–2017 they increased by two times, or by almost 120,000 tonnes. A significant number of supplies are also to the USA. In addition, in 2013–2016, significant quantities of metal were shipped to Malaysia and Singapore, where LME warehouses are located (Figures 4.88, 4.89).

Figure 4.87. World unwrought nickel export by countries and regions in 2008–2017



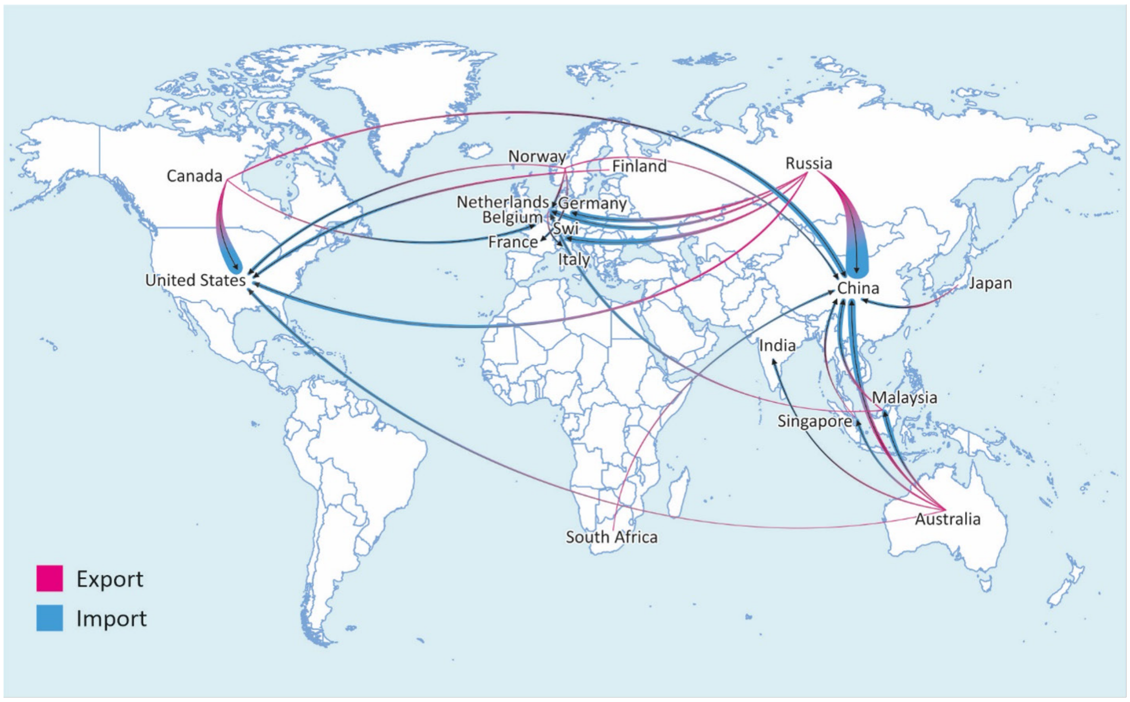
Source: ITC.

Figure 4.88. World unwrought nickel import by countries and regions in 2008–2017



Source: ITC.

Figure 4.89. Major international trade flows of unwrought nickel in 2017



Source: https://resourcetrade.earth/.

Cobalt

451. End products include refined cobalt products, which are divided into metal products (such as cathodes, briquettes, ingots, granules, and powder) and chemical products (such as oxides, carbonates, sulphates, and others).

452. As shown above (section 4.C), in addition to primary refined cobalt, the world also produces secondary refined cobalt, derived from the processing of new and old waste and scrap. Statistics on secondary cobalt production are not available, and estimates vary greatly. Thus, according to CRU estimates, in 2016, about 6,000 tonnes of cobalt were extracted from secondary sources. According to Roskill estimates, world secondary cobalt production currently ranges between 10 and 15,000 tonnes, with 6,500 tonnes produced in China. Antaike estimates current production of secondary cobalt in China at 5,000 tonnes.[147] Based on the information available, statistics on the production of refined cobalt do not include secondary cobalt.

453. According to BGS,[148] in 2017 the production of refined (primary) cobalt exceeded 119,000 tonnes, having increased by more than two times, or by almost 62,000 tonnes, over 10 years (Figure 4.90) In the same period of time, according to USGS estimates, world refinery capacity increased by approximately 1.6 times, from 95,600 tonnes in the beginning of 2008 to 149,000 tonnes in the beginning of 2018.[149],[150] There are reasons to believe that the capacity for the production of refined cobalt and the production itself is higher than that accounted for. This is particularly indicated by statistics on imports of cobalt raw materials. Thus, cobalt ores and concentrates are intermediate products that are supplied to the Republic of Korea, but no statistics are available on the production of refined cobalt products in that country.

454. Refined cobalt production growth was primarily provided by China (+51,400 tonnes, or by 3.8 times). Significant, but fundamentally smaller increases have been demonstrated by Belgium (+4,000 tonnes, or by 2.3 times), Japan (+3,100 tonnes, or by almost four times), Finland (+2,600 tonnes, or +27 per cent). In addition, production of refined cobalt started in 2012 in Madagascar (in 2017, it exceeded 3,000 tonnes) and in New Caledonia (in 2017, it exceeded 2,000 tonnes).

455. Since 2004, the world's largest producer of refined cobalt has been China. In 2017, its share in global metal production was more than 58 per cent, compared to approximately 32 per cent in 2008. In physical terms, metal production in 2017 amounted to 69,600 tonnes versus 18,200 tonnes in 2008.[151] Production is largely driven by imports of cobalt raw materials in the form of ores, concentrates, and intermediate products, mainly from DR Congo. Most of China's refined cobalt is consumed domestically.

456. The top three producers of refined cobalt also include Finland and Belgium,

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147 DERA (2018). *Rohstoffrisikobewertung – Kobalt, Deutsche Rohstoffagentur (DERA) in der Bundesanstalt für Geowissenschaften und Rohstoffe (BGR).* Berlin. https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-36.pdf;jsessionid=5E27543065DB072D00053BC464611B02.2_cid331?__blob=publicationFile&v=2.

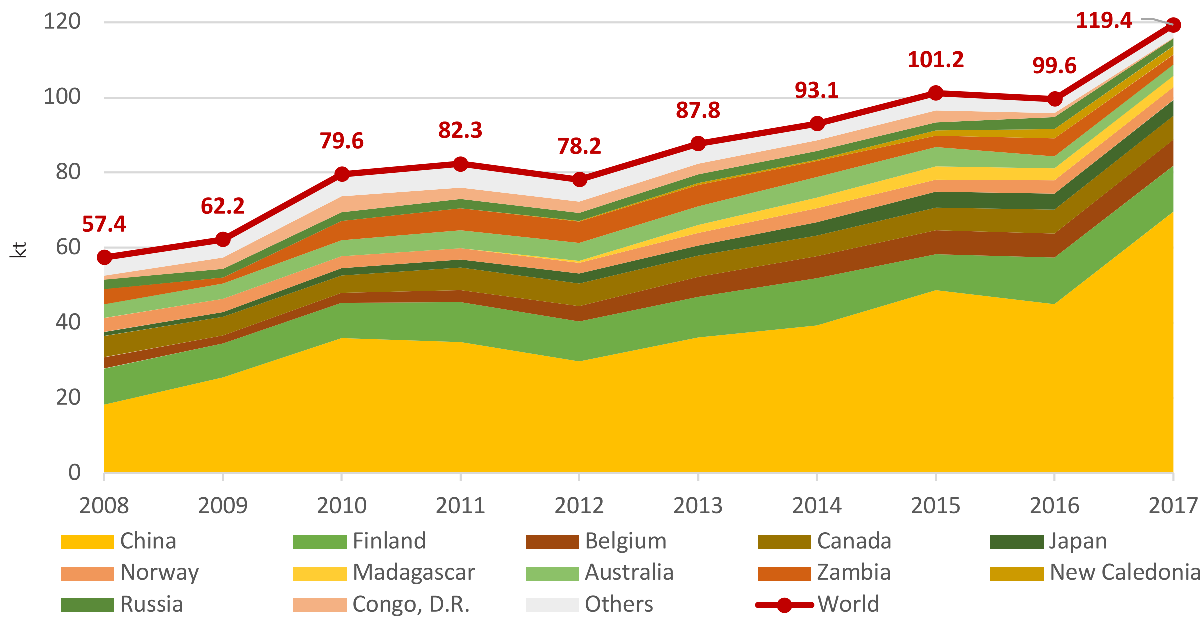
148 BGS (2019). *World Mineral Production 2013–2017.* Keyworth, Nottingham: British Geological Survey, pp. 100. https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html.

149 USGS (2010). Cobalt. *2007 Minerals Yearbook.* https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/cobalt/myb1-2007-cobal.pdf.

150 USGS (2019). Cobalt (advance release). *2016 Minerals Yearbook.* https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2016-cobal.pdf.

151 BGS (2019). *World Mineral Production 2013–2017*. Keyworth, Nottingham: British Geological Survey, pp. 100. https://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html.

Figure 4.90. World primary cobalt refinery production dynamics in 2008–2017 by major producing and other countries



Source: BGS.

whose shares in world production in 2017 were more than 10 per cent and approximately 6 per cent, respectively.

457. Until 1992, the largest producer of refined cobalt in the world was DR Congo, which at that time accounted for about a third of world production. The domestic political situation in the country in the early 1990s, which caused political and social unrest, the cessation of foreign investment and rampant inflation, led to the destruction of the country's economy in general and the production of refined cobalt in particular. The ensuing wars and continuing political instability have prevented them from regaining their former strength. In 2017 DR Congo produced only 200 tonnes of refined cobalt (0.2 per cent of world total), and in 2008–2016, its index varied between 1,000 and 4,200 tonnes.[152] At the same time, the capacities available in the country allow producing up to 9,000 tonnes of refined cobalt per year.[153]

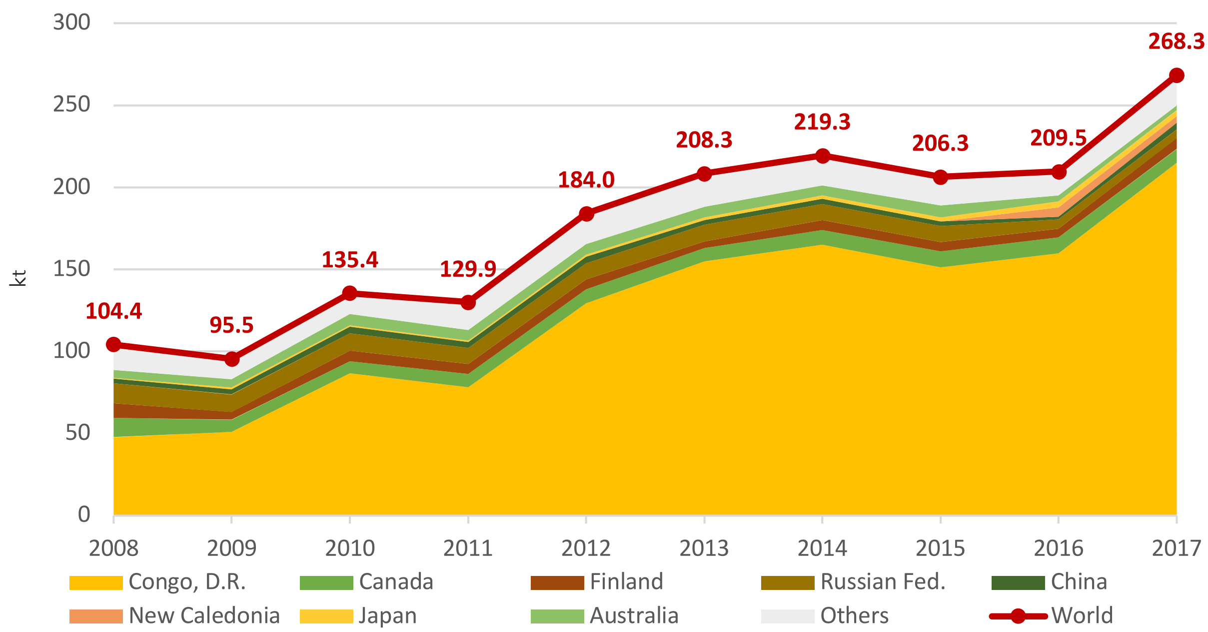
458. According to Cobalt Institute estimates, cobalt consumption in 2017 amounted to 123,000 tonnes, having exceeded the 2008 index by more than two times. As mentioned above (section 4.C), the main reason for this was its use in lithium-ion batteries, whose production is rapidly expanding. Systemic data on cobalt use in specific countries is not available. It is difficult to estimate the apparent consumption of cobalt (calculated by the formula "production + import – export") due to the variability of cobalt content in products grouped into commodity groups with refined products. However, even rough estimates suggest that the main consumer of refined cobalt is China.

459. On the world market, refined cobalt products are traded in the form of metal and chemical compounds. In so doing, international trade statistics take these into account together with intermediate products.

[152] Ibid.

[153] USGS (2019). Cobalt (advance release). *2016 Minerals Yearbook*. https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2016-cobal.pdf.

Figure 4.91. World metal cobalt export dynamics in 2008–2017



Source: ITC.

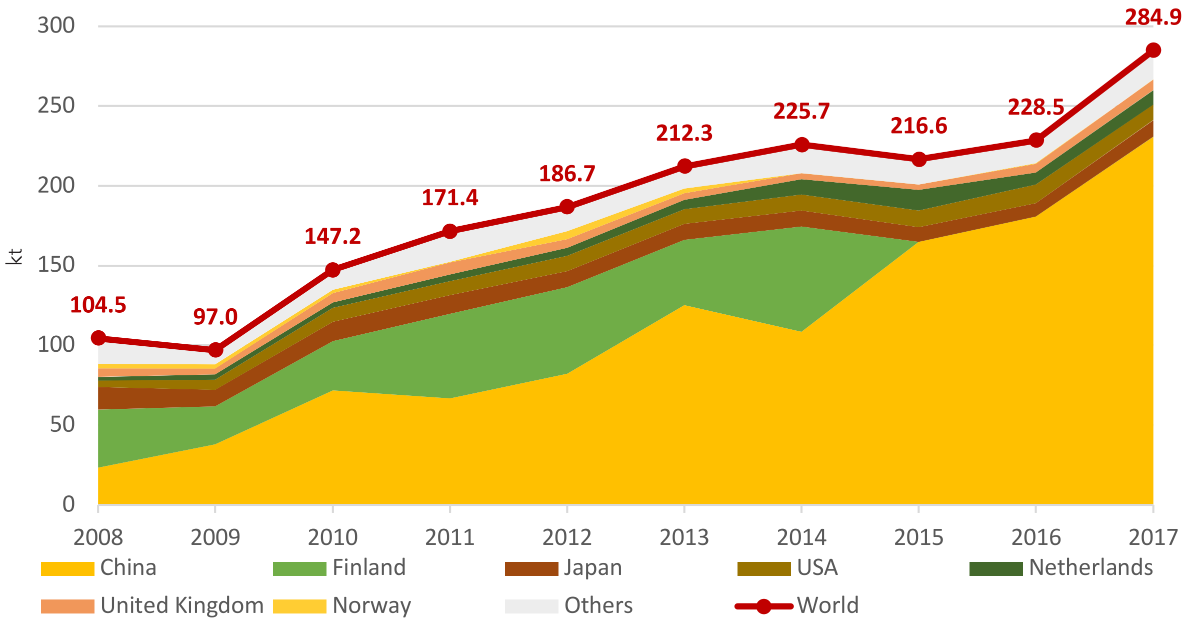
460. International trade statistics take into account refined metal cobalt (unwrought and powders) together with cobalt mattes and other intermediate products of cobalt metallurgy. We will further consider these under the unifying name "metal cobalt". Metal cobalt is a key product in the cobalt market. According to estimates based on international trade data, in 2017 it accounted for more than 51 per cent of world trade in cobalt products in terms of weight and about 65 in economic terms.

461. In 2008–2017, metal cobalt (HS code 810520) exports increased by 2.6 times (+164,000 tonnes). This was provided by DR Congo, which during this period increased its supplies to the world market by 4.5 times (+167,000 tonnes). Exports from New Caledonia (+4,000 tonnes), Japan (+3,000 tonnes) and China (+1,300 tonnes) also increased, with New Caledonia having become one of the exporters of metal cobalt only in 2016. The other top eight exporters reduced their supplies (by more than 14,000 tonnes in total) (Figure 4.91).

462. Since 2007, DR Congo has been the largest metal cobalt exporter. At the same time, almost all exported metal is represented by intermediate products of cobalt metallurgy. This is indicated by the level of refined cobalt production, which, according to BGS, in 2017 only amounted to 200 tonnes. This is also indicated by the export tariff of the product. According to the International Trade Center, in 2017 it was about USD9,000 per tonne, while the export tariff of the product of Canadian origin was about USD51,000 per tonne.

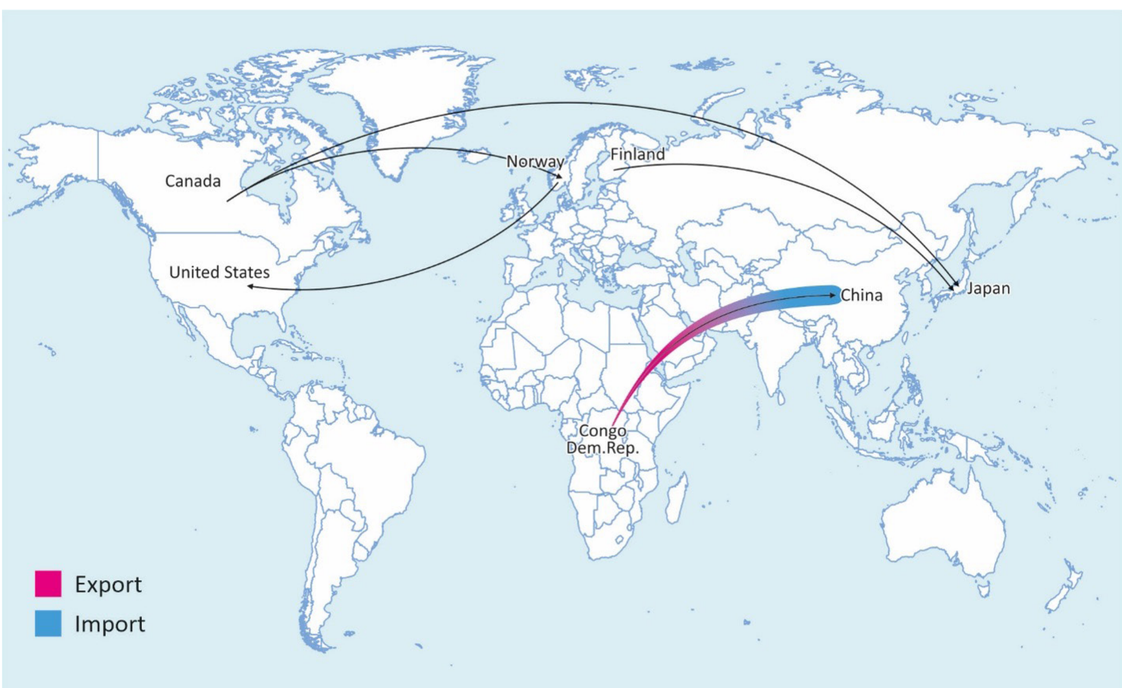
463. A comparison of statistics on the production of refined cobalt and international trade in metal cobalt indicates that the export structure of a number of other major supplier countries, such as Canada, Russia, and New Caledonia, includes intermediate products in various proportions. The main export destination of metal cobalt is China. In 2008–2017, its imports of metal cobalt increased by almost ten times (Figures 4.92, 4.93).

Figure 4.92. World metal cobalt import dynamics in 2008–2017



Source: ITC.

Figure 4.93. Major international trade flows of metal cobalt in 2017



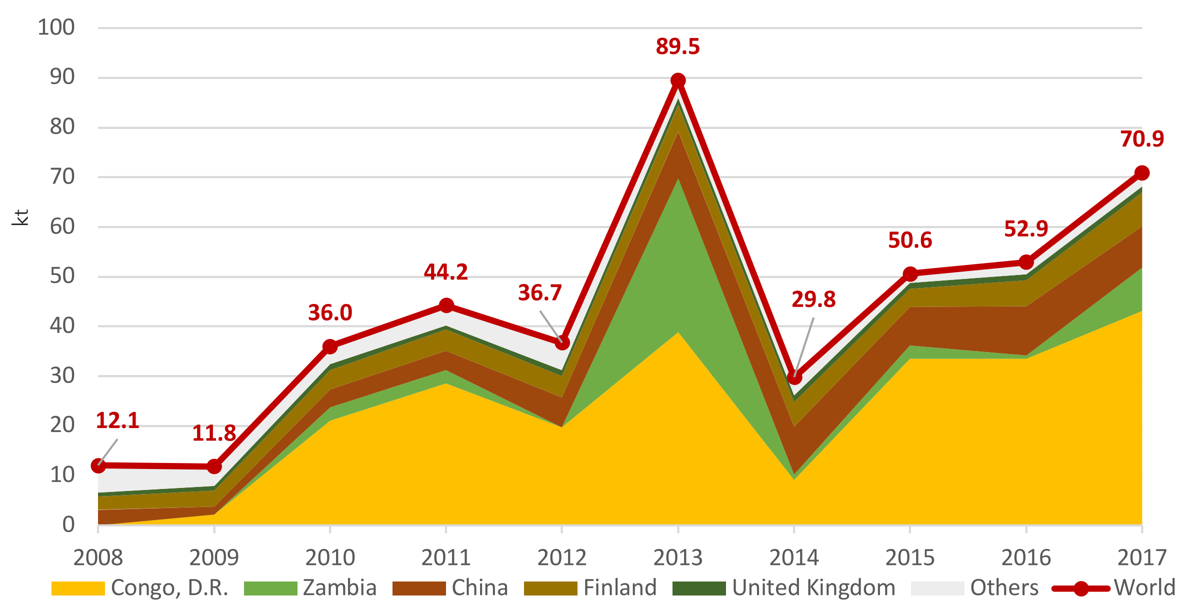
Source: https://resourcetrade.earth/.

464. Cobalt is traded on the world market also in the form of oxides and hydroxides (HS code 2822), which can be both refined and intermediate products of cobalt. Their belonging to a certain group can be evaluated by export tariff. According to estimates based on international trade data, in 2017 they accounted for about 13.5 per cent of world trade in cobalt products in weight terms and about 24 per cent in money terms.

465. In 2008–2017, exports of cobalt oxides and hydroxides increased by almost six times, or by 59,000 tonnes (Figure 4.94). The main reason for this was the beginning of the export of cobalt in this form from DR Congo in 2009, which in 2017 exceeded 43,000 tonnes. At the same time, Zambia began exporting cobalt in the form of oxides and hydroxides, and in 2017 this exceeded 8,500 tonnes. Exports of cobalt oxides and hydroxides peaked in 2013 due to their sharp surge from Zambia. Both countries supply the market with intermediate products, as crude oxides. This is indicated by their export tariffs. In 2017, they were at the level of USD17,000 per tonne, while export tariffs of the product supplied to the world market from China or Great Britain were USD37–38,000 per tonne.

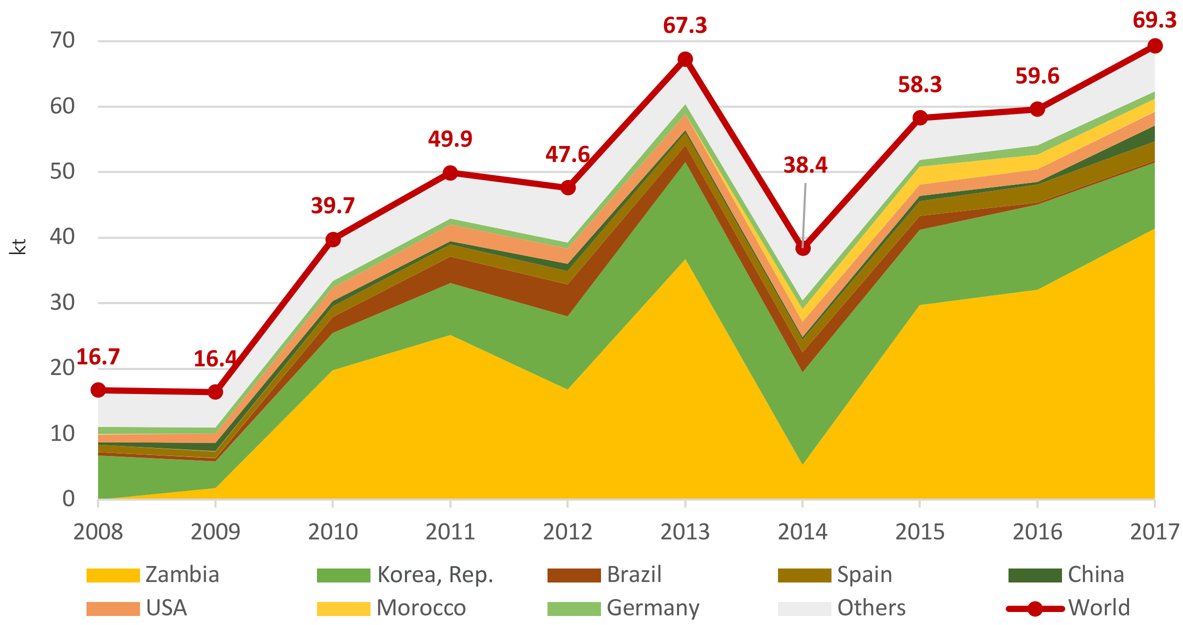
466. The main recipient of cobalt oxides and hydroxides produced in DR Congo is Zambia, where some of them are apparently being refined (Figure 4.95). The Republic of Korea is also a major recipient, and in 2017 China, Belgium, and Finland were its main suppliers. Judging by the level of export tariffs, these countries supply the Republic of Korea with refined products.

Figure 4.94. World metal cobalt import dynamics in 2008–2017



Source: ITC.

Figure 4.95. World metal cobalt import dynamics in 2008–2017



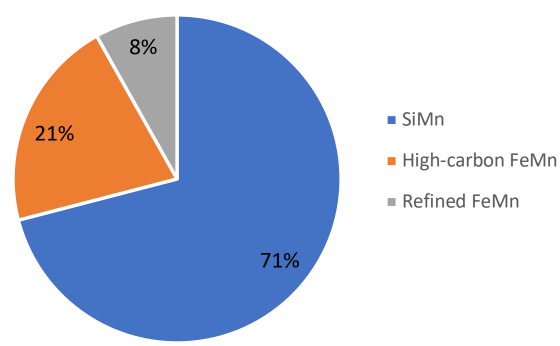
Source: ITC.

Manganese

467. End manganese products include manganese ferro-alloys, manganese metal, manganese dioxide, and other manganese chemicals. The main ones are manganese ferro-alloys, which are an integral component of all steel types (including special). They account for about 90 per cent of manganese products produced in 2017 in terms of weight. At the same time, silico-manganese prevails in the structure of manganese ferro-alloy production (Figure 4.96).[154]

468. According to the available data, in 2008–2017, the world production of silico-manganese increased by 54 per cent, or by 4.8 Mt (Figure 4.97). This increase was mainly provided by China (+3.4 Mt, or 68 per cent), which has been the largest producer of this alloy since the mid-1990s. India, the second largest producer in the world since 2009, also showed significant growth (+1.1 Mt, or 2.3 times). In 2017, the two countries accounted for 62 and 14 per cent of the world total production respectively, and in 2008, they accounted for about 57 and 10 per cent respectively.

Figure 4.96. Distribution of manganese ferro-alloy production by type in 2017

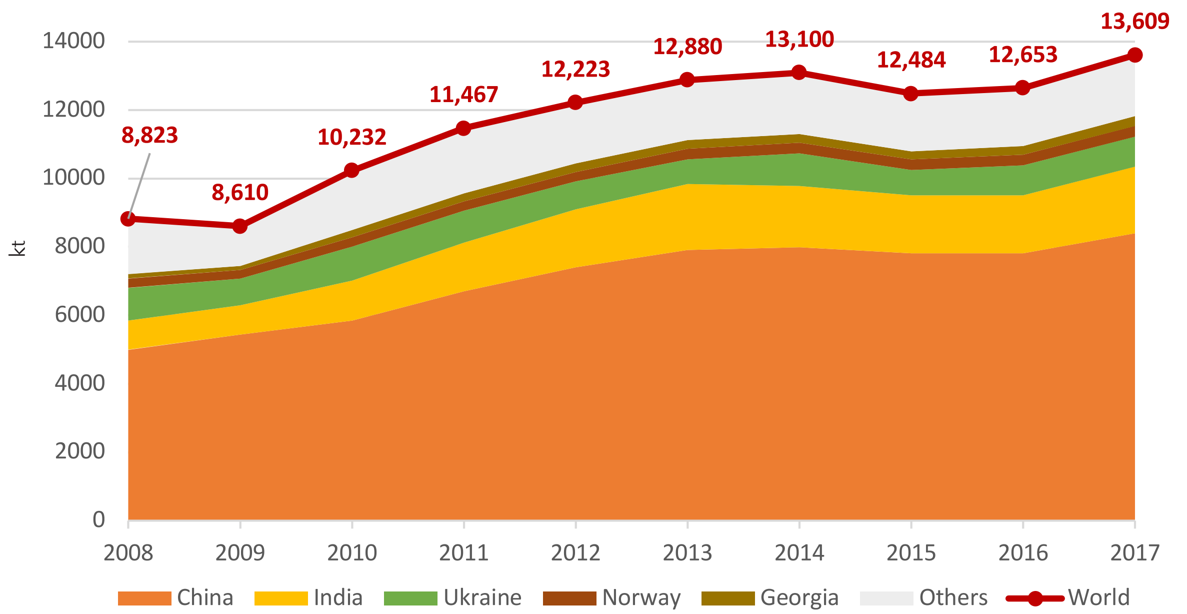


Source: IMnI.

469. Since 2009, almost all silico-manganese produced in China has been consumed domestically (until 2009, significant volumes of alloy were exported to foreign markets, and China was one of the largest suppliers). Such a high demand for this alloy is ensured by the scale of the

[154] IMnI (2019). *Statistics 2019*. https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

Figure 4.97. World silico-manganese production dynamics in 2008–2017 by major producing and other countries



Sources: BGS, USGS, IMnI.

Chinese steel industry, which is currently the largest in the world.

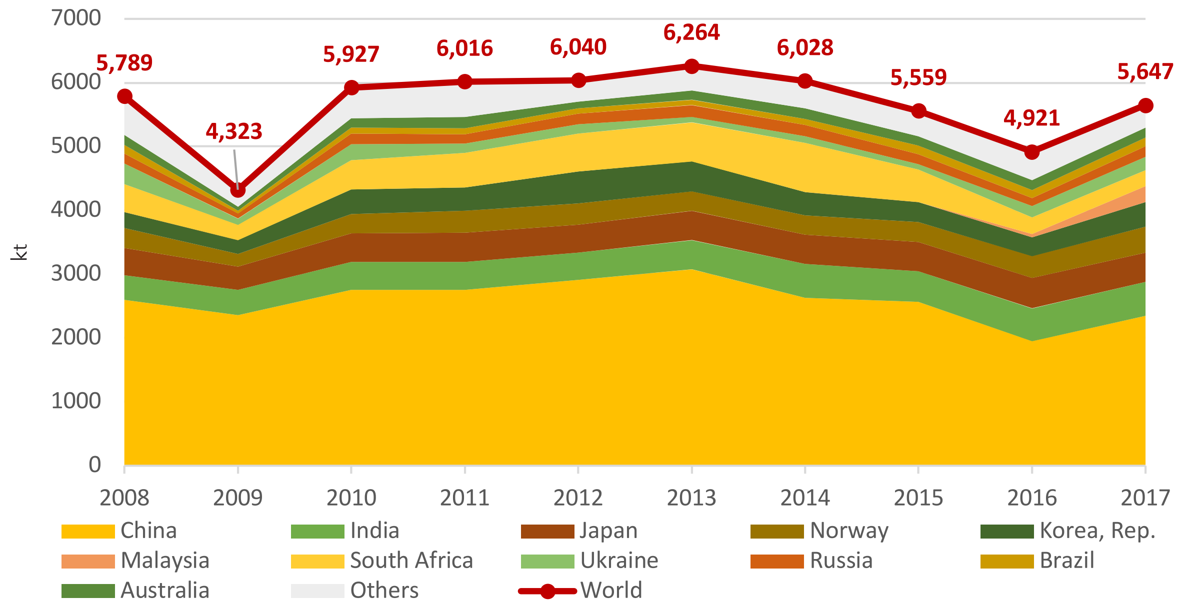
470. Silico-manganese produced in India and Ukraine (which ranks third in the world ranking), is exported in significant quantities. Although the two countries have a strong steel industry, the volume of silico-manganese produced by them is significantly higher than domestic demand and the excess material is supplied to foreign markets. However, it can be expected that when steelmaking expands, their supply may decrease.

471. The relatively large producers of silico-manganese also include Norway and Georgia, whose production is export-oriented.

472. No statistics are available to trace the production of high-carbon and refined ferro-manganese separately, with a country-by-country breakdown for the entire time period under review. Therefore, in this section we consider the production and international trade of ferro-manganese as a whole. In addition, for a number of countries, total production of ferro-alloys is reported without differentiation into specific types; for example, for the US, production of bulk ferro-alloys is reported, which includes chrome and silicon alloys in addition to manganese ferro-alloys. Therefore, the available statistics cannot be considered complete.

473. On the basis of available statistics, ferro-manganese world production in 2008–2017 showed generally unsustainable dynamics, while at the end of the decade it declined slightly (Figure 4.98). However, the dynamics of production of different types of ferro-manganese was differently directed. According to IMnI, production of high-carbon ferro-manganese decreased by 6 per cent, while production of refined ferro-manganese increased by 7 per

Figure 4.98. World ferro-manganese production dynamics, including high-carbon and refined, in 2008–2017 by major producing and other countries



Sources: BGS, USGS, IMnI.

cent.[155,156] At the same time, in 2010–2014, ferro-manganese output was noticeably (5–10 per cent) higher than in 2017. This spike occurred during the period of steel production growth that followed the decline caused by the global financial and economic crisis of 2008–2009.

474. The main ferro-manganese producer is China, which accounted for about 42 per cent of world production in 2017. As the world's largest steel producer, it is also a leading ferro-manganese customer. In 10 years, its share of global alloy production has remained virtually unchanged, although production volumes have declined slightly. This decline, which was also caused by government environmental measures, did not affect the availability of alloy for Chinese industry, as it was fully compensated by an increase in silico-manganese production (Figure 4.97).

475. As shown in Figure 4.99, China is currently the main production centre for manganese ferro-alloys: it accounts for 55 per cent of world production. It is also the main steel-making center, with a share in the world index in 2017 of 50 per cent.[157] At the same time, it can be said that the current production volumes of manganese ferro-alloys and steel practically match each other. This is indicated by small volumes of imports of manganese ferro-alloys to China (at the level of several tens of thousands of tonnes with the total production of manganese ferro-alloys at the level of 10 Mt). There is practically no Chinese product entering foreign markets.

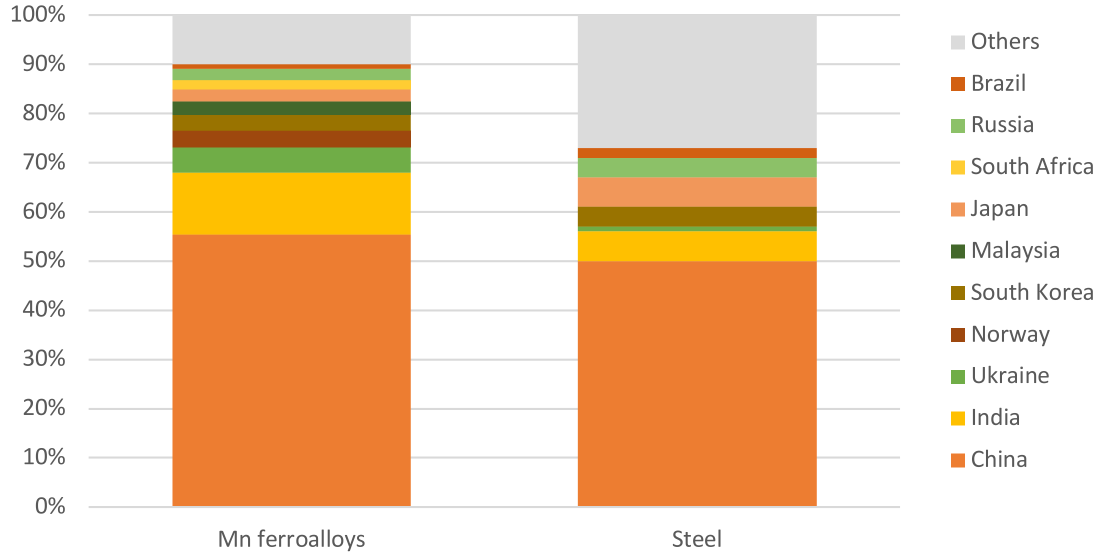
476. Among the producers of manganese ferro-alloys, there are other countries whose ferro-alloy production is oriented to the domestic steel industry. Among them are Japan, South Korea, Russia, and several others. At the same time, ferro-

155 IMnI (2016). *2013 Public Annual Market Research Report*. https://www.manganese.org/files/publications/PUBLIC%20RESEARCH%20REPORTS/2013_IMnI_Public_Report.pdf.

156 IMnI (2019). *Statistics 2019*. https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

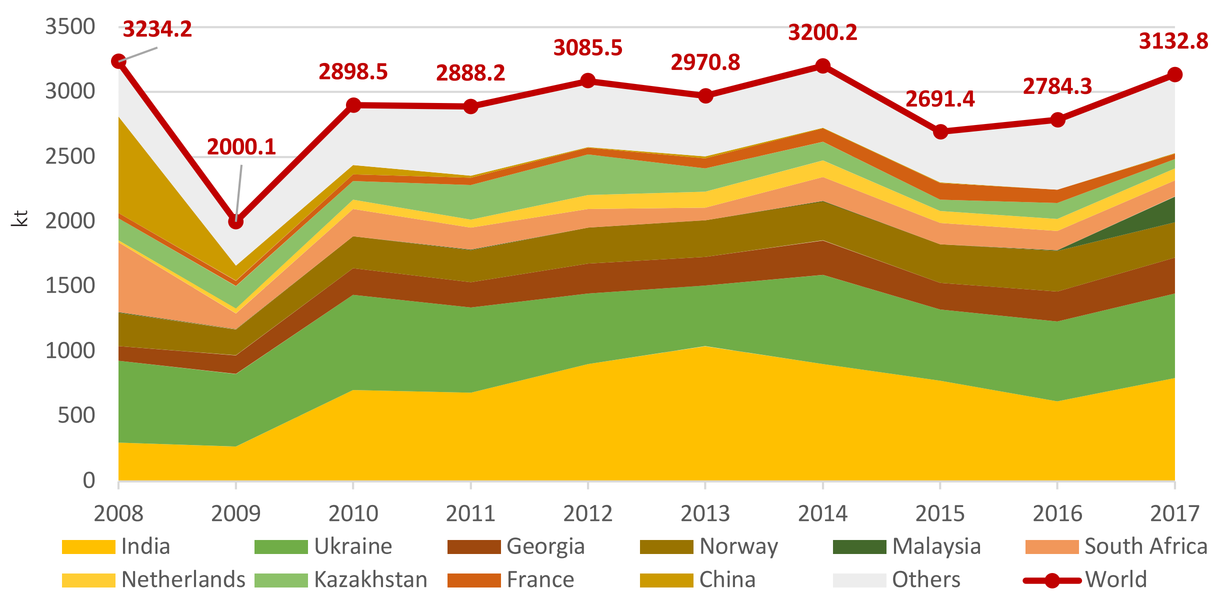
157 World Steel Association (2019). *Steel Statistical Yearbook 2019: Concise Version*. https://www.worldsteel.org/en/dam/jcr:7aa2a95d-448d-4c56-b62b-b2457f067cd9/SSY19%2520concise%2520version.pdf.

Figure 4.99. Distribution of manganese ferro-alloys and steel production among major countries in 2017



Sources: IMnI, World Steel Association.

Figure 4.100. World silico-manganese export dynamics in 2008–2017



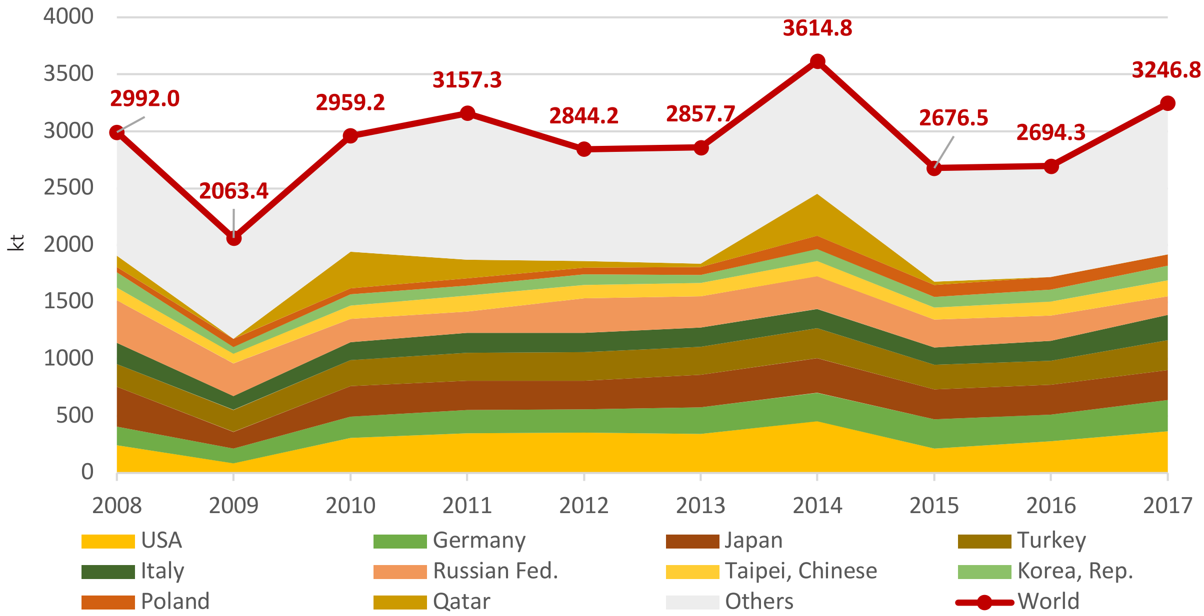
Source: ITC.

alloy production in countries such as India, Ukraine, and Norway, and a number of others, is largely oriented towards foreign markets. In total, about a quarter of manganese ferro-alloys currently produced are involved in international trade.

477. As for silico-manganese (HS code 720230), Chatham House, the Royal Institute of International Affairs[158] estimates that in 2017, it accounted for 8.4 per cent of world trade in manganese products by weight and 26 per cent in economic terms. Its largest exporters are India and

[158] Chatham House, the Royal Institute of International Affairs.

Figure 4.101. World silico-manganese import dynamics in 2008–2017



Source: ITC.

Ukraine, whose combined share in 2017 was about 46 per cent (Figure 4.100), as well as Georgia, Norway, Malaysia, and South Africa, which together supply about 29 per cent more. Their main destinations are the USA, Germany, Japan, Turkey, Italy, and Russia (Figure 4.101).

478. As for ferro-manganese, Chatham House, the Royal Institute of International Affairs[159] estimates that in 2017 it accounted for 5.3 per cent of world trade in manganese products in terms of weight terms and 20.6 per cent in economic terms, including the share of high-carbon ferro-manganese (HS code 720211) at 3.5 and 12 per cent respectively, and the share of high-carbon ferro-manganese (HS code 720219) at 1.8 and 8.6 per cent respectively.

