

The Platform for Cooperation on Tax

DISCUSSION DRAFT:

Addressing the Information Gaps on Prices of
Minerals Sold in an Intermediate Form

Feedback Period

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Organisation for Economic Co-operation and Development (OECD)
World Bank Group (WBG)
International Monetary Fund (IMF)
United Nations (UN)

This discussion draft has been prepared in the framework of the Platform for Collaboration on Tax by the OECD, under the responsibility of the Secretariats and Staff of the four mandated organizations. The draft reflects a broad consensus among these staff, but should not be regarded as the officially endorsed views of those organizations or of their member countries.

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Acronyms

AEOI	Automatic Exchange of Information
ATAF	African Tax Administration Forum
ATAIC	Association of Tax Administrations in Islamic Countries
ATI	Addis Tax Initiative
BEPS	Base Erosion and Profit Shifting
CIAT	Inter-American Center of Tax Administrations
DRM	Domestic resource mobilization
FTA	Forum on Tax Administration
IMF	International Monetary Fund
IOs	International Organizations joined in the Platform for Collaboration on Tax: the IMF, OECD, UN and WBG
IOTA	Intra-European Organisation of Tax Administrations
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PITAA	Pacific Islands Tax Administrators Association
PCT	Platform for Collaboration on Tax
RTO	Regional Tax Organization
SDGs	Sustainable Development Goals
SGATAR	Study Group on Asian Tax Administration and Research
TA	Technical assistance
TP	Transfer Pricing
TIWB	Tax Inspectors Without Borders
UN	United Nations
UNDP	United Nations Development Programme
WBG	World Bank Group

INTRODUCTION

The report has been prepared in the framework of the Platform for Collaboration on Tax, (the “PCT”) by the OECD, with the cooperation and input of the other mandated organizations (IMF, WBG and UN). The report reflects a broad consensus among these staff, but should not be regarded as the officially endorsed views of those organizations or of their member countries.

It responds to the November 2014 request from the G20 Development Working Group for the OECD to:

“...commence a study on the feasibility of addressing the information gap on prices of some natural minerals sold in an intermediate form, e.g. mineral concentrate...”

The request arises in the context of increased recognition of the centrality to development of strong tax systems and of the importance of external support in building them, and a correspondingly increased willingness of advanced economies to provide substantially greater financing and other support for this. It recognizes that, while real progress has been made on increasing tax revenues in low-income countries over the past two decades, for many countries revenues remain well below levels that are likely needed to achieve the SDGs, and to secure robust and stable growth.

This report is sector-specific, focusing on mineral products and markets (excludes hydrocarbons or agriculture). This is in accordance with the mandate for the work, but it also allows a focused examination of the unique characteristics of the extraction, transformation and sale of those products. Work is underway on several fronts, combining sector-specific policy and administrative responses (such as new transfer pricing guidance) with tailored country-level technical assistance.

Domestic Resource Mobilisation from Mining

Mining drives the economies of many developing countries. Mining and mineral product sales contribute to income growth, foreign exchange earnings and employment. In addition, governments rely on these products to generate revenue, which can boost living standards and help achieve the Sustainable Development Goals (SDGs).

Raising revenue from mineral product transactions can be challenging however. For countries that use these products as a key element of the tax base, sales prices are a crucial determinant of potential revenue, particularly when corporate income taxes (CIT) and ad valorem royalties are used.

The cross-border sale and purchase of mineral products between related parties creates base erosion and profit shifting (BEPS) risks. These transactions (between entities within the same MNE) risk separating substantive economic activity from where profit is reported and taxes are paid. One relatively straightforward form of base erosion is for MNEs to sell mineral products to a related entity abroad at prices below equivalent sales to unrelated parties, thereby moving sales revenue and profits offshore, to take advantage of lower tax rates abroad (see Box 1 for stylised example). In other cases, companies may engage in straight tax evasion by mis-reporting the value of product shipments they are making.

Box 1. Potential Revenue Impact – Example from Copper Sales

The example below shows a hypothetical situation in which an exporter of a mineral product – in this case a concentrate – could underprice the true value of their shipment to revenue authorities. As the table below demonstrates, the revenue impact of under-priced shipments can add up quickly. Revenue losses can be from, amongst other things, under-quoting prices, mis-specifying reference prices, excessive deductions or price adjustments, handling or other fees, or simply not declaring the presence of valuable by-products (e.g. gold and silver in a copper concentrate).

Copper Concentrate Shipment	Market Price	10% Under-priced Copper	Copper under-priced, no gold declared
	\$m	\$m	\$m
Gross Value of Cargo FOB [A]	39.5	35.1	32.7
Production Costs [B]	22.5	22.5	22.5
Royalty [C]	1.7	1.5	1.4
CIT Base [A-B-C]	15.4	11.1	8.8
Company Tax Payable [D]	4.6	3.3	2.6
Total Revenue per shipment [C+D]	6.3	4.8	4.0
Potential Revenue Loss Per Shipment		-1.4	-2.2
Potential Annual Revenue Loss		-71.4	-112.3

Source: OECD calculations based on price data from World Bank Group (Pink Sheets), Cost data from Thompson Reuters. Notes: All figures in USD. Assumes the functions, assets and risks of the parties in each case are comparable. The cargo is a 20,000 metric tonne shipment of copper concentrate exported from a developing country. 50 shipments per year. Each shipment contains 31% copper by weight and 4 grams of gold per tonne. Adjustments to the gross value of cargo are made for losses during smelting (1 percentage point of copper, 1 gram of gold). Production cost is assumed to be \$1.70 per pound of copper – an approximate mid-point of copper producers. Royalty rates: copper – 3.5% of copper value; gold – 5% of gold value. CIT rate: 30%.

Mineral exporting countries – particularly developing countries – often find it difficult to assess whether this form of BEPS is occurring. As noted in the 2014 Report to G20 Development Working Group on the Impact of BEPS in Low Income Countries (Part 2):

“ ... countries often find it difficult to apply the criteria contained in the current international tax rules to assess whether intra-group transactions accord with arm’s length practices and consequently, whether transaction terms in controlled transactions are excessive or unwarranted.”