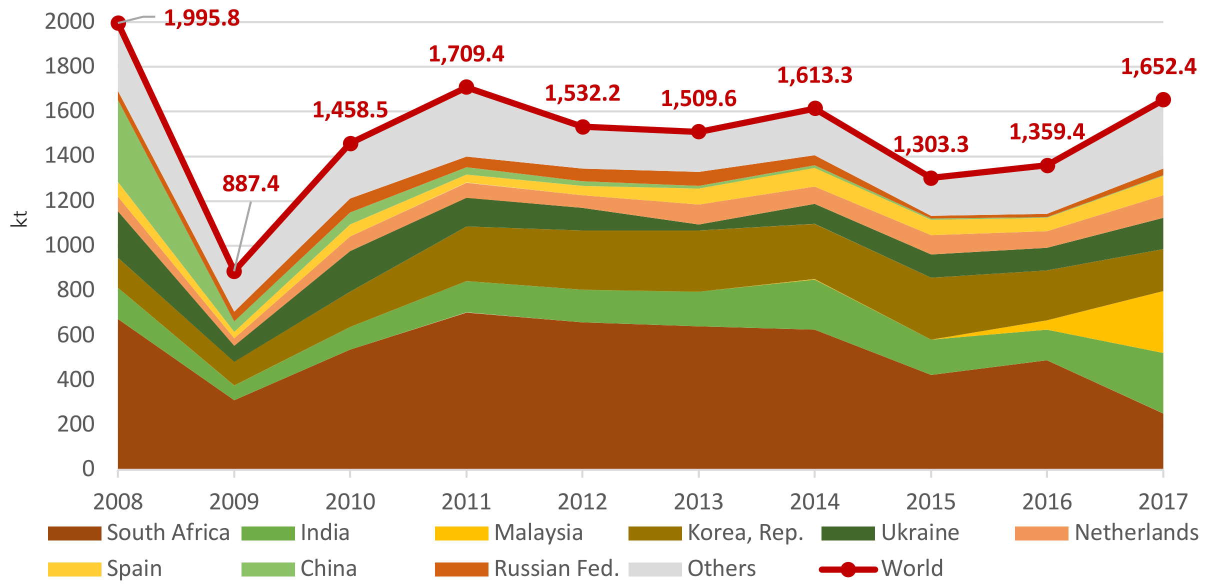
479. In 2008–2017, the geographical structure of ferro-manganese exports underwent significant changes. While in 2008 the main supplier of alloy was South Africa, which accounted for about 34 per cent of world exports (about 674,000 tonnes) and China (over 18 per cent, or about 366,000 tonnes), in 10 years the share of South Africa decreased to about 15 per cent (about 252,000 tonnes), and China practically stopped exporting. At the same time, India and Malaysia have become major suppliers, each with a share of 16–17 per cent (Figure 4.102). Export destinations are very diverse (Figure 4.103).

480. As mentioned above, end manganese products also include manganese metal. According to IMnI, in 2011–2016, its production was relatively stable at 1.2 Mt per year. In 2017, its output rose sharply (by 37 per cent) to 1.74 Mt. Almost all metal is produced in China, which accounts for about 98 per cent of the world total. The rest of the metal is produced in South Africa, Ukraine, Gabon, and Indonesia (since early 2019).[160]

159 Ibid.

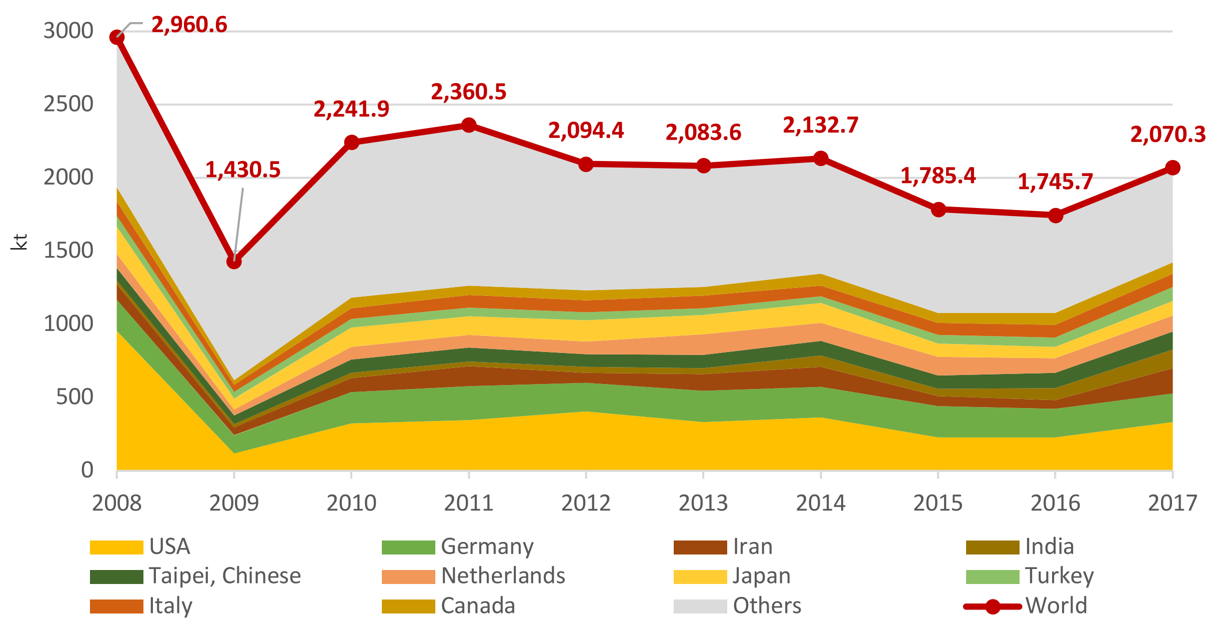
160 IMnI (2019). *Statistics 2019*. https://www.manganese.org/wp-content/uploads/2019/05/IMnI_statistics_2019.pdf.

Figure 4.102. World ferro-manganese export dynamics in 2008–2017



Source: ITC.

Figure 4.103. World ferro-manganese import dynamics in 2008–2017



Source: ITC.

4. Study data and methodology

A. Types of methods of analysis

481. The purpose of current study is to make preliminary assessment of the potential magnitude of any impact on DLBPS, who may suffer serious adverse effects on their export earnings or economies as a result of a reduction in price or reduction in the volume of an affected metal, and where such reductions could be caused by activities in the Area.

482. As it is hard to analyze changes in the economies of developing States before exploitation activities in the Area start, it is possible only to make a preliminary assessment of what impact on the developing States' economies may be. For this purpose, it was decided to analyze exports of affected metals in the world.

483. Firstly, data on quantity and value of exports of affected metals' products in the world for the last 10 years (2008–2017) were collected from an online source called Trade Map.[161] The exporting States were ranked by the value or the quantity of products exported in 2017, so that leading exporter States could be identified. The total value and quantity of exports of affected metals were found by summing up exports of each product.

484. For identification of developing States which are likely to be most seriously affected by seabed production, in this study, two quantifiable yardsticks suggested by Special Commission 1 were considered.[162] Firstly, concerning the export earnings of a developing State, an absolute value of export earnings from four affected metals in total export earnings of the DLBPS was found as follows:

$$S_e = \sum E_i / E_t$$

Where S_e is the absolute value of export earnings from the four affected metals in total export earnings of the DLBPS,

E_i is the annual exported value of product i of each affected metal exported from the DLBPS, and

E_t is the annual exported value of all products exported from the DLBPS.

485. Second, concerning the economies of the DLBPS, another yardstick was used: value of export earnings from the four metals in the economy of the DLBPS (here the economy of the State is expressed by GDP), using the following formula:

[161] Trade statistics for international business development – Trade Map. https://www.trademap.org/Index.aspx.

[162] ISA (1985). Statement of the Chairman of Special Commission 1, provisionally concluding the discussion on the issue of the concrete formulation of the criteria for the identification of developing land-based producer States likely to be most seriously affected by sea-bed production. Preparatory Commission for the International Seabed Authority and for the International Tribunal on the Law of the Sea, Special Commission 1. LOS/PCN/SCN.1/1985/CRP.8.

$$S_{GDP} = \sum E_i / GDP$$

Where S_{GDP} is the value of export earnings from the four metals in the economy of the DLBPS,

E_i is the annual exported value of product i of each affected metal exported from the DLBPS, and

GDP is the GDP of each exporting DLBPS.

486. Data for GDP were taken from the data center of the United Nations Conference on Trade and Development (UNCTAD), called UNCTADstat.[163]

487. Thus, the DLBPS which are likely to be seriously affected by exploitation activities in the Area were identified for each of four affected metals using two yardsticks. Herewith, the export earnings yardstick was considered basic, whereas the economy yardstick was used for checking and reinforcing results.

488. Then, a cumulative value of export earnings from all affected metals in total export earnings and in the GDP of each exporting DLBPS was calculated as follows:

$$S_{ce} = \sum E_m / E_t$$

Where S_{ce} is the value of cumulative export earnings from all affected metals in total export earnings of the DLBPS,

E_m is the annual exported value of affected metal m exported from the DLBPS, and

E_t is the annual exported value of all products exported from the DLBPS.

$$S_{cGDP} = \sum E_m / GDP$$

Where S_{cGDP} is the value of cumulative export earnings from all affected metals in the GDP of each exporting DLBPS,

E_m is the annual exported value of affected metal m exported from the DLBPS,

GDP is the GDP of each exporting DLBPS.

489. When the DLBPS which are likely to be seriously affected are identified, it makes sense to focus further analysis only on these States.

490. Export earnings of the State from affected metals are directly related to the price of these metals on the world market. That is why year-to-year changes in prices of affected metals from 2008 to 2017 were calculated as follows:

$$C_p = (p_n - p_{n-1}) / p_{n-1} \ x\ 100\%$$

Where C_p is a year-to-year change of price,

p_n is the price in year n, and

p_{n-1} is the price in the previous year n-1.

[163] UNCTAD. UNCTADstat. https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en.

491. Source for copper and nickel nominal price data is the World Bank.[164] Price data for manganese were taken from the Financial Model of a Nodules Mining Concession by MIT.[165] Real 2015 price for manganese metal was used. Several sources were used for cobalt nominal prices:

- From 2008 to 2010: from the report by U.S. Geological Survey[166] "Metal prices in the United States through 2010".
- From 2011 to 2013 and from 2014 to 2015: from the U.S. Geological Survey Minerals Yearbook.[167,168]
- From 2016 to 2018: from Macquarie Wealth Management Research.[169]

492. Further analysis requires a comparison of changes in metal prices with changes in export prices (or export tariffs) of each affected metal product per unit. Export price per unit of product was calculated by dividing the exported value of the product to its exported quantity. In addition, these changes in export prices of products for each DLBPS which is likely to be affected were compared with changes in the average export prices of these products in the world market.

493. Export prices for various products of one metal can be different. To look at the added value of different products, exported quantities and exported values of the products were compared.

494. Besides, a share of exports of developing States on the world market and a concentration of the metal market were analyzed using an annually computed Herfindahl-Hirschman Index (HHI). Market share of each State for each product of four affected metals and for the sum of these products for each of four metals was found as follows:

$$S_i = E_i / E_w \; x \; 100\%$$

Where S_i is the market share of the State i,

E_i is the exported value of the metal product exported from the State i, and

E_w is the exported value of the metal product in the world.

495. The market concentration can be found using the following formula:

$$C_m = \overline{\sum} \, (S_i)^2$$

Where C_m is the market concentration, and

S_i is the market share of the State i.

496. HHI ranges between 0 and 10,000 points and indicates the following:

[164] World Bank Commodity Price Data - The Pink Sheet. https://www.worldbank.org/en/research/commodity-markets#1.

[165] R. Kirchain et al. (2019). *Financial Model of a Nodules Mining Concession*. Massachusetts Institute of Technology.

[166] U.S. Geological Survey (2013). *Metal prices in the United States through 2010: U.S. Geological Survey Scientific Investigations Report 2012–5188*. http://pubs.usgs.gov/sir/2012/5188.

[167] U.S. Geological Survey (2013). *Metals and Minerals: U.S. Geological Survey Minerals Yearbook 2013*. https://pubs.er.usgs.gov/publication/70048194.

[168] U.S. Geological Survey (2016). *Advance Data Release of the 2016 Annual Tables, Metals and Minerals: U.S. Geological Survey Minerals Yearbook 2016*. https://www.usgs.gov/centers/nmic/cobalt-statistics-and-information.

[169] Macquarie Wealth Management Research (2018). *Commodities Comment*. https://www.macquarie.com.au/dafiles/Internet/mgl/au/apps/retail-newsletter/docs/2018-01/MacquarieCommoditiesComment240118e.pdf.

- HHI less than 1500 shows low-market concentrations and a competitive market.
- HHI from 1500 to 2500 shows moderately-market concentrations.
- HHI higher than 2500 shows high-market concentrations.

B. Presentation of the approach and assumptions adopted for the potential impact analysis

497. Metals are traded globally in a variety of forms including ores and concentrates, mattes and intermediates, and refined products. The refined products are tailored to end-use market requirements and are traded as oxide, hydroxide, powder, metal, sulphate, chloride, nitrate, acetate, carbonate, and numerous other compounds of varying metal content. Trade statistics do not provide data for all the different metal products, so it is complicated to obtain a world total for refined metal production. Several forms of metals are commonly grouped under a single trade code.[170]

498. In this analysis, trade data following the Harmonized System of trade codes were used. In addition, ISA decided to emphasize different forms of metals, such as primary, semi-finished, and end products. Thus, four copper products were considered:

- *Copper ores and concentrates* (HS 2603), which are primary products of copper production
- *Copper mattes, cement copper (precipitated copper)* (HS 7401), which are semi-finished products of copper production
- *Copper, unrefined, copper anodes for electrolytic refining* (HS 7402), which are also semi-finished products of copper production
- *Copper, refined, unwrought, cathodes and sections of cathodes* (HS 740311), which are end products of copper production.

499. Four products of nickel production were considered:

- *Nickel ores and concentrates* (HS 2604), which are primary products of nickel production
- *Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy* (HS 7501), which are semi-finished products of nickel production
- *Ferro-alloys, ferro-nickel* (HS 720260), which are end products of nickel production
- *Nickel, unwrought, not alloyed* (HS 750210), which are also end products of nickel production.

500. As for cobalt, three products were considered:

- *Cobalt ores and concentrates* (HS 2605), which are primary products of cobalt production
- *Cobalt mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, cobalt powders* (HS 810520), which are end products of cobalt production.
- *Cobalt oxides and hydroxides, commercial cobalt oxides* (HS 2822), which are end products of cobalt production

501. Manganese has no semi-finished products, but there are many end products which were considered:

[170] Petavratzi, E, Gunn, G, Kresse, C. (2019). *Commodity review: Cobalt*. British Geological Survey.

- *Manganese ores and concentrates, including ferruginous manganese ores and concentrates with a manganese content of 20 per cent or more, calculated on the dry weight* (HS 2602), which are primary products of manganese production

- *Manganese oxides* (HS 2820), which are end products of manganese production

- *Ferro-alloys, ferro-manganese, containing by weight more than 2 per cent of carbon* (HS 720211), which are end products of manganese production

- *Ferro-alloys, ferro-manganese, containing by weight 2 per cent or less of carbon* (HS 720219), which are end products of manganese production,

- *Ferro-alloys, ferro-silico-manganese* (HS 720230), which are end products of manganese production

- *Manganese, articles thereof, including waste and scrap* (HS 811100), which are end products of manganese production.

502. However, it is worth noting that usage of Harmonized System gives only an approximate idea of products' flows. The many different forms that metals are refined into complicate obtaining a world total for refined metals production. Metals are moved around the world in "intermediate" forms that are subsequently further refined, and consequently the risk of double-counting is considerable. A product that is considered by one country as an end product may simply be a semi-finished product in another. A product reported as "oxides and hydroxides" for reported as "oxides and hydroxides" for one country is not necessarily the same product that another country exports. The product produced in one country may be of an impure form, which is further refined elsewhere outside the exporting country.[171]

503. No adjustments have been made for metal content in this analysis. Instead, the gross weight of the different traded forms is compared and discussed. Metal content can vary significantly for different traded forms. Adjusting for metal content is not straightforward, especially for the mattes and intermediates, unwrought metal, waste, and scrap, which includes several different metal-bearing materials with metal contents ranging from 20 to 100 per cent.[172]

504. The Harmonized System trade code for mattes and intermediates, unwrought metal, waste, and scrap does not differentiate between metal compounds. As a result, it is not possible to undertake an analysis of specific traded metal compounds from individual countries. Exports for the different countries may represent different compounds and consequently different stages in the metal supply chain.[173]

505. Normally, only formal and legal operations are included in trade statistics. There is, therefore, an element of uncertainty about the trade of metal ores and concentrates produced by informal operations, for example, artisanal cobalt mines. Various sources suggest that cobalt ore produced from informal mining operations is sold to wholesale traders and cooperatives, who, in turn, sell on to

[171] Petavratzi, E., Gunn, G., and Kresse, C. (2019). *Commodity review: Cobalt*. British Geological Survey.
[172] Ibid.
[173] Ibid.

processing companies for the production of cobalt concentrates.[174,175,176] It is likely, therefore, that the majority of the output from informal mining is captured by international trade statistics as the export from these processing companies is recorded. However, some quantities may enter illegal trade routes and be excluded from global trade data. At present, it is not possible to quantify informal trade in cobalt compounds.[177]

506. The issue of identification of the DLBPS which are likely to be most seriously affected by seabed production is important for ISA. However, before the start of commercial production in the Area, it is not possible to make the final identification of such States. It can be carried out by ISA at a time closer to the time of the earliest commercial production from the seabed in the Area. Nevertheless, some kind of preliminary identification can be done at present, and it is presented in the current analysis.

507. Before the actual identification of the DLBPS which are likely to be most seriously affected by seabed production, the Preparatory Commission should first decide on the criteria for identification. In conformity with the provisions of Articles 150 (h) and 151 (10) of UNCLOS,[178] Special Commission 1 decided that such criteria would be related to export earnings or economies of DLBPS. The idea was to see how dependent a DLBPS is on four affected metals for its export earnings or its economy. Concerning the criteria of export earnings and economy, several quantifiable yardsticks, called dependency thresholds, were suggested by Special Commission 1:

- An absolute value of exports of the four metals. If a DLBPS has export earnings of USD100 million a year from these four minerals during the last 5 years before production authorizations are issued to the seabed miners, it is likely to be most seriously affected by seabed production.
- An absolute value of export earnings in total export earnings. If a DLBPS is earning 10 per cent of its total export earnings from these four minerals during the last 5 years before production authorizations are issued to the seabed miners, it is likely to be most seriously affected by seabed production.
- An absolute amount of production of four affected minerals. If a DLBPS produces an average 100,000 tonnes of copper, or 50,000 tonnes of nickel, or 10,000 tonnes of cobalt, or 50,000 tonnes of manganese a year during the last 5 years before production authorizations are issued to the seabed miners, it is likely to be most seriously affected by seabed production.
- Value of production in total GNP or total GDP. A DLBPS whose average production of the four minerals per year during the last 5 years before production authorizations are issued to the seabed miners represent 10 per cent of its GDP on GNP, is likely to be most seriously affected by seabed production.

174 Amnesty International (2016). *This is what we Die For: Human Rights Abuses in the Democratic Republic of the Congo-Power the Global Trade in Cobalt*. https://www.amnestyusa.org/files/this_what_we_die_for_-_report.pdf.

175 Al Barazi, S. (2018). *Rohstoffrisikobewertung – Kobalt, DERA Rohstoffinformationen 36, Berlin, 120 S.* https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-36.pdf.

176 Faber, B., Krause, B., and Sánchez de la Sierra, R. (2017). *Artisanal Mining, Livelihoods, and Child Labor in the Cobalt Supply Chain of the Democratic Republic of Congo*. Center for Effective Global Action, University of California Policy Report 62. https://escholarship.org/content/qt17m9g4wm/qt17m9g4wm.pdf.

177 Petavratzi, E., Gunn, G., and Kresse, C. (2019). *Commodity review: Cobalt*. British Geological Survey.

178 UNCLOS. United Nations, New York, USA.

- Value of export earnings from the four minerals in the economy. If a DLBPS's exports of the four minerals account for 5 per cent or more of its GDP, it is likely to be most seriously affected by seabed production.[179]

508. However, the identification of DLBPS under these yardsticks is solely to study their potential problems and cannot at this time be considered as an automatic basis for future formulation of remedial measures about their specific problems. Besides, these yardsticks do not address the issue of whether or not or how much the effects are attributable to seabed mining.[180]

509. Besides the above mentioned yardsticks, Special Commission 1 has suggested that ISA could use other dependency thresholds ("dependency levels", as these were called in Chapter 2) to determine the importance to a DLBPS of, or its dependence on, the four affected metals for its export earnings or its economy. Concerning these dependency thresholds, ISA should be guided by the following:

- During the relevant period when applications by DLBPS are submitted, either before the commencement of commercial production from the Area or after, those DLBPS which earn 10 per cent or more of their total export earnings per year from the export of one or more of the four affected metals shall be categorized as "dependent".
- In the cases when DLBPS can demonstrate that they actually encounter or that they are likely to encounter special problems resulting from seabed production, although either their export earnings from the export of one or more of the four affected metals may not account for the specified percentage of their total export earnings, as above, ISA shall determine, on a case-to-case basis, whether they can be categorized as "dependent" or not.
- An average shall be used over three years before the year of application by that DLBPS.[181]

510. Thus, according to the suggestions of Special Commission 1, if a DLBPS considers itself affected by seabed production, it can apply to ISA. It should show its statistics on production, the volume of exports, export earnings from one or more of the four minerals concerned, the changes in the economy that it feels occurred because of seabed production, indicating how it considers that these effects have been as a result of seabed production, and, finally, what kind of remedial it requires.[182]

511. Having received the application by the DLBPS, ISA firstly shall determine whether production, the volume of exports, or export earnings from one or more of the four minerals concerned exceed the abovementioned dependency thresholds. If the dependency thresholds are exceeded, then ISA shall determine whether the effects that are considered to have resulted from seabed production exceed any of the levels specified below (so-called trigger thresholds, or "trigger levels" as was said in Chapter 2):

[179] ISA (1985). Statement of the Chairman of Special Commission 1, provisionally concluding the discussion on the issue of the concrete formulation of the criteria for the identification of developing land-based producer States likely to be most seriously affected by sea-bed production. Preparatory Commission for the International Seabed Authority and for the International Tribunal on the Law of the Sea, Special Commission 1. LOS/PCN/SCN.1/1985/CRP.8.
[180] Ibid.
[181] ISA (1992). Draft provisional report of Special Commission 1. Preparatory Commission for the International Seabed Authority and for the International Tribunal on the Law of the Sea, Special Commission 1. LOS/PCN/SCN.1/1992/CRP.22.
[182] Ibid.

- The actual or estimated fall in the export earnings of a particular DLBPS from the export of one or more of the four metals concerned has to be at least 10 per cent in comparison with the situation where there is no seabed production.

- If the actual or estimated fall in export earnings of a particular DLBPS from the export of one or more of the four metals concerned is less than 10 per cent, but more than 5 per cent in comparison with the situation where there is no seabed production, ISA shall determine the necessary remedial measures to help that DLBPS.

- If the actual or estimated fall in export earnings of a particular DLBPS from the export of one or more of the four metals concerned is less than 10 per cent in comparison with the situation where there is no seabed production, but amounts to 2 per cent of the total export earnings, ISA shall determine whether an action would be triggered.[183]

512. As for the last two trigger thresholds, ISA shall determine, on a case-to-case basis, taking into account all relevant factors, bearing in mind considerations of cost-effectiveness and its work efficiency, whether an in-depth investigation needs to be carried out.

513. In the cases of the "least developed" land-based producer States, the dependency thresholds and the trigger thresholds shall be reduced by 33 per cent.[184]

514. However, it is hard to determine a quantifiable effect of seabed mining on the export earnings or on the economy of DLBPS, because various mineral products are considered, and for seabed mining only a targeted production rate of 3 million dry tonnes of manganese nodules per year from one exploitation area is known. Currently, it is not possible to isolate different metal products from this production rate. Only the quantity of refined metal can be calculated, but the quality can differ from those on land. Manganese nodules, collected from the seabed, are considered as an ore, but this ore contains different metals, so it is not possible to compare it even with terrestrial metal ores. For that reason, at this stage of the analysis, only theoretical scenarios of the impact of seabed mining on DLBPS' export earnings are possible to consider.

515. That is why, with the purpose of showing how dependent a DLBPS is on the four affected metals for its export earnings or for its economy, and as a suggestion that this DLBPS is likely to be most seriously affected by seabed production, only two following dependency thresholds, suggested by Special Commission 1, were considered in the current analysis:

- An absolute value of export earnings in total export earnings: if a DLBPS is earning 10 per cent of its total export earnings from these four minerals during the last 5 years before production authorizations are issued to the seabed miners, it is likely to be most seriously affected by seabed production.

- Value of export earnings from the four minerals in the economy: if a DLBPS's exports of the four minerals account for 5 per cent or more of its GDP, it is likely to be most seriously affected by seabed production.[185]

[183] Ibid.
[184] Ibid.
[185] ISA (1985). Statement of the Chairman of Special Commission 1, provisionally concluding the discussion on the issue of the concrete formulation of the criteria for the identification of developing land-based producer States likely to be most seriously affected by sea-bed production. Preparatory Commission for the International Seabed Authority and for the International Tribunal on the Law of the Sea, Special Commission 1. LOS/PCN/SCN.1/1985/CRP.8.

516. Herewith the first threshold was used as the basis in the analysis, while the purpose of the second one was to check and reinforce obtained results.

517. In addition to the identification of dependence of the DLBPS on four affected metals, it makes sense to analyze the dependence of the world market on these States for the trade of these metals, which means analyzing the share of exports of these States on the world market. For that purpose, the concentration of the metal market was covered in the analysis. One way to capture this analytically is through an annually computed HHI, a measure approved by the United States Department of Justice and the Federal Trade Commission for characterizing market concentration. Usually, this index used to measure the concentration of individual firms in the domestic market of the country, but, instead of measuring individual firms, HHIs computed for this study evaluate the concentration of affected metal products exports by country. HHIs theoretically range between 0 and 10,000 points, which indicate low- and high-market concentrations, respectively. Increased risk theoretically corresponds to high HHI measures, and scores exceeding 2,500 show a high concentration.[186]

518. Metal prices affect export earnings of the States, consequently affecting export prices of products. However, the effect of metal prices on the world market can be different for various metal products. Some products are more dependent on the price in the world market than others. Anyway, price changes can affect export earnings and economies of DLBPS. Another issue is that such price changes may occur not necessarily because of the seabed mining activities in the Area. Consideration of price trends is an important part of the analysis.

519. Affected metals tariffs, which were considered as export prices of a product unit, were calculated and compared with the world average export price of the product unit and with metal prices on the world market. This could help to understand the economic processes going on in DLBPS and why prices of products may differ from those on the world market. Such a comparison could show how dependent different products are on metal prices on the world market. For understanding export prices, exported values of products were compared with exported quantities. This can show how export prices change through the value chain.

C. Overview of affected metals tariffs on exports and earnings of developing State producers

520. First of all, exports of each of the four affected metals of the DLBPS were considered. The following results of the analysis include an overview of export earnings of the DLBPS from each of the four metals, as well as identification of the DLBPS which are likely to be seriously affected by seabed production. For such identified States, export prices (export tariffs) of each product of the four metals and the relation between exported quantities and values of these products were considered.

Copper

521. In 2017, by exported values, the leader exporter States of copper products in the world are presented in Table 5.1.[187]

[186] U.S. Department of Justice (2015). Herfindahl-Hirschman index. https://www.justice.gov/atr/herfindahl-hirschmanindex.

[187] Trade statistics for international business development - Trade Map. https://www.trademap.org/Index.aspx.

Table 5.1. The largest exporter States of copper products in the world in 2017

State	Exported value (thousand USD)
Chile*	32,935,691
Peru*	13,729,278
Australia	5,799,489
Zambia*	5,519,946
Indonesia*	4,519,242
Canada	4,276,757
Democratic Republic of the Congo*	3,645,247
Russian Federation	3,472,124
Spain	3,258,407
Kazakhstan	3,161,114

* developing States

522. Of the countries in Table 5.1, Chile, Peru, Zambia, Indonesia, and DR Congo are developing States.

523. Regarding various products of copper, the largest exporter of *copper ores and concentrates* among the DLBPS is Chile (USD15,665,931). The share of Peru is also very high, at USD11,974,968, followed by Indonesia (USD3,439,604), Brazil (USD2,485,258) and Mexico (USD1,891,122).

524. The largest exporter of *copper mattes* is Mexico (USD99,562). The share of Chile is USD46,477, Malaysia USD26,959, and the Republic of Korea USD22,293.

525. As for *unrefined copper*, the largest exporter is Zambia (USD3,618,105), followed by Chile (USD2,485,038).

526. The largest exporter of *refined copper* is Chile (USD14,738,245), followed by DR Congo (USD2,464,846), India (USD2,425,162) and China (USD2,054,824).

527. For all the countries in the world exporting copper products, shares of these products' exports in total exports of these countries were found. An average value of this parameter for 5 years was compared to the dependence level, and if it exceeds this level, a DLBPS is considered likely to be seriously affected. According to Special Commission 1, the dependence level is equal to 10 per cent, it represents the dependence of export earnings of the DLBPS on the exports of copper products and that this DLBPS is likely to be seriously affected by seabed production.[188] Thus, DLBPS exporting copper products, as well as those DLBPS which are likely to be seriously affected by seabed production, are presented in Table 5.2 (hereinafter in such tables, DLBPS with shares of more than 0.5 per cent will be presented, while smaller shares are considered negligible).

528. To look at the dependence of the economy of the DLBPS on exports of copper products, another dependence level was used. Thus, for all the countries in the world exporting copper products, shares of these products' exports in the GDP of these countries were found. The average value of this parameter for 5 years was compared to the dependence level of 5 per cent, and if it exceeds this level, the DLBPS is considered likely to be seriously affected.[189] The results are presented in Table 5.3.

[188] ISA (1985). Statement of the Chairman of Special Commission 1, provisionally concluding the discussion on the issue of the concrete formulation of the criteria for the identification of developing land-based producer States likely to be most seriously affected by sea-bed production. Preparatory Commission for the International Seabed Authority and for the International Tribunal on the Law of the Sea, Special Commission 1. LOS/PCN/SCN.1/1985/CRP.8.

[189] Ibid.

Table 5.2. Share of copper products' exports in total exports of the DLBPS

DLBPS		5-year average share of Cu products' exports in total exports of the DLBPS
DLBPS which are likely to be seriously affected	Zambia	56.1%
	Democratic Republic of the Congo	55%
	Eritrea	50%
	Chile	48.9%
	Mongolia	36%
	Lao People's Democratic Republic	34.4%
	Peru	25.8%
	Mauritania	12%
	Namibia	11.4%
Papua New Guinea		7.9%
United Republic of Tanzania		2.7%
Syrian Arab Republic		2.5%
Indonesia		2.3%
Philippines		2.2%
Myanmar		1.9%

Table 5.3. Share of copper products' exports in the GDP of the DLBPS

DLBPS		5-year average share of Cu products' exports in GDP of the DLBPS
DLBPS which are likely to be seriously affected	Zambia	18.7%
	Mongolia	15.9%
	Chile	12.8%
	Democratic Republic of the Congo	11.1%
	Lao People's Democratic Republic	7.7%
	Eritrea	5.6%
	Peru	5.1%
Namibia		4.9%
Mauritania		4.8%
Papua New Guinea		3.1%
Philippines		0.5%

529. Among the DLBPS which are likely to be seriously affected according to the export earnings dependence threshold, the economies of Namibia and Mauritania did not exceed the economy dependence level, so these States are not included in the further analysis.

530. Share of copper products' exports of the States which are likely to be seriously affected, in world exports of these products in 2017, are shown in Figure 5.1.

531. From Figure 5.1, it becomes clear that exports of different copper products are unevenly distributed among DLBPS. Chile exports mostly *copper ores and concentrates, unrefined copper* and *refined copper,* but its share in exports of *copper mattes* is also high compared to other DLBPS. The main exported copper product of Peru is *copper ores and concentrates.* As for Mongolia, DR Congo, Lao People's Democratic Republic (Laos), and Eritrea, their shares in all copper products are small. Exports of Zambia are mostly based on *unrefined copper*, and the share of *copper ores and concentrates* and *copper mattes* in the world exports of copper products in 2017 is less than 1 per cent. A small amount of *refined copper* was exported from Zambia in 2017.

532. Using the exported values and the quantities of copper products, the export price of a unit of each copper product in 2017 in the world and the DLBPS were found and compared to each other, which is shown in Figure 5.2.

533. The graph in Figure 5.2 shows that, generally, export prices of Chile, Peru, and Laos are quite close to the world export prices. There are gaps for Mongolia and Eritrea because these States did not export all copper products concerned. Export prices of DR Congo are close to the world prices in the case of *copper ores* and *refined copper (cathodes)*, but much higher for *copper mattes* and, in the opposite direction, lower for *unrefined copper.* As for Zambia, only the export price of *refined copper (cathodes)* in 2017 is little higher than in the world, the price of *unrefined copper* is close to the world export price, and for the other two products, export prices in Zambia are much lower, probably because the export of these products from Zambia in 2017 was insignificant.

Figure 5.1. Share of copper products' exports from the DLBPS which are likely to be seriously affected and the ROW in the world's exports of these copper products in 2017

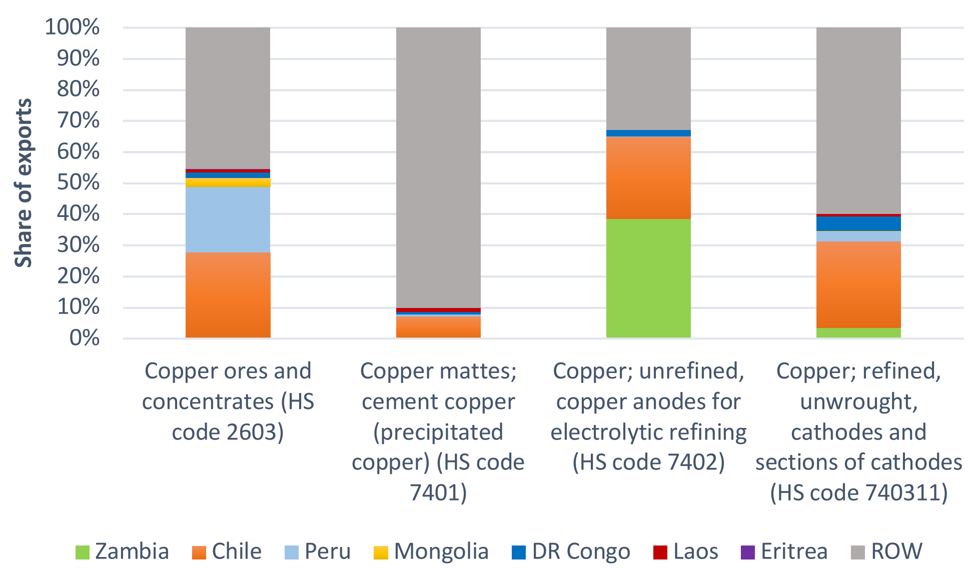
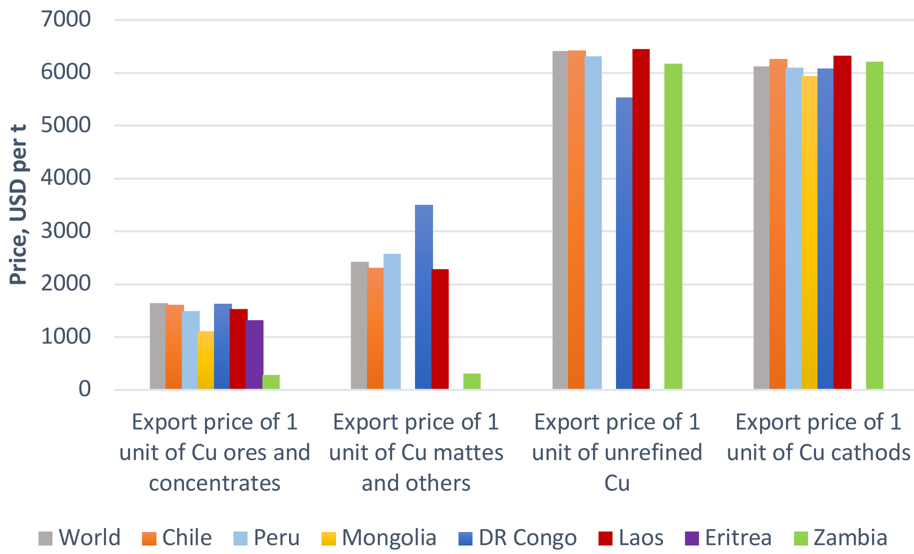


Figure 5.2. Export prices of copper products in the DLBPS and the world in 2017



534. Finally, it makes sense to have a look at the exported quantities of copper products and the values of these products, and compare these data. Copper products' exported quantities of the concerned DLBPS in 2017 and exported values are shown in Figures 5.3 and 5.4, respectively.

535. It can be noticed from Figure 5.4 that in some States, quantities and values of products do not coincide, especially for States which export products other than the primary product. For example, in Chile, an exported quantity of refined copper, which accounts for 20 per cent of all copper products export, obtains for this product about 45 per cent of its export earnings for exported copper products.

Figure 5.3. Share of the quantity of copper products exported from the DLBPS in 2017

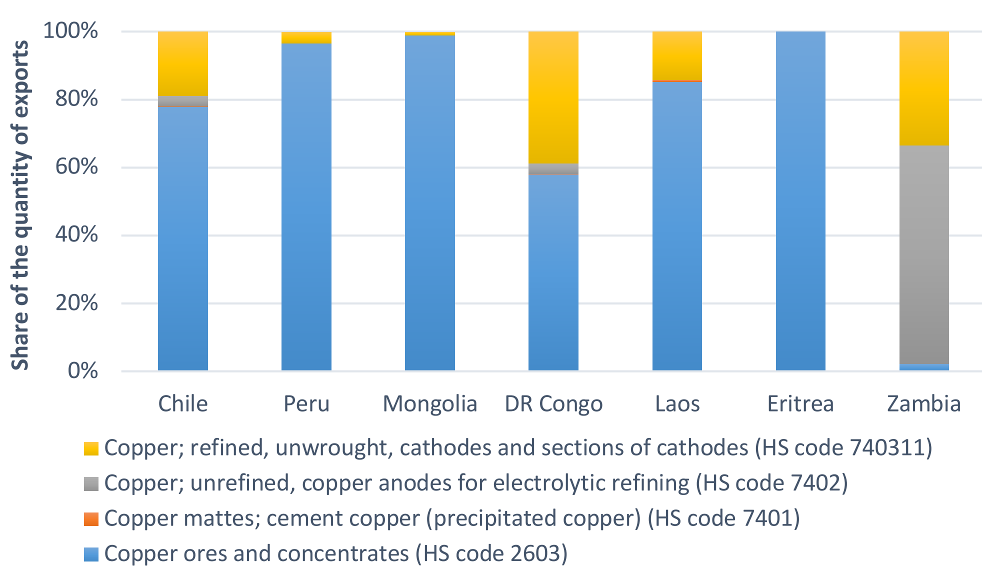
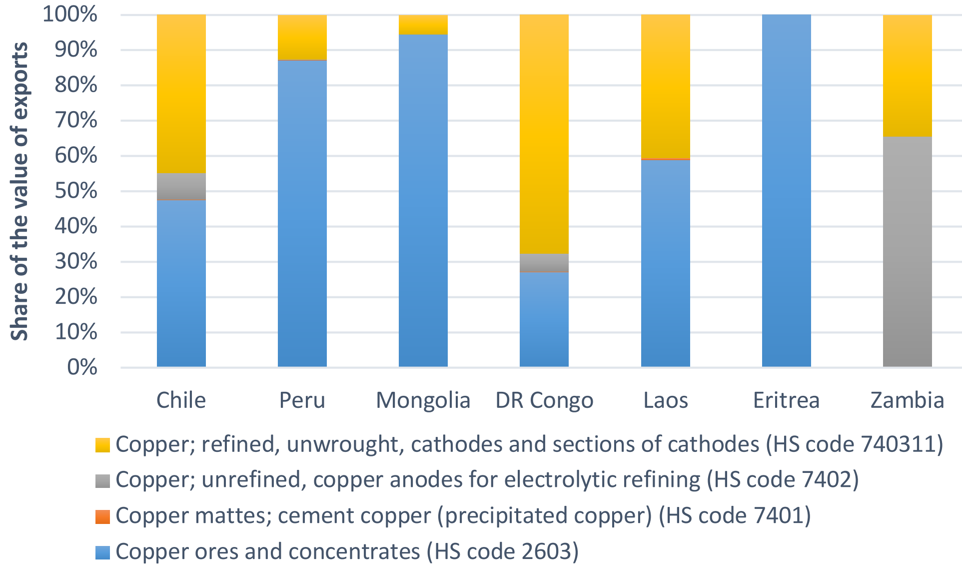


Figure 5.4. Share of the value of copper products exported from the DLBPS in 2017



Nickel

536. In 2017, by the exported values, the largest exporter States of nickel products in the world are shown in Table 5.4.[190]

Table 5.4. The largest exporter States of nickel products in the world in 2017

State	Exported value (thousand USD)
Canada	2,570,308
Indonesia*	2,116,090
Russian Federation	2,006,877
Australia	1,782,150
New Caledonia*	1,502,902
Philippines*	1,129,607
Finland	915,379
Norway	892,731
Zimbabwe*	805,222
Brazil*	538,347

* developing States

537. From these ten States, Indonesia, New Caledonia, Philippines, Zimbabwe, and Brazil are developing States. However, New Caledonia is a non-UN member, so this State cannot claim to be seriously affected by seabed production and will not be considered further in the analysis.

538. Regarding various products of nickel, the main exporters of *nickel ores and concentrates* among developing States are the Philippines (USD685,300) and Zimbabwe (USD369,013).

539. The largest exporters of *nickel mattes and other intermediate products of nickel metallurgy* are Indonesia (USD629,334), Philippines (USD444,307), Zimbabwe (USD436,088), Papua New Guinea (USD367,466), and Cuba (USD140,788).

540. As for *ferro-nickel*, the largest exporter is again Indonesia (USD1,331,567), followed by Brazil (USD538,048), Colombia (USD360,544), and Myanmar (USD345,042).

[190] Trade statistics for international business development, Trade Map: https://www.trademap.org/Index.aspx.

541. As for *unwrought nickel*, top exporters are Malaysia (USD534,350), Madagascar (USD340,961), and Singapore (USD256,024).

542. Talking about DLBPS, which are likely to be seriously affected, the 5-year average share of nickel products' exports in total exports of all DLBPS is shown in Table 5.5.

Table 5.5. Share of nickel products' exports in total exports of the DLBPS

DLBPS		5-year average share of Ni products' exports in total exports of the DLBPS
DLBPS which are likely to be seriously affected	Madagascar	20.3%
	Zimbabwe	15.6%
Cuba		7%
Botswana		3.6%
Papua New Guinea		2.7%
Philippines		2%
Myanmar		1.4%
Guatemala		1.3%
Colombia		1.1%
Indonesia		1%
Dominican Republic		1%
Dominica		0.8%

543. Analysis of the dependence of the economy of DLBPS on exports of nickel products showed that none of the two States which are likely to be seriously affected by seabed production has exceeded the dependence levels (Table 5.6). Anyway, both of the abovementioned States will be considered further.

Table 5.6. Share of nickel products' exports in the GDP of the DLBPS

DLBPS	5-year average share of Ni products' exports in GDP of the DLBPS
Madagascar	3.7%
Zimbabwe	3.1%
Botswana	1.7%
Papua New Guinea	1.1%

544. Share of nickel products exports of the DLBPS which are likely to be seriously affected in world exports of these products in 2017 are shown in Figure 5.5.

545. Thus, Figure 5.5 shows that these States have exported a small amount of all nickel products in the world in 2017. Zimbabwe mostly exports *nickel ores* and nickel mattes. None of the States exports *ferro-nickel*. As for *unwrought nickel*, Madagascar is the main exporter from these two States.

546. Export prices of nickel products in the world and in the DLBPS in 2017 are shown in Figure 5.6.

547. The graph in Figure 5.6 shows that the export price of nickel ores and concentrates in 2017 is very low in comparison with other nickel products. There are gaps in the graph because some States do not export all concerned products. The export price of nickel mattes in Zimbabwe is almost as high as world prices. The export price of unwrought nickel from Madagascar is close to world prices, whereas the price in Zimbabwe is much lower.

548. Nickel products' exported quantities of the DLBPS which are likely to be seriously affected in 2017 and exported values are shown in Figures 5.7 and 5.8, respectively.

Figure 5.5. Share of nickel products' exports from the DLBPS which are likely to be seriously affected and the ROW in the world's exports of these nickel products in 2017

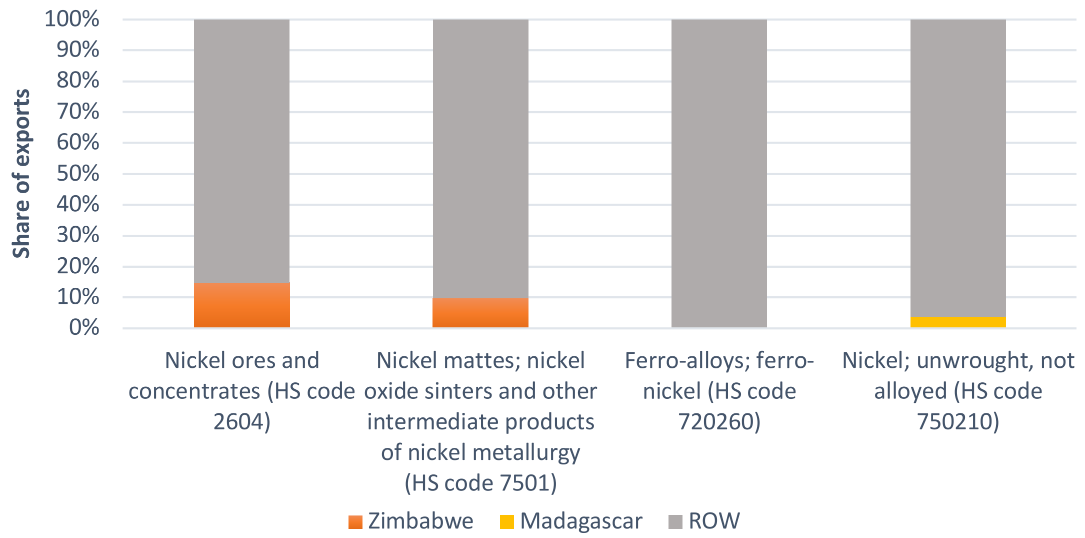
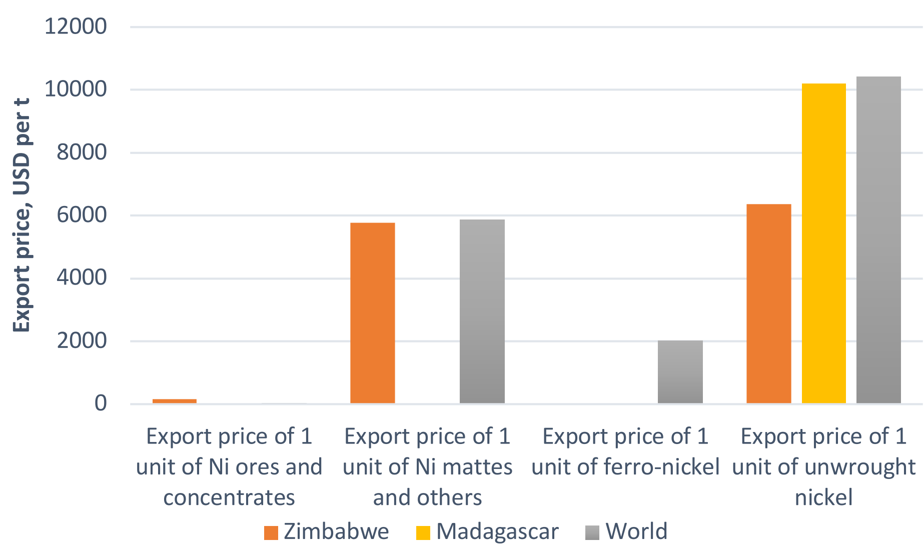


Figure 5.6. Share of nickel products' exports from the DLBPS which are likely to be seriously affected and the ROW in the world's exports of these nickel products in 2017



549. It can be seen from the figures that the quantity and the value of products do not coincide. As for Zimbabwe, its exported quantities of nickel mattes are very low, but the exported value is quite significant. This trend is not relevant for Madagascar, because it exported only unwrought nickel in 2017.

Figure 5.7. Share of the quantity of nickel products exported from the DLBPS which are likely to be seriously affected in 2017

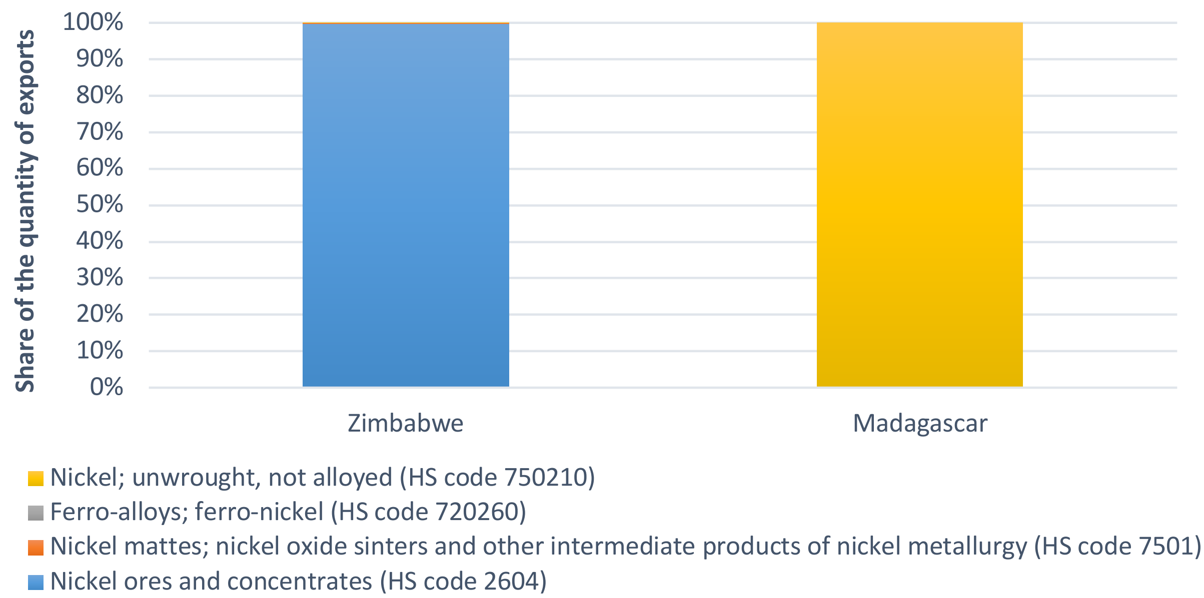
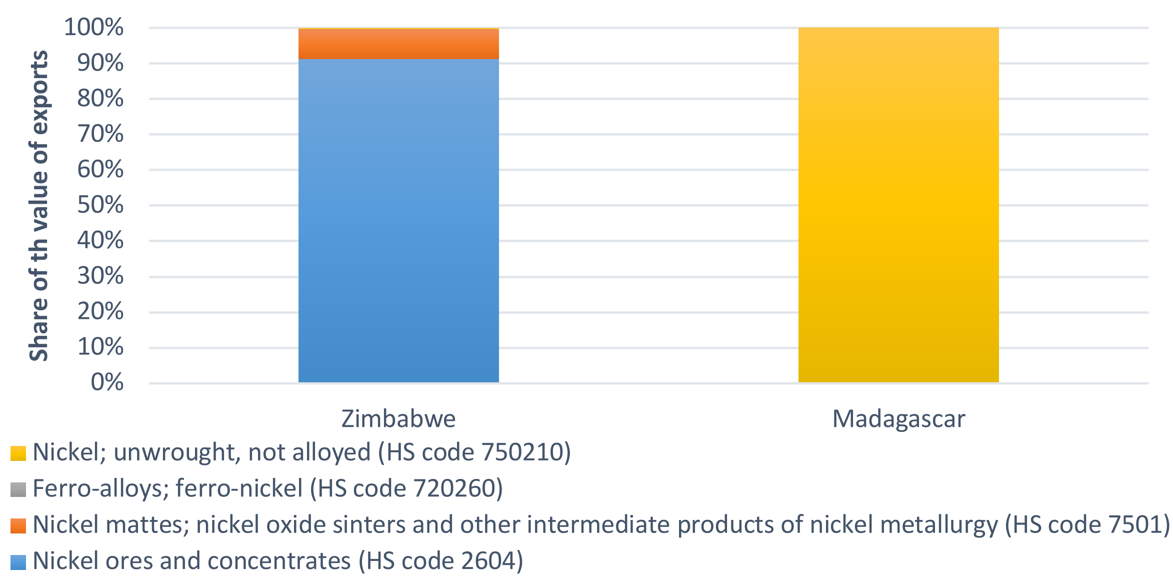


Figure 5.8. Share of the value of nickel products exported from the DLBPS which are likely to be seriously affected in 2017



Cobalt

550. In 2017, by exported values, the largest exporter States of cobalt products in the world are presented in Table 5.7 below.[191]

Table 5.7. The largest exporter States of cobalt products in the world in 2017

State	Exported value (thousand USD)
Democratic Republic of the Congo*	3,154,785
China*	529,245
Canada	420,044
Australia	170,501
Japan	158,747
Madagascar*	151,915
Zambia*	150,834
United States of America	93,672
United Kingdom	86,179
Morocco*	80,965

* developing states

551. From this list, DR Congo, China, Madagascar, Zambia, and Morocco are developing States.

552. Regarding various products of cobalt, an absolute exporter of *cobalt ores and concentrates* among developing States is DR Congo (USD524,045). Shares of other States are insignificant.

553. The largest exporter of *cobalt mattes and other intermediate products of cobalt metallurgy* is DR Congo (USD1,896,638). The share of China is USD208,728, Madagascar USD151,915, and Morocco USD79,680. The share of Zambia is insignificant.

554. As for *cobalt oxides and hydroxides*, the largest exporter is again DR Congo (USD734,112), followed by China (USD320,382) and Zambia (USD150,289).

555. Shares of these products' exports in total exports of all the developing States in the world, exporting cobalt products, were found (Table 5.8). It was found that only DR Congo is likely to be seriously affected by seabed production in the Area, as its share is 24.3 per cent, whereas shares of other States are insignificant. Further analysis regarding cobalt products will be focused on DR Congo only.

Table 5.8. Share of cobalt products' exports in total exports of the DLBPS

DLBPS		5-year average share of Co products' exports in total exports of the DLBPS
DLBPS which are likely to be seriously affected	Democratic Republic of the Congo	24.3%
Madagascar		4%
Zambia		0.8%

556. Moreover, the share of cobalt products' exports in the GDP of DLBPS for the last 5 years does not exceed a 5 per cent dependence level (Table 5.9). For DR Congo it is 4.8 per cent. Even though two dependence thresholds were chosen for the current analysis, there is no necessity to use both at the same time. The economy dependence threshold was used in order to check and reinforce the results, produced by the usage of export earnings dependency threshold, so the fact that the share of cobalt products' exports in the GDP of DR Congo does not exceed the dependence level can be neglected.

[191] Ibid.

Table 5.9. Share of cobalt products' exports in the GDP of the DLBPS

DLBPS	5-year average share of Co products' exports in GDP of the DLBPS
Democratic Republic of the Congo	4.8%
Madagascar	0.8%

557. Share of cobalt products' exports of DR Congo in the world exports of these products in 2017 is shown in Figure 5.9.

558. Figure 5.9 shows that DR Congo gets 97 per cent of world export earnings for cobalt ores and concentrates and half of world export earnings for cobalt mattes and cobalt oxides.

Figure 5.9. Share of cobalt products' exports from DR Congo and the ROW in the world's exports of these cobalt products in 2017

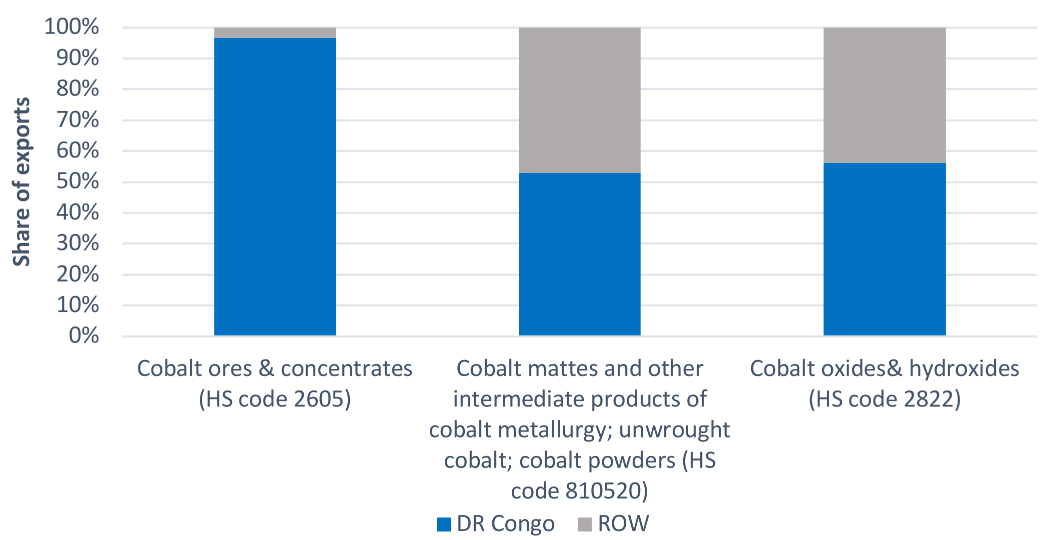
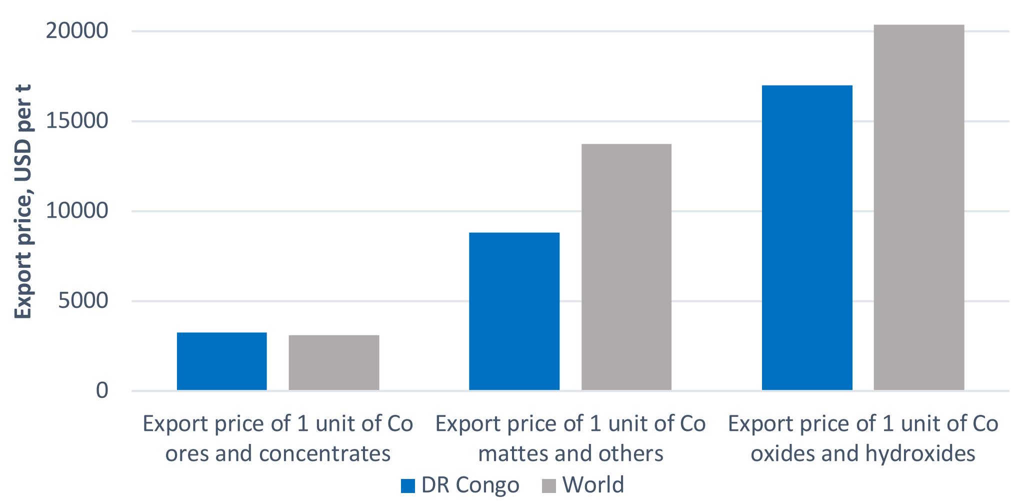


Figure 5.10. Export prices of cobalt products in DR Congo and in the world in 2017



559. Export prices of cobalt products in the world and in DR Congo in 2017 are shown in Figure 5.10.

560. The graph in Figure 5.10 shows that the export price of *cobalt ores and concentrates* in 2017 in DR Congo is higher than in the world, unlike prices for the two other cobalt products.

561. Cobalt products' exported quantities of DR Congo in 2017 and exported values are shown in Figures 5.11 and 5.12, respectively.

Figure 5.11. Share of the quantity of cobalt products exported from DR Congo in 2017

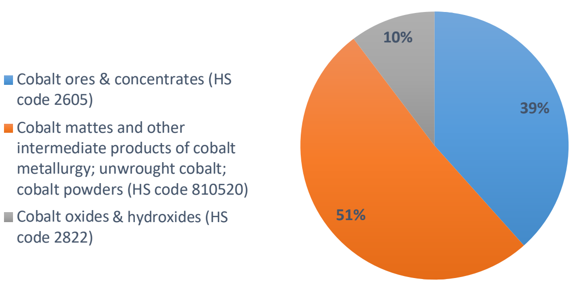
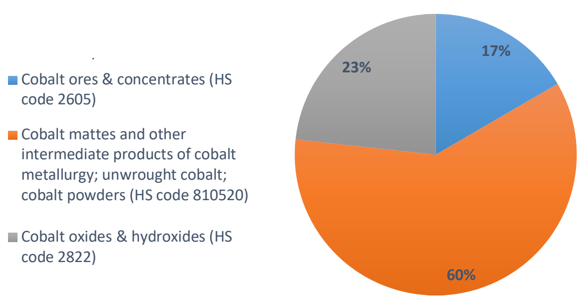


Figure 5.12. Share of the value of cobalt products exported from DR Congo in 2017



562. It can be seen from Figures 5.11 and 5.12 that the quantity and the value of products do not coincide. For example, the exported quantity of cobalt ores and concentrates from DR Congo is high–almost 40 per cent–in total exports of all cobalt products from the country, although the value of this product is the lowest in total exported value of cobalt products.

Manganese

563. In 2017, by the exported values, the largest exporter States of manganese products in the world are presented in Table 5.10.[192]

Table 5.10. The largest exporter States of manganese products in the world in 2017

State	Exported value, thousand USD
South Africa*	3,092,939
Gabon*	1,190,316
India*	1,140,100
China*	961,957
Ukraine	898,811
Malaysia*	529,678
Brazil*	459,929
Netherlands	389,631
Norway	356,580
Republic of Korea	323,565

* developing States

564. From this list, South Africa, Gabon, India, China, Malaysia, and Brazil are developing States.

565. Regarding exports of various products of manganese in 2017, the main exporters of *manganese ores and concentrates* among developing States are South Africa (USD2,527,273), Gabon (USD1,147,697), Brazil (USD365,636), and Ghana (USD155,381).

566. The largest exporter of *manganese oxides* is China (USD95,339), whereas exports of other DLBPS are insignificant.

567. As for *ferro-manganese (more than 2 per cent of carbon)*, the largest exporters are Malaysia (USD300,132), India (USD258,586), and South Africa (USD221,459).

[192] Ibid.

568. The largest exporters of another form of *ferro-manganese (2 per cent or less of carbon)* are the Republic of Korea (USD246,578), South Africa (USD127,030), and India (USD63,968).

569. Top exporter of *ferro-silico-manganese* is India (USD801,204), followed by Malaysia (USD204,654) and South Africa (USD134,387).

570. As for the last considered product, *manganese articles*, the main exporter is again China (USD847,770), while shares of other States are insignificant.

571. Among all manganese exporting countries, there is one State which is likely to be seriously affected by seabed production, and it is Gabon (Table 5.11).

Table 5.11. Share of manganese products' exports in total exports of the DLBPS

DLBPS		5-year average share of Co products' exports in total exports of the DLBPS
DLBPS which are likely to be seriously affected	Gabon	11.8%
South Africa		2.7%

572. Besides, Gabon is at the edge of dependence level, related to the economy of the country, of 5 per cent (Table 5.12). Thus, only this State was considered in the analysis.

573. The share of manganese products exports of Gabon in the world exports of these products in 2017 is shown in Figure 5.13.

Table 5.12. Share of manganese products' exports in the GDP of the DLBPS

DLBPS		5-year average share of Mn products' exports in GDP of the DLBPS
DLBPS which are likely to be seriously affected	Gabon	5%
South Africa		0.7%

574. Gabon did not export manganese oxides and ferro-manganese (more than 2 per cent of carbon) in 2017. The share of this country in world exports of manganese products is low, especially for ferro-manganese (2 per cent or less of carbon), ferro-silico-manganese, and manganese articles. The product which makes the State dependent on exports is manganese ores and concentrates.

575. Export prices of manganese products in the world and in Gabon in 2017 are shown in Figure 5.14.

576. The graph in Figure 5.14 shows that export prices of *manganese ores and concentrates*, *ferro-silico-manganese*, and *manganese articles* are higher in Gabon than in the world in 2017, though exported quantities of the last two products are extremely low compared to world exports of these products. As for *ferro-manganese*, this product was not exported from Gabon in 2017, which is why the export price is unavailable.

Figure 5.13. Share of manganese products' exports from Gabon and the ROW in the world's exports of these manganese products in 2017

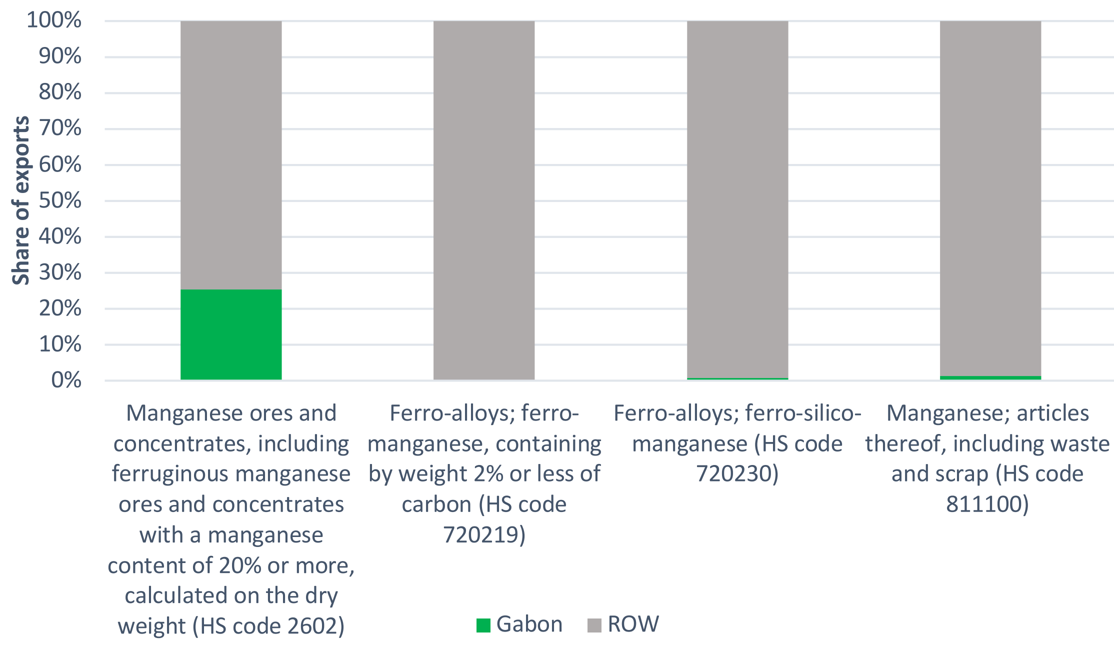
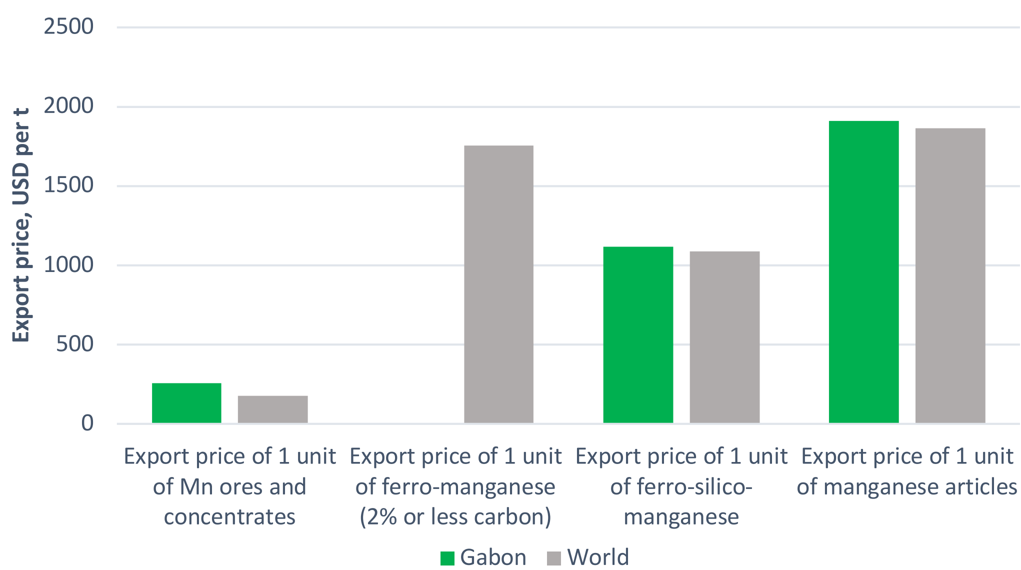


Figure 5.14. Export prices of manganese products in Gabon and in the world in 2017



577. Manganese products' exported quantities and exported values of Gabon in 2017 are shown in Figures 5.15 and 5.16, respectively.

578. It can be seen from Figures 5.15 and 5.16 that the quantity and the value of products coincid, because almost all of the exports of manganese products from

Figure 5.15. Share of the quantity of manganese products exported from Gabon in 2017

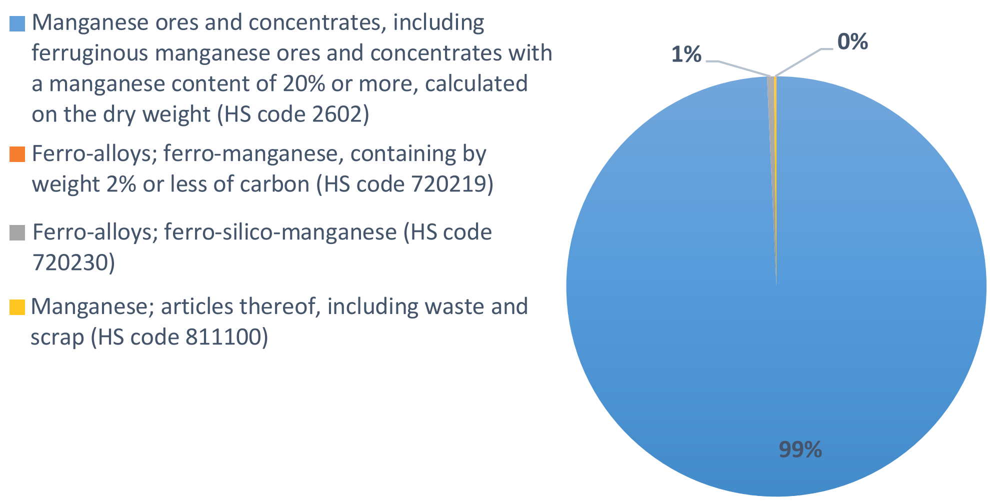
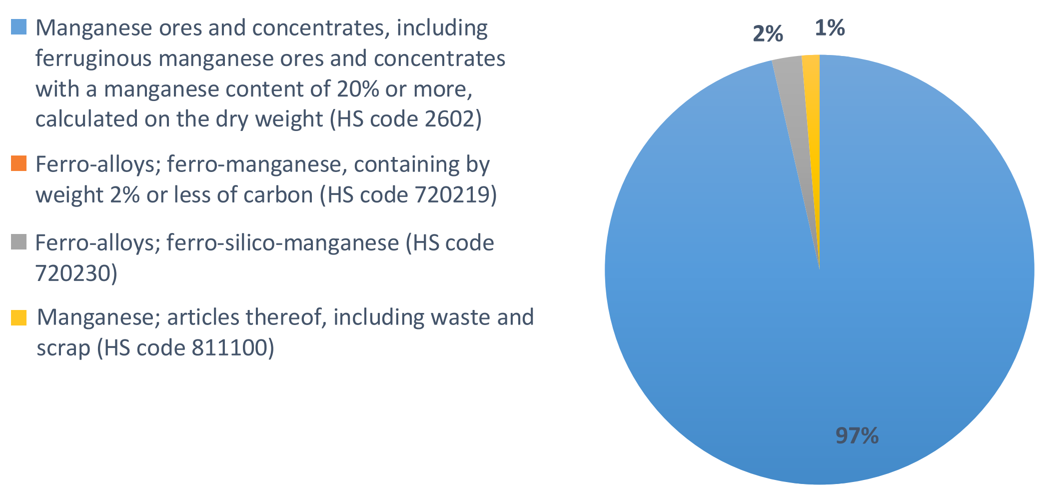


Figure 5.16. Share of the value of manganese products exported from Gabon in 2017



Gabon are based on *manganese ores and concentrates* (99 per cent), and shares of other products are negligible.

All affected metals

579. During the analysis of the four affected metals' share in exports of the DLBPS, it was found that many States are likely to be seriously affected by seabed mining. This applies to some of these States for different metals. That is why it is important to analyze the multiple effects of the sum of affected metals on the exports of the DLBPS. Moreover, Special Commission 1 specified the effect on exports of one or more metals concerned.

580. Calculations have shown that the share of affected metals exports in all exports of the DLBPS is huge, as is the number of DLBPS which are likely to be affected (Table 5.13).

581. Concerning the economies of the DLBPS, results of the usage of the economy dependence threshold are presented in Table 5.14.

Table 5.13. Share of affected metals exports in total exports of the DLBPS

DLBPS		5-year average share of affected metals exports in total exports of DLBPS
DLBPS which are likely to be affected	Democratic Republic of the Congo	79.3%
	Zambia	57.2%
	Eritrea	49.8%
	Chile	48.9%
	Mongolia	36%
	Lao People's Democratic Republic	34.4%
	Peru	25.8%
	Madagascar	24.3%
	Zimbabwe	15.9%
	Mauritania	12%
	Gabon	11.8%
	Namibia	11.4%
	Papua New Guinea	10.6%
Cuba		7.3%
Botswana		4.5%
Philippines		4.2%
Grenada		4%
South Africa		3.5%
Indonesia		3.3%
Myanmar		3.3%
United Republic of Tanzania		2.7%
Syrian Arab Republic		2.5%
Brazil		1.7%
Dominican Republic		1.6%
Guatemala		1.3%
Colombia		1.2%
India		1.2%
Argentina		1%
Dominica		0.8%
Democratic People's Republic of Korea		0.8%
Malaysia		0.8%
Morocco		0.8%
Mexico		0.6%
Plurinational State of Bolivia		0.6%
Islamic Republic of Iran		0.5%

582. Some States are at the edge of the dependence level, particularly Eritrea (5.6 per cent), Peru (5.1 per cent), and Gabon (5 per cent). The remaining States were close to the dependence level but did not exceed it.

Table 5.14. Share of affected metals exports in the GDP of the DLBPS

DLBPS		5-year average share of affected metals exports in GDP of DLBPS
DLBPS which are likely to be affected	Zambia	19.1%
	Democratic Republic of the Congo	16%
	Mongolia	15.9%
	Chile	12.8%
	Lao People's Democratic Republic	7.7%
	Eritrea	5.6%
	Peru	5.1%
	Gabon	5%
Namibia		4.9%
Mauritania		4.8%
Madagascar		4.4%
Papua New Guinea		4.3%
Zimbabwe		3.1%
Botswana		2.1%
South Africa		0.9%
Philippines		0.9%
Myanmar		0.6%
Indonesia		0.6%
Malaysia		0.5%

5. Impact on the affected metals' tariffs for developing State producers

A. Effects of the affected metals' tariffs on overall economic performance

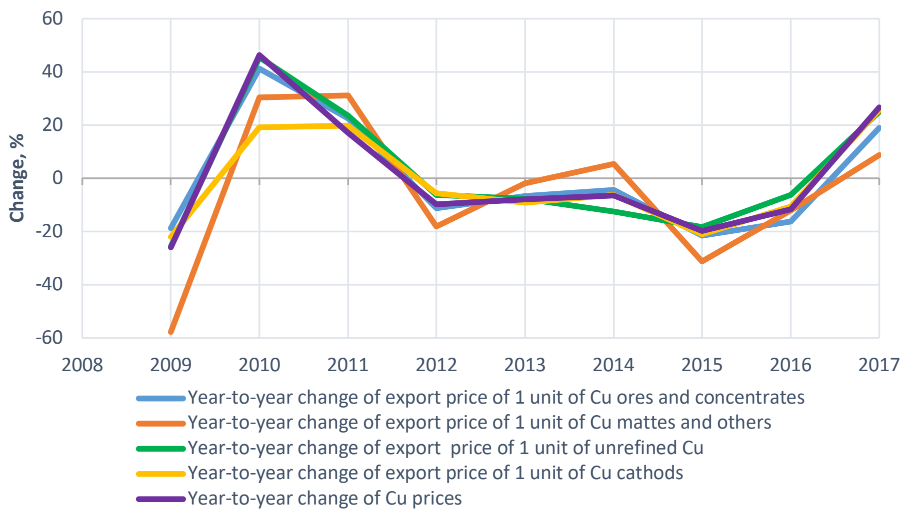
583. Metal prices affect export earnings of the States, consequently affecting export prices of products in the world and in the DLBPS which are likely to be affected by seabed production. However, the effect of metal prices on the world market can be different for various metal products. Some products are more dependent on the price on the world market than others. Metal price changes can affect export earnings and the economies of the DLBPS through changes in the share of exports in the GDP of the State.

584. Another issue is that such metal price changes may occur not necessarily because of seabed mining activities in the Area. Other reasons for metal price changes can be events such as de-stocking, geopolitical unrest, the setting of a joint price, and recession. Besides, usually the price of a commodity varies in response to general global economic conditions, supply and demand fundamentals, and several other factors of relatively short duration. In order to analyze the effect of these changes on export prices of products, the evolution of export prices of metal products was considered together with metal prices on the world market.

Copper

585. Changes in copper prices and export prices of copper products in the world are shown in Figure 6.1.

Figure 6.1. Changes in copper prices and export prices of copper products in the world



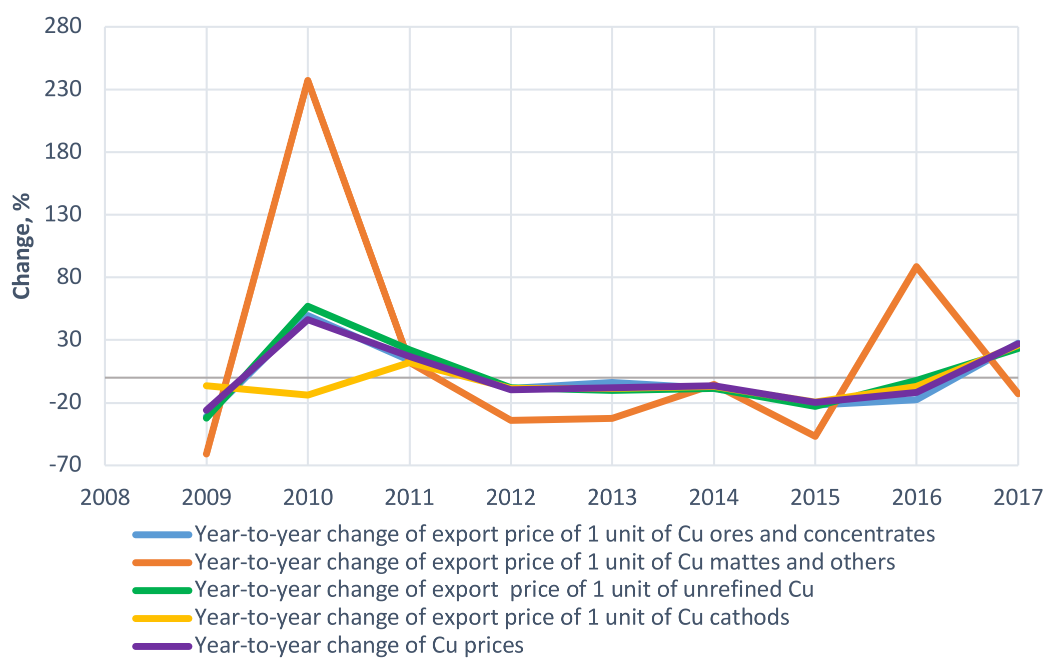
586. In general, there was a sharp rise in copper prices from 2003 to 2011. The financial crisis in 2008 influenced this tendency, and the price slumped to approximately USD5,000 per metric tonne in 2009. However, the prices recovered and rose further basically due to the booming economy and high demand.[193] Right after a peak of almost USD9,000 per metric tonne in 2011, a downward trend in prices appeared since 2011. This was related to weak demand from China and demand for substitutes such as aluminium.[194]

587. Almost all the changes in export prices of copper products coincide with changes in the copper price, especially those for copper ores and unrefined copper. The fall of copper mattes export price because of the 2008 recession was more significant than for other products, and its further increase was, on the contrary, less intense. The trend of more intense slumps persisted over the whole period.

588. Considering exports of copper products of individual DLBPS which are likely to be seriously affected, later in this chapter only Chile and Peru will be discussed as examples of such States. Thus, changes in copper prices and export prices of copper products in Chile are shown in Figure 6.2.

589. The situation in Chile is close to the situation in the world: export prices of unrefined copper and copper ores and concentrates change in accordance with copper price. The export price of copper cathodes does not follow the general trend. It was reduced by 7 per cent from 2008 to 2009 and continued to fall, unlike the prices of other products. The most inconsistent price is the export price of copper mattes. It has faced great upturns, like the 237 per cent rise from 2009 to 2010 and the 88 per cent rise from 2015 to 2016. Its collapses were also more significant than for other products.

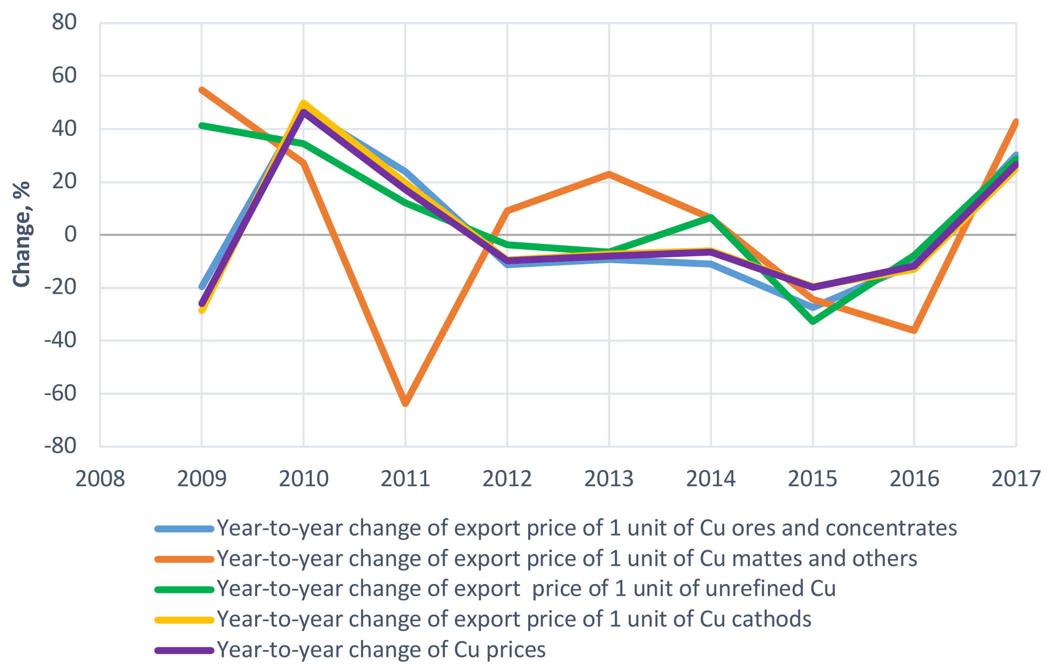
Figure 6.2. Changes in copper prices and export prices of copper products in Chile



[193] Sturmer M. (2014). *150 years of boom and bust: what drives mineral commodity prices?* Federal Reserve Bank of Dallas Research Department. Working Paper 1414, p. 37. https://www.dallasfed.org/~/media/documents/research/papers/2014/wp1414.pdf.

[194] UN (2015). World commodity trends and prospects. Report of the Secretary-General. General Assembly, United Nations, p. 24. https://unctad.org/meetings/en/SessionalDocuments/a70d184_en.pdf.

Figure 6.3. Changes in copper prices and export prices of copper products in Peru



590. Trends for Peru are shown in Figure 6.3.

591. The general trend, that when export prices of unrefined copper and copper ores and concentrates change in accordance with copper price, persists in Peru, but there are some variations. On the other hand, changes in the export price of copper cathodes completely coincide with changes in the copper price. Changes in copper mattes price were not such intense, like for Chile, but they are still quite volatile. For example, from 2010 to 2011 in the world and in Chile, the price increased, but in Peru it decreased by 64 per cent. Such sharp changes happened during the whole period.

592. As mentioned above, changes in metal prices affect export earnings of the States with affected export prices. This additionally affects the economies of the DLBPS through changes in the share of exports in the GDP of the State. Thus, the GDP of Chile and Peru, the share of copper products exports in their GDP, and copper price were considered.

593. Figure 6.4 shows that changes in export earnings from all copper products exports are fully consistent with changes in the metal price. In general, the GDP of the State changes accordingly. For example, in the period when export earnings from copper products exports decreased, there was also a decrease in the GDP (2014–2016), so probably the State's economy is quite dependent on exports of these products. According to UNCTADstat data on individual States' GDP by type of expenditure and gross value added (VA) by kind of economic activity,[195] the average share of exports of all goods and services from Chile in the GDP of the State during the last 10 years is 34 per cent, but it is decreasing throughout the period. As for the average share of mining,

[195] UNCTAD – UNCTADstat. Data center, Economic trends, National accounts, GDP by type of expenditure, VA by kind of economic activity. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95.

Figure 6.4. Changes in copper prices, GDP, and export earnings from the copper products exports in Chile

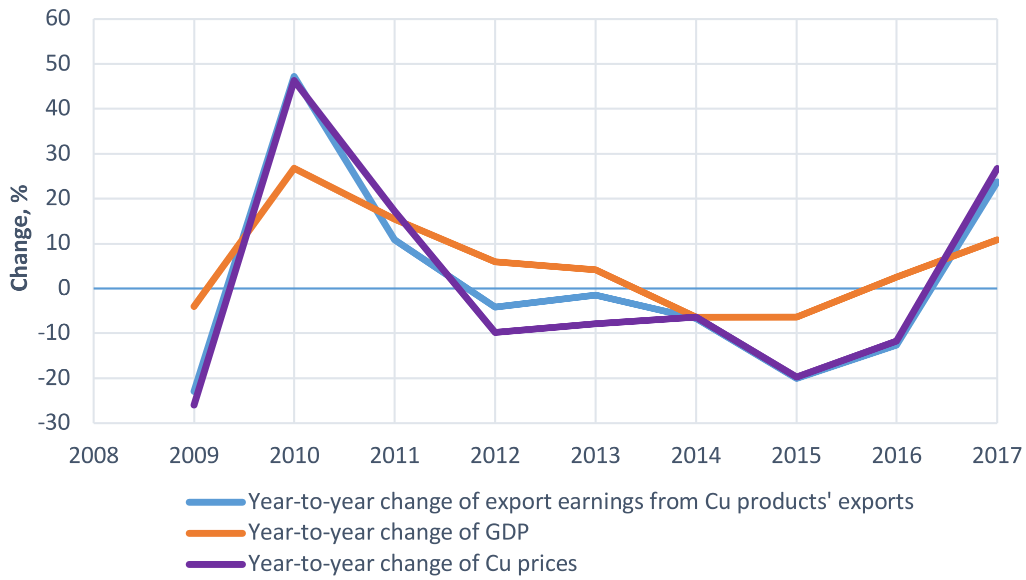


Figure 6.5. Changes in copper prices, GDP, and export earnings from the copper products exports in Peru

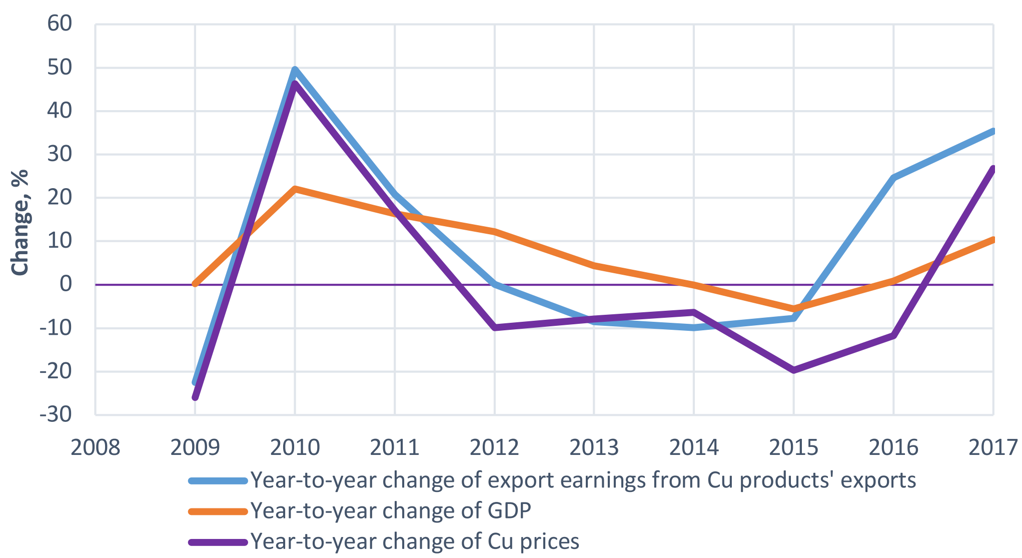
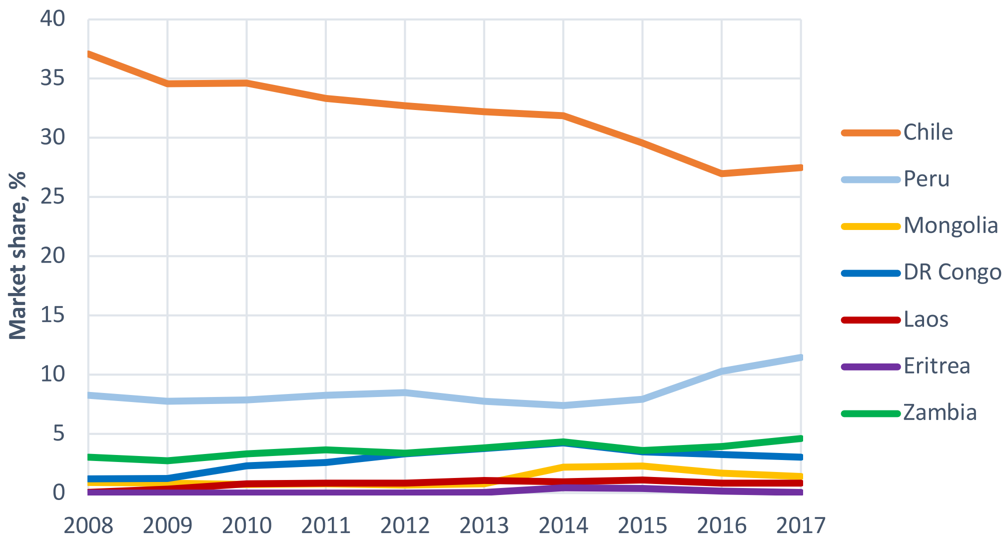


Figure 6.6. Market share of the DLBPS which are likely to be seriously affected (all copper products)



manufacturing, and utilities in the VA, it is 28 per cent over the last 10 years.