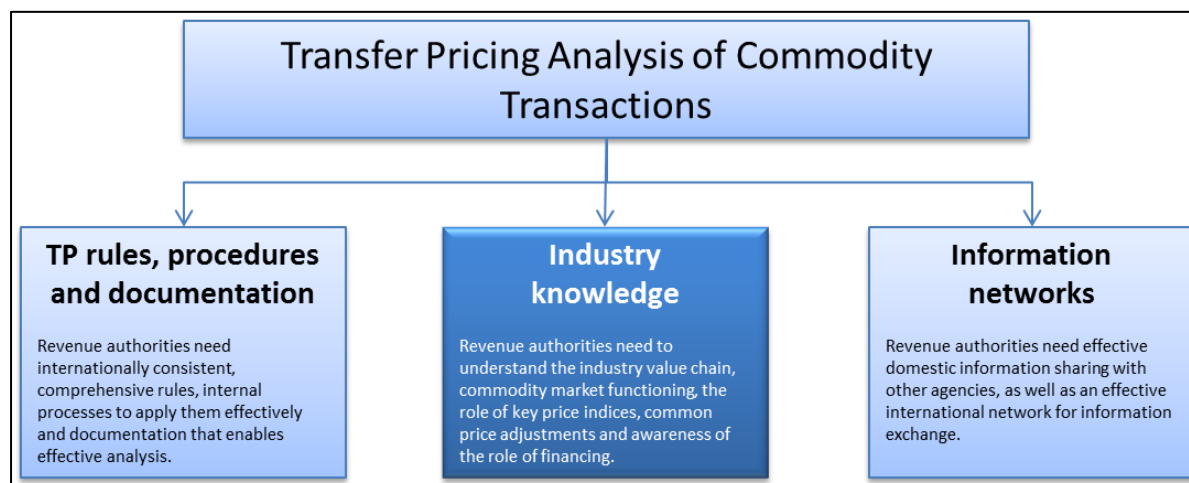
There are diverse reasons why developing countries are vulnerable to this form of base erosion. These include:

- **Revenue authorities may be building their sector knowledge and administrative capabilities.** At the most basic level, authorities may not have a sufficient number of qualified staff to apply tax rules. In addition, authorities may be uncertain as to how particular mineral products are priced, which means they may struggle to test the validity of claims such as that particular product shipments are in some way ‘unique’ and therefore unable to be compared with other transactions. In addition, authorities may need assistance to build their experience with transfer pricing comparability analysis. This may occur where, for example, a country has a newly developed mining sector, or simply needs additional training in transfer pricing analysis and application (such as how to make transfer pricing adjustments in a systematic and reliable way).
- **Countries may not know what information they require or where to look for it.** Revenue authorities may have only limited resources available to search for comparable uncontrolled transactions, or may not be aware of publications that could assist.
- **The information may be difficult or expensive to obtain.** This may be particularly challenging where formal and informal networks with fellow revenue authorities are limited, or where taxpayers deliberately place information on a transaction in locations offshore that make them difficult to obtain. Procurement rules and/or a lack of funds may also limit information purchases by revenue authorities.
- **The information needed to review transactions simply may not exist.** For example, for some rare earth elements, transactions may be so infrequent and opaque that finding an international reference price or comparable transaction may be almost impossible.

In response, this is a practical report to assist developing countries to improve their understanding of how mineral products are priced. This is also an important step in informing transfer pricing analysis of the income of MNEs, emphasising the importance of building industry-specific knowledge that countries can then extend and apply to their domestic mines as needed (see Box 2).

Box 2. Comprehensive Tools and Information are Needed for TP Analysis

Transfer pricing rules can be a complex area of tax law, requiring specialised officials. Applying transfer pricing rules to mineral sales often requires information from multiple sources, which is applied to firstly assess which transactions pose significant risks of transfer pricing, and then to analyse transactions in detail. TP adjustments may be needed, where related party transactions are assessed to be inconsistent with comparable arm's length transactions.



Addressing pricing risks therefore requires support across several fronts, including legislation, processes, accessing information and data, and sector-specific knowledge. This report therefore forms part of a suite of tools and activities (such as the toolkit on comparability analysis, and information exchange initiatives), and also builds on the tailored, country-specific assistance being provided through the IOs and other technical assistance providers.

Report Structure

The structure of the report is as follows: It begins by outlining a systematic process that could help developing countries map the transformation chain for a particular mineral; identify key traded products and establish common pricing practices. To demonstrate the process, the OECD has applied it to deliver detailed case studies on copper, gold, thermal coal and iron ore. For each mineral examined, the report also provides a list of data sources available to revenue authorities. The report concludes with comments on possible future direction of this work, and where additional related work would help meet the needs of developing countries.

BUILDING AN UNDERSTANDING OF THE MINING SECTOR – A METHODOLOGY

Introduction

Building an understanding of the mining sector operating within a country can be challenging. But as noted earlier, it is an essential component to understanding potential base erosion risks and to applying transfer pricing analysis. The key is to build that knowledge in a systematic way.

The OECD has developed a systematic process to assist revenue authorities to build their understanding of mining products and pricing practices. The process has 6 steps which sequentially help officials understand the profile and structure of the domestic mining industry, the mines in operation and what they are producing. Once the mining sector has been mapped, this allows administrators to identify key mineral products to be examined, as well as data that may be needed to assist in understanding the economic context of the industry.

As mineral product knowledge becomes increasing sophisticated, information asymmetries should narrow and revenue authorities should be able to use market pricing information more effectively. Naturally, different revenue authorities are at different stages of expertise with mining practices and mineral product markets, which will affect the amount of time needed for each step. Revenue authorities can then use this information to inform their transfer pricing analysis. In addition, this knowledge should help to narrow areas of dispute with taxpayers based on misunderstandings of common industry practices.

Steps in the Methodology

The first step is to review each mine for how minerals are extracted and transformed to saleable products. This is essential to understanding what extraction and transformation methods might be possible (for example, leaching processes or gravity separation processes), the extent of local value adding that may be possible and the machinery and equipment that the mine will use during production.

Steps	Focus Questions to Build Sector Knowledge
<p>Step 1: Identify the type of mine and production methods.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> What kind of mine is it? <input type="checkbox"/> What type of ore is the mine extracting? <input type="checkbox"/> What products can be produced from the ore? <input type="checkbox"/> Who verifies the products produced? <p><i>(for example, is testing/assay reliable?)</i></p> <ul style="list-style-type: none"> <input type="checkbox"/> What method of transformation and beneficiation is used to produce those products? <input type="checkbox"/> Where does this take place? <input type="checkbox"/> Does this mine have similarities with other mines domestically? <p><i>(These similarities might be in, for example, inputs used; products produced; transportation methods employed; and/or customers.)</i></p> <ul style="list-style-type: none"> <input type="checkbox"/> What entities are involved in the transformation and what are their key functions?

The second step is to identify in detail the actual products each mine produces and sells, and whether the processing facilities are also used by third parties under tolling arrangements. This means understanding the exact products the mine produces (for example, iron ore concentrate or “direct shipping ore”) and the economic context for those decisions. By-products should also be looked for. There may be occasions where the mine offers its processing facilities to other mines on a tolling basis.

<p>Step 2: Identify the mineral products coming from the mine.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> What product quantities are being produced per month/year? <input type="checkbox"/> Is the mine’s beneficiation equipment used to process ores from other mines (eg on a tolling basis)? <input type="checkbox"/> Who is checking this production and is the check reliable? <input type="checkbox"/> How will those products be transported when they are sold? <input type="checkbox"/> How will they be exported? <input type="checkbox"/> Who will the mining company sell the product to? <ul style="list-style-type: none"> <input type="checkbox"/> In particular, are they a related party? <input type="checkbox"/> If so, where are they located? <input type="checkbox"/> Is this product routinely sold to independent parties (i.e., at arm’s length?) <ul style="list-style-type: none"> <input type="checkbox"/> If so, under what terms?
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The third step is to understand what those products are used for, what drives their prices and how they are traded internationally. This means understanding who potential customers for the product might be (for example, smelters are a key buyer of copper concentrates, as are traders looking to arbitrage the product to make profits) and what features those buyers expect from the product (for example, do they expect low levels of impurities?).

<p>Step 3: Understand the price drivers for those products and how they are traded internationally.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> What are the key features of the product market? <ul style="list-style-type: none"> <input type="checkbox"/> For example, is it a global market, or regional? <input type="checkbox"/> What are the market conditions and concentration of buyers and sellers? Are they changing? <input type="checkbox"/> What adjustments are made to account for physical attributes, and which have the largest potential impact on price? <input type="checkbox"/> Is the product traded on an open exchange? <i>for example, the London Metal Exchange?</i> <ul style="list-style-type: none"> <input type="checkbox"/> If so, on what terms? <input type="checkbox"/> Are there other physical features that can affect price, such as the size of the ore pieces? <input type="checkbox"/> Does the location of the product or delivery date materially affect the price? <input type="checkbox"/> Is the transaction a one-off or part of a longer-term agreement between the parties?
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The fourth step is to identify related party sales and understand the economic context to those transactions (including their functions, assets and risks of the related parties). This means understanding the economic model of the MNE, and how they have structured their international business affairs, including for example, where production decisions are made and which entity within the MNE will manage key business risks and find buyers). It also means understanding the evolution of product trading and key terms that will be part of a contract (for example, whether “price participation” clauses are appropriate).

<p>Step 4: Understand the economic context to the transactions.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Has the taxpayer entered into a controlled transaction at this point in the process? <ul style="list-style-type: none"> <input type="checkbox"/> If so, obtain details of: <ul style="list-style-type: none"> <input type="checkbox"/> who sold to <input type="checkbox"/> where they are tax resident <input type="checkbox"/> documentation of the transactions including composition of the traded product, transportation details, payment details <input type="checkbox"/> Has some of the product been sold to a third party? If so: <ul style="list-style-type: none"> <input type="checkbox"/> who was it sold to and where are they tax resident? <input type="checkbox"/> What documentation exists (eg sales contract) that describes the key terms of the transaction including composition of the traded product, reference prices used, transportation details, payment details <input type="checkbox"/> Does the taxpayer have a unique production process or are all the processes the same? Are they publicly known? <input type="checkbox"/> Have assets (related to the production process), and mainly, valuable unique assets been purchased by the taxpayer from a related party?
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The fifth step is to identify available information, analysis and data that could be used to review product sales transactions between related parties. This means finding data publications, databases and other information that could assist officials to establish whether the MNE's transactions are in line with common industry approaches and trading at particular times).

<p>Step 5: Identify data and other information that could assist in reviewing the transaction.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Is there data that could be used to compare the transaction (either publicly available or available for purchase)? <input type="checkbox"/> How reliable is that information? <i>(for example, would it be accepted as evidence in a dispute in a court? Do other mining companies use this data?)</i> <input type="checkbox"/> Would the information need to be adjusted to ensure it is comparable with the transaction under review? <i>(for example, to adjust for geographical or quality differences)?</i> <ul style="list-style-type: none"> <input type="checkbox"/> Can this be done reliably? <input type="checkbox"/> How much does it cost to purchase the information? <input type="checkbox"/> Is the information easy to use? <ul style="list-style-type: none"> <input type="checkbox"/> If not, is support provided to use the data? <input type="checkbox"/> What revenue is at risk? <ul style="list-style-type: none"> <input type="checkbox"/> How does this compare to other revenue risks?
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The last step is to devise approaches or methodologies that can address as many of those information gaps as possible. This issue is addressed comprehensively in the Toolkit on Comparability, but includes where to look for additional data, and which transfer pricing methods might be most appropriate given the facts and circumstances of the taxpayer.

<p>Step 6: Devise a way forward when there are information gaps.</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Are there alternate sources of information? <i>(for example, could information on smelting or refining costs be obtained from elsewhere?)</i> <input type="checkbox"/> Are there commonly used methodologies to derive a price from another product? <input type="checkbox"/> Would these withstand dispute resolution processes? <input type="checkbox"/> Is it worth investing in additional data or consultancy expertise? <ul style="list-style-type: none"> <input type="checkbox"/> If so, how much will this cost? <input type="checkbox"/> How long will it take to receive the information? <input type="checkbox"/> What legal powers are available if the taxpayer refuses to provide information? <input type="checkbox"/> Which other countries might be able to assist? <input type="checkbox"/> Can informal country networks help reinforce understanding of key pricing practices for that product? <input type="checkbox"/> Can information be obtained through formal information exchange mechanisms? <input type="checkbox"/> Do taxpayer documentation requirements enable satisfactory review of transactions?
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WIDER ISSUES RELATED TO MINERAL PRODUCT PRICING

Relationship Between Prices Under Corporate Income Tax and for Royalties

A common issue that producing countries must confront is how their royalty systems and corporate income tax (CIT) treat the value of shipments of mineral products. Often these prices will not be the same, even though intuitively they may appear that they should be.

This is driven by several factors. One key issue is the point on the transformation chain at which each tax is imposed:

- royalties are typically applied to products at the early stages of the transformation chain, for example they may be imposed at the point the minerals leave the mine site (the “mine gate”). This approach is used so as not to tax companies on the value-adding that occurs as they beneficiate the minerals, since this is primarily the role of CIT (some countries attempt to approximate this by reducing royalty rates if beneficiation occurs before the products are sold).
- CIT in contrast is usually applied to the revenue from product sales or when the ownership of the minerals otherwise is transferred. Within MNE groups, this can occur at any point on the transformation chain, even in situations where the mineral is at a stage where it is not usually traded to third parties (for example, as is discussed in the copper case study, copper concentrates are widely traded internationally, but blister copper products are not since companies usually continue with further smelting).