594. Figure 6.5 shows a quite similar situation for Peru. In most years, changes in export earnings from all copper products exports are consistent with changes in the metal price. This continued until 2011, and then a shift happened when export earnings reduction occurred one year later than a decrease in the metal price. However, since 2015, export earnings rose sharply, one year before it happened to metal price. In the evolution of the GDP, similar trends can be noticed, like growth in 2010, then a slowdown of growth until 2014, followed by a decrease of the GDP until 2016. However, this can hardly be related to changes in export earnings only. More likely, it was a cumulative effect of different processes in the economy, which also influenced metal prices and export earnings correspondingly. According to UNCTADstat data on individual States' GDP by type of expenditure and VA by kind of economic activity,[196] the average share of exports of all goods and services from Peru in the GDP during the last ten years is 26 per cent. As for the average share of mining, manufacturing, and utilities in the VA, it is 30 per cent for the last 10 years.

595. Indeed, a market definition for affected metals was defined, which includes a market share of each DLBPS and market concentration. Market shares of the DLBPS which are likely to be seriously affected are shown in Figure 6.6.

596. It was found that Chile has the greatest market share of all copper products (32 per cent on average).

597. Regarding markets of each product, Chile on average has the largest market share of *copper ores and concentrates* in value (30 per cent), followed by Peru (15.3 per cent) (Figure 6.7).

598. Among the DLBPS which are likely to be seriously affected, Chile has the largest share in *copper mattes'* markets (13.8 per cent on average) (Figure 6.8).

[196] Ibid.

Figure 6.7. Market share of the DLBPS which are likely to be seriously affected (copper ores and concentrates)

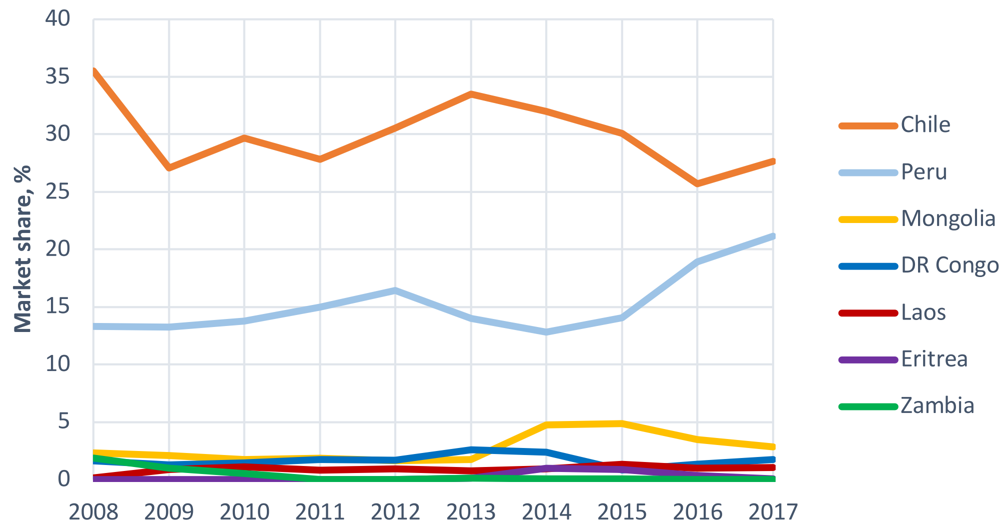
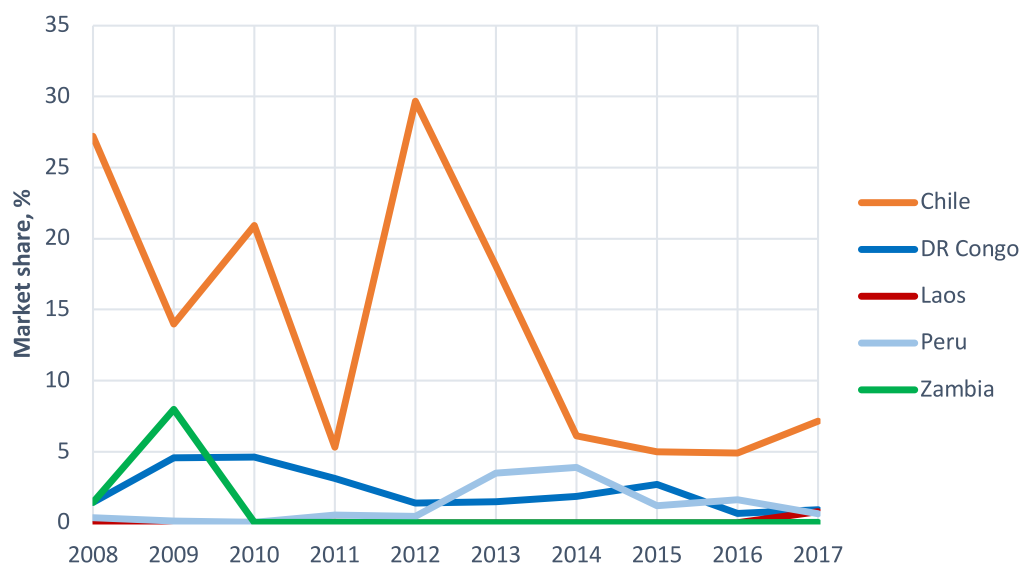


Figure 6.8. Market share of the DLBPS which are likely to be seriously affected (copper mattes)



599. Again, Chile has the greatest market share of *unrefined copper,* at 42.5 per cent on average. Zambia follows with its average market share of 8.3 per cent, and then DR Congo (6.6 per cent) (Figure 6.9).

600. Chile has the largest market share of *refined copper*, at 32.7 per cent on average. Shares of other States are much less (Figure 6.10).

601. However, from Figure 6.11, it seems that concentrations of copper markets are not very high.

Figure 6.9. Market share of the DLBPS which are likely to be seriously affected (unrefined copper)

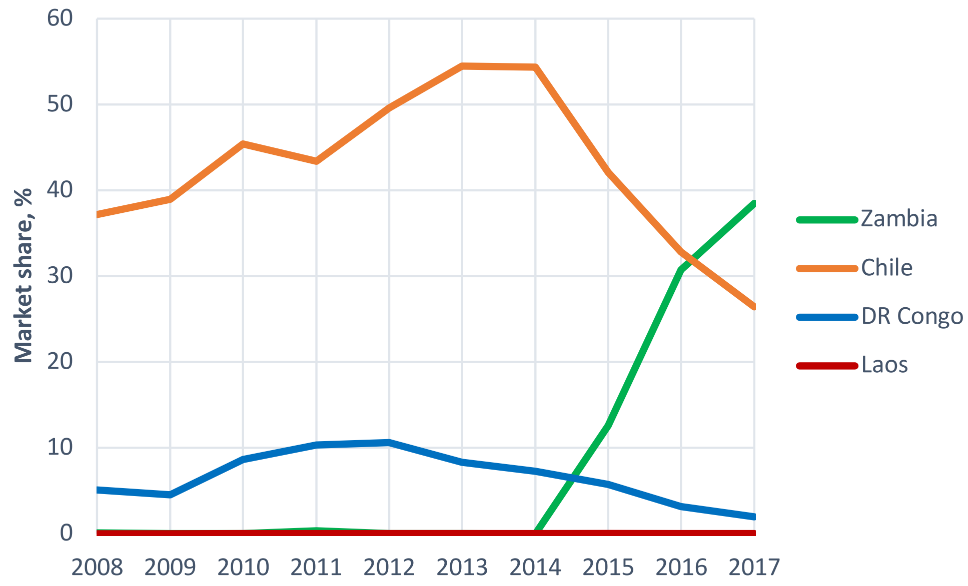


Figure 6.10. Market share of the DLBPS which are likely to be seriously affected (refined copper)

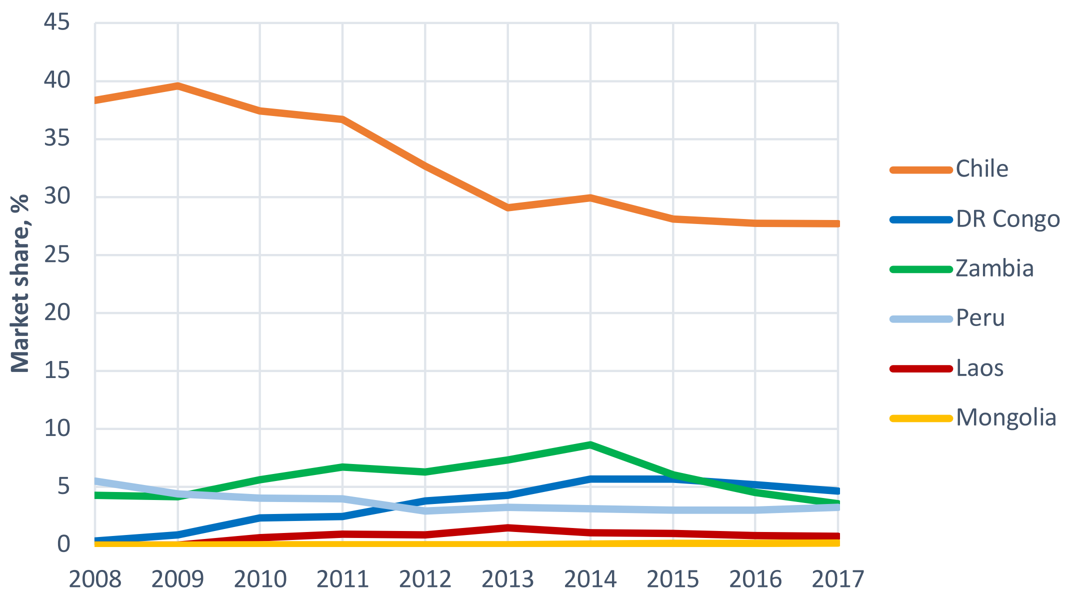
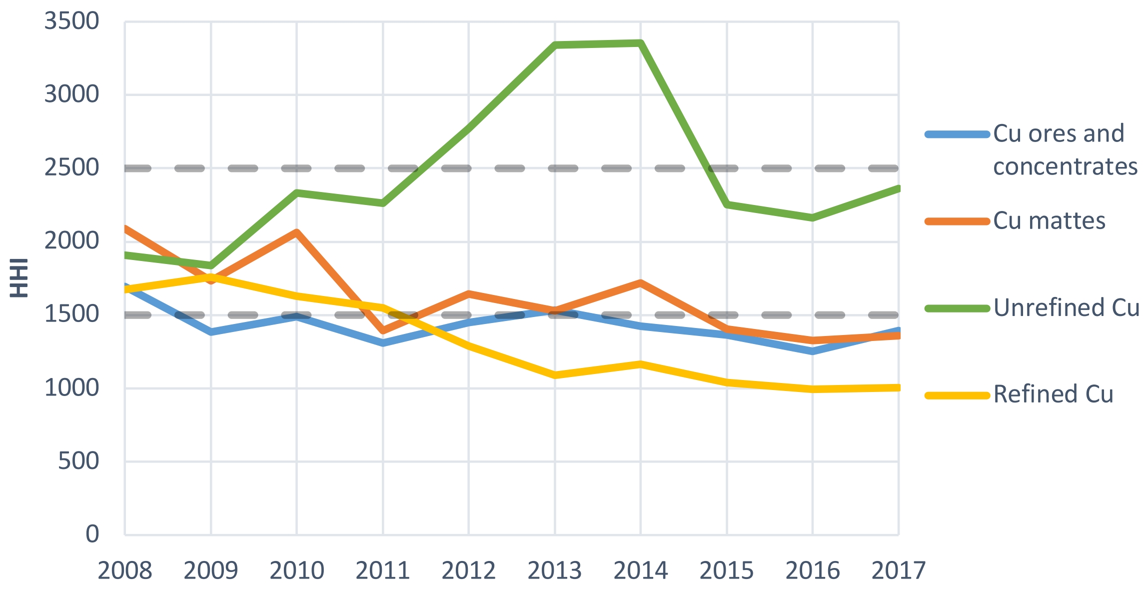


Figure 6.11. The concentration of copper products markets

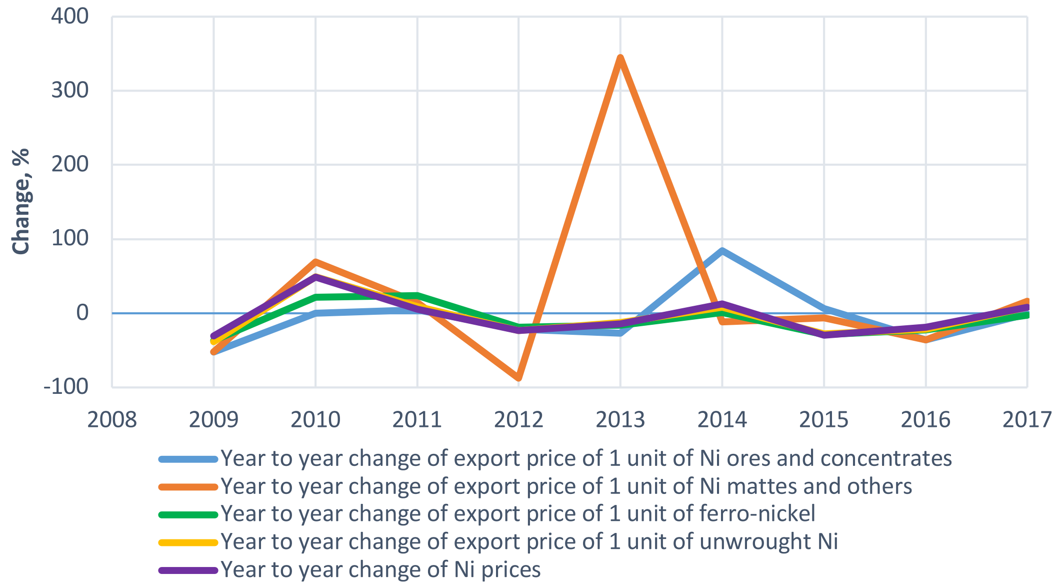


602. Thus, the average HHI for *copper ores and concentrates* is about 1400, which proves that this market has low concentration and is competitive. As for *copper mattes'* markets, it has HHI of 1600, meaning moderate concentration. The concentration of the *unrefined copper* market is higher, with HHI of almost 2500 on average, so this market is moderately concentrated but is on the edge of high concentration. The market for *refined copper* has the lowest concentration, with HHI 1300. This means that generally speaking, copper products markets are quite competitive and have moderate to low concentrations. Global production is distributed evenly over a large number of countries.

603. Thus, based on the results of the analysis of copper products' exports, it can be concluded that among all the copper products, *copper ores and concentrates* export prices are the most correlated with copper prices. In the world in general, export prices of other copper products are also more or less correlated with copper prices. This, however, changes for some States, as for example, export prices of copper mattes are not correlated with copper prices in Chile and Peru. In addition, copper prices are directly related to the export earnings of the States which export copper products. Export earnings, in turn, affect States' GDP to some extent.

604. A possible decrease in copper prices as a result of deep-sea mining can lead to the decrease of export prices of copper products, first of all of those products which are highly correlated with copper prices, for example *copper ores and concentrates or unrefined copper*. The market of *unrefined copper* is quite highly concentrated, with the highest market share by Chile. A decrease in the export price of this product can result in low export earnings of the State. One may expect that the share of Chile on the *unrefined copper* market will fall, when a new actor on the market will appear, as happened in 2014 since exports of Zambia increased and the market share of this State increased. Probably, the situation would not be as painful for markets which have lower concentration, like *refined copper* or *copper ores and concentrates*.

Figure 6.12. Changes in nickel prices and export prices of nickel products in the world



Nickel

605. Changes in nickel prices and export prices of nickel products in the world are shown in Figure 6.12.

606. The decrease of nickel prices since the world economic crisis in 2007 was related to oversupply.[197] After the fall until it reached almost USD14,500 per metric tonne in 2009, there was a short rise in the price with a peak of almost USD23,000 per metric tonne in 2011. Then the falling trend that started earlier continued, and the price slumped to USD9,500 per metric tonne in 2016. However, the trend changed from 2016, following the enforcement of an export ban on unprocessed ores in 2014 by Indonesia, the world-leading nickel producer.[198]

607. Almost all the changes in export prices of nickel products coincide with changes in nickel prices, especially those for *ferro-nickel* and *unwrought nickel*. Export prices of nickel mattes and nickel ores in some years have changed according to metal price. However, there were some extreme changes, like a 344 per cent growth of the *nickel mattes* export price.

608. Considering individual States, changes in nickel prices and export prices of nickel products in Zimbabwe and Madagascar are shown in Figure 6.13.

609. Export prices for all products in Zimbabwe are volatile and do not follow changes of nickel prices generally. However, it worth mentioning that export prices for *nickel ores and concentrates* and *nickel mattes* do not seem to be credible. There is a sharp increase in *nickel ores and concentrates* export price in 2014, by 401 per cent, which is inconsistent with nickel price changes. In addition, there is a significant increase in unwrought nickel export price in 2012 in Zimbabwe, by 253 per cent, whereas world metal prices were declining by 23 per cent. Since Madagascar started exports of *unwrought*

[197] Ehrlich L.G. (2018). *What drives nickel prices – A structural VAR Approach.* HWWI Research Paper 186. Hamburg Institute of International Economics (HWWI), 44 p. http://www.hwwi.org/fileadmin/hwwi/Publikationen/Publikationen_PDFs_2018/ HWWI_ResearchPaper_186.pdf.

[198] UN (2015). World commodity trends and prospects. Report of the Secretary-General. General Assembly, United Nations, 24 p. https://unctad.org/meetings/en/SessionalDocuments/a70d184_en.pdf.

Figure 6.13. Changes in nickel prices and export prices of nickel products in Zimbabwe and Madagascar

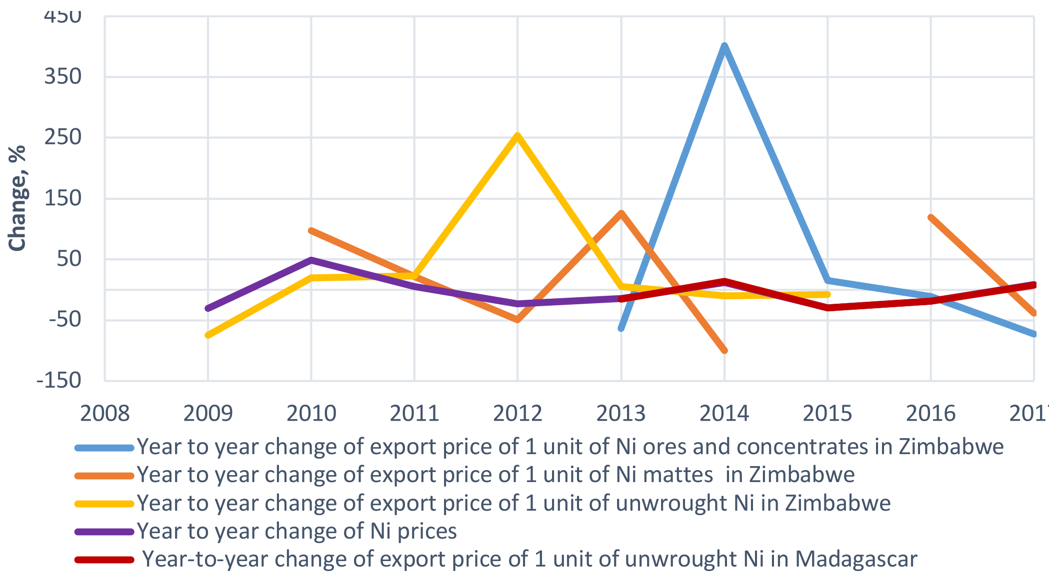
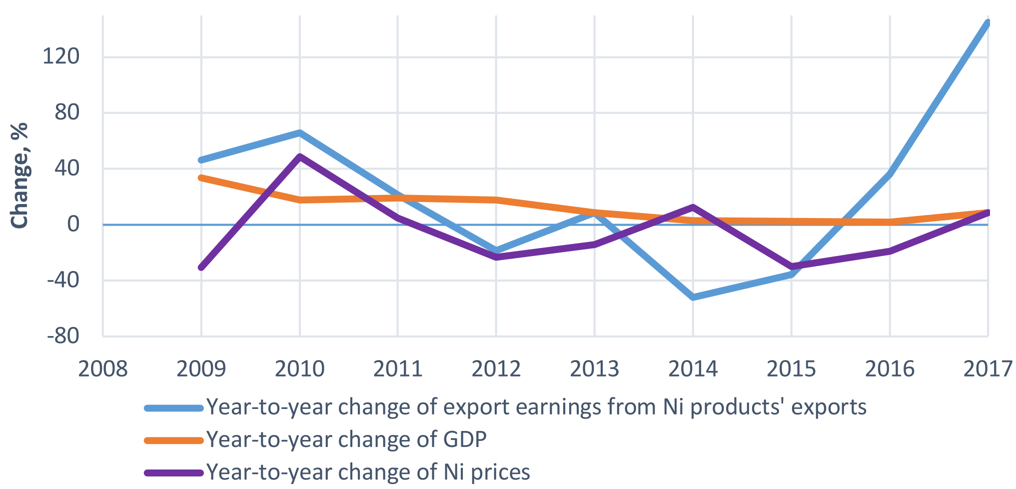


Figure 6.14. Changes in nickel prices, GDP, and export earnings from nickel products exports in Zimbabwe



nickel in 2012, its export price changes fully are consistent with metal price changes.

610. The GDP of Zimbabwe, the share of nickel products' exports in the GDP, and nickel prices were considered (Figure 6.14).

611. Figure 6.14 shows that changes in export earnings from all nickel products exports are quite consistent with changes in the metal price. However, there were periods when the metal price decreased by 30 per cent whereas export earnings increased by 46 per cent (in 2009), or when an increase in export earnings (145 per cent) was higher than an increase of prices (8 per cent) (in 2017). There was a period when the metal price increased by 12 per cent but export earnings decreased by 52 per cent, in 2014. The GDP of the State has never changed negatively

Figure 6.15. Changes in nickel prices, GDP, and export earnings from nickel products exports in Madagascar

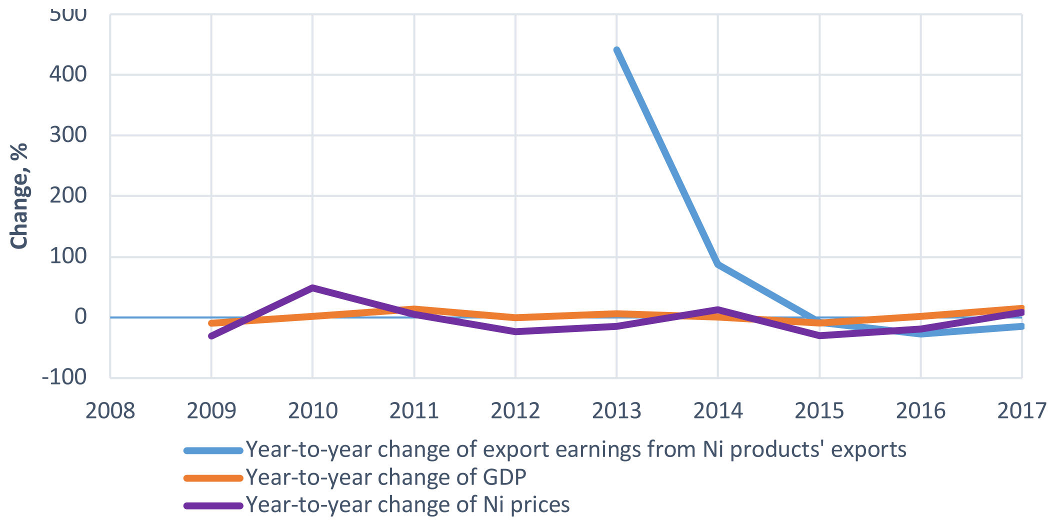
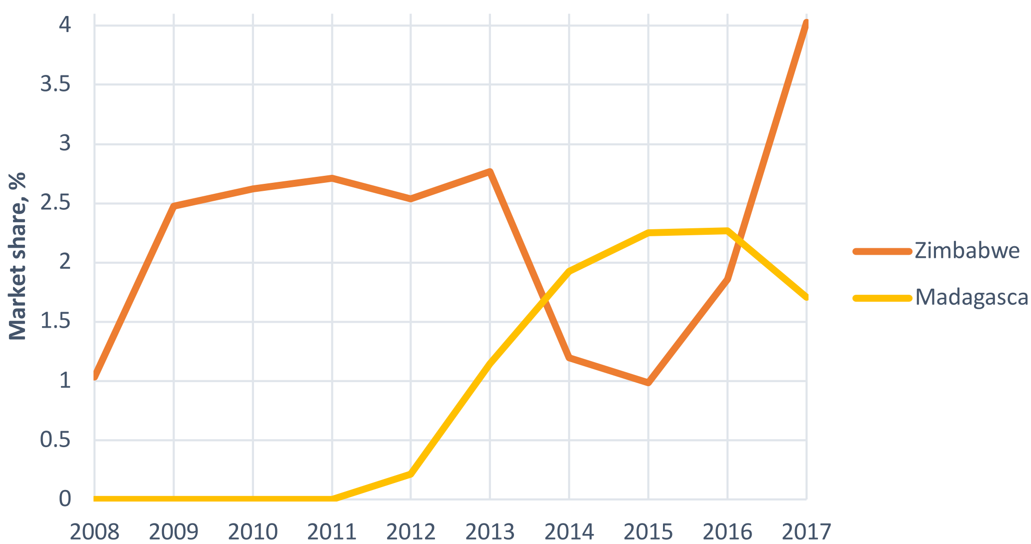


Figure 6.16. Market share of the DLBPS which are likely to be seriously affected (all nickel products)



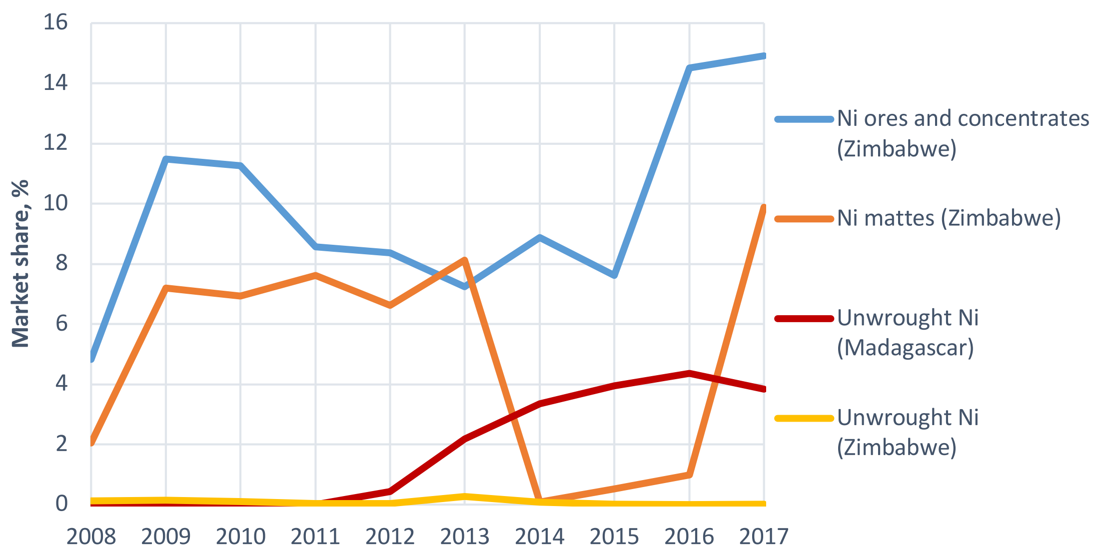
during the analyzed period. According to UNCTADstat data on individual States' GDP by type of expenditure and VA by kind of economic activity,[199] the average share of exports of all goods and services from Zimbabwe in the GDP of the State during the last 10 years is 29.3 per cent. As for the average share of mining, manufacturing, and utilities in the VA, it is 23.6 per cent for the last 10 years.

612. The GDP of Madagascar, the share of nickel products exports in GDP, and nickel price are shown in Figure 6.15.

613. Figure 6.15 shows that changes in export earnings from nickel products exports are intense compared to changes in the metal price. The GDP of the State generally shows positive changes. According to UNCTADstat data

[199] UNCTAD – UNCTADstat. Data center, Economic trends, National accounts, GDP by type of expenditure, VA by kind of economic activity. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95.

Figure 6.17. Market share of Zimbabwe and Madagascar (nickel products)



on individual States' GDP by type of expenditure and VA by kind of economic activity,[200] the average share of exports of all goods and services from Madagascar in the GDP of the State during the last 10 years is 18.6 per cent. The average share of mining, manufacturing, and utilities in the VA is 9 per cent for the last 10 years.

614. Market shares of the DLBPS which are likely to be seriously affected are shown in Figure 6.16.

615. It was found that both Madagascar and Zimbabwe have very low market shares of all nickel products.

616. For markets of each product, shares of Zimbabwe and Madagascar are shown in Figure 6.17.

617. The average share of Zimbabwe in the *nickel ores and concentrates* market is 9.8 per cent. Its share in nickel mattes markets is 5 per cent. As for *unwrought nickel*, the average market share of Zimbabwe is less than 1 per cent, and Madagascar 1.8 per cent.

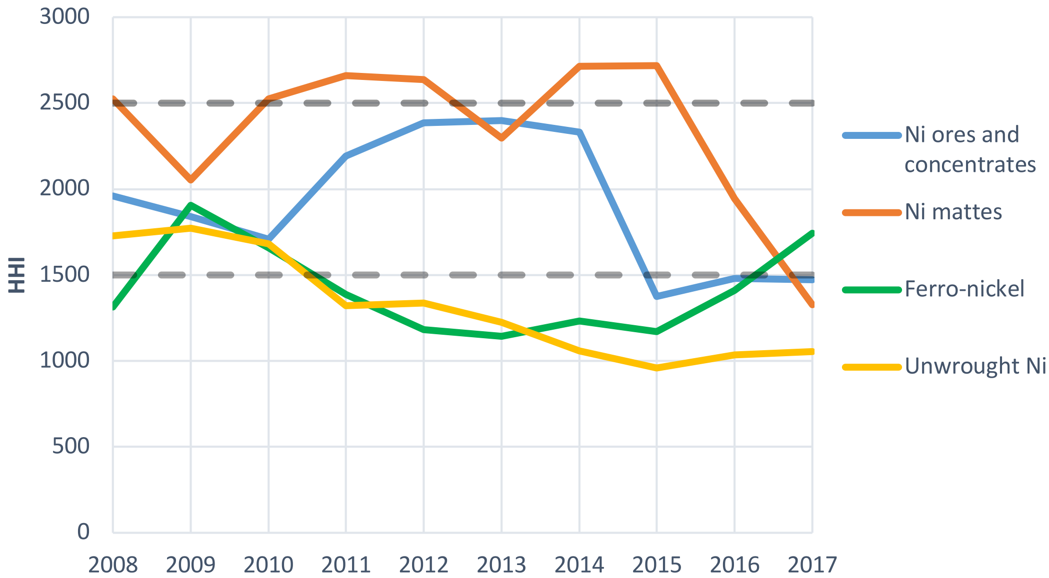
618. It seems that nickel products markets do not have very high concentration, but exports are concentrated in Indonesia, the Philippines, Zimbabwe, and other DLBPS (Figure 6.18).

619. The average HHI for the *nickel ores and concentrates* market is about 1900, so the market has moderate concentration. The *nickel mattes* average market concentration is also moderate (HHI=2300). The concentration of the *ferro-nickel* market is low (HHI=1400). The HHI rate for the *unwrought nickel* market is 1317, so the market has low concentration. Thus, markets for nickel products are moderate- to low-concentrated and competitive.

620. Analysis of nickel products' exports had shown that, in general, all nickel products' export prices are quite well correlated with nickel prices. However, consideration of individual States, particularly Zimbabwe, show totally opposite results, which could be because of uncertainties in the data. As for export prices of *unwrought nickel* from Madagascar, these are highly correlated with nickel prices.

[200] Ibid.

Figure 6.18. The concentration of nickel products markets



621. It is hard to say what would happen to export earnings of Zimbabwe with the beginning of seabed mining, because, in general, export earnings seem to be correlated with nickel prices, but there are sharp deviations, probably caused by uncertainties in the exports data. However, it was found that the GDP of the State is not very consistent with export earnings from the sale of nickel products. As for Madagascar, the State exports only *unwrought nickel,* and export earnings of the State from the sale of this product seem not to be related to the metal price. The same is true for the GDP of the State; it is not correlated with export earnings. These States both have a low share of nickel products markets, especially in the market of *unwrought nickel*. This market has low concentration, so it could happen that seabed mining would not harm the market, as it is already highly competitive. What could happen is that exporters which have low market share, or which export low-quality nickel products, would have to leave the market.

Cobalt

622. Changes in cobalt prices and export prices of cobalt products in the world are shown in Figure 6.19.

623. With the ensuing global financial crisis and economic downturn, demand fell and cobalt prices slumped to below USD40,000 per metric tonne in December 2008. This also was related to the instability of DR Congo. Despite a short-lived upturn during 2009, attributed to growing battery demand and concerns about supply from Canada and Zambia, the cobalt price followed a general downward trend between 2010 and late 2016, caused by cobalt surplus and China de-stocking.[201] While prices have remained relatively stable and low since 2012 (on average USD30,000 per metric tonne), these nearly doubled to values around USD60,000 per metric tonne in 2017.[202] The fundamental reasons for this spectacular increase were strong demand from consumers in China for rechargeable batteries, together with

[201] Alves Dias, P., Blagoeva, D., Pavel, C., and Arvanitidis, N. (2018). *Cobalt: demand-supply balances in the transition to electric mobility*. EUR 29381 EN. Luxembourg: Publications Office of the European Union.
[202] S&P Global Market Intelligence (2018). SNL Metals & Mining database.

Figure 6.19. Changes in cobalt prices and export prices of cobalt products in the world

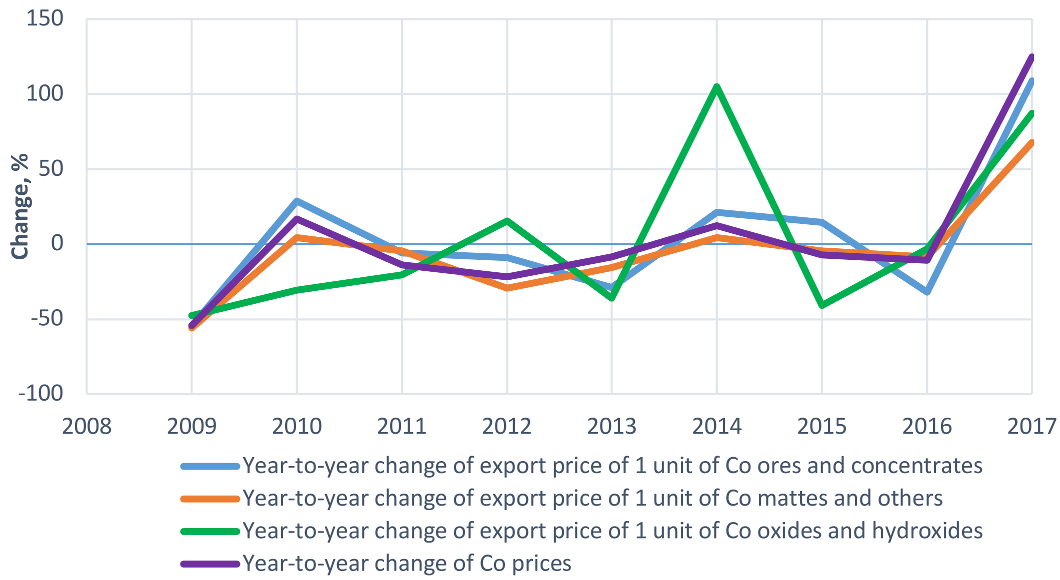
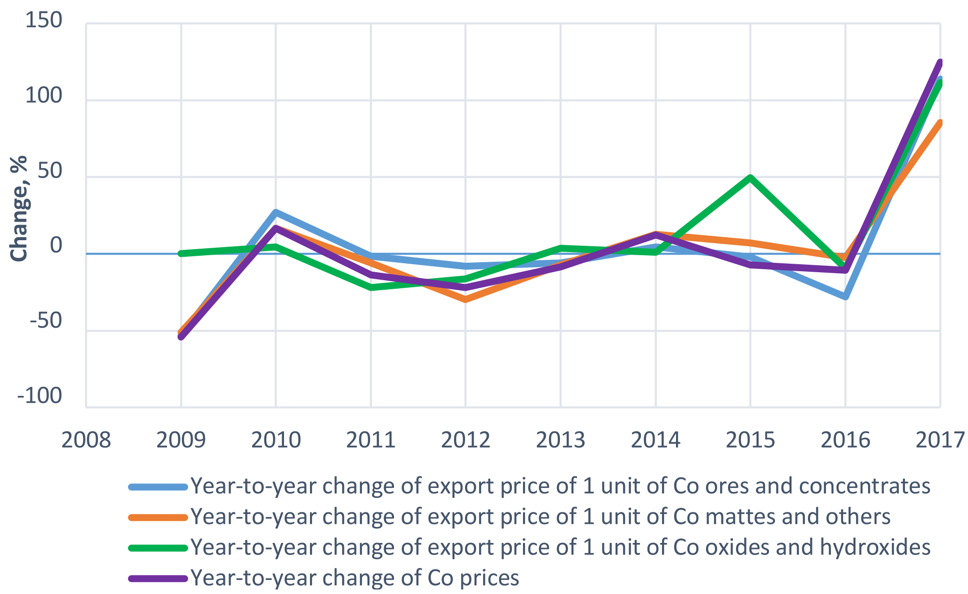


Figure 6.20. Changes in cobalt prices and export prices of cobalt products in DR Congo



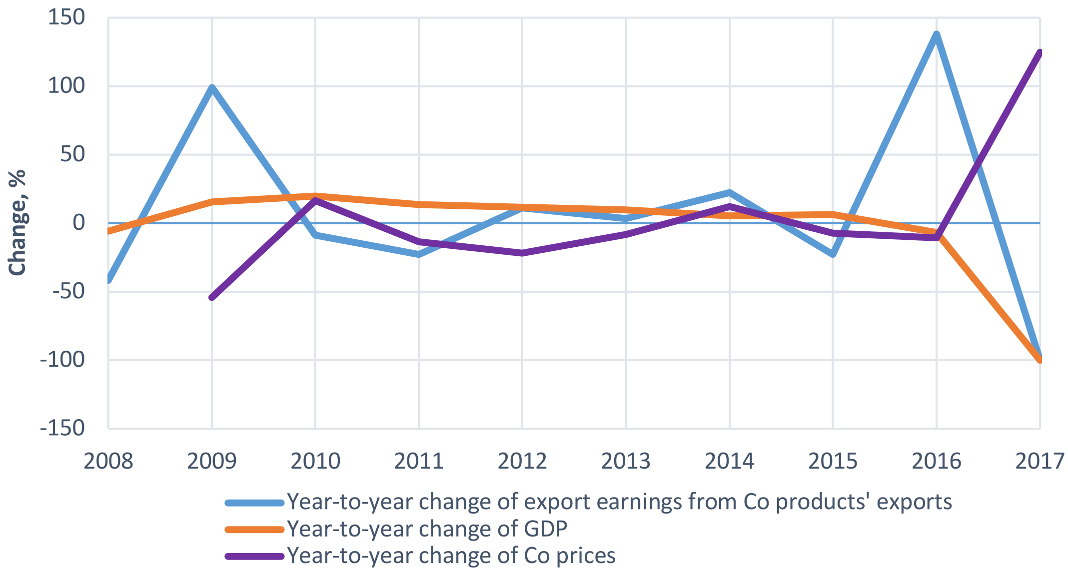
concerns about mine production from DR Congo and the availability of cobalt metal from refineries in China.[203] This upward trend could be transitory, with the industry returning to the lower prices of the recent past, or further price increases may occur due to limited cobalt output.[204]

624. Almost all the changes in export prices of cobalt products coincide with changes in cobalt prices, especially those for *cobalt ores* and *cobalt mattes*. Changes in *cobalt oxides* export prices are different. For example, while the prices for other products and the metal price rose in 2010, the *cobalt oxides* price decreased by 31 per cent, and conversely, while its price

[203] Petavratzi, E., Gunn, G., and Kresse, C. (2019). *Commodity review: Cobalt*. British Geological Survey.

[204] Alves Dias, P., Blagoeva, D., Pavel, C., and Arvanitidis, N. (2018). *Cobalt: demand-supply balances in the transition to electric mobility*. EUR 29381 EN. Luxembourg: Publications Office of the European Union.

Figure 6.21. Changes in cobalt prices, GDP, and export earnings from cobalt products exports in DR Congo



increased by 15 per cent in 2012, other prices have fallen. Further upturns and slumps were much more intense for *cobalt oxides* prices than for the prices of other products.

625. Considering individual States, changes in cobalt prices and export prices of cobalt products in DR Congo are shown in Figure 6.20.

626. The situation in DR Congo is the same as in the world: export prices of *cobalt ores* and *cobalt mattes* change in accordance with cobalt price. The export price of *cobalt oxides* does not follow the general trend, but its volatility is not as high as in the world. The main inconsistency is the rise of the *cobalt oxides* export price in 2015 by 49 per cent while the price of *cobalt mattes* rose by 7 per cent, the price of *cobalt ores* decreased by 2 per cent, and the price of cobalt metal decreased by 7 per cent.

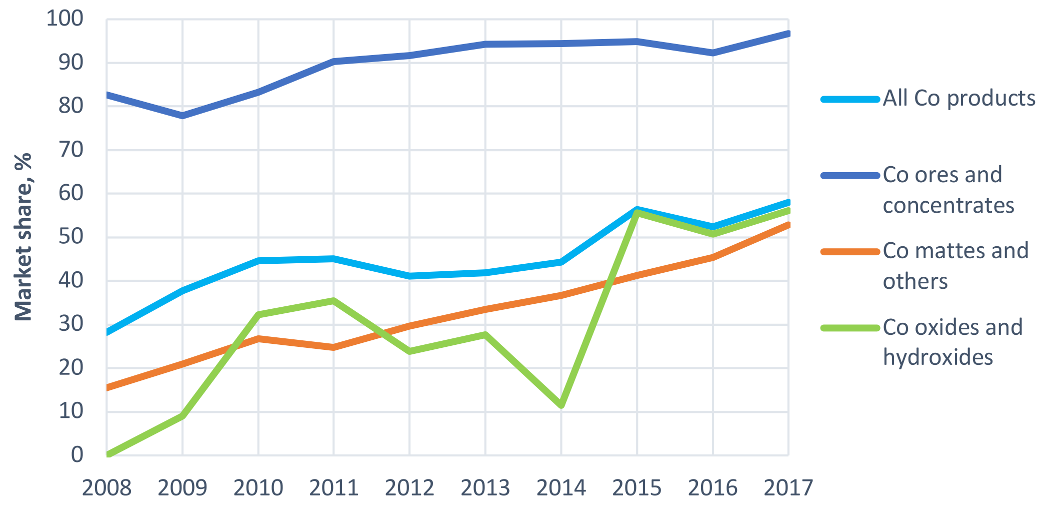
627. The GDP of DR Congo, the share of cobalt products exports in its GDP, and cobalt prices were considered (Figure 6.21).

628. Figure 6.21 shows that changes in export earnings from all cobalt products exports are not consistent with changes in the metal price. The general trend is that changes in metal prices are shifted by at least one year ahead from changes in export earnings. It is hard to say whether changes in the GDP of the State are associated with changes in export earnings. These changes have different rates. According to UNCTADstat data on individual States' GDP by type of expenditure and VA by kind of economic activity,[205] the average share of exports of all goods and services from DR Congo during the last 10 years is 34 per cent, and the average share of mining, manufacturing, and utilities in the VA is 40 per cent for the last 10 years.

629. Market shares of DR Congo including each cobalt product are shown in Figure 6.22.

[205] UNCTAD – UNCTADstat. Data center, Economic trends, National accounts, GDP by type of expenditure, VA by kind of economic activity. URL: https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95.

Figure 6.22. Market share of DR Congo (cobalt products)

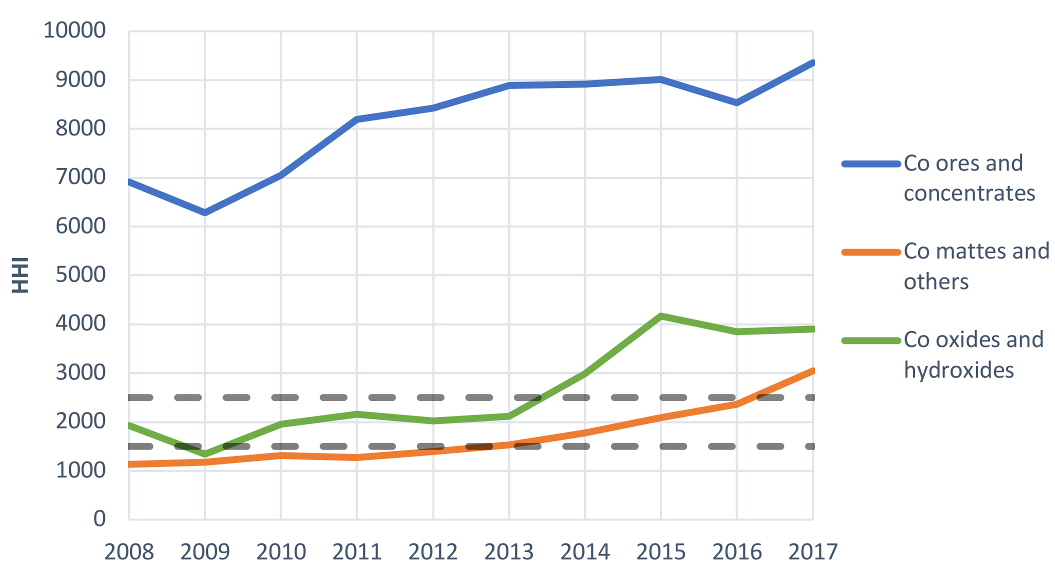


630. It was found that DR Congo has on average 45 per cent market share of all cobalt products. Regarding markets of each product, the largest share of DR Congo is in the *cobalt ores* market, at 90 per cent. As for *cobalt mattes*, the DR Congo share in this market is 33 per cent, and 30 per cent in the *cobalt oxides* market.

631. It was found that the cobalt products market is highly concentrated, with the concentration of production of cobalt products in DR Congo (Figure 6.23).

632. On average, the HHI score for the exported values of *cobalt ores and concentrates* is approximately 8100, so this market is highly concentrated in DR Congo. As for *cobalt mattes and other intermediate products of cobalt metallurgy*, the HHI is about 1700 on average, so the market is moderately concentrated. The market of *cobalt oxides and hydroxides* has an average HHI of about 2600, so the market is highly concentrated.

Figure 6.23. The concentration of cobalt products markets



633. Thus, it was found that export prices of cobalt products are highly correlated with cobalt prices both in the world and in DR Congo. Export earnings of DR Congo are correlated with cobalt prices, but with a shift of two years. The economy of the State is quite dependent on cobalt products, especially on *cobalt ores and concentrates*.

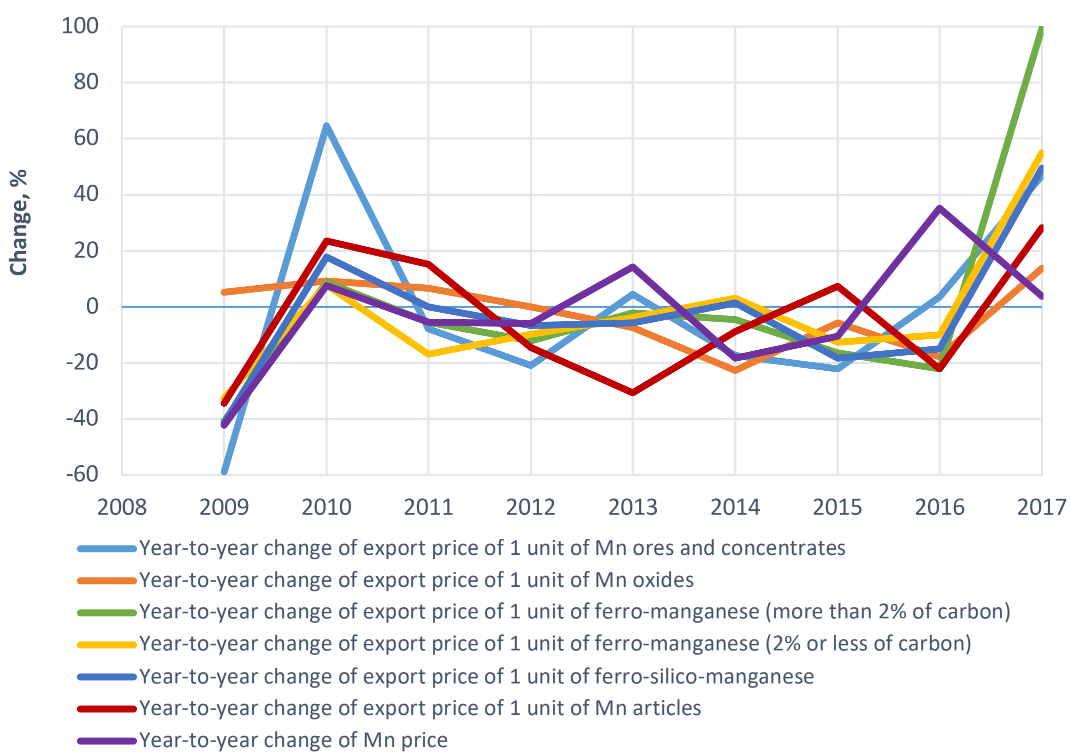
634. The fact that the mined cobalt supply is highly concentrated in one country poses high risk compared to a circumstance where the global mine production is distributed more evenly over a large number of countries. Currently, no alternative country is positioned to increase production to meet global demand if production from DR Congo were to be constrained or disrupted.[206]

635. Problems in DR Congo, such as natural disasters or high sociopolitical instability, can result in vulnerability to supply-chain disruptions. Reduction of production in the largest exporter can lead to political and social unrest, declining economic conditions, a lack of foreign investment, and declining cobalt mine production, like in 1990 in DR Congo. From 2000 to 2015, cobalt mine production in DR Congo continued to trend upward and by 2015, one-half of world mine production was from DR Congo. As a result, the geographic distribution of world cobalt mine production became increasingly concentrated.[207]

Manganese

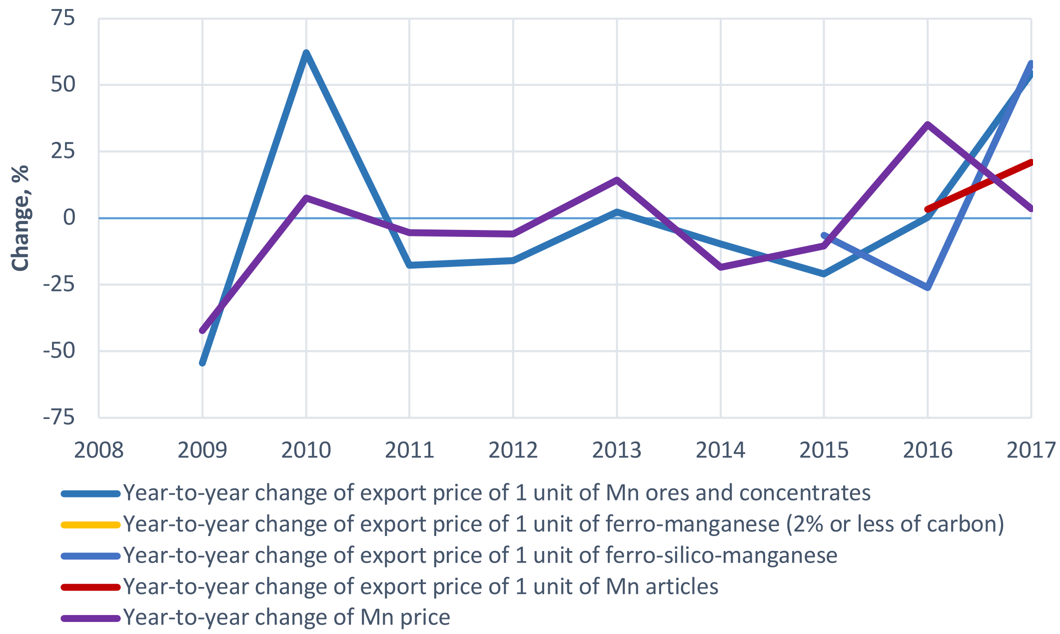
636. Changes in manganese prices and export prices of manganese products in the world are shown in Figure 6.24.

Figure 6.24. Changes in manganese prices and export prices of manganese products in the world



[206] Shedd K. et al. (2017). Global trends affecting the supply security of cobalt. Mining Engineering, December 2017, pp. 37–42.
[207] Ibid.

Figure 6.25. Changes in manganese prices and export prices of manganese products in Gabon



637. The economic crisis in 2008 caused a sharp decrease in manganese prices, similar to other metals,[208] to almost USD1,500 per metric tonne. Another decrease in manganese prices in 2010 again to USD1,500 per metric tonne, and in 2013 to an even lower level of USD1,200 per metric tonne, is probably related to the decrease in global crude steel production. The manganese ore market was oversupplied, as demand fell faster than production, but recent production cuts are contributing to rebalancing the market. It returned to equilibrium in 2017,[209] reaching below USD1,700 per metric tonne.

638. Export prices of almost all products, except *manganese articles* and *manganese ores*, are close to the manganese price and follow its fluctuations. One noticeable inconsistency of the *manganese ores* price is its growth higher than other products in 2010 by 64 per cent. As for *manganese articles*, the price significantly decreased by 31 per cent in 2013, unlike other products' prices. It is worth to note the inconsistency of all products with metal prices in 2016, when manganese prices peaked, while export prices of manganese products decreased.

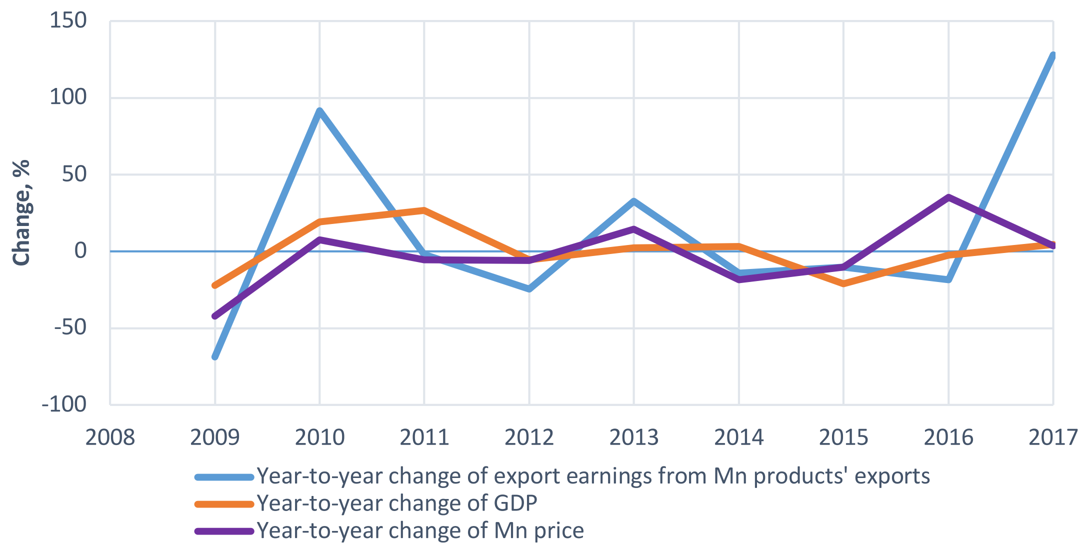
639. Considering individual States, changes in manganese prices and export prices of manganese products in Gabon are shown in Figure 6.25.

640. There are gaps in the graph in Figure 6.25 because Gabon does not export *manganese oxides*, *ferro-manganese (more than 2 per cent of carbon)*, and *ferro-silicon*, and also because *ferro-manganese (2 per cent or less of carbon)* was exported from Gabon only once during this period, in 2013. *Ferro-silico-manganese* was exported in 2011, then exports stopped and started again as of 2014. Exports of *manganese articles* started in 2015. The

[208] Papp J. F., Corathers L. A., Edelstein D. L., Fenton M. D., Kuck P. H., and Magyar M. J. (2007). *Cr, Cu, Mn, Mo, Ni, and Steel Commodity Price Influences, Version 1.1*. Reston, VA: U.S. Geological Survey Open-File Report 2007–1257, 112 p. https://pubs.usgs.gov/of/2007/1257/ofr2007-1257v1.1.pdf.

[209] d'Harambure A. (2016). Overview of the Global Manganese Industry with a special focus on China. IMnI, Metal Bulletin Conference, March 24, 2016, Singapore. https://www.metalbulletin.com/events/download.ashx/document/speaker/8479/a0ID000000ZP1jZMAT/Presentation.

Figure 6.26. Changes in manganese prices, GDP, and export earnings from manganese products exports in Gabon



export price changes of many products do not coincide with manganese prices due to the abovementioned gaps. The export price of *manganese ores* had great inconsistency with manganese price changes in 2009 when the growth of the *manganese ores* export price was above 60 per cent.

641. The GDP of Gabon, the share of manganese products exports in its GDP, and manganese prices were considered (Figure 6.26).

642. Figure 6.26 shows that changes in export earnings from all manganese products exports are inconsistent with changes in the metal price. There is a great increase in export earnings in 2010, by 92 per cent, while the increase in price was just 8 per cent. The GDP of the State hardly follows the trend of price and export earnings changes. However, according to UNCTADstat data on individual States' GDP by type of expenditure and VA by kind of economic activity,[210] the average share of exports of all goods and services from Gabon during the last 10 years is 53 per cent, so probably it includes exports of manganese products also. As for the average share of mining, manufacturing, and utilities in the GDP, it is also high at 52 per cent for the last 10 years.

643. Market shares of each manganese product for Gabon are shown in Figure 6.27.

644. Gabon has a quite large share of the *manganese ores* market (19 per cent), which is the only significant contribution of the State to manganese products markets.

645. Figure 6.28 shows concentrations of each manganese market.

646. The average HHI score for the *manganese ores* market is above 2500, which shows high market concentration. The market for *manganese oxides* has low concentration, with HHI=1200. As for *ferro-manganese (more than 2 per cent of carbon)*, the market has an HHI score of 1800, showing moderate concentration of the market. The *ferro-manganese (2 per cent or less of carbon)* market also has moderate concentration, as its HHI score equals approximately 1700. The

[210] UNCTAD – UNCTADstat. Data center, Economic trends, National accounts, GDP by type of expenditure, VA by kind of economic activity. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95.

Figure 6.27. Market share of Gabon (all manganese products)

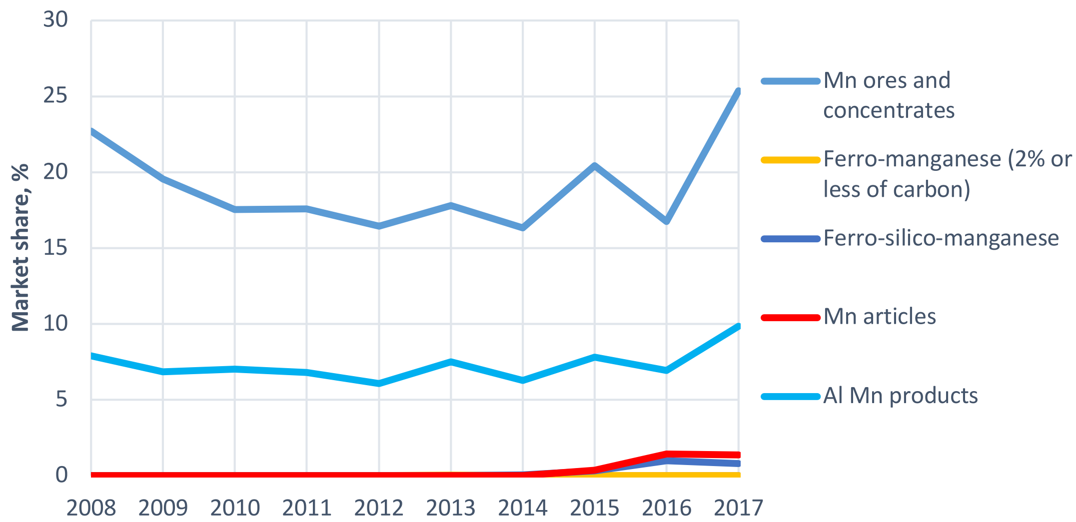
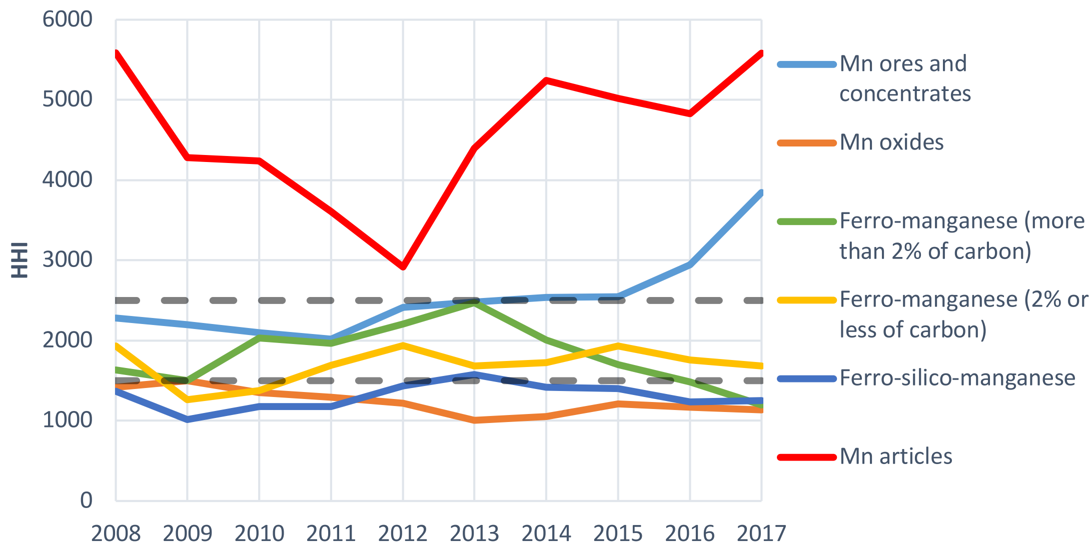


Figure 6.28. The concentration of manganese products markets



market for *ferro-silico-manganese* has low concentration with average HHI=1300. The *ferro-silicon* market has even lower concentration (HHI=900). However, the concentration of the *manganese articles* market is very high (HHI=4500).

647. The analysis of manganese products' exports results in the conclusion that in general, in the world, export prices of almost all concerned manganese products are correlated with manganese prices, except for *manganese ores* and *manganese articles.* In the concerned State, Gabon, none of these products' export prices are correlated with manganese price, probably because of the gaps in exports of some products from Gabon. The same thing is true for the relation of export earnings to manganese price and to the GDP of the State. However, Gabon has quite a high share of the *manganese ores* market, which is highly concentrated.

Summary

648. Production of metals from manganese nodules can lower metal prices on the world market because of increased supply. A decrease in metal prices can cause a decrease in export prices of this metal's products, as exporters cannot sell their products at high prices anymore, but the products should still be sold. Thus, the export earnings of the State can fall. This can lead to the closure of mines, especially if the profits of a mining company are less than production expenditures in a situation when export prices are low. Closure of mines, in turn, will cause unemployment and other social problems.

649. The present problem of the international economy is a high concentration of metal markets. Probably, this problem would be solved if production in the country with the highest market share decreases considerably, or if there is increased production in another country. Low market concentration may become even lower if there is a new production and exports source in the international market. Concentration can also increase if production in one State increases until it displaces other exporters and becomes a monopolist.

650. These changes could happen with the start of seabed production in the Area. Exports of metal products from the DLBPS can decrease and, consequently, export earnings of the State can decrease. Potentially, this would decrease market concentration for metal products and stabilize the world market if the State had a high market share. If the State has a low market share, and if the market has low concentration, the start of seabed activities could lead to even greater growth of competition on the market.

651. One of the possible reasons for high exports from the States concerned is economic processes in the States, like devaluation of national currency. Devaluation means depreciation of the national currency against the US dollar. Trade in the world market and export of products occur in the US dollars. Income received by the country when exchanging the foreign currency to its national currency is called devaluation income. This income is noticeable when national currency rates are lower than the US dollar rates. Devaluation processes lead to an increase in exports from the State. With this, the competitiveness of the national economy and local goods in the international market increases. At the same time, domestic production is stimulated. In particular, the devaluation of the national currency makes it possible for exporters in the country to lower the prices of their products in foreign currency. They can receive a premium when exchanging the proceeds of a more expensive foreign currency for a cheaper national currency, and sell goods at prices below the world average, which leads to their enrichment at the expense of material losses of their country.

652. However, devaluation has disadvantages for the economy of the State. It can cause an increase in the inflation rate in the State. The inflation rate increases, because when domestic products become cheaper, manufacturers raise prices on the domestic market. Imported products become less competitive and inaccessible to the average consumer, and their prices increase. Lowering of the exchange rate leads to a decrease in the inflow of foreign and national capital into the country.

653. At the beginning of devaluation, countries that artificially lowered the exchange rate of their own currency face a revival of the economy caused by an increase in export competitiveness. However, further restrictions on intra-and inter-sectoral redistribution of resources increase, and most of the national income is directed to the sphere of production by reducing the share of consumption in it, which leads to an increase in consumer

prices in the country, due to which there is a decline in the standard of living of the population.

654. The DLBPS exports metal products and receives earnings in the US dollars, which are then exchanged for State's local currency. The lower the exchange rate, the more devaluation income is received by the State. However, in case of a reduction of exports, for instance, because of seabed production, the lower the exchange rate, the more is the loss of export earnings of the State.

655. The economic performance of the State in terms of exports is directly related to the production of minerals. If there is a high demand for some products, production increases, especially in countries which have high reserve bases. Certainly, there are several barriers that can limit production. These factors include reserves depletion or unforeseeable production stoppages at active mines, the slow speed of developing mining projects from exploration to production, economic and socio-environmental determinants, high costs of production restricting extraction at certain prices, events such as strikes, plant failures, and other factors that can lead to unforeseeable production stoppages.[211]

656. Probably, seabed production is going to be started by countries like China, Japan, France, Russia, Germany, and Belgium. Currently, these countries are importers of metal ores from the DLBPS. Seabed production will provide these States raw materials, so their imports from the DLBPS will be stopped. This will create negative effects on the export earnings of the developing States. Besides, increased volumes of raw materials in international markets will push the prices of metals down. Thus, export prices of metal products from the DLBPS, and respectively their export earnings, will fall. A decrease in exports may lead to a decrease in production rates, closure of mine sites, and consequently a decrease in export earnings of the State.

657. However, the reduction of exports of raw materials could stimulate the DLBPS to process these materials in their own territory, to develop the metallurgical sector. This will provide a population with jobs and maintain the economy, as well as allow the DLBPS to export more valuable semi-finished and end products of metals.

B. Sectoral effects of the affected metals tariffs

658. As was mentioned before, economies of the DLBPS are directly related to the production of minerals. In periods of high demand for some mineral product, production of this mineral increases, especially in the States which are rich in this mineral resource, like Chile (copper), Zimbabwe (nickel), DR Congo (cobalt), and Gabon (manganese). Mostly these are developing States, and for implementation of new mining projects, they need capital, which is rarely available in such States. Foreign investments can help, but it is preferable to invest in projects in the States with a stable economic, social, and political situation.

659. Besides, barriers such as reserves depletion, unforeseeable production stoppages at active mines, slow speed of developing mining projects from exploration to production, economic and socio-environmental determinants, high costs of production restricting extraction at certain prices, strikes, plant failures, and other factors can lead to unforeseeable production stoppages.[212]

660. Probably, seabed production is going to be started by contractors in States such as China, Japan, France, Russia, Germany,

[211] Alves Dias, P., Blagoeva, D., Pavel, C., and Arvanitidis, N. (2018). *Cobalt: demand-supply balances in the transition to electric mobility*. EUR 29381 EN. Luxembourg: Publications Office of the European Union.
[212] Ibid.

and Belgium. Currently, these countries import metal ores from the DLBPS, including those which are likely to be seriously affected by seabed production. Raw materials obtained from manganese nodules will be used by these States to produce finished products, and they will no longer be dependent on the DLBPS. This will create negative effects for economies of developing States by reducing their export earnings from exports of affected metals and, consequently, by decreasing export prices of these metals' products.

661. In addition, increased volumes of raw materials on international markets will push prices of metals down, which is another related reason for the reduction of export prices of metal products in the DLBPS and, respectively, decrease of their export earnings. After all, a decrease in exports because of the low demand for affected metals from the DLBPS may lead to a decrease in production rates of raw materials in these States, closure of mine sites, and, consequently, a decrease in export earnings of the State. Thus, the decrease in export prices of raw materials directly influences the extractive sector of the DLBPS.

662. However, the reduction of exports of raw materials has positive sides: it can stimulate the DLBPS to process these materials in their territory, developing the metallurgical sector. This will provide the population with jobs and maintain the economy, as well as allowing the DLBPS to export more valuable semi-finished and finished metal products.

663. An important issue for future seabed production is where manganese nodules are going to be processed. What is also important is that currently there are no special metallurgical plants to extract metal products from nodules. Such a plant could be located either in the host nation of a contractor or in another State. In the first case, all the revenues will go to the contractor and the processor, which would probably be part of one vertically integrated system, and to their host nation, not counting royalties. In the second case, even if the contractor and the processor are part of one vertically integrated system, some part of the revenues will go to the State where the processing facilities are located. If such plants are located in the DLBPS, this can be an additional source of revenue for these States.

664. It is expected that developed States, who are planning to start seabed mining in the nearest future, are going to process raw materials in order to use finished products in their country, not for the primary purpose of exports, but to be independent of other States. However, the rest of the finished products, which are not demanded in the State, probably can be sold on the international market to other States. Thus, a new competitor on the market can appear, and its effect on market conditions will depend on the quantity of its supply and export prices, as well as on the existing concentration of the market. In the case of a highly concentrated market, a new competitor, wanting to sell products for lower prices, can change market concentration, reduce monopoly, and stabilize the market. In the case of a low concentrated market, lower prices of a new competitor could be a reason for the States who sell for higher prices to reduce their share or even exit the market.

665. Thus, increased supply on the international market may reduce metal prices and export prices of metal products. As was mentioned before, a high supply of raw materials on the international market can reduce exports of these materials from the DLBPS. This will stimulate the sale of these materials on the domestic market for cheaper prices. Thus, industries that are located downstream from the mining sector can source the raw material at a lower price. In the vertical structure of the minerals industries, the metallurgical sector and the sector of manufacture of metal products are sufficiently close to

the extractive sector in the value chain, so these sectors can benefit when more and cheaper raw material becomes available. Consequently, such industries can sell produced finished products at a cheaper price than would otherwise be possible. In turn, this can enable the State to export the end products at a relatively cheaper price that therefore may get a larger share of the export market and receive more export earnings.

666. The higher-value products are able to compete successfully in the domestic or international market, so the share of processed products in the State's overall export activity rises relative to that of the ROW. Economies can benefit from downstream production through higher and more stable export earnings resulting from a more diversified export offer, more employment, the acquisition of skills, and more advanced technology and linkages to other sectors. However, this again can have negative results when returns, profits, and welfare of producers of the primary raw material diminish, which may lead them to cut back existing mining operations or new investments.

C. Potential effects of a targeted tariff on semi-finished products

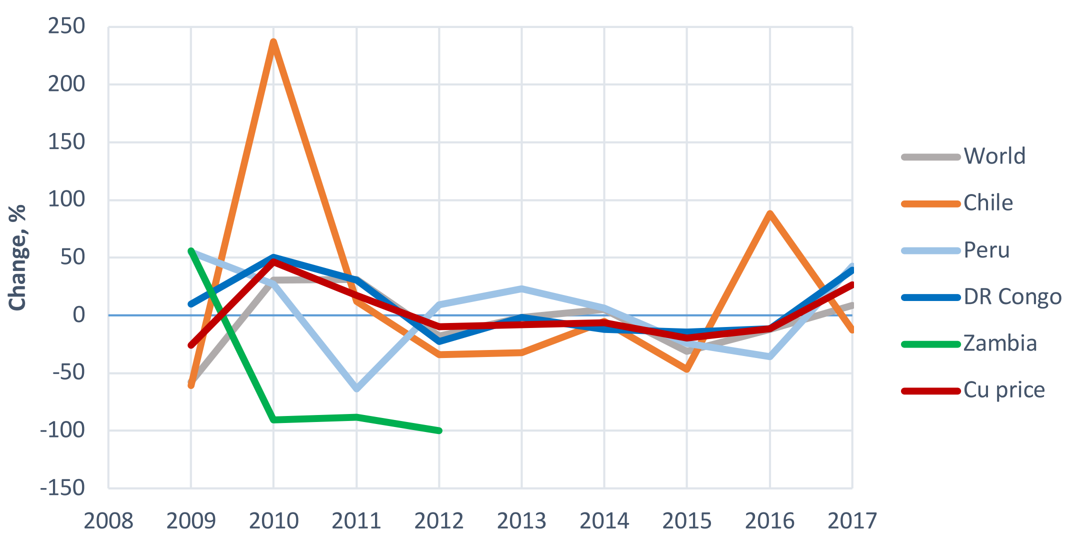
667. For the four metals concerned in this study, there are three semi-finished products which were considered:

- *Copper mattes, cement copper (precipitated copper)* (HS 7401): semi-finished products of copper production
- *Copper, unrefined, copper anodes for electrolytic refining* (HS 7402): end products of copper production
- *Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy* (HS 7501): semi-finished products of nickel production.

Copper

668. Export prices for relevant products and metal prices for the DLBPS which are likely to be seriously affected, and for the world in general, were analyzed together. A comparison of *copper mattes* price changes is in Figure 6.29.

Figure 6.29. Year-to-year changes in copper prices and copper mattes export prices for the DLBPS which are likely to be seriously affected and the world



669. It can be seen in Figure 6.29 that export prices of *copper mattes* vary widely for different States and in comparison with the metal price. Export prices of DR Congo are consistent with the world export price, and with the copper price. The greatest inconsistencies are for Chile, Peru, and Zambia. The decrease of export price for the latter may be related to the fact that Zambia terminated exports of copper mattes in 2011 until 2017. To 2010, when export prices rose for all the States on average by 36 per cent, the rise in Chile was by 237 per cent. In 2016, during the decrease in prices, the export price in Chile increased by 88 per cent. As for Peru, in 2011 its export price fell by 64 per cent, while prices in other States and in the world increased. The opposite trend held from 2012 to 2013, when all the prices were falling, unlike the price in Peru, which was rising.

670. A comparison of *unrefined copper* price changes is in Figure 6.30.

671. It can be seen in Figure 6.30 that export prices of *unrefined copper* are consistent with copper prices for all States, except Zambia, probably because exports of this product were temporary and terminated in 2012. Some discrepancies are noticeable for the export prices of Peru. In 2009 and in 2014, for example, the export price of *unrefined copper* increased by 41 per cent and 6 per cent, respectively, while export prices of other States and metal prices were decreasing.

672. It worth considering exported values and quantities of copper semi-finished products for the DLBPS together with metal prices. Chile, Peru, and DR Congo were chosen for further analysis. For *copper mattes,* these are shown in Figures 6.31, 6.32, and 6.33.

673. In general, a decrease in metal price leads to a decrease in export prices and export earnings, and vice versa. However, an increase in export price does not necessarily lead to the same rate of increase in export earnings, for example, in Chile in 2010, export price rose by 237 per cent while the rise of export earnings was 121 per cent, and in DR Congo in 2011 export price rose by 30 per cent while the rise of export earnings was just 3 per cent. In some years, the increase of export price was in line with the decrease of export earnings (in 2011 in Chile), and in the opposite direction, a decrease of

Figure 6.30. Year-to-year changes in copper prices and unrefined copper export prices for the DLBPS which are likely to be seriously affected and the world

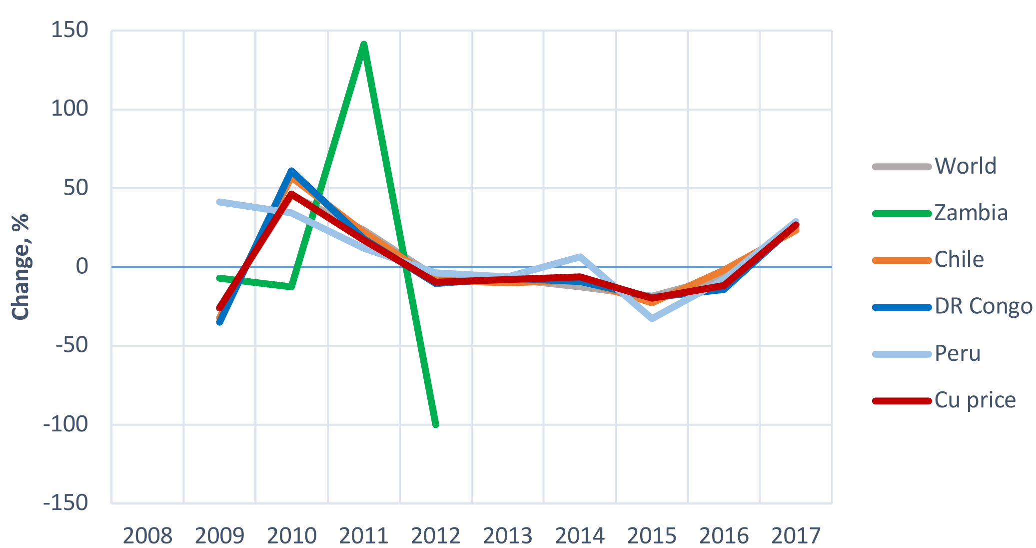


Figure 6.31. Year-to-year changes in copper prices, copper mattes export prices, exported quantities, and export earnings of Chile

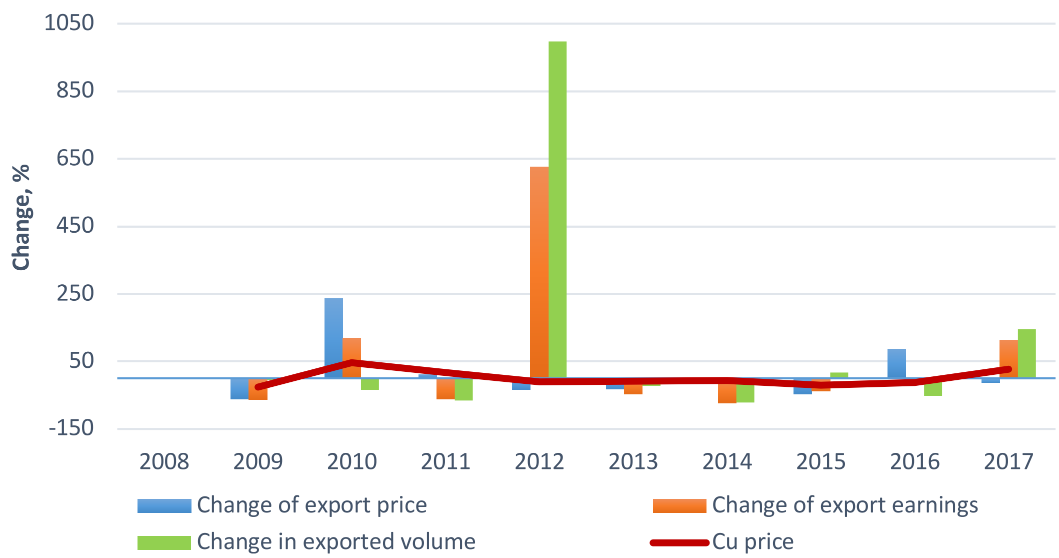
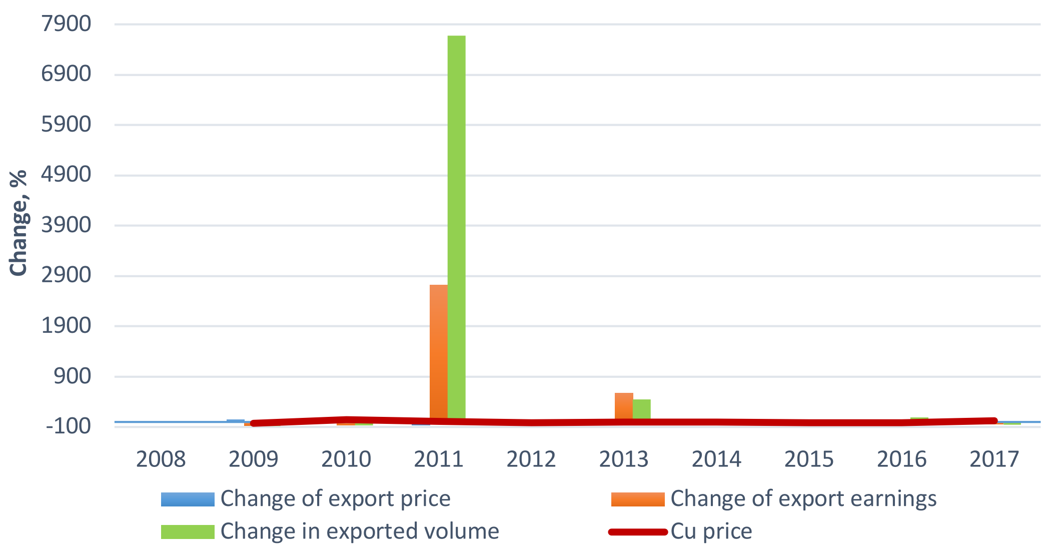


Figure 6.32. Year-to-year changes in copper prices, copper mattes export prices, exported quantities, and export earnings of Peru



export price sometimes was associated with an extreme rise of export earnings (in 2012 in Chile). For example, the decrease in export price and at the same time the rise of export earnings happened in DR Congo in 2014–2015. During some years of high metal prices, even the decrease in exported volumes could be in line with an increase of export prices, like in 2011 in DR Congo and 2010–2011 in Chile.

674. Analyses of *unrefined copper* prices for these States are in Figures 6.34, 6.35, and 6.36.

Figure 6.33. Year-to-year changes in copper prices, copper mattes export prices, exported quantities, and export earnings of DR Congo

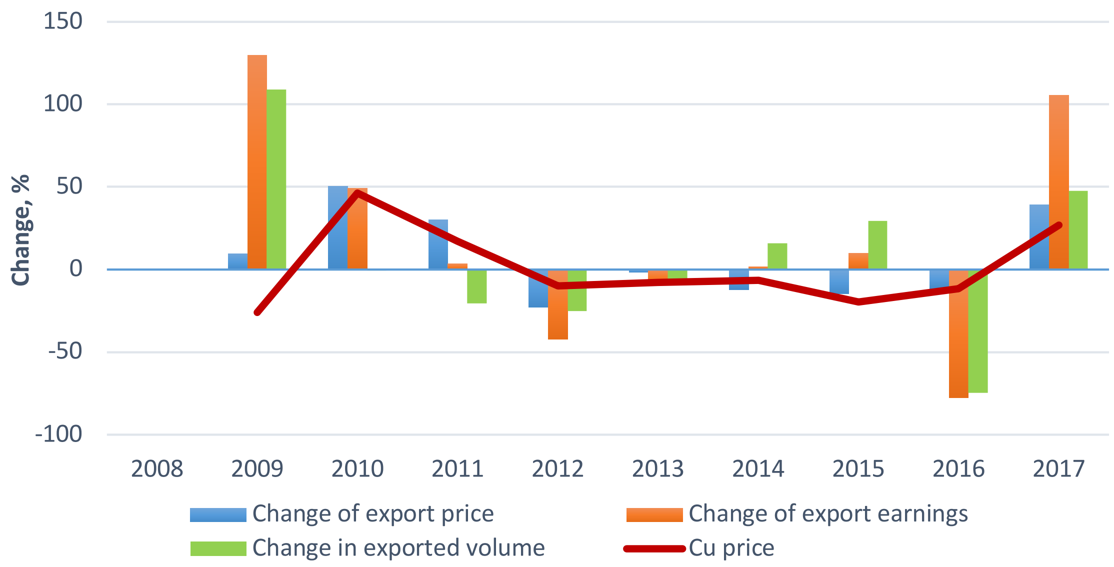


Figure 6.34. Year-to-year changes in copper prices, unrefined copper export prices, exported quantities, and export earnings of Chile

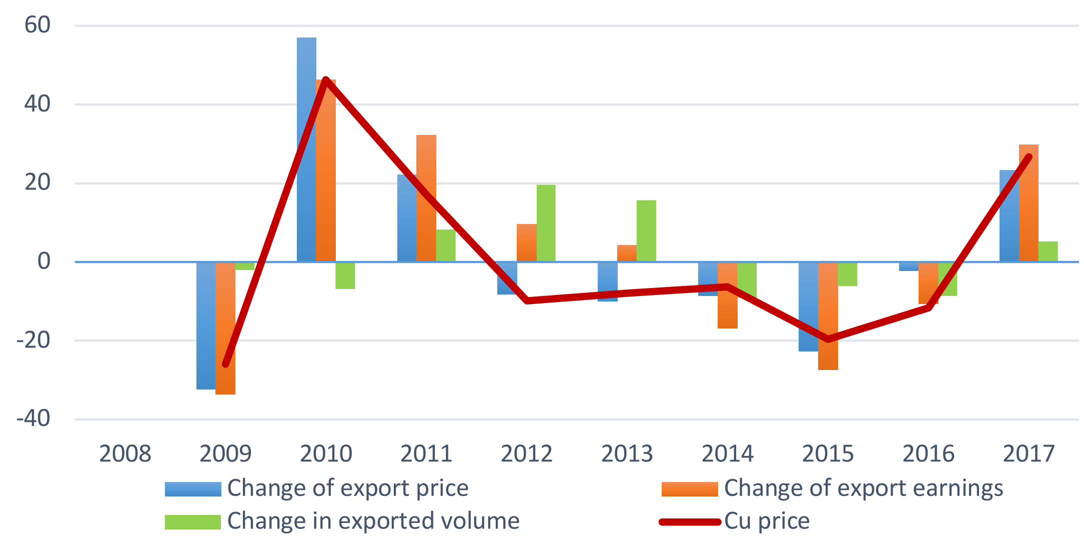


Figure 6.35. Year-to-year changes in copper prices, unrefined copper export prices, exported quantities, and export earnings of Peru

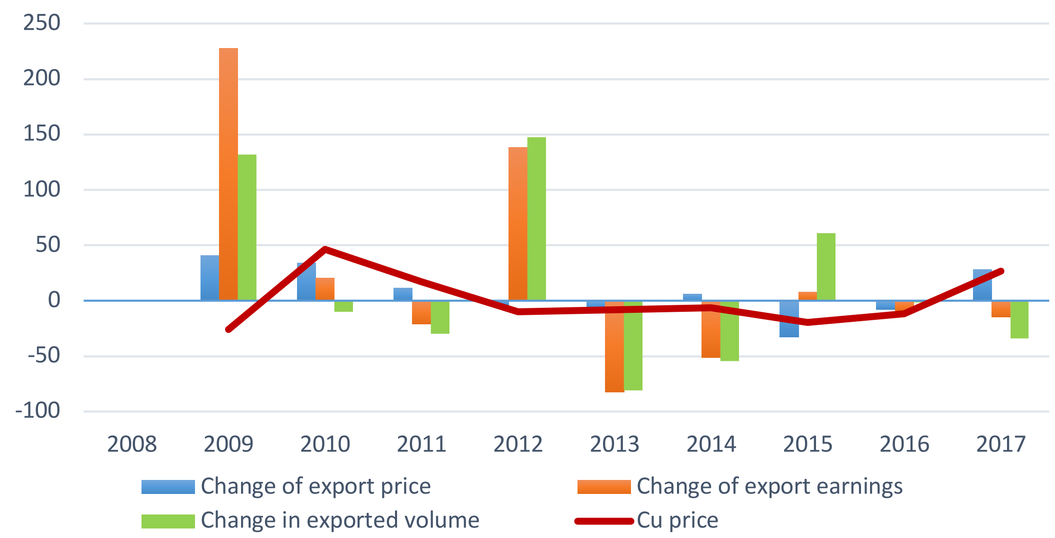
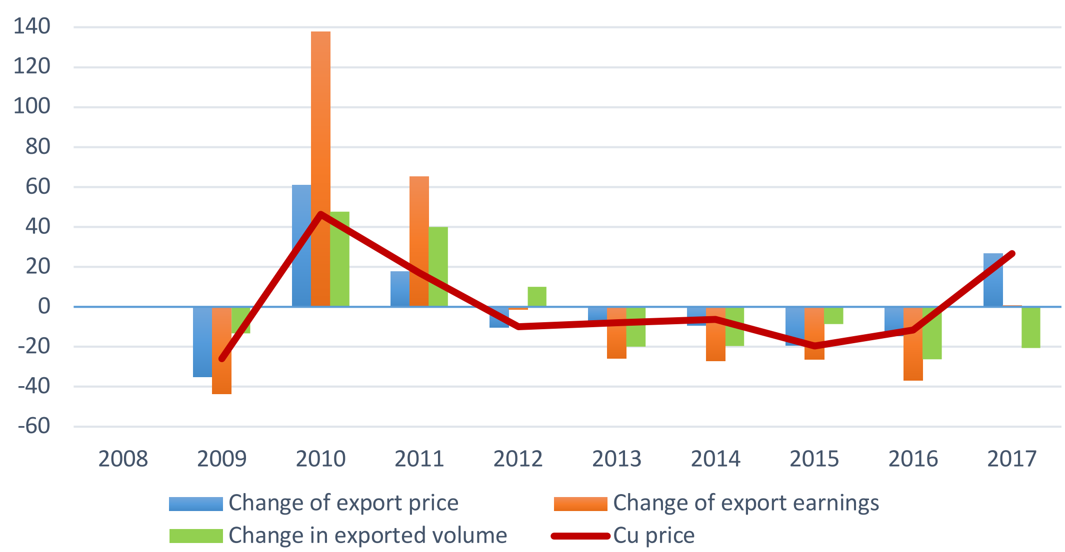


Figure 6.36. Year-to-year changes in copper prices, unrefined copper export prices, exported quantities, and export earnings of DR Congo



675. In general, a decrease in metal prices leads to a decrease in export prices and export earnings, and conversely, an increase in prices leads to an increase in export prices. However, an increase of export prices never leads to the same rate of increase of export earnings, for example, in Chile in 2010 export prices rose by 57 per cent while the rise of export earnings was 46 per cent, and in Peru in 2010 export prices rose by 34 per cent while the rise of export earnings was 20 per cent. In some years, the increase of export price was consistent with the decrease of export earnings (in 2011, 2013, and 2017 in Peru), while conversely a decrease of export price sometimes was associated with a rise of export earnings (in 2012–2013 in Chile and in 2015 in Peru). During some periods of high metal prices, even the decrease in exported volumes could be associated with the increase of export

prices, like in 2017 in DR Congo, in 2010 in Chile, and in 2010–2011 in Peru.