Another issue is the operation of transfer pricing rules under CIT. Where the international transfer pricing standards are used, wider contextual and business factors - such as the economic circumstances to the transaction, the functions, assets and risks of the two related parties to the transaction and the contractual terms of the transaction - are taken into consideration in computing an arm’s length price for the purpose of CIT. Most commonly, the Comparable Uncontrolled Price method would generally be an appropriate way of establishing the arm’s length price for the transfer of commodities between related parties. Where this is the case, and the taxing point noted above is the same for royalty and CIT, there is likely to be a high degree of consistency between the price used for royalties and the price used to calculate CIT liabilities.

Some countries – particularly developing countries - have attempted to simplify these arrangements by defining pricing mechanisms. This may be for royalty calculations or for CIT purposes, particularly where countries are concerned about mis-pricing of transactions within MNE groups. This may be done via legislation, or in a more tailored way with companies via Advance Pricing Agreements.

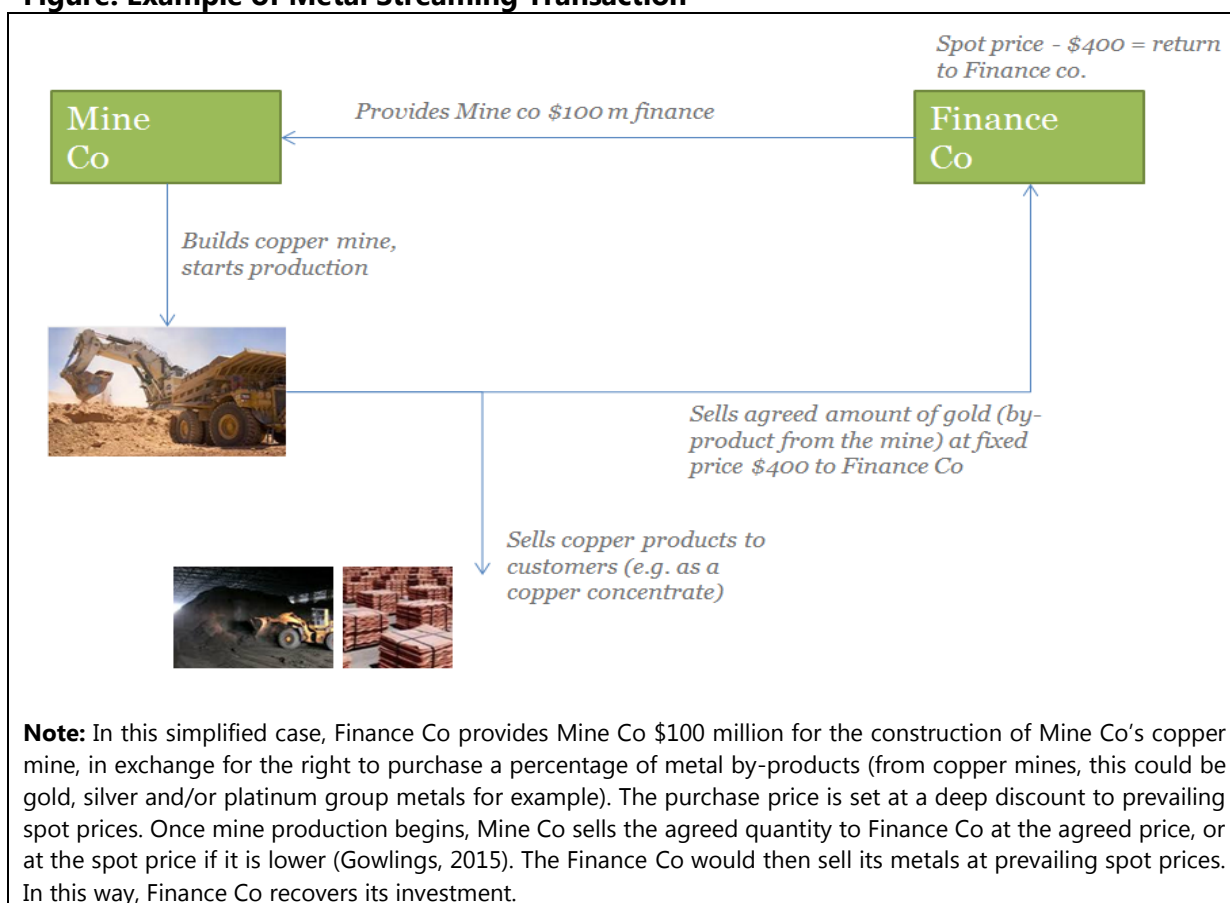
These transfer pricing issues are discussed in depth in the related *Toolkit for Addressing Difficulties in Accessing Comparables Data for Transfer Pricing Analyses*.

Financing Arrangements Affecting Transacted Product Prices - “Metals Streaming”¹

In recent years, mine construction financing arrangements that are tied to subsequent mine production have become increasingly common. They can fill a financing gap for mining companies where capital is not available from traditional sources such as banks.

But these financing arrangements can reduce the tax base of mineral producing countries and transfer profits offshore. This is because they result in mines selling a portion of their mineral products or mine by-products at severely discounted prices (an example arrangement is provided below).

Figure: Example of Metal Streaming Transaction



Streaming agreements can be between unrelated or related parties,² with terms that appear relatively advantageous to financiers. For example, significant risks are borne by the mine, such as the risk the mine is not brought to production (addressed by the financier

¹ This section is drawn from an OECD issues note prepared in October 2016 for a joint working-level meeting on tax challenges in mining held with the Inter-Governmental Forum on Mining (IGF).

² •Streaming arrangements are commonly not, of themselves, tax avoidance mechanisms. Rather, agreed terms reflect the relative bargaining position of each side of the transaction. In the absence of more advantageous funding from more ‘traditional’ sources, companies may be forced to agree to relatively tougher terms if they wish to see a project proceed.

obtaining title over a share of the proven reserves of the mine) and any cost over-runs in bringing the mine to production must be met by the mine. In addition, the commitment to selling mine output is applied over the life of mine in many of these arrangements, meaning the sales commitment also applies to additional discoveries.

Streaming reduces the tax base of resource-producing countries, where fiscal settings (such as ad valorem royalties and CIT) use sales revenue as part of tax calculations. In addition, since the amount of financing provided is linked to the discounted price, mines have strong incentives to agree to lower fixed prices, since this increases the up-front finance provided to them. Streaming agreements also pose challenges for revenue authorities because they contain both debt and equity characteristics, which can add complexity for developing countries and give rise to mismatches in tax treatment if different tax authorities treat the same payments in different ways.³

Moreover, product sales require careful transfer pricing analysis when undertaken between related parties to identify possible base erosion through transfer pricing. Also adding to the challenge for developing countries, participants may locate the agreement in a low-tax jurisdiction where the relationship of the parties is difficult to establish.⁴

3. For a broader analysis of hybrid mismatch arrangements and potential options for dealing with them, see OECD (2015), *Neutralising the Effects of Hybrid Mismatch Arrangements, Action 2 - 2015 Final Report*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264241138-en>

4. There may be however, ways to address this, such as through the implementation of controlled foreign corporation rules, which tax certain types of income earned in low/no-tax jurisdictions.

INTRODUCTION TO MINERAL PRODUCT CASE STUDIES

The OECD has prepared several case studies on the key mineral products produced at different mines. These case studies are intended to provide developing countries with detailed industry information and contribute to building greater mining sector knowledge in tax administrations.

The case studies are on products from copper, iron ore, thermal coal and gold mines. These minerals were chosen because each has products that are commonly sold in intermediate forms and because each is particularly relevant to many developing countries. These studies are focused on medium and large-scale mines, since these are predominantly operated by MNEs.

Copper

Copper is an important metal across numerous industries due to its thermal and electrical conductivity. Its applications include in construction and telecommunications. It is also resistant to bacteria and fungi, making it useful to applications such as cooking equipment and water sanitation. The process for transforming the copper ore to pure metal depends on the type of ore (oxide-based or sulphide-based).

Many developing countries such as Peru, Zambia and Kazakhstan export copper as a concentrate, which is a powder typically containing around 30 percent copper following initial beneficiation. Some countries such as Zambia also export copper anodes and others, as Democratic Republic of Congo, export refined copper cathodes.

Iron Ore

Iron ore is a bulk commodity that provides the ferrous content for steelmaking. The collective use of "iron ore" refers to several different types of deposits, which can be broadly grouped into "high-grade" and "low-grade" ores. High-grade ores of between approximately 50 to 65 percent iron are made up primarily of hematite, while low-grade ores are primarily composed of magnetite (contains up to 30 percent iron) and taconite (usually less than 30 percent iron).

Key exports for developing countries are iron ore fines, lumps, concentrates, pellets and sinter feed. For countries with higher-grade ore, these are more likely to be exported as fines or lumps, whilst for countries with lower grade ores, further domestic beneficiation is usually required to create concentrates, pellet or lump products. Along with traditional exporters such as Brazil and South Africa, Sierra Leone, Liberia and Mauritania are all emerging as iron ore exporters.

Thermal Coal

Thermal coal is a bulk commodity used primarily as an energy source (for electricity generation). Thermal coal varies by grade, based on energy content, and levels of impurities. Coal from different mines may be blended, for instance to achieve a particular energy content,

with coal products sold either directly to final users (such as electricity suppliers and cement producers) or via traders.

Thermal coal is predominantly traded as ore, or cleaned up to produce concentrates. Key developing country exporters include South Africa, Indonesia and Colombia.

Gold

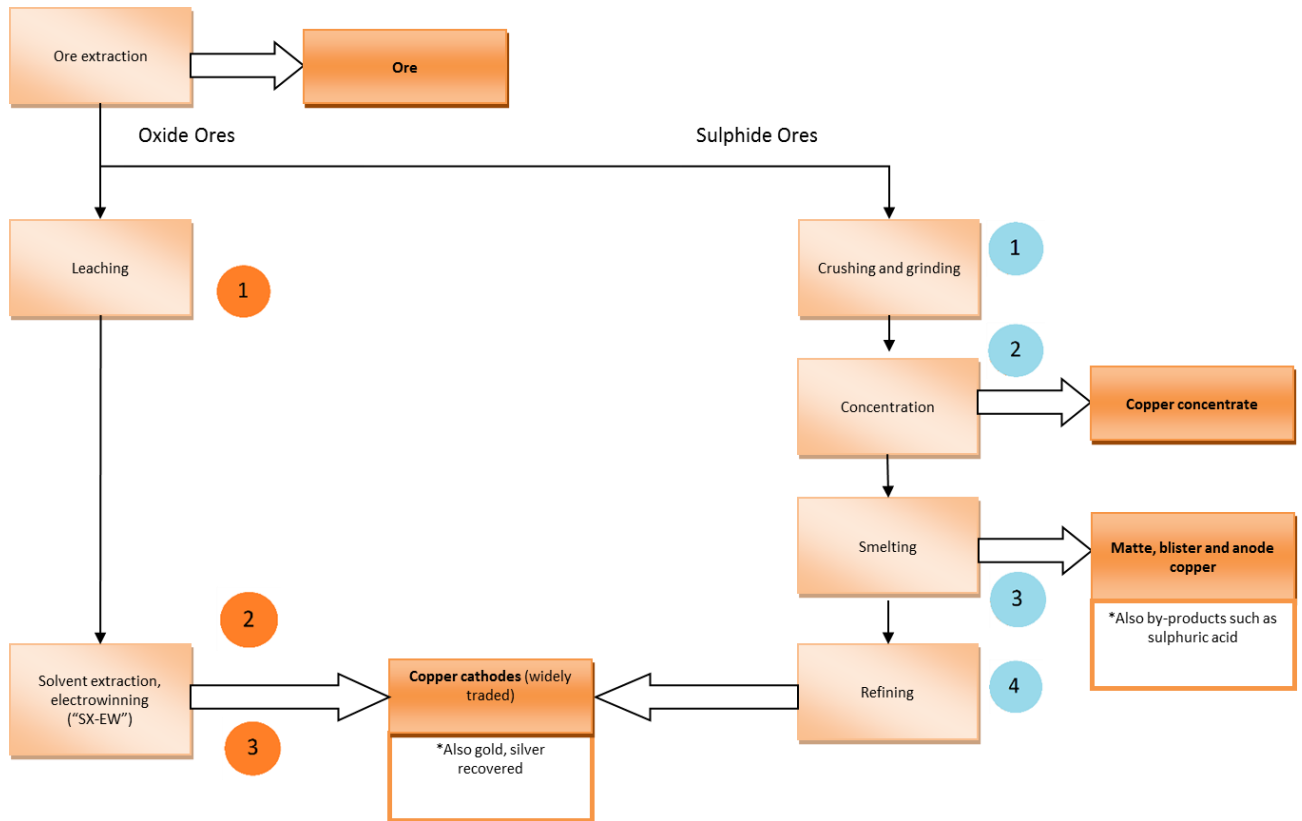
Gold is a precious metal with a strong resistance to chemical and environmental deterioration; wide use in jewellery; and function as a financial asset. Gold is mined in its own right, but it is also recovered as a by-product from other mineral deposits (such as copper) with other precious metals.

Gold is usually exported from medium and large-scale mines in developing countries as unrefined doré bars for refining elsewhere.