676. It worth remembering that export data has many uncertainties, and cannot be considered as absolute true information. That is why some extreme changes, like on the graph for Peru for *copper mattes*, may be the result of mistakes in the data.

Nickel

677. Comparison of *nickel mattes* price changes is in Figure 6.37.

678. It can be seen in Figure 6.37 that export prices of *nickel mattes,* in general, followed the metal price trends, but discrepancies happened. Until 2011, export prices in the world and in Zimbabwe coincided with the metal price. After that, significant variations of export prices started. For example, in 2013 the metal price decreased, while export prices in the world rose by 345 per cent, and in Zimbabwe by 126 per cent. After 2014, when the export price in Zimbabwe has fallen by 100 per cent, exports of *nickel mattes* from the State were terminated until 2016.

679. It worth considering exported values and quantities of the product for the DLBPS together with metal prices. A comparison for Zimbabwe is shown in Figure 6.38.

680. In general, a decrease in metal price leads to a decrease in export prices and export earnings, and vice versa. However, an increase in export price does not necessarily lead to the same rate of increase in export earnings. For example, in 2010 export prices rose by 97 per cent, while the rise of export earnings was 65 per cent, or in 2016, export price rose by 119 per cent, while the rise of export earnings was 58 per cent. In some years, the increase of export prices coincided with a decrease of export earnings (2011), and conversely, a decrease of export price sometimes was associated with an extreme rise of export earnings (2014). During some years of high metal prices, even the decrease in exported volumes can coincide with the increase of export prices and export earnings, like in 2010.

681. It is worth mentioning for nickel also that exports data has many uncertainties, and cannot be considered as absolute true information. That is why some extreme

Figure 6.37. Year-to-year changes in copper prices, unrefined copper export prices, exported quantities, and export earnings of DR Congo

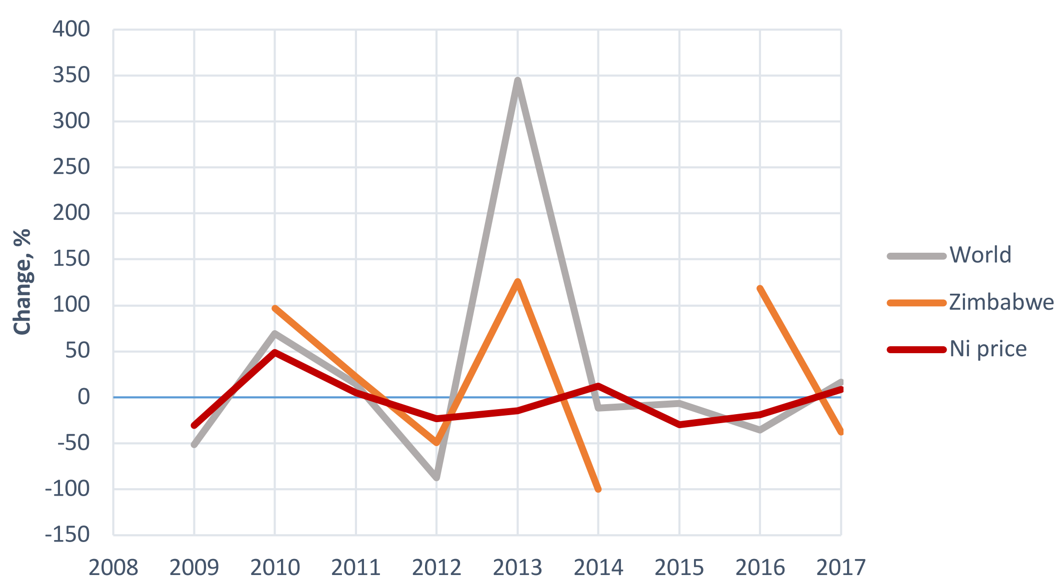
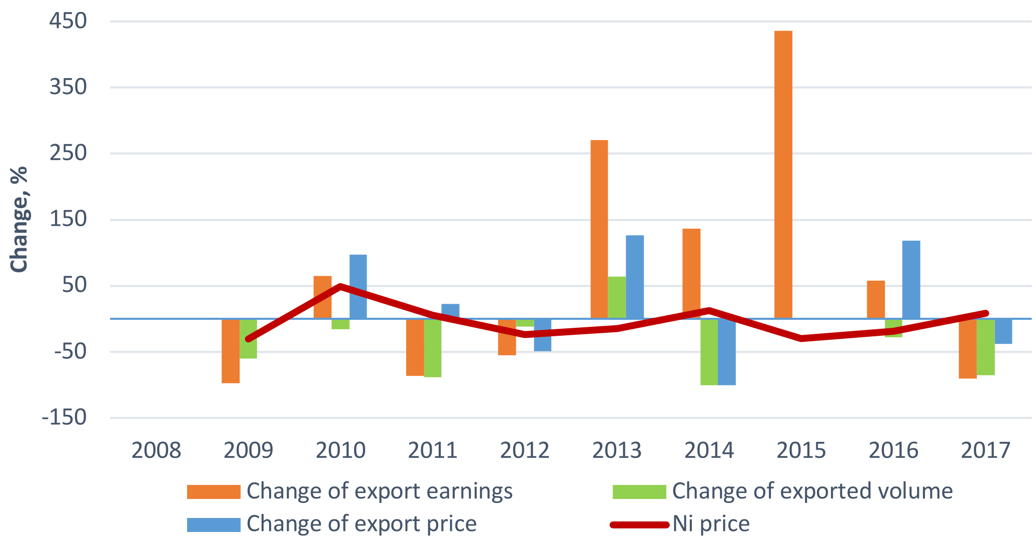


Figure 6.38. Year-to-year changes in nickel prices, nickel mattes export prices, exported quantities, and export earnings of Zimbabwe



changes (2013 or 2015) may be the result of mistakes in the data. Besides, there are gaps in the graph because Zimbabwe exported nickel mattes with breaks.

682. Thus, it can be concluded that export prices are not as easy as they may seem. In general, they depend on export earnings and exported values, as well as on metal prices, but these are not the only drivers. Sometimes under the effect of external factors, export prices can change completely inconsistent with the abovementioned internal factors.

D. Potential effects of targeted tariff on end products

683. For the four affected metals, most of the products are considered primary end products. Changes in export prices of the end products were analyzed.

Copper

684. There is only one end product of copper production. Export prices of *refined copper* for the relevant DLBPS, which are likely to be seriously affected, and for the world in general, were compared to metal prices on the world market. The graph for *refined copper* is shown in Figure 6.39.

685. It can be seen in Figure 6.39 that export prices of *refined copper* vary significantly from metal prices for some States and for the world in general. Export prices of the world, Chile, and Zambia experience the highest variations. For example, when metal prices and other States' export prices peaked in 2010 with growth by about 50 per cent, the increase in the world price was 19 per cent, whereas the price in Peru decreased by 14 per cent. The fall of prices in 2012 was more significant for Zambia, as prices decreased by 18 per cent but then started to rise, unlike other prices. Thus, in 2014, the price in Zambia increased by 4 per cent, while other prices kept negative growth rates. However, the fall of prices in 2015 was stronger for Zambia, like in 2012.

686. It is worth considering exported values and quantities of the products for the DLBPS together with metal prices. The same as for semi-finished products, Chile, Peru, and DR Congo were chosen for further analysis of end products' prices.

Figure 6.39. Year-to-year changes in copper prices and refined copper export prices for the DLBPS, which are likely to be seriously affected, and the world

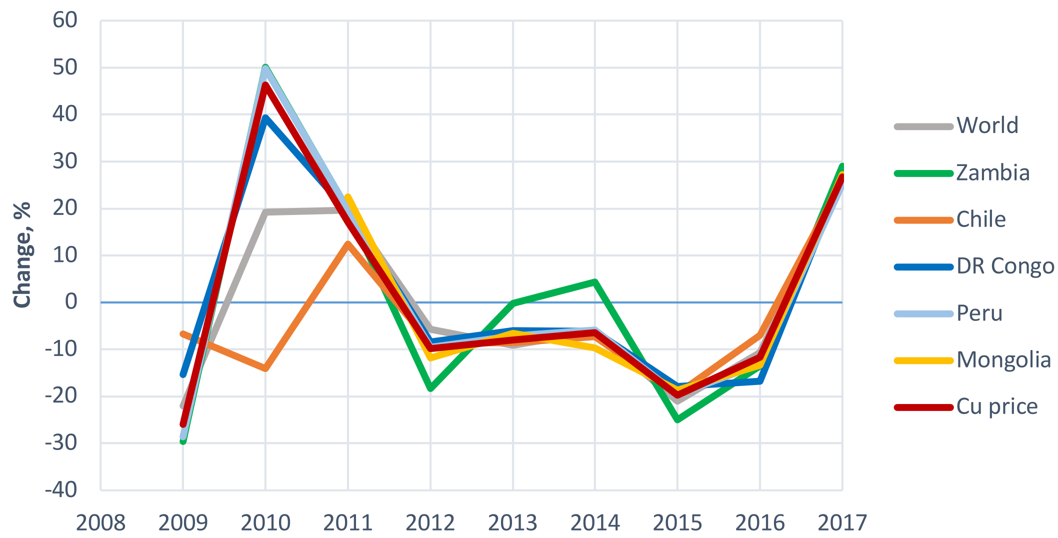
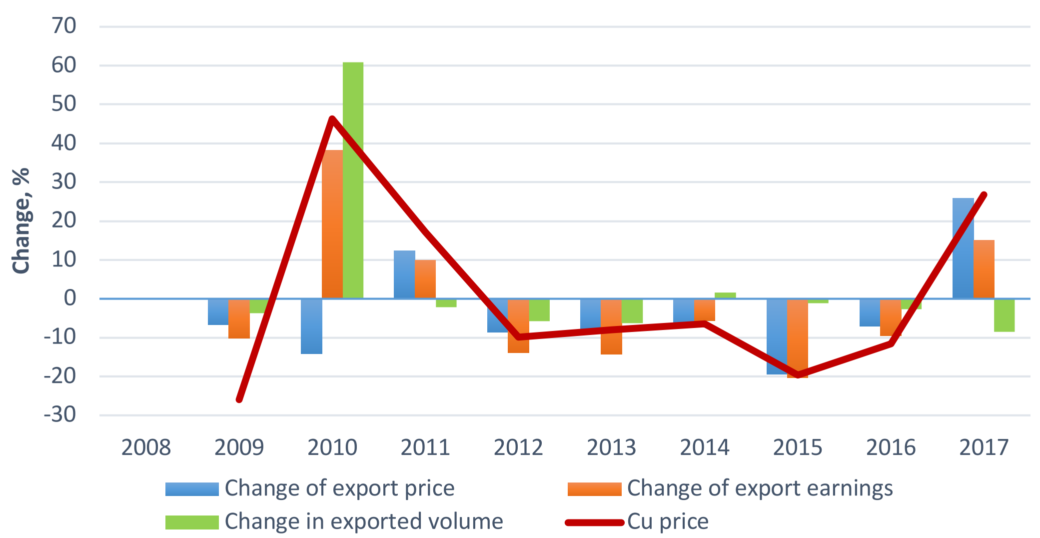


Figure 6.40. Year-to-year changes in copper prices, refined copper export prices, exported quantities, and export earnings of Chile



Analyses of *refined copper* prices follow in Figures 6.40, 6.41, and 6.42.

687. The general trend for refined copper is that a decrease in metal prices leads to a decrease in export prices and export earnings, and conversely, an increase in prices leads to increase in export prices. However, there were some periods when an increase in metal price led to a decrease of export price, like in 2010 in Chile, while export earnings increased extremely. In periods of high metal prices, export earnings and export prices can increase, even if exported quantities decrease. For example, in 2010 the metal price rose by 46 per cent, export earnings of Peru increased by 36 per cent, and the export price of *refined copper* increased by 50 per cent, but exported value decreased by 9 per cent.

Figure 6.41. Year-to-year changes in copper prices, refined copper export prices, exported quantities, and export earnings of Peru

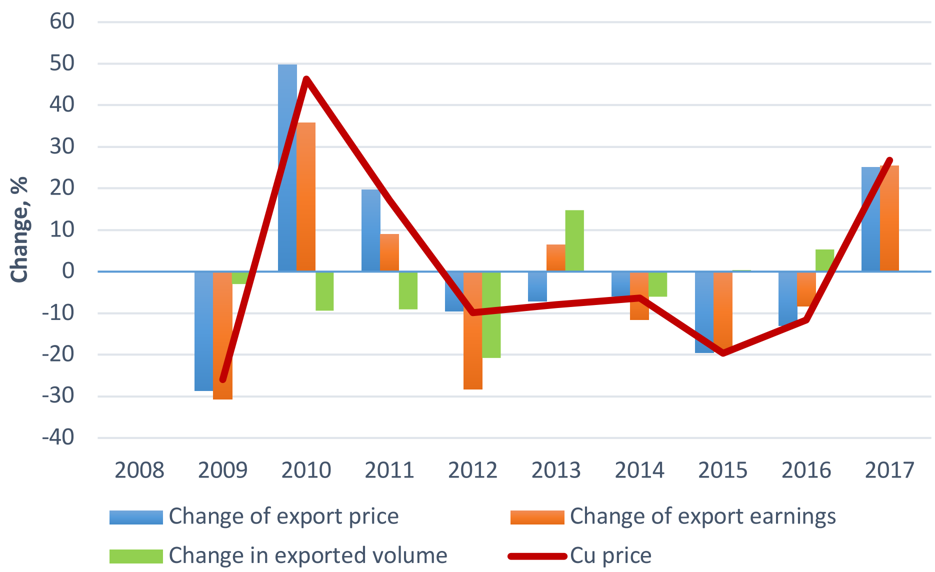
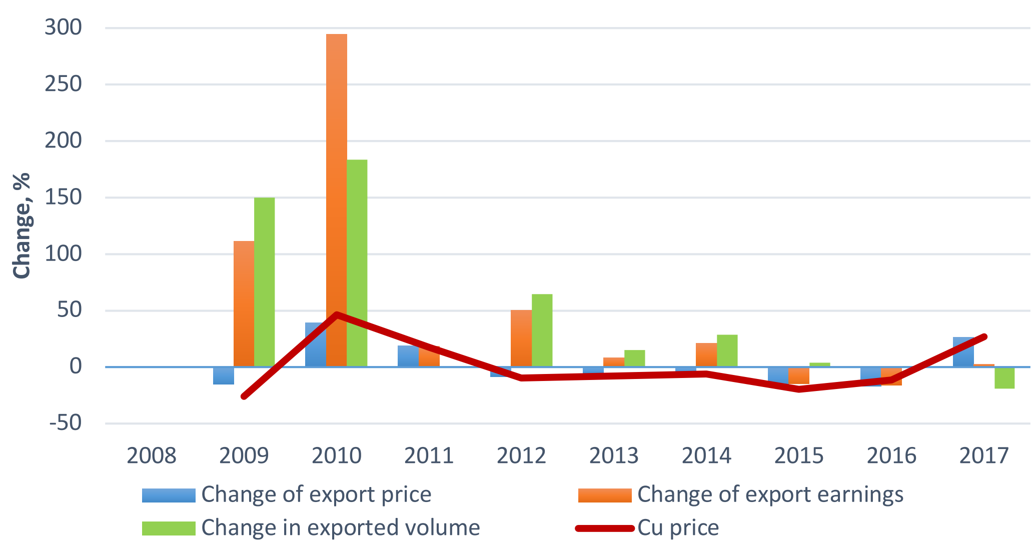


Figure 6.42. Year-to-year changes in copper prices, refined copper export prices, exported quantities, and export earnings of DR Congo

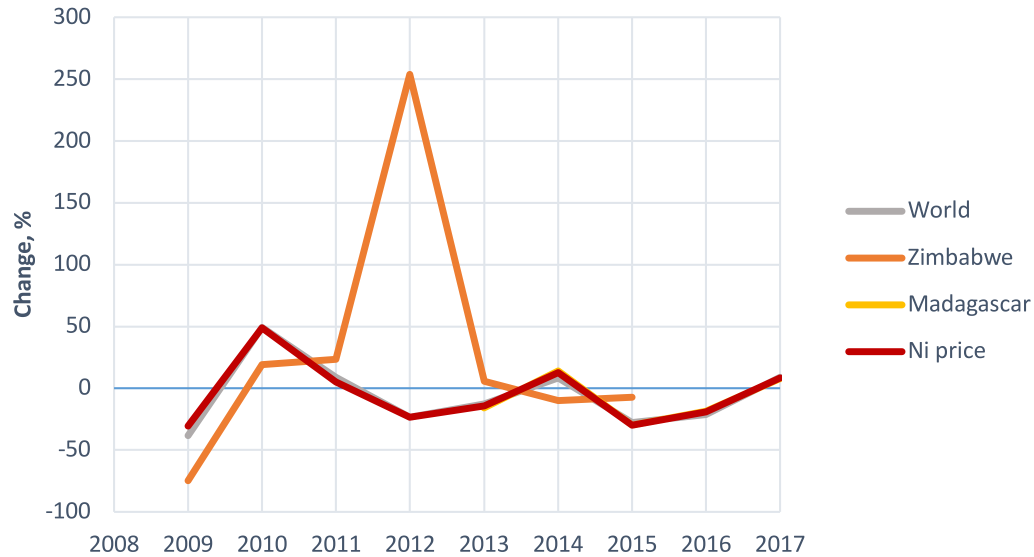


Nickel

688. There are also two end products of nickel production, but these are not exported by two concerned DLBPS, so they will not be considered. A comparison of *unwrought nickel* export price with nickel price is in Figure 6.43.

689. It can be seen in Figure 6.43 that export prices of *unwrought nickel* for Madagascar and for the world are fully consistent with nickel prices. Export prices of Zimbabwe vary widely from other prices. For instance, in 2012, when metal prices and export prices in Madagascar and in the world decreased by about 23 per cent, the

Figure 6.43. Year-to-year changes in nickel prices and unwrought nickel export prices for the DLBPS which are likely to be seriously affected and for the world



price in Zimbabwe rose by 254 per cent. Probably, there could be uncertainties in the export data.

690. Analyses of the exported values and quantities of *unwrought nickel* for the DLBPS together with nickel prices are shown in Figures 6.44 and 6.45.

691. In general, a decrease in metal prices leads to a decrease in export prices, and conversely, an increase in prices leads to an increase in export prices. There was one discrepancy in Zimbabwe in 2012, when the metal price decreased by 23 per cent but the export price rose by 254 per cent. Such great peaks happened several times for the exported volumes and earnings also. An increase in exported volume does not necessarily mean a consequent increase in export prices and export earnings

Figure 6.44. Year-to-year changes in nickel prices, unwrought nickel export prices, exported quantities, and export earnings of Zimbabwe

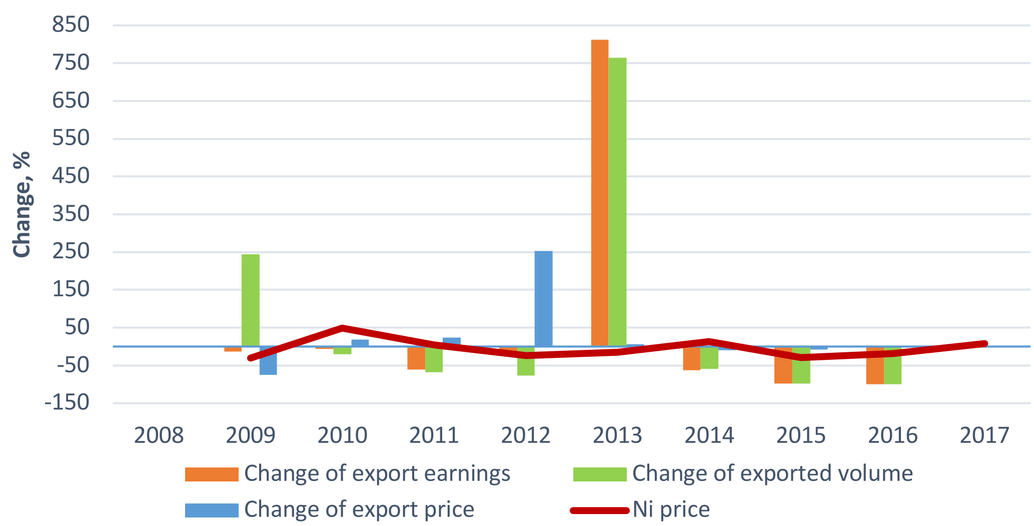


Figure 6.45. Year-to-year changes in nickel prices, unwrought nickel export prices, exported quantities, and export earnings of Madagascar

(Zimbabwe in 2009 or Madagascar in 2015). Contrarily, sometimes a decrease in exported volumes may be associated with growth in export prices (Madagascar in 2017 or Zimbabwe in 2010–2012).

Cobalt

692. There are also two end products of cobalt production. A comparison of *cobalt mattes* export price with cobalt price is in Figure 6.46.

693. It can be seen in Figure 6.46 that export prices of *cobalt mattes* for DR Congo and for the world are quite consistent with cobalt prices. Generally, price growth rates of DR Congo are higher than in the world as, for instance, in 2017 the DR Congo price rose by 85 per cent, whereas the world price rose by 68 per cent. The metal price increase in 2017 was 125 per cent.

Figure 6.46. Year-to-year changes in cobalt prices and cobalt mattes export prices for DR Congo and for the world

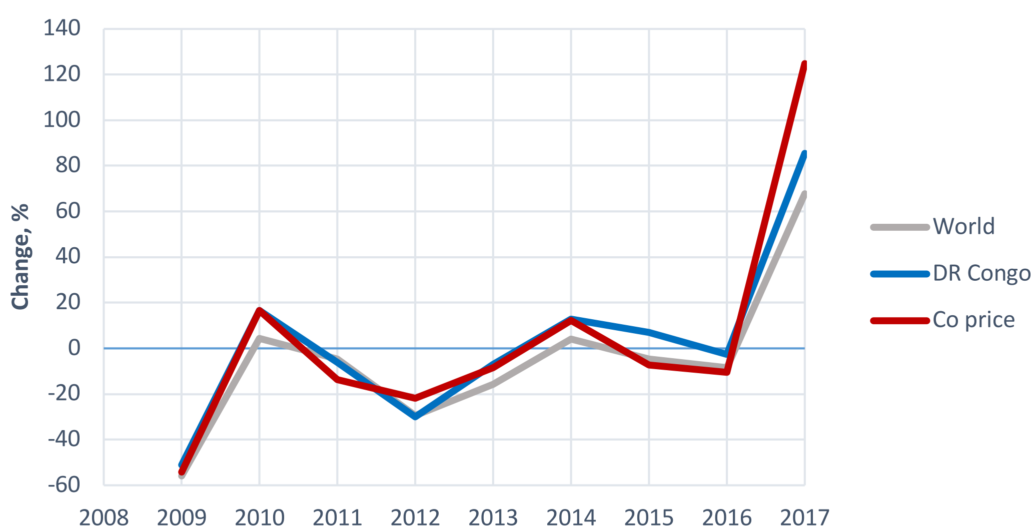
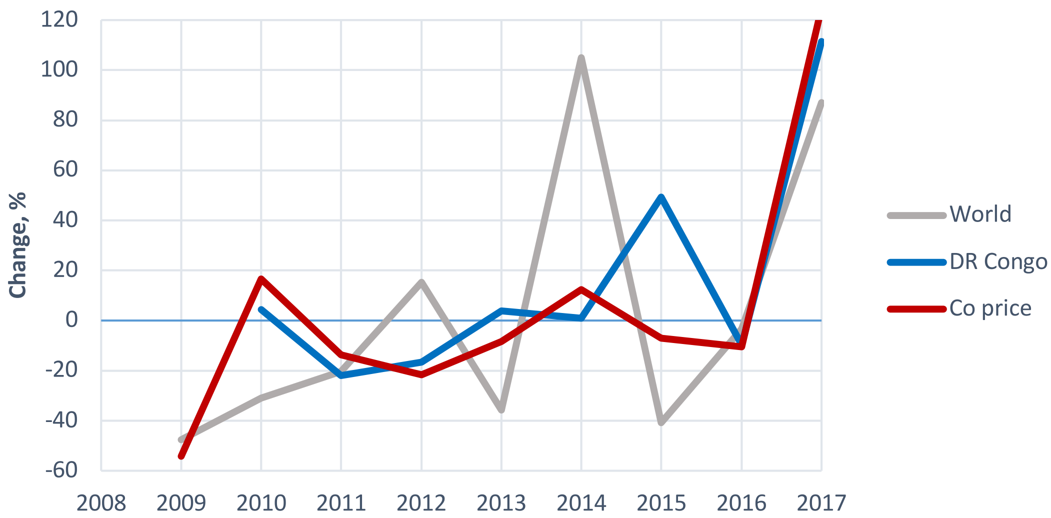


Figure 6.47. Year-to-year changes in cobalt prices and cobalt oxides export prices for DR Congo and for the world



694. Comparison of the *cobalt oxides* export prices for DR Congo with cobalt prices is shown in Figure 6.47.

695. Unlike *cobalt mattes*, export prices for *cobalt oxides* vary from metal prices, but the variations of export prices of DR Congo are close to metal prices during some periods. In 2010, when the metal price increased by 17 per cent, the export price in DR Congo increased by 4 per cent, whereas the world price fell by 31 per cent. In 2012, conversely, the world price rose by 15 per cent while other prices fell. The greatest rise of the world price was in 2014 (105 per cent), when the metal price rose by 12 per cent, and the DR Congo price by just 1 per cent. In 2015, in turn, the price in DR Congo rose by 49 per cent while the metal price fell by 7 per cent, and the world price by 41 per cent.

Figure 6.48. Year-to-year changes in cobalt prices, cobalt mattes export prices, exported quantities, and export earnings of DR Congo

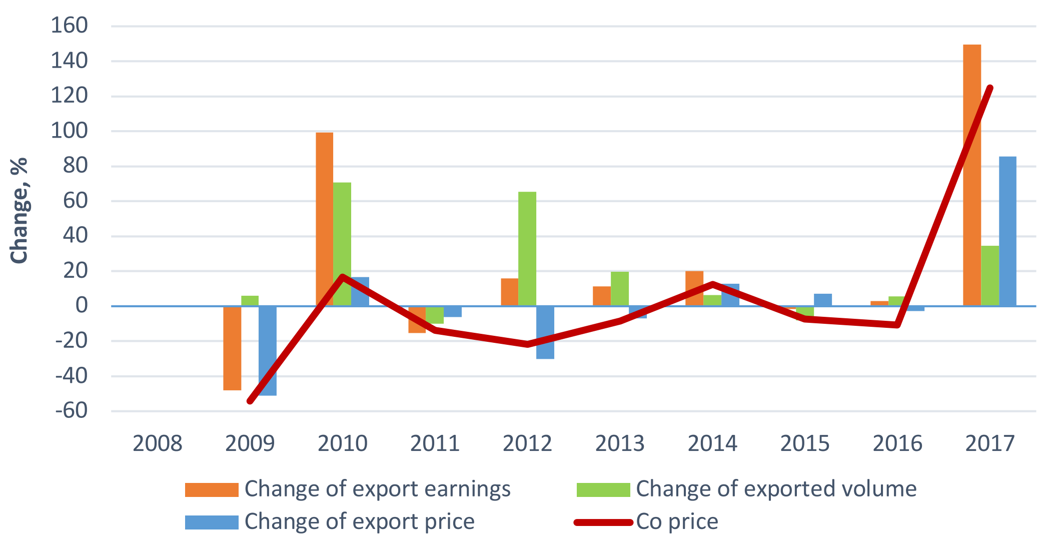


Figure 6.49. Year-to-year changes in cobalt prices, cobalt oxides export prices, exported quantities, and export earnings of DR Congo

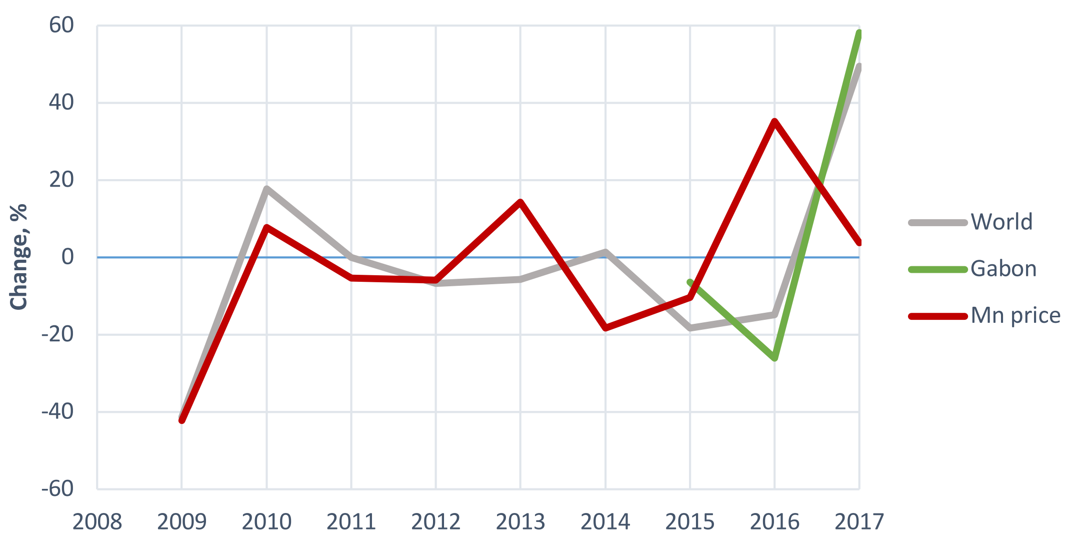
696. Comparison of export prices of each product with export earnings, exported volumes, and metal prices follow (Figures 6.48 and 6.49).

697. The general trends for other metals' end products are noticeable for the cobalt end products also. An increase in metal price causes an increase in export prices, except for *cobalt mattes* in 2015, when the metal price decreased by 7 per cent and the export price increased by 7 per cent. *Cobalt oxides* experienced extremely high growth rates in export earnings and exported volumes in 2010 and 2015.

Manganese

698. Many manganese end products were considered in the analysis, but only three of them are exported from Gabon, which is the only DLBPS concerned in the study. However, exports of *ferro-manganese (2 per cent or less of carbon)* from Gabon

Figure 6.50. Year-to-year changes in cobalt prices, cobalt mattes export prices, exported quantities, and export earnings of DR Congo



only occurred in 2013, so it does not make sense to consider this product. In addition, it is worth noting that exports of two other products from Gabon did not occur during the whole10 years period.

699. Comparison of *ferro-silico-manganese* export prices for Gabon and the world with manganese prices is given in Figure 6.50.

700. It can be seen in Figure 6.50 that, generally, export prices of *ferro-silico-manganese* in the world are quite consistent with manganese prices. The same is for export prices of Gabon where available. However, in 2013, when the manganese price increased by 14 per cent, the world export price fell by 6 per cent, and in 2016, the metal price rose by 35 per cent whereas the export price in the world decreased by15 per cent and in Gabon by 26 per cent. In 2017, the metal price increase was 4 per cent, but the world export price rose by 49 per cent, and in Gabon the price increased by 58 per cent.

701. Comparison of *manganese articles* export prices for Gabon and the world with manganese price is in the following Figure 6.51.

702. The graph in Figure 6.51 shows that export prices of *manganese articles* in the world are fully inconsistent with manganese prices. It seems that the metal price is shifted against the world export price. Thus, in 2011 the metal price fell by 5 per cent and the world export price increased by 15 per cent, while in 2013 the metal price conversely increased by 14 per cent whereas the world export price decreased by 31 per cent. In 2015, the metal price again decreased by 10 per cent and the export price increased by 7 per cent. The greatest discrepancy happened in 2016, when the manganese price peaked by 35 per cent but the world export price fell by 22 per cent.

703. Comparison of export prices of each product with export earnings, exported volumes, and metal price are given in Figures 6.52 and 6.53.

704. From the graph in Figure 6.53, it is hard to say anything about *manganese articles* because exports of this product from Gabon just started in 2014, which is why the growth rate is extremely high. Exports of *ferro-silico-manganese* restarted in 2014 also, so growth rates are also high, despite negative movement of

Figure 6.51. Year-to-year changes in manganese prices and manganese articles export prices for Gabon and for the world

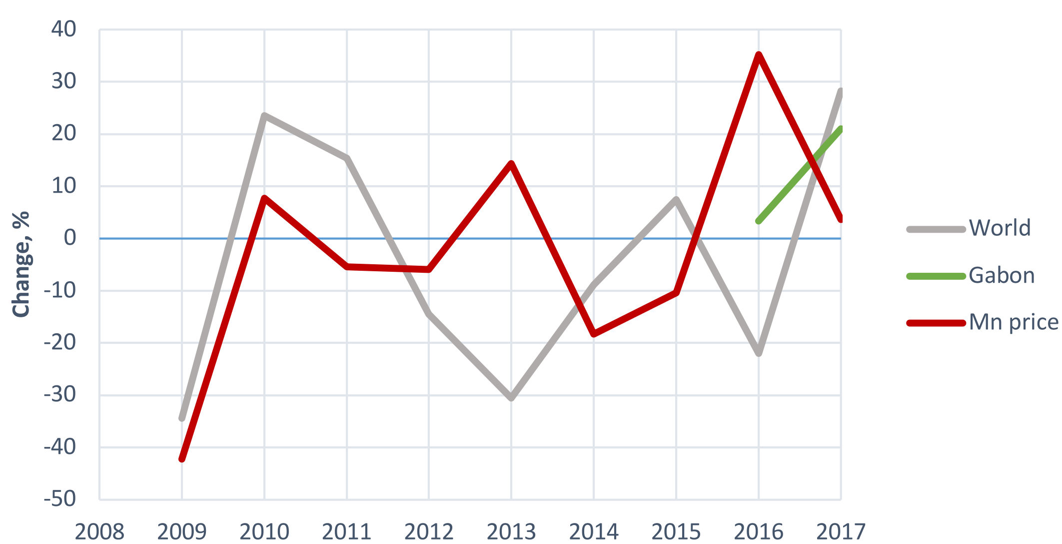


Figure 6.52. Year-to-year changes in manganese prices, ferro-silico-manganese export prices, exported quantities, and export earnings of Gabon

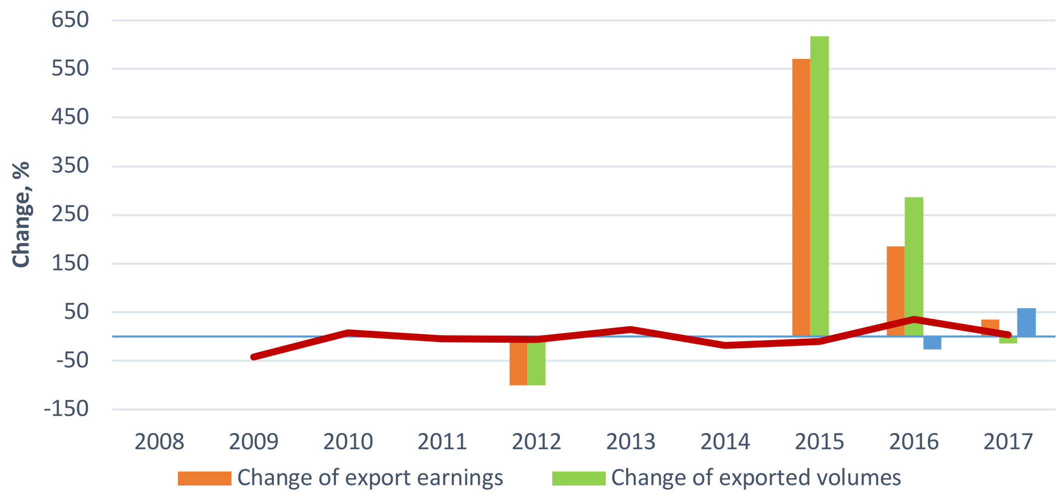
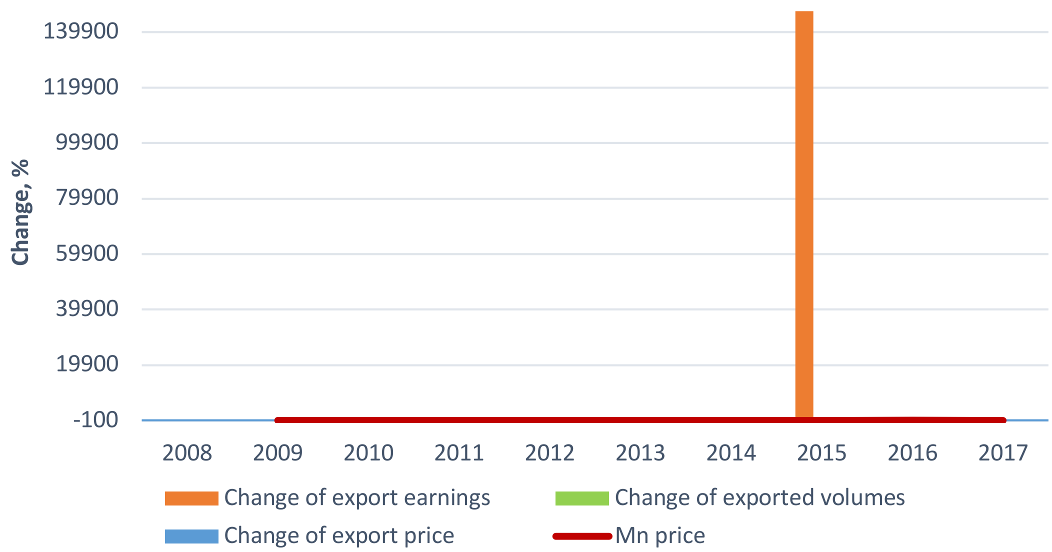


Figure 6.53. Year-to-year changes in manganese prices, manganese articles export prices, exported quantities, and export earnings of Gabon



the metal price. In 2016, the export price of *ferro-silico-manganese* decreased by 26 per cent, whereas the metal price rose by 35 per cent and export earnings and volumes increased too. In 2017, despite the negative growth rate of exported volume of *ferro-silico-manganese,* the export price and, consequently, export earnings increased by 58 and 35 per cent, respectively.

705. Thus, it can be concluded that, the same as for semi-finished products, export prices depend on export earnings and exported values, as well as on metal price, but there are also external factors which can strongly influence export prices and they, in turn, can influence export earnings and economies of the DLBPS which are likely to be seriously affected.

6. Potential impact analysis and discussion

A. Identification of relevant developing land-based producers

706. Tables 6.1–6.4 show DLBPS that mine copper, nickel, cobalt, and manganese. Some of them process mining products.

Table 6.1. Developing countries producing copper products

Mine producers	Blister copper producers (primary)	Refined copper producers (primary)
Chile	China*	China*
Peru	Chile	Chile
China*	India*	India*
D.R. Congo**	Zambia **	D.R. Congo**
Zambia**	Peru	Zambia **
Indonesia*	Mexico*	Mexico*
Mexico*	Indonesia*	Peru
Brazil*	Philippines*	Indonesia*
Mongolia	Iran	Philippines*
Iran	Brazil*	Iran
Laos**	South Africa*	Brazil*
Papua New Guinea	Turkey*	Myanmar**
Saudi Arabia	Namibia	Turkey*
Turkey*	Pakistan	South Africa*
Philippines*	Vietnam	Laos**
South Africa*	Oman	Namibia
India*	North Korea	Mongolia
Morocco	Botswana	Oman
Myanmar**		North Korea
Mauritania		Vietnam
Argentina		Zimbabwe
Eritrea**		Bolivia
North Korea		

Mine producers	Blister copper producers (primary)	Refined copper producers (primary)
Namibia		
Vietnam		
Pakistan		
Colombia		
Dominican Rep.		
Zimbabwe		
Bolivia		
Botswana		
Tanzania**		

≥10% of the world's production	2–10% of the world's production	<2% of the world's production

Source: ICA.
* NIC ** LDCs

Table 6.2. Developing countries producing nickel products

Mine producers	Intermediate products producers	Primary nickel producers
Indonesia*	Indonesia*	China*
Philippines*	Philippines*	Indonesia*
China*	Cuba*	Brazil*
Brazil*	Papua New Guinea	South Africa*
Cuba	Turkey*	Colombia
Guatemala		Madagascar**
South Africa*		Myanmar**
Colombia		Cuba
Madagascar**		Dominican Rep.
Papua New Guinea		Guatemala
Myanmar**		
Turkey*		
Zimbabwe		
Dominican Rep.		

≥10% of the world's production	2–10% of the world's production	<2% of the world's production

Source: INSG.
* NIC ** LDCs

Table 6.3. Developing countries producing cobalt products

Mine producers	Refined cobalt producers
D.R. Congo**	China*
China*	Madagascar**
Cuba	Zambia**
Papua New Guinea	Morocco
Zambia**	South Africa*
Madagascar**	D.R. Congo**
Philippines*	Brazil*
Morocco	
South Africa*	
Brazil*	
Indonesia*	

≥10% of the world's production	2–10% of the world's production	<2% of the world's production

Source: BGS.
* NIC ** LDCs

Table 6.4. Developing countries producing manganese products

Mine producers	Ferro-alloys producers
China*	China*
South Africa*	India*
Gabon	Malaysia*
Ghana	South Africa*
Brazil*	Brazil*
India*	Mexico
Malaysia*	Gabon
Mexico	Egypt
Myanmar**	
Côte d'Ivoire	
Morocco	
Iran	
Turkey	
Namibia	
Egypt	
Peru	
Vietnam	
Thailand	
Sudan	
Kenya	
Oman	
Pakistan	
Philippines	

≥10% of the world's production	2–10% of the world's production	<2% of the world's production

Source: BGS.
* NIC ** LDCs

B. Assessment of potential impact on relevant developing land-based producers

707. As shown in section 4.C, mining of polymetallic nodules may bring to the market significant quantities of metals contained in nodules. These quantities would be proportional to the number of contractors operating at a given time, each of whom would be mining 3 million nodules per year. It is clear that 12 contractors could generate the maximum revenue. Their combined production would correspond to approximately 50 per cent of current cobalt and manganese production, approximately 20 per cent of nickel, and approximately 2 per cent of copper. However, such development is unlikely. The market entry of two or six contractors seems more realistic. Possible scenarios for the development of deep-sea mining and its relationship to projected consumption with different numbers of active contractors are discussed in detail in section 4.C.