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Case Study: Copper

MINING PRODUCTION AND KEY PRODUCTS



Copper Mining

To separate the copper ore from the surrounding rock, drilling and blasting processes are used. The broken ore is then conveyed to a stockpile for further processing. At this point, the copper content is typically 1-2 per cent by mass or less. Other valuable metals may also be present, such as gold, silver, nickel and cobalt – indeed many mines are considered as ‘multi-mineral’.

The ore may be of consistent grade or, if not, be separated by grade into different piles. It is then taken to be broken down into smaller pieces of roughly uniform size at a mill at the mine site, or transported to an off-site mill by road or rail.

Crushing and screening are the first steps of transformation. For sulphide-based ores, the ore will be ground down further in preparation for concentration processes. For oxide ores, the rocks will be heaped in preparation for leaching processes.

COPPER OXIDE ORE

- 1 Copper oxide ores usually follow a **leaching process**.

The ore is heaped into piles in special leaching areas, and a sulphuric acid solution is sprayed over the heap to gradually dissolve the copper, separating it from the surrounding gangue. The copper-rich liquid is collected in pools and pumped into a plant for refining.

- 2 An organic solvent is added to the solution, which binds with the copper.

The copper-rich electrolyte floats to the top of the liquid and is separated off and pumped through to the next stage of the process. This is known as "**solvent extraction**".

- 3 An acidic solution is then added to increase the concentration of copper and allow the liquid to conduct electricity. The liquid is moved to tanks containing thin sheets of either copper ("starter sheets") or stainless steel ("blanks"). An electrical charge is applied to the liquid, causing the copper to attach to the sheets. Over approximately 10 days, the starter sheets fatten to a width of 2.5 centimetres, forming 99.9

SULPHIDE ORES

- 1 Sulphide-based ores follow a **separation-smelting-refining process**.

The ore is ground to the consistency of sand, then mixed with water and chemicals to coat the copper sulphide particles, along with a frothing substance.

- 2 This slurry is moved to **flotation** tanks, where air is pumped through the mixture, forming bubbles which attract the chemically coated copper sulphide. The bubbles float to the surface and overflow or are skimmed off, filtered, and then dried to form a powder (copper concentrate). This process is usually able to recover 85-95 percent of the copper in the ore.

At this point the dried concentrate contains approximately 20-30 percent copper by mass, around 30 per cent iron, 30 per cent sulphur, with the remainder including small amounts of gold, silver, and unwanted elements such as arsenic and mercury.

Exported copper **concentrates** are transported by sea as a bulk commodity, either in drums, packages, or as loose powder.

- 3 **Smelting** removes most of the iron, sulphur and other unwanted materials from the concentrate. The concentrate may be initially roasted to remove sulphur and moisture.

The concentrate is combined with silica sand and limestone and transferred to a furnace. As the materials melt they separate, with the heavier copper sinking to the bottom of the furnace, while the silica, which draws away impurities, floats and is poured off as slag.

Following this furnace process, the copper is in '**matte**' stage with copper concentration

percent copper cathodes. This process is known as “**electro winning**”.

between 50 and 70 percent. In most instances the matte is transferred directly as a molten liquid to a converter, but it may also be poured into ingots, cooled, and moved to a separate facility.

In the converter, more silica is added to the matte and air is blown through the furnace to again melt the materials and separate the copper from another slag containing the iron. Following this process, the copper is known as “**blister**” copper, and is typically around 99 percent pure. Small impurities including oxygen, sulphur and iron are still present, requiring further treatment. Depending again on the type of smelter, the blister copper may be cooled and shaped into ingots for transportation to another facility, or carried directly to an anode furnace for casting.

During the casting process, natural gas is blown into the melt to burn off excess oxygen. At end of the process, molten copper of approximately 99.4 percent purity is poured into moulds and cooled. These shapes are ‘**anodes**’.

4

Refining is the final step in the production of effectively pure copper. The anodes are refined using an electrolytic process where the anodes are placed in tanks with a sulphuric acid solution along with fine “starter” sheets of pure copper. An electrical current is applied to the solution causing the anodes to dissolve and copper to attach to the starter sheets, eventually forming 99.9 percent pure copper cathodes. Precious metals do not dissolve in the solution, instead dropping to the base of the refining cell and forming ‘**anode slime**’. This slime is collected and the precious metals recovered through a leaching process.

PRICING PRACTICES

The copper products most commonly traded at arm's length are copper concentrates and refined copper cathodes. Trade in copper ore is uneconomic because much of the ore material is gangue (i.e. commercially worthless).⁵ Blister and anode copper products are traded, but these markets are more opaque because transactions occur much less frequently.

Copper concentrate pricing and market conditions

Copper in concentrate is traded widely between independent parties, and final contract terms depend on the nature of the relationship between buyer and seller, as well as prevailing market conditions. In addition, terms may change over time as market conditions change (see Box below).

Box: Copper Concentrate Market Conditions

Understanding the economic context to a transaction is an essential element of considering whether it is likely to reflect trades between arm's length parties. Factors influencing prices include:

- **Customer identity:** Smelters/refiners are significant customers of concentrates, but transactions may also involve trading companies, either as stand-alone intermediaries or within corporate groups.
- **the nature of the transaction:** particularly whether it is short-term or part of a longer-term supply agreement. Longer-term arrangements may be preferred by small to medium-sized mines without extensive marketing and trading functions. In addition, mines may pay smelters to process the concentrate on their behalf ("tolling") without transferring ownership.
- **Market dynamics:** concentrate prices are affected by demand-supply conditions in the concentrates market directly, but also upstream market conditions (including copper mine production, the availability of raw materials) and downstream conditions (including the availability of refined copper and scrap).
- **Customer needs:** smelters seek concentrates best suited for the smelter. For example, smelters often seek a combination of clean and dirty concentrates based on the tolerance of the facility to impurities (the smelter may be able to blend in dirtier concentrates without suffering a loss in performance). In addition, smelters aim to operate at peak capacity, so will consider the reliability of supply, and may prefer to purchase from mines with a reputation for consistency and reliability.

⁵ There may be parts of a mine that do produce "direct shipping" copper ore with copper percentages around 25 percent or above – for example the DeGrussa copper and gold mine in Western Australia owned by Sandfire Resources.

Components of an Agreement

The agreed price for concentrates is typically based on a formula, which is the sum of value of the contained metals (“payable metals”) less the sum of deductions and penalties imposed. A typical contract would contain provisions to:

- calculate the value of payable metals;
- calculate deductions and penalties (typically, treatment and refining charges, and penalties for impurities and/or penalties for excessive moisture where needed);
- outline other concessions that may be extracted by the purchaser, such as “price participation”;
- allocate related costs such as insurance, sea freight, taxes and duties; and⁶
- outline payment terms.

Assay of the concentrate is essential to pricing calculations, because the physical characteristics of the concentrate directly affect its price. The further away from standard specifications, the more adjustments that could be expected to attain the final agreed price.

Payable Metals - Copper Reference Price

The agreed payment will be based on the percentage of copper present in the concentrate, which is valued by referencing the price of refined copper on one of the major commodity exchanges: the London Metal Exchange (LME); Shanghai Futures Exchange (SHFE) or the Commodity Exchange Division of the New York Mercantile Exchange (COMEX). Taking the LME as an example, contracts would typically specify the “LME Grade A Settlement Quotation price” as the reference price for payable copper, averaged over some time period (the “quotation period”).

For products early in the value chain such as concentrates, contracts usually refer mechanically to this exchange price. For example, the quotation period may be the average price during the third month after the month of scheduled shipment, reflecting expected delivery time to the smelter. For copper products later in the value chain, however, the specific details of the reference price – in particular the physical location of the metal - take greater importance (discussed under copper cathodes, below).

Payable Metals – Losses

For common concentrate grades of around 30 percent copper, the payable metals percentage will typically align with the actual percentage of copper present. However, an adjustment is also

⁶ Contracts between related parties may also contain commissions for the sale of the concentrate to third parties. Further research is continuing into these fees, but broadly, they relate to the functions performed by the intermediary which affects the fee structure adopted. They may be embedded into the contract by directly reducing the payable metals amount.

made to account for the fact that the buyer (eg a smelter) cannot recover all of the copper during the smelting and refining processes. Rates of recovery vary between smelters, but payments are typically adjusted in a routine way with more efficient smelters taking advantage of their efficiency by receiving essentially “free metal”. For concentrates around 30 percent copper, smelters typically pay for 96-97 per cent of the value of the copper present, so a concentrate with 30 percent copper might actually be paid for around 29 percent copper.⁷ Below 30 percent, typically the payable percentage is reduced by 1 unit (100 basis points). Below 22 percent, the deduction increases to 1.1 percent (Boliden, 2008). Conversely, if the percentage exceeds 30 percent, the smelter might reduce the recovery adjustment.⁸

Payable Metals – Precious Metals (Gold and Silver)

For gold, quantities below 1 gram per dry tonne of concentrate typically do not receive payment, because they are uneconomic for smelters to recover. For gold above one gram per tonne, the concentrate buyer typically pays based on the London Bullion Market Association (LBMA) gold spot price (see Gold chapter for pricing information), noting that only around 97.5 percent of the material is paid for, to account for metals lost during the recovery process.⁹

For silver, typically no payment is made if there is less than 30 grams of silver per dry tonne of concentrate. Above this quantity, the weight of the silver is multiplied by the LBMA spot silver price. The quotation period for both precious metals may match the copper quotation period. Sellers typically receive around 90 percent of the value of the silver, to account for losses during the recovery process (Teck, 2013).

Charges and Penalties – Treatment and Refining

Treatment and refining charges (TC and RC) are commonly applied to concentrate sales, reducing the payment to the seller. These charges are determined both on spot markets and in longer-term contracts. In forming spot TC/RCs, mines for example may produce more concentrate than they had expected during the year, which they will sell on spot markets to independent traders or to smelters with excess capacity.

Under longer-term supply contracts, annual TC/RCs are commonly used. These are based on annual negotiations between many of the largest global mining companies and major Asian refineries on key terms applying to concentrate shipments over the coming year (Boliden, 2008). These negotiations typically conclude by December each year, and the terms frequently incorporated into similar supply arrangements between parties not involved in the agreement.¹⁰

⁷ 30 percent times 97 percent equals 29.1 percent.

⁸ These percentages however can vary over time and across regions - for example, one Canadian Company observes that for a concentrate with copper above 32 percent, smelters would pay 96.65 percent, rising to 96.75 percent for copper above 38 percent.

⁹ However, there appears to be a wide range of adjustments acceptable to revenue authorities – for example, the Australian state of Queensland accepts a deduction of 1 gram of gold per tonne of concentrate when applying royalties, with the adjusted quantity then reduced further by 10 percent. No adjustment is made for gold sold in any other form.

¹⁰ News on these negotiations is commonly reported in the financial press.

TCs are usually expressed in US dollars per tonne of concentrate. For example, the 2015 TC was around USD 107 per tonne. TCs may increase for concentrates with copper content above 40 percent, but this depends on conditions in the concentrate market (that is, if it's hard to source concentrates, smelters may reduce the charge). RCs are usually expressed in USD cents per pound of payable copper in the concentrate. For example, 2015 RC is expected to be USD 10.7 cents/pound (USD 23.6 cents per kg).

Charges and Penalties – Deleterious Elements

Concentrate purchasers will also seek deductions from payable metals for the removal of deleterious elements that exceed levels commonly found in concentrates (see Additional Information for a summary of these elements). Penalties may also be applied for concentrates with excessive moisture.

Charges will vary, depending on the process used to smelt and refine the concentrate, but typically the penalty is a USD per tonne amount for incremental percentages above a specified threshold. If too high, excess concentrations of some elements will result in the concentrate being rejected, usually because they either exceed environmental or safety limits; are unreasonably difficult (and therefore expensive) to treat; or the materials are expensive to dispose of (such as mercury).

A penalty TC for "complex concentrates" may also be imposed, but this will depend again on market conditions. For example, if smelters are struggling to acquire the amount/type of concentrates needed, this fee might be reduced or dropped.

Other terms

Additional terms may also be negotiated depending on market conditions. For example, until around 2007, smelters were able to negotiate additional payments from concentrate sellers known as "price participation" clauses, to share in higher metals prices. Another key factor affecting final price will be the costs of insuring and transporting the concentrate to the buyer. Concentrates are sold using several different incoterms (see Annex 1 of this Report) depending on the bargaining power of each side.

Blister and Anode Copper

As noted, blister copper trading is less common and consequently pricing practices are more opaque. Blister and anode products are often sold from smelters to refineries, and this often is confined within corporate groups.¹¹ Consequently, there is much less pricing data available.

Similar to concentrates, pricing is based on a calculation of the value of payable metals less charges and deductions. As noted earlier, at the blister stage, the product is around 98 to 99 percent copper, and sellers are paid based on the percentage of copper present. Payments are

¹¹ Within corporate groups, companies often use toll arrangements for certain transformations (e.g. refining) rather than transferring ownership of the intermediate product.

also made for precious metals, with an adjustment (reduction) applied to account for losses of metal during subsequent processes. Refining charges are also applied for the final removal of impurities, but these are lower than the RC applied to concentrates, reflecting the reduced processing required. Blister and anode copper are typically sold on a CIF basis.