708. When considering individual markets of affected metals, we noted that even relatively small additional portions of metal that entered the market at an unfavorable moment (when it is oversaturated or in a balanced state) can lead to a fall in prices for the affected metals. We also noted that even if new metal supplies did not upset the supply/demand balance, they could still cause prices to fall, as they would reduce supply tensions and also put psychological pressure on other market participants. The consequences of lower prices will be determined by their scale and financial and economic conditions of market participants at all levels (from individual enterprises to industries of entire countries and regions). At the same time, we consider it important to note that three of the metals under consideration (copper, nickel, and cobalt) are often found in ores together (copper and nickel; nickel and cobalt; or copper, nickel and cobalt). In case of asynchronous price dynamics for these metals, the decrease of one of them can be compensated by the level of the other. However, in case of a synchronous decrease, the negative effect may increase significantly.

709. In addition, in assessing the potential impact of polymetallic nodule mining, the cost of nodules as an analogue of ore or concentrate for processing operations and the cost of copper, nickel, cobalt, and manganese products from the processing of polymetallic nodules should be taken into account compared to those from land-based mining. However, this issue has not been sufficiently studied to date.

710. If the market situation develops unfavorably, the start of production may lead to global, regional (affecting individual countries or groups of countries), or local (affecting individual enterprises/companies) consequences. At the same time, we believe it is important to emphasize the close causal links between the consequences of all three levels.

711. Global effects may include changes in the market supply/demand balance, which may cause excess supply of one or more of the four metals in question.

712. With regard to the decline in prices for commodities derived from the metals under consideration as a result of increased supply, we would like to emphasize once again that its scope will be determined by the specific conditions that characterize the market at that time. At the same time, even a relatively small price decline may lead to critical consequences for specific market participants.

713. Decrease in prices for one or more of the four metals under consideration will trigger a cascade of diverse local and regional effects.

714. Here are some examples of such cascades:

i. decrease in profitability of enterprises up to their transition to the category of unprofitable → reduction in production (transition to partial capacity utilization) or suspension of enterprises → reduction in the volumes of marketed products → reduced revenue and profits → tax cuts and reduced revenues to budgets of different levels

ii. decrease in profitability of enterprises up to their transition to the category of unprofitable → reduction of production (transition to operation with partial capacity utilization) or suspension of enterprises → reduction in the volumes of marketed products → reduction of export volumes → reduction of export revenues to the state budget

iii. decrease in profitability of enterprises up to their transition to the category of unprofitable → reduction in production (transition to operation with partial capacity utilization) or suspension of enterprises → reduction in wages or reduction in the number of employees in affected enterprises → decrease in living standards and purchasing capacity of families of workers in affected enterprises → decrease in consumer demand from families of workers in affected enterprises → decrease in financial revenues to service enterprises serving families of workers in affected enterprises until they become unprofitable → closure of some service enterprises → reduction in the number of people employed in the service sector → ... → general decline in living standards and employment in the zone of influence of affected enterprises → emergence of social tensions, migration, etc.

iv. decline in profitability of enterprises up to their transition to the category of unprofitable → reduction of production (transition to operation with partial capacity utilization) or suspension of enterprises → closure of enterprises serving affected production → ... → general decline in living standards and employment of population in the zone of influence of affected enterprises → emergence of hotbeds of social tension, migration of population, etc.

715. It should be noted that different cascades of consequences will act synchronously.

716. Local and regional impacts are spreading at the global level. This transmission will manifest itself, inter alia, in a decline in world production of one or more of the four metals in question, which will entail a shift in the demand/supply balance towards deficit and a corresponding change in price movements. The structure of the mining and metallurgy industries and the GVC will be affected.

717. As for the structure of the mining and metallurgical industries and the GVC, they may be affected by the intended purpose of the extracted polymetallic nodules. Let us assume that the “destinations” of nodules are operations that focus on supplying the metals under consideration to the sponsoring states of the contractors. The sponsoring states of the contractors that may start production before 2035 include China, Japan, France, Germany, Belgium, and Russia. All these states are major importers of mining and/or

metallurgical products of one or more of the four metals under consideration. The emergence of new sources of production will lead to a reduction in their imports from traditional supplier countries. For example, China imports manganese ore in large quantities (the main suppliers among developing countries are South Africa, Gabon, Ghana, and Brazil), copper products (Chile, Peru, Mongolia, etc.), nickel (Philippines, Indonesia) and cobalt (DR Congo). These countries are the main suppliers of the metals under consideration to other sponsoring states. As a result of the commencement of polymetallic nodule mining, the import requirements of sponsoring states from traditional supplier countries will decrease or no longer exist. These supplier countries will be faced with the need to enter new markets.

C. Discussion of uncertainties in impact analysis, including future supply and demand prospects

718. The sustainable functioning and progressive development of the mining industry as a whole and its individual enterprises in particular, as well as the development and mastering of the mineral resource base, is subject to the influence of multiple factors: economic (including macroeconomic), financial, market (including price), political (external and/or internal), social, environmental, technological, and even climatic. At the same time, these can have both positive and negative impacts on the situation.

719. In addition, there is a separate category of purely negative factors—contingencies that may affect enterprises at any stage of their development. These may include various production risks (energy supply disruptions, equipment failures, geotechnical failures, etc.), natural disasters, accidents, etc. The effect of their influence can be both short-term and long-term. In some cases (such as natural disasters), they may affect not only individual enterprises, but also entire countries and regions.

720. With regard to the metals under consideration, such factors as the growth rate of the world economy are of universal nature. Manganese and copper markets are most affected by this factor, while cobalt is the least affected, which is determined by the specifics of use of these metals.

721. In terms of the current situation, all international organizations and experts have noted a slowdown in pace. Thus, the IMF, in the October issue of its regular review "World Economic Outlook", noted that the global economy is experiencing a synchronized slowdown.[213] This was the reason for the systematic decrease in the forecast indicators of the world economy growth rates in 2020–2021, which could be observed in each new issue in 2019 and in the beginning of 2020.

722. The same universality is characterized by factors of growth in the consumption of the considered metals, such as development of "green technologies" including EVs and renewable energy (wind and solar power generations, etc.). This may even have some impact on the growth of manganese consumption, although it is fundamentally less than for copper, cobalt, or nickel.

723. Despite optimistic forecasts, the global transition to "green technologies" may be severely slowed down or even stopped. The reasons for this may be the lack of energy capacity and necessary infrastructure for the development of the electric transport industry, the reduction of government support, which is currently

[213] IMF (2019). World Economic Outlook, October 2019. https://www.imf.org/en/Publications/WEO/Issues/2019/10/01/world-economic-outlook-october-2019.

the main engine of "green technologies", especially in China, and a number of other factors. Moreover, China has already announced changes in its policy of stimulating new energy vehicles to reduce subsidies by an average of 50 per cent from July 2019. As already reported, without these subsidies, Chinese EV manufacturers will have to raise prices, which leads to lower sales and production volumes as they become less affordable for consumers.[214]

724. EV-revolution risks are often overlooked, such as reputational risks in the closely-linked extractive sector, the scarcity of essential raw materials, and underestimated environmental impacts (the climate and environmental impact of electric transport is often underestimated).[215]

725. Speaking about deep-sea mining, its commissioning will create additional risks for land producers. The extent of their impact will largely depend on the supply/demand balance that will actually emerge in the market by the time it begins and will remain as it increases.

726. In the first quarter of 2020, the world was struck by an outbreak of coronavirus infection, COVID-19, which became a pandemic. As a result of the measures taken, the world economy virtually stopped. As IMF noted in its April review,[216] in 2020 the world economy would face the worst recession since the Great Depression, with global economic growth in 2020 projected to be negative at -3 per cent. This is much more than during the 2008–2009 financial crisis. Moreover, economically developed countries will suffer the most, as their decline will amount to -6.1 per cent. For emerging markets and developing economies, the projected decline is fundamentally less (-1 per cent). World trade volumes will decrease by 11 per cent (and by 9.6 per cent for emerging market and developing economies).

727. At the same time, IMF believes that due to reasons specific to the current crisis, the recession caused by it will be short-lived. According to the baseline scenario, the global economy is expected to grow by 5.8 per cent already in 2021 (6.6 per cent for emerging markets and developing economies). At the same time, world trade volumes will increase by 8.4 per cent (and by 11 per cent for emerging markets and developing economies).

728. If these forecasts are confirmed, the current recession will not affect the medium- and long-term forecasts for the development of the mining industry in general and the metals in particular. It is unlikely that the recession will affect the prospects for deep-sea mining as well.

729. However, if the recession is prolonged or the pace of economic recovery is slower than expected, it could lead to noticeable negative consequences for the entire mining and processing industry, including the metals under consideration. These may manifest both in decrease of expected consumption growth rates and in the development of the extractive sector. This is also expected to shift the terms of subsea production to a more distant future, both because of the lack of necessary investments for its development and because of changes in the market situation in general.

730. Besides universal factors, there are specific risks for the market of each

[214] Mining Review Africa (2020). Battery metals: Long term demand remains strong. https://miningreview.com/battery-metals/battery-metals-long-term-demand-remains-strong-despite-price-woes/.

[215] Global Risk Insights (2018). Special Report: The hidden risks of the electric car revolution. https://globalriskinsights.com/2018/01/electric-car-revolution-risks/.

[216] IMF (2020). World Economic Outlook, April 2020. https://www.imf.org/en/Publications/WEO/Issues/2020/04/14/weo-april-2020.

particular metal. We consider the main risks below.

Copper

731. The supply of raw materials to the global copper industry as a whole is quite high, with 35 years on the basis of reserves and more than 100 years on the basis of resources. The prospects for growth of copper production and its supply to the world market, as noted in section 4.C, are mainly related to the possible involvement of new deposits, as well as to the expansion of capacities of some existing operations.

732. The world's leading copper producer and supplier of mine copper is Chile, providing 28 per cent of global copper mine production. Chile has the largest copper mines in the world, where the reduction or increase in production volumes may have a significant impact on the global market situation. Production levels are negatively affected by strikes, which have increased in recent years. For example, in 2017, 120,000 tonnes of copper were lost due to a 43-day strike at Escondida mine alone. Strikes are also taking place in the mines of the Chilean state-owned company Codelco, which is the world's largest copper producer. At the end of 2019, the company reported that it had to cut its investment program by 20 per cent due to increased allocations to the country's budget amid numerous protests. Thus, the plans for the transition to underground exploitation of Chuquicamata's largest mine, as well as the El Teniente mine life extension project, may be adjusted.

733. Unpredictable factors affecting copper production in Chile also include climate, in the form of severe droughts common to the region, and heavy rains. While mining companies are building desalination plants to minimise the impact of droughts, heavy rains can cause mines to suspend operations, as happened in March 2019.

734. Similar problems are also relevant for Peru and Mexico, the world's major copper producers.

735. Other DLBPS included in the top ten world-leading copper-producing countries are China, DR Congo, Zambia, and Indonesia.

736. China, as a major copper producer, is also a major global copper consumer. Moreover, its own mine production is unable to meet the demand of its domestic consumers. There are few large mining enterprises in China, the bulk of copper production is provided by numerous medium and small mines. This made the country the largest importer of copper concentrates. However, Chile and Peru provide more than half of the supply in roughly equal proportions. Consequently, a possible reduction in production in these two countries could have a negative impact on China as well.

737. Of African countries, the most problematic is DR Congo, where artisanal mining, including with the involvement of child labour, provides a significant proportion of copper production (about 20 per cent). The world community is taking measures to control mining in the country, and a number of major car companies have announced the termination of copper (and cobalt) supplies from DR Congo.

738. In Zambia, two copper smelters, Mufulira and Nchanga, were shut down in 2019 for various reasons, which may cause a decline in copper production and output, exports of which account for more than half of the country's total export revenues.

739. In Indonesia, copper-mining problems may arise from a ban on export of certain types of minerals, which will primarily affect the nickel industry, but will also affect the copper industry. The ban will enter into force in January 2022, and it is assumed that by that time, metallurgical capacities for processing of raw materials

will be created in the country. Currently, about 40 per cent of copper concentrates are processed in the country.

740. In addition to the problems of specific countries, it is important to note the general trend towards expensive underground mining of copper deposits and a decrease in the average metal content in ores. In addition, it is necessary to take into account the constant shifting of the terms of development of so-called "sleeping giants"—large and giant new copper deposits—for various reasons, from financial and economic to environmental. At the same time, the commissioning of one or more such facilities may have a significant impact on the global copper market.

741. As follows from the above, the presence of significant resources of metal in the subsoil is not yet a guarantee of ensuring its sustainable production and, moreover, of increasing its pace. Therefore, any forecasts of global copper production (as well as any other metal) have a rather large probability ratio, and in developing countries with unstable economic and political environment, this uncertainty will be maximized.

742. In addition to copper mining from the subsoil, we need to take into account the possible growth rate of secondary metal production, for which the situation is ambiguous. On the one hand, the trend towards recycling in general should lead to the growth of secondary copper production. At the same time, China, the main producer of secondary copper, in mid-2019 imposed a ban on the import of copper scrap, while increasing the import of concentrates. Meanwhile, a major German copper semi producer, Aurubis, in late 2019 reported on the production reorientation from the production of flat products to copper scrap recycling.

743. Due to its wide range of applications, demand for copper is expected to grow. As shown in section 4.C, its projected growth rate varies between 1.8 and 4 per cent. High growth rates of copper consumption are primarily associated with the development of "green technologies", meaning EVs and renewable energy (wind and solar power generations, etc.). Nevertheless, as mentioned above, despite optimistic forecasts, the global transition to "green technologies" may be severely slowed down or even stopped.

744. If the global energy industry continues to be based on carbon fuels, copper consumption could also grow rapidly. However, this requires strong economic growth, and, as mentioned above, there are currently not many prerequisites for it. At the same time, against the background of a slowdown in the growth rates of such countries as China, USA, and Japan, economic improvement is expected in a number of developing countries including India, Indonesia, Mexico, and South Africa, which can provide for the growth of demand for red metal.

745. However, China will remain the main copper consumer in the future, which will largely determine the growth rate of demand for the metal. In general, "trade wars" between China and the US, unstable economic situation and tense geopolitical situation have a negative impact on the world copper market.

746. As for the impact on deep-sea mining, according to the scenarios we are considering (section 4.C), at the time of its proposed start (i.e. by 2027) only a 3.5 per cent annual growth in consumption could cause a copper deficit in the market. In this case, even under the maximum scenario (with the participation of 12 contractors) the copper supply/demand balance would not be seriously affected. However, it could still lead to some price reductions, as it would reduce possible supply tensions. With lower consumption growth rates, copper shortages may manifest themselves either in the early 2030s or

not at all, as all the world economy's copper needs may be met by land-based production and secondary metal. In such a situation, the untimely appearance of even small volumes of copper from polymetallic nodules may put pressure on the market and give an additional incentive to lower prices.

747. In the face of low or declining prices, competition between producers of all types (including deep-sea producers) will intensify. In this struggle, enterprises whose products are characterized by the lowest cost will have an advantage. This competition may result in the exclusion from the market of the least cost-effective operations, which may include contractors.

Nickel

748. The supply of raw materials to the world nickel industry at the current level of production as a whole is quite high, with more than 40 years on the basis of reserves and more than 60 years on the basis of resources. The prospects for the growth of nickel production and its supply to the world market, as noted in section 4.C, are related to the development of new deposits and, to a lesser extent, to the increase in production at existing operations.

749. The main consumer of all nickel products, from nickel ore to refined metal, is China. Almost all the changes that have taken place in the structure of the nickel industry are related to the development of the Chinese economy and the growth of nickel consumption within the country. As a result, countries that produce nickel products have become dependent to varying degrees on the state of China's consuming industries. First of all, it concerns countries whose nickel industry was developing with an emphasis on Chinese consumers. These include primarily DLBPS such as Indonesia and the Philippines, as well as Papua New Guinea and Myanmar. Some traditional nickel-producing countries have reoriented their exports to China as Chinese demand develops and are also highly dependent on the situation in that country. These include South Africa, Cuba, Brazil, Colombia, and some others. Obviously, the decline in nickel consumption by China will lead to the emergence of huge surpluses in the market and disruption of the existing trade flows. Thus, the demand factor for nickel from the Chinese industry is currently a global risk for the entire nickel industry.

750. However, there are also local risks that not only affect the status of a particular market participant but influence its partners.

751. Among the major nickel suppliers are Indonesia and the Philippines. As shown in Chapter 4 (sections C, D, E, and F), nickel production in these countries has undergone the most significant changes in the past decade, affecting the global nickel industry as a whole. Nickel production in the other top-ten countries remained fairly stable.

752. For both countries, the government's policy towards the mining and metals industry has been a determining factor in production dynamics. In Indonesia, however, emphasis was placed on domestic development of the processing sector, while in the Philippines more ecological activities, especially tourism, were emphasized. This led to a reduction in raw material supplies from these countries, which affected primarily China, its main consumer. As a result, a number of Chinese operations had to reduce production of nickel metallurgical products.

753. However, the market supply of the metal as a whole was only affected slightly, as the ban on the export of nickel ore in Indonesia in 2014–2017 led to the accelerated construction of ferro-nickel plants. As a result, by 2017 the country's metallurgical production increased by ten times (from 22,000 tonnes in 2014 to

204,000 tonnes in 2017)[217] and continues to grow. Analysts estimate that it is expected to grow to 530,000 tonnes by 2020.[218] In so doing, Indonesian operations are launched at the expense of Chinese investors. Thus, the retired Chinese facilities were quickly replaced and the nickel market remained in a fairly balanced state.

754. In this regard, the risk of reducing the supply of raw materials for Chinese consumers remains. The ban on the export of nickel ore from Indonesia was renewed on January 1, 2020, and the situation with production in the Philippines remains, as the banned operations are still not active. This may lead to further decrease in metallurgical capacities in China.[219]

755. However, the situation with raw material supply should not affect the consumers of final products, as the outgoing production capacity will be compensated by Indonesian goods to be produced at enterprises owned by Chinese companies. Under these circumstances, possible changes in the Indonesian government's policy aimed at further development of its industry and consumption sector, with similar export bans on other nickel-containing products, will remain the main risk for consumers.

756. The main risk for the consumption prospects is a slowdown in transport electrification. As mentioned above, the reasons for this may be, inter alia, the lack of energy-generating capacities and the necessary infrastructure for the creation and functioning of electric transport production, the lack of state support, which is now the main engine of "green technologies", especially in China, and a number of other factors. EV-revolution risks are often overlooked, such as reputational issues in the closely-linked extractive sector, the scarcity of essential raw materials, and underestimated environmental impacts (the climate and environmental impact of electric transport is often underestimated).[220]

757. As shown in section 4.C, at present, it is the demand for nickel products from manufacturers of high-capacity batteries for EVs that is developing most dynamically. To ensure this, new operations are being launched and new deposits prepared for development. It should be noted here that, for these purposes, specific products are produced, which are in demand mainly and specifically in batteries. In case of a slowdown in the development of the EV industry, the demand for nickel and, consequently, its prices may decrease. This will lead to the shutdown of most of the new deposit development projects, as the nickel market is close to the balance without taking into account EV demand.

758. The nickel market is expected to face a deficit in the next two years.[221] In the long term, if the rate of development of electrification of transport is maintained, it will grow, but it is impossible to estimate what the real rate of its growth will be. As shown in section 4.C, under the pessimistic scenario of consumption growth (case 1), primary metal production will not be able to meet demand for it only after 2029. At the same time, it should be taken into account that, in the period of excess nickel production in 2012–2015 (section 4.C), substantial stocks have been accumulated

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217 INSG (2019). *World Nickel Statistics. Yearbook. Vol XXVIII. No. 12.*

218 Reuters (2109). Commodities News: Miners welcome Indonesian export ore ban, plan smelting expansion. https://www.reuters.com/article/us-nickel-indonesia/miners-welcome-indonesian-export-ore-ban-plan-smelting-expansion-idUSKCN1VW2AP.

219 INSG (2019). Press Release, INSG October 2019 Meeting, 22.10.2019. http://insg.org/wp-content/uploads/2019/10/pressrel_INSG_Press_Release_October2019.pdf.

220 Global Risk Insights (2018). Special Report: The hidden risks of the electric car revolution. https://globalriskinsights.com/2018/01/electric-car-revolution-risks/.

221 INSG (2019). Press Release, INSG October 2019 Meeting, 22.10.2019. http://insg.org/wp-content/uploads/2019/10/pressrel_INSG_Press_Release_October2019.pdf.

at stock exchanges, and their introduction to the market, as well as the expected increase in recycling, will help to reduce the expected deficit.

759. As for the impact on the mining situation, according to the scenarios under consideration (section 4.C), provided that deep-sea mining starts in 2027, its entry into the market will not lead to nickel oversaturation and thus there is no reason to expect severe consequences for other market participants. Nevertheless, even under these conditions, there may be some decline in prices caused by the very fact of additional quantities of metal.

760. If production starts earlier than our scenarios suggest, it is likely to shift the supply/demand balance towards surplus. Then a drop in prices will become inevitable. Its consequences will depend on the scale of the fall and the situation at specific nickel enterprises. In the competition that will unfold among producers, the enterprises producing the lowest-cost products will have the advantage. This competition may result in the displacement of the least economically efficient enterprises from the market, which may include contractors.

Cobalt

761. The supply of raw materials to the world cobalt industry as a whole is quite high, at 45 years on the basis of reserves and more than 100 years on the basis of resources. Growth prospects of cobalt production and its supply to the world market, as noted in section 4.C, are mainly related to the possible involvement of new fields, as well as to the expansion of the capacity of some existing operations.

762. As noted earlier, cobalt is mainly a by-product of copper and nickel production. Therefore, its current and future mining production is practically not controlled by the situation in the market for this metal. This makes it particularly sensitive to the market when the trends in consumption of cobalt and basic copper and nickel by-products are omnidirectional.

763. Mining production of cobalt is characterized by high geographical concentration. Currently, more than 60 per cent of global cobalt mine production is provided by DR Congo, and by the mid-2020s its share may increase to more than 70 per cent. Such a high concentration of production itself represents a high risk for supplies. In the case of DR Congo, this risk is fundamentally increased due to the domestic political and economic situation in the country.

764. A large proportion of the risks associated with DR Congo are due to the high proportion of artisanal mining (about 15–20 per cent), where child labour is often involved. While the main growth in DR Congo's production will come from industrial mining, the rise in metal prices in 2017–2018 ensured an influx of labour into small-scale mining, which is of vital importance for the poverty-stricken local population. Although artisanal mining is legislated (DRC Mining Code 2002 and new DRC Mining Code 2018) and is legal in formally-established artisanal mining areas, in practice it is largely illegal and unregulated. Typically, illegally-produced concentrates are sold to local intermediaries and resold by them to larger trading companies and processors.

765. In recent years, civil society has repeatedly criticized the cobalt supply chains associated with DR Congo and called for greater consumer compliance with due diligence requirements in order to confront social disadvantages such as child labour or unstable working conditions during extraction. "Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and

High-Risk Areas",[222] developed by the OECD, which is applicable to all types of minerals and therefore cobalt, provides a basis for addressing relevant supply chain risks. Although not defined as a "conflict mineral", cobalt is subject to similar risks due to framework conditions in the artisanal and small-scale mining sector in DR Congo. The problem is not the artisanal origins per se, but a review and improvement of mining conditions. The OECD recommends that international buyers and their customers, when purchasing cobalt from DR Congo, ensure that mining and processing in the country complies with due diligence requirements such as legality, absence of child labour, lack of conflict financing, and supply chain traceability. This requirement must be critically reviewed, particularly in the case of documented or suspected origin of the ores from small-scale artisanal mining. Since supply chains with cobalt that is allegedly only industrially mined may also contain artisanal cobalt, a detailed assessment of supply-chain risks is essential. As a result, some companies and industry associations in the downstream cobalt supply chain also emphasize the need for due diligence. Specifically, two general risk categories can be distinguished for cobalt sourcing from DR Congo. On the one hand, there are supply chain-related risks that must be considered in the context of due diligence and corporate reputation. In addition to these supply chain-related risks, raw materials sourced from DR Congo are also exposed to generally higher country risks due to relatively weak government structures and the volatility of the security and political situation in the country, which can also influence relatively stable areas such as the former province of Katanga, where the majority of the country's copper and cobalt production takes place.

766. The production of cobalt in DR Congo and, consequently, the volume of its supply to the world market will be significantly affected by any changes in the country's legislation and tax policy with regard to production. The adoption of the new Mining Code in 2018 is an example of this. Among its key provisions are introduction of a 10 per cent royalty for strategic minerals, which include cobalt, and creation of a special 50 per cent tax on excess profits, defined as profits made when a commodity exceeds by 25 per cent the price used in the bankable feasibility study.

767. Thus, there is a whole series of diverse risks related to the supply of cobalt from DR Congo and its increasing production. This was one of the reasons for including cobalt on the list of critical minerals in the USA and EU.[223,224]

768. At the same time, high supply risks from DR Congo could become a powerful incentive for the development of new fields in countries and regions with stable economic and domestic political conditions, as well as for exploration for cobalt there. They can stimulate an increase in the number of operations processing laterite cobalt-nickel ores to produce cobalt products, as well as an increase in extraction of cobalt from secondary sources.

769. Future prospects for cobalt consumption are mainly related to the sector of lithium-ion batteries used in electric transport, electronic devices and stationary batteries. Consumption in non-

[222] OECD (2016). *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: Third Edition*. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264252479-en.

[223] USGS (2017). Cobalt. Chapter F of Schulz, Klaus J., John H. DeYoung, Jr., Robert R. Seal II, and Dwight C. Bradley, eds. *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*. https://pubs.usgs.gov/pp/1802/f/pp1802f.pdf.

[224] EC (2017). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the 2017 list of Critical Raw Materials for the EU. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0490.

battery areas will not play a significant role in the forecasts.

770. Cobalt consumption growth projections are based mainly on expectations of the pace of development of electric transport. However, as mentioned above, in reality the global transition to "green technologies" may be severely slowed down or even stopped.

771. Changes in the chemical composition of lithium-ion batteries aimed at the complete replacement of cobalt or at reducing its content may reduce the potential consumption of cobalt. This process is already underway in batteries for electronic devices, and is expected to spread to EV after 2020. However, there are no quantitative estimates of its consequences yet.

772. Thus, the development of the situation in the cobalt market is subject to a large number of risks both in terms of demand and supply. Nevertheless, there are reasons to believe that by the mid-2020s the cobalt market will be saturated.

773. As for the influence on the situation with deep-sea mining, if the mining of deep-water nodules starts from 2027, as the scenarios under consideration (see section 4.C) suggest, it is quite likely that it will be carried out against the background of metal deficit on the market. However, there is no certainty as to the scale of this deficit. It will be determined by the real production level (some of it may be provided by deposits which are currently being explored and are not taken into account in our forecast) and consumption at the time the production of polymetallic nodules starts. The degree of impact of deep-sea mining on land-based mining will be determined by the ratio of its volume to the deficit. If it exceeds the deficit, the market will move from a state of saturation, and this will create the conditions for a price decline whose scale cannot be assessed.

774. If deep-sea mining starts earlier, it will increase market surpluses that can be maintained until around mid-2025 to 2027, depending on the rate of consumption growth. It would then cause increased competition among producers of all types (including deep-sea producers). It is believed that in such a struggle the enterprises whose production is characterized by the lowest prime cost have advantages in that they are the ones with greater resistance to market fluctuations. As far as cobalt producers are concerned, it is becoming more and more complicated due to the fact that this metal is present as a by-product component in the ores of practically all developed deposits. Nevertheless, this struggle may result in displacement of the least economically efficient enterprises from the market, which may include contractors. Among land-based producers, the most affected may be the enterprises located in DR Congo due to the fact that their share is the main production.

Manganese

775. The world industry's manganese ore supply is generally high. Depending on the level of their output, it is estimated at 70–90 years based on reserves and 150–200 years based on resources. However, the quality of the ores is not uniform. Low-grade (China) and mid-grade (South Africa, India) ores account for a significant share of reserves and resources. High-grade manganese ore is concentrated in a limited number of countries, including Australia, Gabon, Brazil, South Africa, Indonesia, and some others.

776. The global production and consumption of manganese ores is determined mainly by the volume of steelmaking and the rate of its growth, which in turn depends largely on the global economic situation. During stagnation or economic downturn, steel production may decrease both in individual countries and globally. Accordingly, when the world

economy slows down, the demand for manganese ores decreases. This, in turn, leads to lower prices for them, while some mines reduce production volumes or suspend production, and production of manganese ores decreases.

777. As mentioned above, the global economy is in a synchronized slowdown.[225] Therefore, throughout 2019 short-term growth forecasts for the world economy as a whole and for the economies of key countries and regions, in particular China, were declining. Should these forecasts be confirmed, they will have a corresponding impact on the world steel industry and, subsequently, on manganese ore production.

778. It should also be noted that more recycled materials are steadily being used in steelmaking, including steel scrap already containing manganese. As a result, the consumption of manganese ores for the production of one tonne of steel decreases, and thus the increase in their consumption gradually becomes more restrained.

779. Since China is the main producer of both steel and manganese alloys, production is heavily influenced by the cycles of the Chinese economy, as well as by the Chinese government's economic policy, in particular that aimed at tightening environmental requirements and modernizing the industry. Numerous small metallurgical plants smelting silico-manganese and polluting the environment are being shut down or modernized. This also applies to manganese mines. Thus, in 2018 environmental and safety inspections suspended the operating of many medium and small mines,[226] and in 2019 the National Development and Reform Commission of China started a public discussion on the prospects for closing down low-yielding and outdated manganese ore production. In particular, it could affect the largest-by-reserves and most important mining region in China, the so-called "manganese ore triangle" of the provinces of Húnán and Gùizhōu.[227]

780. In addition, there is uncertainty regarding manganese consumption in China. On the one hand, some decline in steel production is forecasted in the short term,[228] while on the other hand, the requirements for manganese content per tonne of steel have increased. Actual consumption will be determined by which of these trends will have a greater impact.

781. Many countries where the mining of manganese ore is currently underway or planned are characterized by a relatively unstable political and business environment. This creates additional risks for the manganese industry. Thus, in Indonesia, a significant number of mines were forced to close down under the Indonesian government's beneficiation policy in 2013, which banned the export of unprocessed ores.[229] In DR Congo, Kisenge mine was inactive for more than 40 years due to the Congolese wars as well as the civil war in Angola, through which manganese ore from Kisenge mine was exported.

782. Tax policy of the producing countries

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[225] IMF (2019). *World Economic Outlook, 2019 October*. https://www.imf.org/en/Publications/WEO/Issues/2019/10/01/world-economic-outlook-october-2019.

[226] SMM (2018). News: Highlights of China's manganese industry in 2018. https://news.metal.com/newscontent/100864496/Highlights-of-China%27s-manganese-industry-in-2018/.

[227] Metal of Ukraine and the World. Forecast: Global prices for manganese are promised stability. https://ukrmet.dp.ua/2019/06/07/prognoz-mirovym-cenam-na-marganec-obeshhayut-stabilnost.html.

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also influences changes in production volumes. Thus, the government of Gabon launched a new mining code in effect from July 2019 in a bid to attract more mining investments and reduce reliance on oil (crude oil sales account for about 30 per cent of state revenue). The measure will cut corporate taxes by slashing fees on mineral exports. The country is aiming to draw investors interested in manganese, gold, and iron ore as it tries to boost the mining sector's GDP contribution.[230]

783. In the future, despite increased demand for manganese from battery manufacturers, the steel industry will remain the main area of use, while China will remain the main consumer. The observed slowdown in the world economy, and especially in China, does not imply high growth rates of manganese ore consumption in the short term. The situation may change in the medium and long term.

784. Regarding the prospects of deep-sea mining, based on the current macroeconomic situation, the most probable scenarios are those where the manganese consumption growth rate will not exceed 2 per cent per year. In that case, the potential demand can be fully met by land-based production. Moreover, with consumption growth at 1 per cent, only operating mines with sufficient capacity to provoke overproduction will be able to satisfy the demand. If production of manganese ore begins in such circumstances, it will finally bring down the manganese ore market to the limit, aggravating the competition between operations of all types (including deep-sea operations). The winners in this struggle will be the operations whose production are characterized by the lowest cost at the best quality. The result of this struggle may be the ousting of the least economically efficient operations from the market, which may include contractors. If the sale price of nodules is higher than that of manganese ore from land-based mines, there will be no demand for manganese alloy and electrolytic manganese producers.

785. If, after all, the growth rate of consumption of manganese ores will exceed 2 per cent per year, the manganese market may face a deficit, which will not be able to compensate for the currently operating mines and manganese projects. The extent of this deficit will be determined by the specific situation. Based on the scenarios we are considering (see section 4.C), if consumption increases by 3 per cent per year, the deficit may occur in the mid-2020s and reach a maximum of 18 Mt of manganese ore in 2035. These volumes correspond to the total productivity of six contractors. If the number of contractors entering the market by 2035 is greater and all the on-land projects we take into account are successfully commissioned, there will be a surplus in the market again.

Polymetallic nodules

786. Factors influencing the situation in the markets of affected metals (collectively and individually) will also affect the prospects for implementation of deep-sea mining projects.

787. A decrease in the price of one or more of the four metals by any cause (including the very beginning of deep-sea mining) automatically reduces the market value of the polymetallic nodules as raw materials for these metals. Such a decline may result in some or even all of the deep-sea mining projects becoming subeconomic or unprofitable. Such transformation of markets is possible both before and during seabed mining. At the

[230] Mining Weekly (2019). Sector News: Gabon's new mining code to boost revenue, attract investment. https://www.miningweekly.com/article/gabons-new-mining-code-to-boost-revenue-attract-investment-2019-08-05/rep_id:3650.

same time, as noted above, there will be an intensification of competition between different market participants, which will include seabed mines. The survival of each of the participants in this struggle will depend on the level of its profitability at a certain level of prices for affected metals.

788. It should be emphasized that the level of prices for affected metals that will be in place by the time deep-sea production begins may prove critical for contractors and force them to postpone their entry into the market.

789. It is important to bear in mind that the market position of polymetallic nodules and, consequently, the profitability of their production projects will be significantly (if not fundamentally) influenced by the organization of their processing. It is now estimated (including by the MIT economic model) that nodules will first be processed to extract copper, nickel, and cobalt, with the remainder to be sold to manganese-rich slag (ferro-alloys or EMM) producers. In this connection, the issue of interaction between different links of such organizational and production chains remains unsolved.

790. An important technological feature of polymetallic nodules as a source of manganese is the relatively high content of phosphorus, which is a harmful impurity for manganese raw materials. Its presence in the ores of land-based producers forces producers of manganese alloys to include the process of dephosphorization in technological schemes. In manganese-rich slag, phosphorus content remaining after extraction of non-ferrous metals may become a critical parameter for the prospects of their implementation.

791. In this regard, the technological and economic aspects of polymetallic nodule processing in general, and manganese rich slag in particular, require more careful consideration.

7. Summary and conclusions

792. Activities in the Area may result in serious adverse effects on export earnings or the economies of DLBPS as a result of a decline in the prices or supply volumes of affected metals. In doing so, as stipulated in the UNCLOS, developing States shall be protected from "… adverse effects on their economies or on their export earnings resulting from a reduction in the price of an affected mineral, or in the volume of exports of that mineral, to the extent that such reduction is caused by activities in the Area…" (UNCLOS, Articles 150 (h) and 1 (3)). This identified the need to study the potential impact of mining in the Area on the economies of DLBPS of these minerals which are likely to be most severely affected, with a view to minimizing their difficulties and helping them to adapt to the economy. This need was enshrined in the 1994 Agreement.

793. Potential impacts of seabed mineral production (including polymetallic nodules) for DLBPS and criteria for its assessment were considered by Special Commission 1 of the Preparatory Commission. Recommendations developed by Special Commission 1 concerning research directions required to study the possible impacts of seabed mineral production on DLBPS are comprehensive and have not lost their relevance.

794. The basis for the assessment of possible consequences of seabed mineral production is the forecast of the balance of demand/supply (consumption/production) in the markets of affected metals which will be in place by the time of possible start of offshore mining. The optimal option for the market to start offshore production will be a period of deficit, when land-based production will be insufficient. Given the multiplicity of factors affecting both consumption and land-based production prospects, and given the forecast horizon, any forecast will be subject to a significant degree of uncertainty. This makes scenario-based forecasting advisable.

795. There is a high degree of uncertainty about the timing and intensity of commercial production of polymetallic nodules. One of the factors in this uncertainty is the level of prices for commercial metals which will be in the market at the time the contractors are ready to start production. It could be that contractors' work would not be profitable. It is possible, however, that a single contractor may start work around 2027 and that the number of such contractors may increase from 2030.

796. This report considers three scenarios for the development of mining: minimum (two contractors), base (six contractors) and maximum (twelve contractors). All scenarios imply that the first contractor starts production in 2027 and the second in 2030, and the remaining contractors (subject to their involvement) will join the process in 2031–2033. It is also assumed that the maximum aggregate production level of six or twelve contractors may be reached in 2035. According to these introductory conditions, three deep-sea

Table 7.1. Estimated extraction rates of polymetallic nodules and production rates of affected metals for 2, 6 and 12 contractors

	2 contractors	6 contractors	12 contractors
Start of production, year	2027	2027	2027
Reaching full capacity, year	2032	2035	2035
Mining of polymetallic nodules at full capacity, tonnes	6,000,000	18,000,000	36,000,000
Production of affected metals at full production capacity, tonnes			
Cobalt	10,200	30,600	61,200
Nickel	74,100	222,300	444,600
Copper	59,400	178,200	356,400
Manganese	1,533,600	4,600,800	9,201,600

mining scenarios are considered for each of the metals under consideration (Table 7.1).

797. The analysis of the development of the situation on the markets of the metals under consideration in the period up to 2035 shows that in the case of commissioning of all the projects for the development of new deposits of copper, nickel, cobalt, and manganese with the minimum projected growth rates of consumption (they are individual for each metal), deficits on the markets of copper and manganese will not appear, and on the markets of nickel and cobalt they will appear only after 2029. At the maximum consumption growth rate, deficit on the nickel market will appear in the next two years, on the cobalt and manganese ore markets after 2025, and on the copper market only after 2030. Provided that a deficit in the copper, nickel, and cobalt markets is formed, regardless of the consumption growth scenario under review, it will exceed the potential production of these metals even by twelve contractors. In the case of manganese ores, the maximum number of contractors should not exceed six.

798. The asynchronous and disharmonious development of situations in the related markets of the metals under consideration makes possible a scenario in which a deficit will appear in some of them, while in others it will not. This makes it more difficult to assess the impact of the start of deep-sea mining on DLBPS. However, it can be said that there are conditions under which the start of mining after 2027 by no more than six contractors will not cause oversaturation of the market with the metals under consideration.

799. Production of metals from manganese nodules may cause the price of metals to fall even without a surplus, due to increased supply. This may trigger a decrease in export prices of metal products and, as a result, export revenues to the country. The only way to avoid a drop in export revenues in this scenario is to increase export volumes, which is likely to be impossible or lead to a further drop in prices. There is an opinion that the situation may be mitigated by organizing or expanding processing of raw materials on the territory of DLBPS. This can be seen as a dual positive effect, through the development of domestic industry and economy, and through the emergence or expansion of export opportunities for more expensive products. However, it should be taken into account that any additional products

Table 7.2. Countries exporting copper, nickel, cobalt, and manganese products which are likely to be most seriously affected by seabed production

	Products share in export revenues (%)	Products share in GDP (%)
Exporters of copper products		
Zambia	56.1	18.7
Democratic Republic of the Congo	55	11.1
Eritrea	50	5.6
Chile	48.9	12.8
Lao People's Democratic Republic	34.4	7.7
Mongolia	26	15.9
Peru	25.8	5.1
Exporters of nickel products		
Madagascar	20.3	3.7
Zimbabwe	15.6	3.1
Exporters of cobalt products		
Democratic Republic of the Congo	24.3	4.8
Exporters of manganese products		
Gabon	21.9	5
Cumulative effect of exports of all affected metals		
Mauritania	12	4.8
Namibia	11.4	4.9
Papua New Guinea	10.6	4.3

must find consumers (and it is not clear whether there will be such consumers). In addition, it will in any case put pressure on the market. As a result, the development of the processing industry in DLBPS may not bring the expected effect.

800. The analysis of the role of export earnings from the four affected metals in total DLBPS export earnings and in their GDP allowed identification of the countries which are likely to be most seriously affected by seabed production. The criterion for their allocation was the share of export earnings from metals in total export earnings of the country, which should be at least 10 per cent. The second criterion (used to check and reinforce the results) was the share of export revenues from affected metals to the country's GDP, which should be at least 5 per cent. These countries included seven countries exporting copper products, two countries exporting nickel products, and one country exporting cobalt and manganese products. A further three countries were included in this category based on the share of total exports of all four metals

(Table 7.2). However, identifying the full list of countries which may truly be most seriously affected by seabed production will be possible only after the actual start of deep-sea mining.

801. Furthermore, the decrease in prices will result in aggravation of competition between operations of all types (including contractors). This may result in the closure of the least cost-effective land-based mining operations or their transition to variable-capacity functioning, which may have a cascade of negative consequences, not only economic but also social and political. At the same time, it is possible that the decline in prices will reach a level at which deep-sea mining will be on the verge of profitability or will become completely unprofitable.

802. As part of this study, we do not offer any assistance or compensation for losses of DLBPS that could be seriously affected by deep-sea mining. The 1994 Agreement takes account of this issue. According to that document, ISA shall establish an economic assistance fund for which only receipts in the form of royalty payments from contractors, including the Enterprise, and voluntary contributions to ISA shall be used (1994 Agreement, Article 7). ISA therefore needs to determine the rates of royalty payments by contractors in order to be able to pre-assess the possible extent of the economic assistance fund for affected DLBPS. Once deep-sea mining begins, the amount and duration of economic assistance will be determined on a case-by-case basis, taking into account the nature and extent of the problems faced by the affected DLBPS (1994 Agreement, Article 7).

Tables and figures

Tables

Figures

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Recommendations for further studies

803. The results of the study reflect the market development prospects mainly based on the data available for analysis as of the end of 2019. However, the market situation is changing rapidly. A clear indication of this is the outbreak of coronavirus infection, which in just three months has not only spread around the world, but also resulted in a sharp downturn in the global economy. Therefore, it is advisable to conduct studies such as this one on a regular basis, at intervals of at least 3–5 years. In addition, we consider it necessary to conduct such a study immediately before the start of deep-sea mining. This will create a factual basis for assessing its real impact on the markets of affected metals and on their DLBPS participants.

804. In addition, for a more complete picture of the possible impact of offshore mining, it seems useful to make a comparative assessment of the cost of deep-sea mining and ore extraction by different methods on land, and the cost of processing of polymetallic nodules with the production of marketable metal products with the cost of similar products received from ores and concentrates of land-based producers. This will allow for a more correct assessment of the potential impact of seabed mining, as well as the degree of resilience of land-based producers to the impacts of offshore mining.

805. To further elaborate the issue of possible consequences of the beginning of deep-sea mining for DLBPS, we believe it would be advisable to assess in detail the impact of changes in prices for the affected metals on the situation in these countries. At the same time, we should consider changes in the situation both in case of falling and rising prices. In this regard, we consider it interesting to assess the impact of organizing the production of products with higher added value in DLBPS which may be most seriously affected.

806. With respect to offshore production taking place in the deepest areas, we consider it important to assess technological, financial and economic, and market aspects of extraction of metals other than copper, nickel, cobalt, and manganese from polymetallic nodules. It is obvious that with technological opportunities for profitable extraction of additional types of metals, the economic performance of deep-sea mining and all derivatives will increase. At the same time, this could have a negative impact on a wider range of commodity markets and widen the list of DLBPS that are likely to be affected by mining in the Area, which also requires separate consideration.

807. It also seems important to conduct a study to assess the possible positive impact of polymetallic nodule mining on the economies of DLBPS. The need for such a study is determined by the opinion that a decline in the prices of affected metals will reduce not only export earnings to DLBPS, but also the cost of goods produced from

these metals. This, in turn, will ensure cheaper imports of such goods into DLBPS, which will somewhat compensate for losses in export earnings of these countries, as well as make imported goods more accessible to their population and businesses. Such price reduction, if it is indeed possible, can act as an incentive for the development of DLBPS' economies.

Annexes

Annex 1. Terms and definitions

Anode	Crude metal (nickel or copper) obtained from anode smelting and fed for electrolytic refining (electrolysis) whereby it is dissolved.
Artisanal (small-scale) mining	A complex and diversified sector that includes a range from poor informal individual miners seeking to eke out or supplement a subsistence livelihood, to small-scale formal commercial mining activities that can produce minerals in a responsible way respecting local laws.
Blister copper	The product of a converting furnace. It is an intermediate, more concentrated (with respect to the desired metal) material than matte, from which it is made, and is usually transferred to another furnace for further concentration.
Cathode	Pure metal (nickel or copper) obtained as a result of electrolytic refining of anodes.
Cement copper (precipitated copper)	A product obtained by precipitation (cementation), i.e. by adding iron to the aqueous solution resulting from the leaching of certain ores or waste. It is a finely devised black powder containing oxides and insoluble impurities. Cement copper is often added to the charge which goes to a converting furnace to produce copper matte.
Cobalt alliage blanc	An alloy of cobalt, copper, and iron.
Concentrate	A product of ore concentration with a high grade of the extracted mineral, which gives its name to the concentrate (copper, nickel, etc.).
Concentration	Artificial improvement of metallurgical feedstock mineral grades by removal of a major portion of waste rock not containing any valuable minerals.

Conversion	An autogenous pyrometallurgical process, where ferrous and other detrimental impurities are oxidised and removed as slag. The result of conversion is blister copper (copper concentrate smelting) or high-grade matte (copper and nickel concentrate smelting).
Copper electrowon	Product of SX-EW process. High-grade electrowon (Commercial Cathode) is an SX-EW product that can be treated as refined cathode and sold as such. Low-grade electrowon is an SX-EW product that must be re-refined.
Direct melt copper scrap	Direct melt, or re-melt, scrap is secondary material that can be used directly in a furnace without cleanup through the use of fluxes and poling and re-refining.
Electrolytic nickel	A finished nickel product, with a nickel content of 99 per cent or more.
Electrolytic manganese dioxide (EMD)	A complex composite of various crystals of manganese and oxygen that is produced through electrowinning. It is used primarily as the active constituent of alkaline batteries and increasingly as the feedstock for the cathode material in lithium-ion batteries.
Electrolytic manganese metal (EMM)	A type of electrolytic manganese, which is a refined manganese product created through the purification and electrolysis of a manganese-rich solution that is made by dissolving manganese carbonate ore or calcined manganese oxide ore.
Feasibility study	A detailed technical plan and financial budget for the construction and operation of a project.
Ferro-alloys	Various alloys of iron with a high proportion of one or more other elements such as manganese, aluminium, or silicon. They are used in the production of steels and alloys.
Ferro-manganese	Ferro-alloy with high content of manganese, made by heating a mixture of the oxides MnO_2 and Fe_2O_3, with carbon, usually as coal and coke, in either a blast furnace or an electric arc furnace-type system, called a submerged arc furnace.
Silico-manganese	Ferro-alloy with high contents of manganese and silicon, made by heating a mixture of the oxides manganese oxide (MnO_2), silicon dioxide (SiO_2), and iron oxide (Fe_2O_3), with carbon in a furnace.
Ferro-nickel	Alloy of iron and nickel obtained by direct reduction during reduction smelting.

Flotation	A concentration process where specific mineral particles suspended within the pulp attach to air bubbles. Poorly-wettable mineral particles attach to the air bubbles and rise through the suspension to the top of the pulp, producing foam, while well-wettable mineral particles do not attach to the bubbles and remain in the pulp. This is how the minerals are separated.
Green technologies	The application of one or more of environmental science, green chemistry, environmental monitoring, and electronic devices to monitor, model, and conserve the natural environment and resources, and to curb the negative impacts of human involvement.
Hydrometallurgical processes	Extraction of metal from ore by preparing an aqueous solution of a salt of the metal and recovering the metal from the solution. The operations usually involved are: leaching, or dissolution of the metal or metal compound in water, commonly with additional agents; separation of the waste and purification of the leach solution; and the precipitation of the metal or one of its pure compounds from the leach solution by chemical or electrolytic means. The most common leaching agent is dilute sulfuric acid.
Laterite	A consolidated product of humid tropical weathering predominantly composed of goethite, hematite, kaolin, quartz, bauxite, and other clay minerals. Laterite ores are the source of nickel.
Magmatic nickel-copper-cobalt sulphide deposits	Deposits in which sulphur saturation of mafic magma causes dense cobalt and nickel sulphides to be concentrated in basal sections of magma chambers.
Matte (cobalt, copper, nickel)	An intermediate product in the form of an alloy of sulphides of iron and nonferrous metals with a varying chemical composition. Matte is the main product accumulating precious metals and metal impurities the feedstock contains.
Mine	A mining location for extraction of ores.
Mineral deposit	A mass of naturally occurring mineral material (near the surface or deeper underground) which is economically valuable in terms of quantity, quality, and conditions.
Mixed Hydroxide Precipitate (MHP)	One of intermediate products of nickel laterite ore processing through a hydrometallurgical route.
Mixed Sulphide Precipitate (MSP)	An intermediate product that is re-dissolved to make concentrated solutions of nickel and cobalt suitable for high-purity metal production.

Nickel Pig Iron (NPI)	A low-grade ferro-nickel invented in China as a cheaper alternative to pure nickel for the production of stainless steel.
Ore	Natural minerals containing metals or their compounds in economically valuable amounts and forms.
Polymetallic nodules	Rounded accretions of manganese and iron hydroxides that cover vast areas of the sea floor, but are most abundant on abyssal plains at water depths of 4,000-5,000 m.
Prefeasibility study	An early stage analysis of a potential mining project. Conducted by a small team and designed to give company stakeholders the basic information they need to green-light a project or choose between potential investments.
Pyrometallurgical processes	Metallurgical processes performed at high temperatures, including roasting, smelting, and conversion, which are distinguished depending on their technological characteristics.
Refining	Purification of primary metals from impurities.
Reserves	The economically mineable part of a measured or indicated mineral resource. It includes diluting materials and allowances for losses, which may occur when the material is mined.
Proved reserves	Ore reserves that represent the economically mineable part of a measured mineral resource. Includes diluting materials and allowances for losses which may occur when the material is mined.
Probable reserves	The economically mineable part of an indicated, and in some circumstances measured, mineral resource. It includes diluting materials and allowances for losses which may occur when the material is mined.
Resources	A concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality, and quantity that there are reasonable prospects for eventual economically viable extraction.

Measured resources Resources representing that part of mineral resources from which tonnage, densities, shape, physical characteristics, grade, and mineral content can be estimated with a high level of confidence, based on detailed and reliable exploration, sampling, and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings, and drill holes. The locations are spaced closely enough to confirm geological and/or grade continuity.

Indicated resources Resources representing that part of mineral resources from which tonnage, densities, shape, physical characteristics, grade, and mineral content can be estimated with a reasonable level of confidence, based on exploration, sampling, and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings, and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.

Inferred resources Resources representing that part of mineral resources from which tonnage, grade, and mineral content can be estimated with a low level of confidence, inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques.

Economic resources This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Sub-economic resources The part of identified resources that does not meet the economic criteria of reserves.

Undiscovered resources Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or sub-economic.

Roast-leach-electrowon (RLE) process The electrolysis process, consisting of 4 steps: leaching, purification, electrolysis, and melting and casting.

Scrap Recyclable materials left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. Unlike waste, scrap has monetary value, especially recovered metals, and non-metallic materials are also recovered for recycling.

Sediment-hosted stratiform (stratabound) deposits	Copper and cobalt deposits, characterized by ore minerals contained within organic-rich pyritic shales and sandstones deposited in a near-shore lagoonal environment, under reducing conditions.
Smelting	A pyrometallurgical process performed at high temperatures enabling the complete melting of the processed material.
Solvent Extraction - Electrowining (SX-EW)	A two-stage hydrometallurgical process that first extracts and upgrades copper ions from low-grade leach solutions into a solvent containing a chemical that selectively reacts with and binds the copper in the solvent. The copper is extracted from the solvent with strong aqueous acid, which then deposits pure copper onto cathodes using an electrolytic procedure (electrowinning).
Super-alloys	A group of nickel, iron–nickel, and cobalt alloys used in aircraft turbine engines for their exceptional heat-resistant properties.

Annex 2. Data and information tables

A. Copper production

Table A.1. Mine production of concentrates and SX-EW

COUNTRY*	Medium (TMT Cu)	2017 (TMT Cu)	2017 (%)
Chile	5,520.3	5,503.5	27.5
Peru	1,558.0	2,445.6	12.2
China	1,501.6	1,706.4	8.5
Congo, D.R.	650.9	1,002.0	5.0
Zambia	694.3	794.1	4.0
Mexico	481.1	742.2	3.7
Indonesia	627.6	622.0	3.1
Brazil	271.6	384.4	1.9
Mongolia	209.7	310.9	1.6
Iran	254.9	302.0	1.5
Laos	143.4	153.3	0.8
Myanmar	33.6	115.1	0.6
Papua New Guinea	115.6	105.0	0.5
Turkey	99.7	83.0	0.4
Philippines	67.6	67.8	0.3
South Africa	86.4	65.5	0.3
Saudi Arabia	10.8	43.0	0.2
Argentina	108.2	33.3	0.2
India	32.0	31.1	0.2
Mauritania	35.7	28.8	0.1
North Korea	16.0	20.0	0.1
Pakistan	20.0	20.0	0.1
Morocco	16.0	18.0	<0.1
Tanzania	11.1	15.8	<0.1
Namibia	7.4	15.5	<0.1
Vietnam	13.2	15	<0.1
Dominican Rep.	9.5	11.1	<0.1
Colombia	3.4	9.4	<0.05
Eritrea	20.6	8.0	<0.05
Zimbabwe	6.5	8	<0.05
Bolivia	5.8	6.4	<0.05
Botswana	28.8	1.4	<0.05
Oman**	12.4	0	0
DLBPS Total	12,673.7	14,687.6	73.3
World Total	17,628.9	20,038.4	100.0

Source: ICSG.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the “Medium” column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.2. Smelter production of copper in primary blister and anode

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
China	4,136.1	6,050.0	37.3
Chile	1,426.5	1,404.7	8.7
India	713.5	813.1	5.0
Zambia	542.7	787.9	4.9
Peru	319.2	316.9	2.0
Mexico	223.3	270.0	1.7
Indonesia	244.3	245.8	1.5
Philippines	196.7	240.0	1.5
Brazil	169.0	118.8	0.7
Iran	164.8	114.2	0.7
South Africa	75.4	70.0	0.4
Turkey	35.5	46.0	0.3
Namibia	29.1	44.9	0.3
Pakistan	20.0	20.0	0.1
Oman**	11.7	12	<0.1
Vietnam	7.2	8.0	<0.1
Botswana	17.0	0	0
DLPBS Total	8,342.0	10,572.3	65.2
World Total	14,111.6	16,209.3	100.0

Source: ICSG.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.3. Refinery production of primary copper

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
China	4,404.0	6,614.3	34.0
Chile	2,878.8	2,429.5	12.5
India	713.5	813.1	4.2
Congo, D.R.	495.5	717.5	3.7
Zambia	491.2	466.1	2.4
Mexico	362.8	441.0	2.3
Peru	368.9	335.3	1.7
Indonesia	246.1	268.2	1.4
Philippines	160.9	205.0	1.1
Brazil	177.9	118.3	0.6
Myanmar	33.6	115.1	0.6
Iran	140.6	103.2	0.5
Turkey	63.9	88.0	0.5
South Africa	74.3	70.0	0.4
Laos	77.0	62.9	0.3
Namibia	4.3	15.5	<0.1

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Mongolia	5.0	14.4	<0.1
Oman**	11.7	12.0	<0.1
North Korea	10.0	10.0	<0.1
Vietnam	7.2	8.0	<0.05
Zimbabwe	4.5	5.0	<0.05
Bolivia	2.3	3.0	<0.05
DLBPS Total	10,733.8	12,915.4	66.3
World Total	17,289.6	19,469.5	100.0

Source: ICSG.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

B. Copper export

Table A.4. Export of copper ores and concentrates (2603)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Chile	7,699.1	9,727.5	28.3
Peru	4,433.2	8,023.2	23.4
Indonesia	1,652.7	1,539.8	4.5
Mexico	688.3	1,483.4	4.3
Mongolia	928.4	1,447.2	4.2
Brazil	837.8	1,248.3	3.6
Iran	283.1	612.4	1.8
Congo, D.R.	388.4	607.6	1.8
Papua New Guinea	439.8	415.5	1.2
Laos	246.1	377.8	1.1
Turkey	319.1	246.3	0.7
Philippines	274.3	198.8	0.6
Morocco	80.3	166.0	0.5
Argentina	425.2	154.6	0.4
Mauritania	179.7	142.0	0.4
Saudi Arabia	33.0	107.9	0.3
Namibia	32.4	56.4	0.2
Colombia	16.0	51.2	0.1
India	17.0	45.8	0.1
Dominican Rep.	28.4	43.2	0.1
Eritrea	66.4	29.8	<0.1
Oman**	79.1	27.9	<0.1
Bolivia	28.5	27.2	<0.1
Zambia	106.6	19.6	<0.1
Tanzania	17.6	7.2	<0.05

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Botswana	67.0	5.0	<0.05
Myanmar	0.3	1.3	<0.05
Pakistan	2.1	0.8	<0.05
North Korea	23.6	0.5	<0.05
Zimbabwe	0.6	0.3	<0.001
China	2.4	0.2	<0.001
Vietnam	4.8	0.2	<0.001
DLBPS Total	19,401.2	26,814.9	78.0
World Total	24,702.3	34,358.7	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.5. Export of copper ores and concentrates (2603)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Chile	14,167.5	15,665.9	27.7
Peru	7,301.4	11,975.0	21.1
Indonesia	3,751.2	3,439.6	6.1
Brazil	1,634.9	2,485.3	4.4
Mexico	1,114.6	1,891.1	3.3
Mongolia	1,307.2	1,613.1	2.8
Congo, D.R.	809.8	988.7	1.7
Papua New Guinea	1,009.3	814.5	1.4
Laos	425.7	578.0	1.0
Iran	97.3	575.0	1.0
Argentina	1,008.5	409.2	0.7
Philippines	461.9	371.4	0.7
Turkey	343.2	234.8	0.4
Namibia	149.4	220.8	0.4
South Africa	379.2	209.2	0.4
Mauritania	211.5	195.0	0.3
Saudi Arabia	52.8	177.4	0.3
Morocco	87.9	164.3	0.3
Colombia	23.7	58.3	0.10
Dominican Rep.	37.4	48.3	<0.1
India	17.0	42.9	<0.1
Eritrea	119.8	39.3	<0.1
Tanzania	86.6	38.9	<0.1
Bolivia	28.6	31.6	<0.1
Ecuador	12.7	28.6	<0.1

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Oman**	35.7	**27.9**	<0.05
Zambia	138.1	**5.5**	<0.05
Zimbabwe	1.9	**5.1**	<0.05
Botswana	75.7	**3.7**	<0.05
Myanmar	0.2	**1.6**	<0.05
Vietnam	7.5	**0.2**	<0.001
China	3.2	**0.1**	<0.001
North Korea	13.3	**0.1**	<0.001
DLBPS Total	34,914.5	**42,340.6**	74.8
World Total	47,253.1	**56,622.1**	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.6. Export of copper unrefined (7402)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Zambia	108.4	**586.5**	40.0
Chile	380.2	**387.2**	26.4
Namibia	34.0	**42.1**	2. 9
Philippines	7.2	**35.2**	2.4
Congo, D.R.	61.4	**33.6**	2.3
South Africa	11.0	**20.5**	1.4
Mexico	4.1	**12.1**	0.8
Peru	12.8	**3.3**	0.2
Laos	0.08	**0.11**	<0.05
Iran	0.1	**0.1**	<0.05
China	1.9	**0.1**	<0.05
Oman**	0.4	**0.05**	<0.05
Brazil	0.3	**0.04**	<0.05
Morocco	0.2	**0.02**	<0.05
India	1.4	**0.02**	<0.05
Indonesia	0.9	**0.01**	<0.05
Turkey	4.0	**0.01**	<0.001
Botswana	0.01	<**0.01**	<0.001
Dominican Rep.	12.3	**0.0**	0
Tanzania	0.2	**0.0**	0
Vietnam	0.1	**0.0**	0
Myanmar	0.02	**0.0**	0
Colombia	0.01	**0.0**	0
North Korea	0.01	**0.0**	0

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Saudi Arabia	0.01	0.0	0
DLBPS Total	641.1	1,121.1	76.5
World Total	936.5	1,465.5	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.7. Export of copper unrefined (7402)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Zambia	608.6	3,618.1	38.5
Chile	2,589.5	2,485.0	26.4
Philippines	64.2	316.1	3.4
Namibia	163.5	275.4	2.9
Congo, D.R.	403.7	185.8	2.0
South Africa	59.5	139.3	1.5
Mexico	43.1	71.0	0.8
Peru	87.8	20.7	0.2
Pakistan	0.6	1.7	<0.05
Laos	0.5	0.7	<0.05
China	12.4	0.5	<0.05
Tanzania	0.1	0.5	<0.05
Brazil	2.4	0.2	<0.05
Oman**	1.5	0.2	<0.05
Morocco	1.3	0.1	<0.05
Indonesia	5.3	0.1	<0.001
Turkey	25.5	0.1	<0.001
Botswana	<0.05	<0.05	<0.001
Iran	0.6	<0.01	<0.001
Colombia	<0.05	<0.01	<0.001
Dominican Rep.	20.9	0.0	0
Myanmar	0.5	0.0	0
North Korea	<0.05	0.0	0
DLBPS Total	4,091.5	7,115.4	75.7
World Total	6,202.1	9,400.9	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.8. Export of copper refined, unwrought (740311)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Chile	2,575.4	**2,358.9**	24.8
Zambia	663.8	**413.2**	4.3
Congo, D.R.	312.5	**407.9**	4.3
India	271.1	**400.6**	4.2
China	217.3	**337.7**	3.6
Peru	306.4	**284.2**	3.0
Philippines	108.3	**209.3**	2.2
Indonesia	132.2	**177.6**	1.9
Mexico	116.3	**159.7**	1.7
Iran	129.2	**136.2**	1.4
Myanmar	23.0	**85.8**	0.9
Laos	36.4	**62.8**	0.7
Brazil	68.9	**49.3**	0.5
South Africa	20.8	**48.2**	0.5
Mongolia	6.0	**15.6**	0.2
Turkey	10.4	**15.5**	0.2
Pakistan	4.2	**8.5**	<0.1
Namibia	37.1	**7.0**	<0.1
Bolivia	1.1	**2.1**	<0.05
Saudi Arabia	1.5	**1.6**	<0.05
Argentina	0.3	**1.2**	<0.05
Morocco	1.0	**1.0**	<0.05
Zimbabwe	2.5	**0.4**	<0.05
Colombia	2.2	**0.2**	<0.05
Oman**	2.1	**0.1**	<0.001
Botswana	0.5	**0.02**	<0.001
Vietnam	3.7	**0.01**	<0.001
Dominican Rep.	0.3	**<0.01**	<0.001
North Korea	1.4	**0.0**	0
Tanzania	0.4	**0.0**	0
DLBPS Total	5,056.3	**5,184.5**	54.5
World Total	9,033.8	**9,518.4**	100.00

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.9. Export of copper refined, unwrought (740311)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Chile	18,439.2	14,738.2	27.7
Congo, D.R.	2,011.4	2,464.8	4.6
India	2,197.0	2,425.2	4.6
China	1,479.2	2,054.8	3.9
Zambia	3,317.5	1,896.3	3.6
Peru	2,037.8	1,729.7	3.3
Philippines	726.7	1,269.9	2.4
Indonesia	846.0	1,078.4	2.0
Mexico	635.3	952.4	1.8
Myanmar	136.0	489.9	0.9
Laos	449.5	397.5	0.7
Brazil	429.4	270.3	0.5
South Africa	89.4	185.5	0.3
Iran	366.0	157.4	0.3
Mongolia	35.0	92.7	0.2
Namibia	124.0	21.0	<0.05
Bolivia	7.5	12.3	<0.05
Saudi Arabia	1.2	7.0	<0.05
Vietnam	22.8	0.0	0
Turkey	6.6	0.1	<0.05
North Korea	9.0	0.0	0
Zimbabwe	5.7	0.0	0
Oman**	4.9	0.0	0
Colombia	0.7	0.0	0
Tanzania	0.4	0.0	0
Argentina	<0.05	0.0	0
Botswana	<0.05	0.0	0
Morocco	<0.05	0.0	0
DLBPS Total	33,378.3	30,243.4	56.8
World Total	56,377.2	53,208.3	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

C. Nickel production

Table A.10. Mine production of Ni

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Indonesia	363.6	355.0	16.7
Philippines	294.8	339.4	16.0
China	90.9	94.5	4.4
Brazil	80.4	76.8	3.6
Guatemala	21.5	53.7	2.5
Cuba	61.6	52.9	2.5
South Africa	45.2	48.4	2.3
Colombia	62.3	45.6	2.1
Madagascar	21.1	38.5	1.8
Papua New Guinea	12.0	34.7	1.6
Myanmar	8.5	20.0	0.9
Zimbabwe	10.8	17.7	0.8
Turkey	5.3	17.0	0.8
Dominican Rep.	8.2	15.6	0.7
Botswana**	25.9	0.0	0
Venezuela***	6.5	0.0	0
Vietnam**	2.0	0.0	0
DLBPS Total	1,120.7	1,209.7	56.9
World Total	2,013.6	2,125.4	100.0

Source: INSG.
* – DLBPS only.
** – Mine production has not been conducted since 2017.
*** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.11. Production of nickel intermediate products

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Indonesia	74.5	76.8	28.7
Philippines	32.3	50.6	18.9
Cuba	40.1	37.1	13.9
Papua New Guinea	12.0	34.7	13.0
Turkey	0.6	4.0	1.5
Botswana**	18.7	0.0	0
Brazil	5.6	0.0	0
DLBPS Total	183.7	203.1	76.0
World Total	256.5	267.4	100.0

Source: INSG.
* – DLBPS only.
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.12. Production of primary nickel (including ferro-nickel)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
China	489.8	600.0	29.4
Indonesia	48.8	204.3	10.0
Brazil	53.3	68.5	3.4
South Africa	35.2	43.0	2.1
Colombia	43.6	40.6	2.0
Madagascar	19.3	35.5	1.7
Myanmar	8.5	20.0	1.0
Cuba	21.5	15.8	0.8
Dominican Rep.	8.2	15.6	0.8
Guatemala	3.7	12.4	0.6
Venezuela**	6.4	0.0	0
Zimbabwe	2.7	0.0	0
DLBPS Total	741.1	1,055.6	51.7
World Total	1,742.9	2,041.7	100.0

Source: INSG.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

D. Nickel export

Table A.13. Export of nickel ores and concentrates (2604)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Philippines	26,633.3	38,015.8	72.5
Indonesia	20,168.3	4,882.7	9.3
Guatemala	1,039.2	2,474.6	4.7
Turkey	174.6	239.9	0.5
Zimbabwe	139.0	230.1	0.4
Papua New Guinea	0.1	1.1	<0.05
China	2.4	0.5	<0.05
South Africa	26.9	0.0	0
Myanmar	0.6	0.0	0
Brazil	40.5	0.0	0
Vietnam**	7.1	0.0	0
Botswana**	10.7	0.0	0
DLBPS Total	48,242.7	45,844.8	87.5
World Total	53,651.4	52,418.5	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.14. Export of nickel ores and concentrates (2604)

Country	Medium (million USD)	2017 (million USD)	2017 (%)
Philippines	646.7	685.3	27.7
Zimbabwe	283.9	369.0	14.9
Indonesia	617.8	155.2	6.3
Guatemala	35.4	66.2	2.7
Turkey	7.7	9.2	0.4
China	2.3	0.3	<0.05
Papua New Guinea	0.02	0.2	<0.05
South Africa	36.1	<0.01	<0.001
Botswana**	13.3	0	0
Brazil	56.3	0	0
Vietnam**	20.8	0	0
DLBPS Total	1,720.3	1,285.4	51.9
World total	3,081.7	2,474.5	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.15. Export of intermediate products of nickel metallurgy (7501)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Papua New Guinea	67.9	160.1	21.3
Indonesia	94.5	96.5	12.8
Philippines	25.0	84.2	11.2
Turkey	3.2	21.3	2.8
Cuba	21.6	21.7	2.9
Zimbabwe	5.3	9.8	1.3
China	1.3	0.0	0.0
Botswana**	48.4	0.0	0.0
Brazil	14.4	0.0	0.0
South Africa	9.0	0.0	0.0
DLBPS Total	290.6	393.7	52.4
World Total	513.7	751.7	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.16. Export of intermediate products of nickel metallurgy (7501)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Indonesia	954.6	**629.3**	14.3
Philippines	136.3	**444.3**	10.1
Zimbabwe	263.1	**436.1**	9.9
Papua New Guinea	126.3	**367.5**	8.3
Cuba	283.3	**140.8**	3.2
Turkey	5.0	**34.5**	0.8
South Africa	50.2	**<0.01**	<0.001
China	5.9	**0**	0
Botswana**	361.2	**0**	0
Brazil	95.6	**0**	0
DLBPS Total	2,281.5	**2,052.5**	46.5
World Total	5,164.0	**4,412.8**	100.0

Source: ITC.
* – DLBPS only
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.17. Export of ferro-nickel (720260)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Indonesia	212.4	**1,016.7**	49.0
Brazil	91.4	**209.9**	10.1
Colombia	131.9	**111.0**	5.3
Myanmar	21.1	**98.1**	4.7
Dominican Rep.	21.1	**43.8**	2.1
Guatemala	9.0	**30.5**	1.5
China	4.9	**2.2**	0.1
Venezuela**	12.8	**<0.01**	0.0
South Africa	0.1	**<0.01**	0.0
Vietnam***	0.1	**0.0**	0.0
Philippines	0.7	**0.0**	0.0
DLBPS Total	505.5	**1,512.3**	72.9
World Total	1,075.8	**2,075.1**	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
*** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.18. Export of ferro-nickel (720260)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Indonesia	454.9	**1,331.6**	31.7
Brazil	333.8	**538.0**	12.8
Colombia	670.4	**360.5**	8.6
Myanmar	83.7	**345.0**	8.2
Dominican Rep.	145.3	**156.0**	3.7
Guatemala	36.7	**120.6**	2.9
China	28.7	**8.8**	0.2
Turkey	0.0	**0.1**	<0.05
South Africa	0.7	**<0.01**	<0.001
Venezuela**	66.6	**<0.01**	<0.001
Philippines	1.704	**0**	0
Vietnam***	0.317	**0**	0
DLBPS Total	1,822.8	**2,860.7**	68.1
World Total	3,702.6	**4,203.4**	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2016.
*** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.19. Export of nickel unwrought (750210)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Madagascar	18.5	**33.4**	3.9
China	34.6	**18.3**	2.1
South Africa	5.6	**6.3**	0.7
Turkey	0.2	**0.4**	0.0
Zimbabwe	1.7	**<0.05**	0.0
Brazil	11.9	**<0.01**	0.0
Colombia	<0.01	**<0.01**	0.0
Philippines	0.1	**0.0**	0.0
Indonesia	<0.01	**0.0**	0.0
Cuba	2.4	**0.0**	0.0
DLBPS Total	75.1	**58.4**	6.8
World Total	862.7	**858.4**	100.0

Source: ITC.
* – DLBPS only.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.20. Export of nickel unwrought (750210)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Madagascar	227.3	341.0	3.8
China	646.2	189.8	2.1
South Africa	80.7	63.8	0.7
Turkey	3.3	2.7	<0.05
Brazil	173.8	0.3	<0.05
Zimbabwe	10.9	0.1	<0.05
Colombia	0.1	0.06	<0.001
Indonesia	0.1	0	0
Cuba	39.3	0	0
DLBPS Total	1,181.8	597.8	6.7
World Total	13,673.2	8,335.4	100.0

Source: ITC.
* – DLBPS only.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

E. Cobalt production

Table A.21. Mine production of Co

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Congo, D.R.	76.9	82.5	59.4
China	8.0	9.0	6.5
Cuba	3.6	3.6	2.6
Papua New Guines	1.2	3.3	2.4
Zambia	4.4	3.2	2.3
Madagascar	1.6	2.8	2.0
Philippines	2.4	2.7	1.9
Morocco	1.6	1.9	1.4
South Africa	1.0	1.1	0.8
Brazil	2.6	0.8	0.6
Zimbabwe	0.2	0.4	0.3
Indonesia	1.6	0.3	0.2
Uganda**	0.3	0.0	0
Botswana***	0.2	0.0	0
DLPPS Total	105.7	111.7	80.1
World Total	129.2	139.4	100.0

Source: BGS.
* – DLBPS only.
** – Mine production has not been conducted since 2014.
*** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.22. Refinery production, including metal, oxides, carbonates, sulphates and other compounds

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
China	38.3	69.6	58.3
Madagascar	1.5	3.1	2.6
Zambia	4.3	2.5	2.1
Congo, D.R.	2.4	0.2	0.2
Morocco	1.6	1.9	1.6
South Africa	0.9	1.1	0.9
Uganda**	0.3	0.0	0
Brazil	1.2	0.0	0
DLBPS Total	50.6	78.4	65.7
World Total	86.1	119.4	100.0

Source: BGS.
* – DLBPS only.
** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

F. Cobalt export

Table A.23. Export of cobalt ores and concentrates (2605)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Congo, D.R.	272.1	160.8	92.1
South Africa	2.6	0.2	0.1
China	0.0	0.1	<0.1
Brazil	0.1	0.1	<0.05
Zambia	12.2	0.1	<0.05
Indonesia	7.6	0.0	0
Cuba	4.4	0.0	0
Uganda**	0.2	0.0	0
Morocco	0.1	0.0	0
Botswana***	<0.01	0.0	0
DLBPS Total	299.3	161.2	92.3
World Total	311.6	174.6	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2014.
*** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.24. Export of ores and concentrates (2605)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Congo, D.R.	648.9	524.0	96.7
South Africa	9.1	6.7	1.2
Brazil	0.1	0.3	0.1
China	0.05	0.1	<0.05
Zambia	29.7	0.0	0
Cuba	24.7	0.0	0
Uganda**	3.7	0.0	0
Indonesia	0.2	0.0	0
Morocco	0.1	0.0	0
Zimbabwe	0.01	0.0	0
Botswana***	<0.01	0.0	0
Vietnam	<0.01	0.0	0
DLBPS Total	716.6	531.2	98.0
World Total	732.9	541.8	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2014.
*** – Mine production has not been conducted since 2017.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.25. Export of cobalt intermediate products of cobalt metallurgy and unwrought cobalt (810520)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Congo, D.R.	123.9	214.9	80.1
South Africa	1.0	2.0	0.8
China	3.2	4.2	1.6
Madagascar	1.4	2.8	1.1
Morocco	1.7	2.0	0.7
Zambia	0.5	0.1	0.1
Brazil	0.9	0.0	0.0
Uganda**	0.3	0.0	0.0
Cuba	0.3	0.0	0.0
Zimbabwe	0.01	0.0	0.0
Indonesia	<0.001	0.0	0.0
Vietnam	<0.010	0.0	0.0
DLBPS Total	133.0	226.1	84.3
World Total	176.1	268.3	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2014.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.26. Export of cobalt intermediate products of cobalt metallurgy and unwrought cobalt (810520)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Congo, D.R.	724.2	**1,896.6**	52.9
China	129.9	**208.7**	5.8
Madagascar	47.1	**151.9**	4.2
Morocco	56.1	**79.7**	2.2
South Africa	8.8	**25.3**	0.7
Zambia	3.1	**0.5**	0.0
Brazil	13.7	**[illegible]0.05**	<0.001
Uganda**	6.9	**0.0**	0
Indonesia	<0.01	**0.0**	0
Vietnam	<0.1	**0.0**	0
Zimbabwe	<0.1	**0.0**	0
Cuba	0.9	**0.0**	0
DLBPS Total	990.8	**2,362.8**	65.8
World Total	2,194.5	**3,588.4**	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2014.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.27. Export of cobalt oxides and hydroxides (2822)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Congo, D.R.	23.0	**43.2**	60.9
Zambia	4.9	**8.6**	12.2
China	6.3	**8.4**	11.8
South Africa	0.15	**0.15**	0.21
Morocco	0.01	**0.03**	<0.05
Brazil	0.03	**0.01**	<0.05
Cuba	0.05	**0.06**	<0.1
DLBPS Total	34.5	**60.4**	85.2
World Total	43.5	**70.9**	100.0

Source: ITC.
* – DLBPS only.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.28. Export of cobalt oxides and hydroxides (2822)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Congo, D.R.	209.4	734.1	56.1
China	170.6	320.4	24.5
Zambia	38.6	150.3	11.5
South Africa	1.7	1.3	0.1
Morocco	0.4	1.3	0.1
Cuba	0.6	0.5	<0.05
Brazil	0.6	0.4	<0.05
DLBPS Total	421.9	1,208.3	92.4
World Total	603.6	1,308.1	100.0

Source: ITC.
* – DLBPS only.
Note: The value in the “Medium” column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

G. Manganese production

Table A.29. Production of manganese ore (gross weight)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
South Africa	10,456.3	13,889.3	26.9
China	14,615.0	12,500.0	24.2
Gabon	3,556.9	4,163.0	8.1
Ghana	1,672.8	3,003.6	5.8
Brazil	2,751.2	2,880.0	5.6
India	2,523.9	2,589.3	5.0
Malaysia	807.0	1,226.1	2.4
Mexico	515.9	561.6	1.1
Myanmar	389.8	310.0	0.6
Côte d’Ivoire	196.4	295.0	0.6
Morocco	82.1	99.0	0.2
Iran	128.8	80.0	0.2
Turkey	147.6	77.9	0.2
Namibia	66.7	27.9	0.1
Thailand	28.9	13.8	c
Vietnam	23.0	13.4	<0.05
Sudan	7.4	9.5	<0.05
Kenya	0.9	9.1	<0.05
Oman	20.3	9.0	<0.05
Egypt**	22.3	0.0	0
DLBPS Total	38,013.4	41,757.5	81.0
World Total	48,612.1	51,556.9	100.0

Source: BGS.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the “Medium” column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.30. Production of ferro-silico-manganese

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
China	7,030.5	8,400.0	61.7
India	1,506.5	1,950.0	14.3
Malaysia	21.0	210.0	1.5
South Africa	213.1	210.0	1.5
Brazil	209.0	200.0	1.5
Mexico	137.9	148.1	1.1
Gabon	8.4	30.0	0.2
DLBPS Total	9,126.4	11,148.1	81.9
World Total	11,608.1	13,608.6	100.0

Source: BGS, USGS.
* – DLBPS only.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.31. Production of ferro-manganese (including high-carbon and refined)

COUNTRY*	Medium (TMT)	2017 (TMT)	%
China	2,595.0	2,346.0	41.5
India	459.7	533.7	9.5
Malaysia	29.6	250.7	4.4
South Africa	465.9	248.0	4.4
Brazil	101.9	133.1	2.4
Mexico	72.7	90.0	1.6
Egypt	21.3	12.0	0.2
DLBPS Total	3,746.2	3,613.5	64.0
World Total	5,651.4	5,647.0	100.0

Source: BGS, USGS.
* – DLBPS only.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

H. Manganese export

Table A.32. Export of manganese ores and concentrates (2602)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
South Africa	9,312.1	15,604.6	50.4
Gabon	3,204.5	4,478.1	14.5
Brazil	2,009.2	2,683.3	8.7
Côte d'Ivoire	197.3	636.1	2.1
Malaysia	713.6	521.9	1.7
Morocco	95.4	79.0	0.3

COUNTRY*		Medium (TMT)	2017 (TMT)	2017 (%)
Mexico		57.3	73.0	0.2
Thailand		39.5	40.0	0.13
China		49.2	36.3	0.12
Namibia		65.6	31.9	0.10
Turkey		92.7	30.2	0.10
Oman		12.1	15.8	0.05
Kenya		4.9	12.1	0.04
Ghana		1.2	2.3	0.01
India		93.7	2.2	0.01
Iran		1.2	0.5	0.00
Egypt**		4.4	0.1	0.00
Myanmar		0.0	0.0	0.00
Vietnam		0.9	0.0	0.0
Sudan		0.2	0.0	0.0
	DLBPS Total	15,954.9	24,247.3	78.3
	World Total	23,408.2	30,961.8	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.33. Export of manganese ores and concentrates (2602)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
South Africa	1,452.6	2,527.3	55.9
Gabon	798.9	1,147.7	25.4
Brazil	287.4	365.6	8.1
Ghana	77.4	155.4	3.4
Côte d'Ivoire	20.5	53.0	1.2
Malaysia	33.4	23.2	0.5
Morocco	16.7	17.4	0.4
Mexico	11.5	16.2	0.4
China	11.5	8.0	0.2
Turkey	13.6	4.8	0.1
Thailand	4.6	2.3	0.1
Namibia	6.3	2.0	<0.05
Oman	1.1	0.8	<0.05
Kenya	0.7	0.7	<0.05
India	10.1	0.3	<0.05
Iran	0.2	0.2	<0.01
Vietnam	1.5	0.1	<0.01
Egypt**	3.1	0.05	<0.01
Myanmar	0.1	0.01	<0.01
Sudan	<0.05	0.0	0

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
DLBPS Total	2,751.4	4,326.9	95.6
World Total	4,150.9	4,524.1	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.34. Export of ferro-manganese, containing by weight >2% of carbon (720211)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
Malaysia	32.0	276.6	22.7
India	136.0	228.6	18.8
South Africa	399.0	181.1	14.9
Brazil	12.1	21.0	1.7
Vietnam	1.1	4.4	0.4
China	24.6	2.3	0.2
Mexico	2.6	1.4	0.1
Turkey	0.6	0.6	<0.1
Egypt**	1.3	0.1	<0.01
Thailand	0.1	0.1	<0.01
Oman	<0.05	0.1	<0.01
Iran	<0.05	0.01	0.0
DLBPS Total	609.5	716.2	58.8
World Total	1,048.2	1,218.8	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.35. Export of ferro-manganese, containing by weight >2% of carbon (720211)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Malaysia	32.8	300.1	20.7
India	145.7	258.6	17.8
South Africa	395.1	221.5	15.3
Brazil	16.2	22.2	1.5
Vietnam	1.1	5.8	0.4
China	49.6	2.6	0.2
Mexico	3.6	1.7	0.1
Turkey	0.9	0.8	<0.1
Egypt**	1.9	0.1	<0.01

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
Thailand	0.1	0.0	<0.01
Oman	<0.01	<0.05	<0.01
Iran	<0.05	<0.05	<0.01
DLBPS Total	646.9	813.4	56.1
World Total	1,149.5	1,449.6	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average; black is for values corresponding to the 10-year average.

Table A.36. Export of ferro-manganese, containing by weight ≤2% of carbon (720219)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
South Africa	132.6	71.1	16.4
India	17.8	41.2	9.5
Vietnam	6.2	12.1	2.8
Mexico	14.5	10.8	2.5
Brazil	2.3	0.8	0.2
Turkey	1.5	0.8	0.2
China	30.4	0.4	0.1
Malaysia	0.2	0.4	0.1
Thailand	0.1	<0.05	<0.05
Egypt**	1.1	0.0	0
Iran	<0.05	0.0	0
Ghana	0.1	0.0	0
Oman	0.2	0.0	0
Gabon	0.1	0.0	0
DLBPS Total	207.0	137.5	31.7
World Total	453.9	433.6	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.37. Export of ferro-manganese, containing by weight ≤2% of carbon (720219)

COUNTRY	Medium (million USD)	2017 (million USD)	2017 (%)
South Africa	180.1	127.0	16.8
India	27.6	64.0	8.5
Vietnam	9.7	23.0	3.0
Mexico	27.2	17.9	2.4

COUNTRY	Medium (million USD)	2017 (million USD)	2017 (%)
Brazil	6.1	1.5	0.2
Turkey	3.2	1.5	0.2
China	85.4	0.8	0.1
Malaysia	0.3	0.6	0.1
Thailand	0.1	<0.05	<0.01
Ghana	0.1	0.0	0
Oman	0.1	0.0	0
Egypt**	0.3	0.0	0
Iran	<0.05	0.0	0
Gabon	<0.05	0.0	0
DLBPS	340.4	236.2	31.3
World total	762.7	755.8	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.38. Export of ferro-silico-manganese (720230)

COUNTRY*	Medium (TMT)	2017 (TMT)	2017 (%)
India	699.4	794.6	25.4
Malaysia	21.3	197.5	6.3
South Africa	173.9	124.9	4.0
Vietnam	47.4	59.9	1.9
Brazil	46.9	55.1	1.8
Mexico	30.0	27.8	0.9
Gabon	6.0	24.0	0.8
China	98.0	6.7	0.2
Turkey	1.9	5.2	0.2
Iran	0.2	0.6	0.019
Kenya	0.2	0.6	0.018
Egypt**	0.4	0.3	0.008
Morocco	<0.05	0.2	0.008
Oman	0.1	0.0	0.000
Thailand	<0.05	0.0	0.000
DLBPS Total	1,125.8	1,297.3	41.4
World Total	2,872.3	3,132.8	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.39. Export of ferro-silico-manganese (720230)

COUNTRY*	Medium (million USD)	2017 (million USD)	2017 (%)
India	684.7	801.2	23.5
Malaysia	21.9	204.7	6.0
South Africa	173.3	134.4	3.9
Vietnam	45.2	68.8	2.0
Brazil	56.1	61.1	1.8
Mexico	32.8	31.7	0.9
Gabon	5.5	26.8	0.8
China	169.2	7.4	0.2
Turkey	2.3	8	0.2
Kenya	0.2	0.8	<0.05
Iran	0.2	0.4	<0.05
Egypt**	0.6	0.3	<0.05
Morocco	<0.05	0.3	<0.05
Oman	<0.05	0.0	0
Thailand	<0.05	0.0	0
DLBPS Total	1,192.2	1,343.4	39.4
World Total	3,157.0	3,408.2	100.0

Source: ITC.
* – DLBPS only.
** – Mine production has not been conducted since 2015.
Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

Table A.40. Total annual GDP of DLBPS (at current prices)

COUNTRY	Medium (million USD)	2017 (million USD)	2017 (% of world GDP)	2017 (% of total developing states GDP)
China	8,652,503.4	12,237,781.8	15.20	38.47
India	1,893,637.2	2,575,666.6	3.20	8.10
Brazil	2,123,246.2	2,055,512.2	2.55	6.46
Mexico	1,144,505.5	1,158,229.1	1.44	3.64
Indonesia	829,568.1	1,015,539.0	1.26	3.19
Turkey	834,719.5	851,541.6	1.06	2.68
Saudi Arabia	637,034.6	683,827.1	0.85	2.15
Argentina	525,769.8	637,486.2	0.79	2.00
Iran	478,859.7	460,976.1	0.57	1.45
Thailand	377,870.5	455,302.5	0.57	1.43
South Africa	345,023.8	348,872.1	0.43	1.10
Malaysia	286,992.0	314,707.3	0.39	0.99
Philippines	248,403.5	313,595.1	0.39	0.99
Colombia	310,908.7	309,191.4	0.38	0.97
Pakistan	222,961.8	302,139.5	0.38	0.95

COUNTRY	Medium (million USD)	2017 (million USD)	2017 (% of world GDP)	2017 (% of total developing states GDP)
Chile	240,002.5	277,081.0	0.34	0.87
Venezuela	336,205.8	255,092.5	0.32	0.80
Vietnam	159,216.0	223,779.9	0.28	0.70
Peru	174,866.6	211,403.0	0.26	0.66
Egypt	242,993.4	195,135.5	0.24	0.61
Sudan	49,520.0	120,265.8	0.15	0.38
Morocco	100,939.8	109,708.8	0.14	0.34
Cuba	76,309.7	96,851.0	0.12	0.30
Dominican Rep.	61,316.1	75,931.7	0.09	0.24
Guatemala	53,687.5	75,619.6	0.09	0.24
Kenya	53,164.8	74,938.2	0.09	0.24
Oman	67,648.3	70,783.8	0.09	0.22
Myanmar	54,179.1	67,101.9	0.08	0.21
Ghana	50,268.5	58,996.3	0.07	0.19
Tanzania	40,729.3	53,481.4	0.07	0.17
Côte d'Ivoire	29,889.9	38,054.9	0.05	0.12
Congo, D.R.	29,962.7	37,642.5	0.05	0.12
Bolivia	27,281.7	37,508.6	0.05	0.12
Uganda	23,463.3	27,698.8	0.03	0.09
Zambia	22,573.1	25,868.1	0.03	0.08
Papua New Guinea	18,753.4	22,005.8	0.03	0.07
Zimbabwe	13,385.9	18,036.9	0.02	0.06
Botswana	14,239.9	17,406.5	0.02	0.05
North Korea	15,531.1	17,364.7	0.02	0.05
Laos	11,029.5	16,853.1	0.02	0.05
Gabon	15,604.9	14,623.4	0.02	0.05
Namibia	11,578.5	13,244.6	0.02	0.04
Madagascar	11,532.5	13,208.4	0.02	0.04
Mongolia	10,060.7	11,135.0	0.01	0.03
Eritrea	3,376.1	5,812.7	0.01	0.02
Mauritania	4,800.3	4,992.1	0.01	0.02
DLBPS Total	20,936,115.3	26,007,994.2	32.31	81.75
World Total	72,631,911.8	80,501,414	100.00	

Note: The value in the "Medium" column corresponds to the average level of the indicator in 2008–2017.
Legend: Coloring of indicator values for 2017 means the following: green is for values which are higher than the 10-year average; red is for values which are lower than the 10-year average.

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