Refined Copper Cathodes

Refined copper cathodes are, of course, globally traded using exchanges such as the LME and COMEX. For example, copper cathode prices are quoted on the LME, where the spot price has several features:

- It is published in USD per tonne of copper, along with corresponding exchange rates;
- It is based on the last cash offer price for a copper lot that would be “settled” (that is, paid for and the warrant delivered) in two business days;
- It is “Grade A” is copper that conforms to particular standard of chemical composition (essentially 99.9935 percent pure copper).

For cathodes, price setting reflects key pricing attributes including the physical characteristics of the metal (in particular, whether it complies with chemical composition standards imposed by commodity exchanges);¹² whether it is within or outside the official warehousing systems of the major exchanges; the location of the metal; and the delivery terms (in particular, how quickly the copper can be delivered – see Box on Cathode Price Premiums).¹³ Costs associated with delivery typically include rental charges for the use of warehouse space, load-out charges for removing the metal from the warehouse, and delivery costs to a specified location (LME, 2013).

¹² See for example, the Physical Contract Specifications set by the LME for copper.

¹³ Delivery date considerations are outside the scope of this paper, but their implication for price premiums are discussed in the Box on Exchange Prices and Price Premiums.

Box: Commodity Exchange Prices and Cathode Price Premiums

Exchange prices such as the spot price quoted on the London Metal Exchange (LME) are commonly used as a reference price to calculate payable copper for products earlier in the transformation chain (such as concentrates and blister/anode products). These exchange prices also form the basis of physical trades in refined copper cathodes, but the exact payments in a particular transaction are the result of several factors such as metal quality and proposed delivery time relative to other options in the market. This means LME spot price for copper cathodes may not be the only pricing information needed by revenue authorities looking to verify the price used in a related party transaction.

Exchange prices refer to a document of possession (a “warrant”) for a standardised unit of metal (“lot”) located at one of the network of storage warehouses approved by the exchange. For example, an LME copper warrant will be copper physically located at a specific warehouse - say, Rotterdam, the Netherlands. Copper traded on exchanges such as the LME can be used for physical product delivery, but where there are no major disruptions to physical supply, this is rare (for example, for the four months of 2015, 73,375 tonnes of copper were delivered from LME warehouses, compared to 373.4 million tonnes of copper traded on the LME over the same period [LME, 2015a]).

Under certain market conditions, cathode manufacturers may be able to offer their products at prices above exchange traded prices, thereby obtaining a “premium”.¹⁴ This is usually because they are offering products that will be physically delivered to the customer more quickly than the customer could obtain from suppliers elsewhere. The premium is typically enjoyed by all sellers offering the product to that market on those terms, although the extent of premiums may differ between sellers depending on their particular sales strategies. This is distinct from an isolated sale between two parties which may be at prices more favourable than contemporary market transactions.¹⁵

Whether a premium will form part of a related party transaction on copper cathodes will therefore depend on the particular circumstances of that transaction. Relevant factors include the physical location of the metal that is being sold relative to the location of the buyer and the delivery terms available to the buyer from other suppliers (i.e. whether delivery is faster than from other sellers in the market). For example, copper cathodes shipped from Australia to a purchaser in Europe could attract a European price premium if the delivery time matches European suppliers (all other factors such as cathode quality being equal).

¹⁴ For example, in 2015 copper cathode suppliers to European market were able to achieve premiums of around 1-2 percent over the LME cash price, based on offering prompt delivery (usually 8-10 working days).

¹⁵ Within the official warehousing systems of the major exchanges, premiums may also be paid in certain circumstances by cathode purchasers taking physical delivery of the metal. In particular, if the amount of metal a warehouse must deliver increases such that waiting times also rise, warrant holders wishing to receive cathodes more quickly may instead purchase a warrant that is higher in the delivery queue, paying the seller a premium over the cash price.

ADDITIONAL INFORMATION

Copper – Impurities in Copper Concentrates

The table below outlines the common penalty elements that may be found in copper concentrate contracts. Please note - these tolerances are indicative.

Penalty Element	Reason for Penalty	For each %	Exceeding %
Arsenic	Reduces conductivity of copper, raises recrystallization temperature of copper, causes cracking at the copper grain boundaries. Also a known human carcinogen, requiring environmental mitigation measures. Expensive to dispose of.	0.1	0.2
Antimony	Reduces copper cathode conductivity, annealability (ability of the copper to be strengthened through annealing process), drawability (ability to stretch out copper rods into finer wire). Also a possible human carcinogen.	0.01	0.1
Bismuth	Causes cracking of copper rods, poor drawability even at very low concentrations. As concentrations increase, the copper will work-harden more quickly (broadly, the copper hardens when bent or deformed).	0.01	0.05
Selenium	Makes cathode copper more prone to cracking during wire drawing. Toxic to humans at higher concentrations. Combines with copper during refining, reducing amount of copper recovered.		
Tellurium	Increases the brittleness of copper, causing rod cracking and poor drawability. Combines with copper during electrolytic refining, reducing amount of copper recovered.		
Lead	Toxic to humans, requiring environmental mitigation measures.	1.0	1.0
Nickel	Nickel in anodes decrease the solubility of copper in the electrolyte liquid during the refining stage. It must also be removed from the electrolyte. Nickel is also a human carcinogen, requiring environmental mitigation measures. But the recovered nickel sulphate can be sold.	0.1	0.5
Cobalt	Toxic to humans at higher concentrations. But can be recovered and sold if concentrations are high enough.	0.1	0.5
Chlorine	Causes corrosion in smelter components such as smelter flues if it condenses as hydrochloric acid. Can require environmental mitigation.	0.01	0.05
Fluorine	Can pose significant difficulties for smelters if it mixes with water and forms hydrofluoric acid which corrodes and in high concentrations, causes health problems. Smelters are reluctant to accept concentrates with high fluorine, or charge significant handling penalties.	10 ppm	330 ppm
Cadmium	A toxic heavy metal classed as a carcinogen to humans, requiring mitigation measures.	n.a.	n.a.
Mercury	Highly toxic, raising waste disposal costs and can damage smelter equipment. Can remain in smelter gases, requiring the gas to be cooled below zero degrees Celsius to reduce its concentration. Techniques to remove mercury add to capital and operating costs. Requires disposal.	1 ppm	10 ppm
Zinc	In high enough concentrations, will increase viscosity of the slag during smelting, increasing the loss of copper.	1.0	3.0
Silica, Alumina, Magnesia	In high enough percentages, smelter melting point is increased, requiring higher operating temperatures (therefore more energy) to limit lost copper.	1.0	5.0

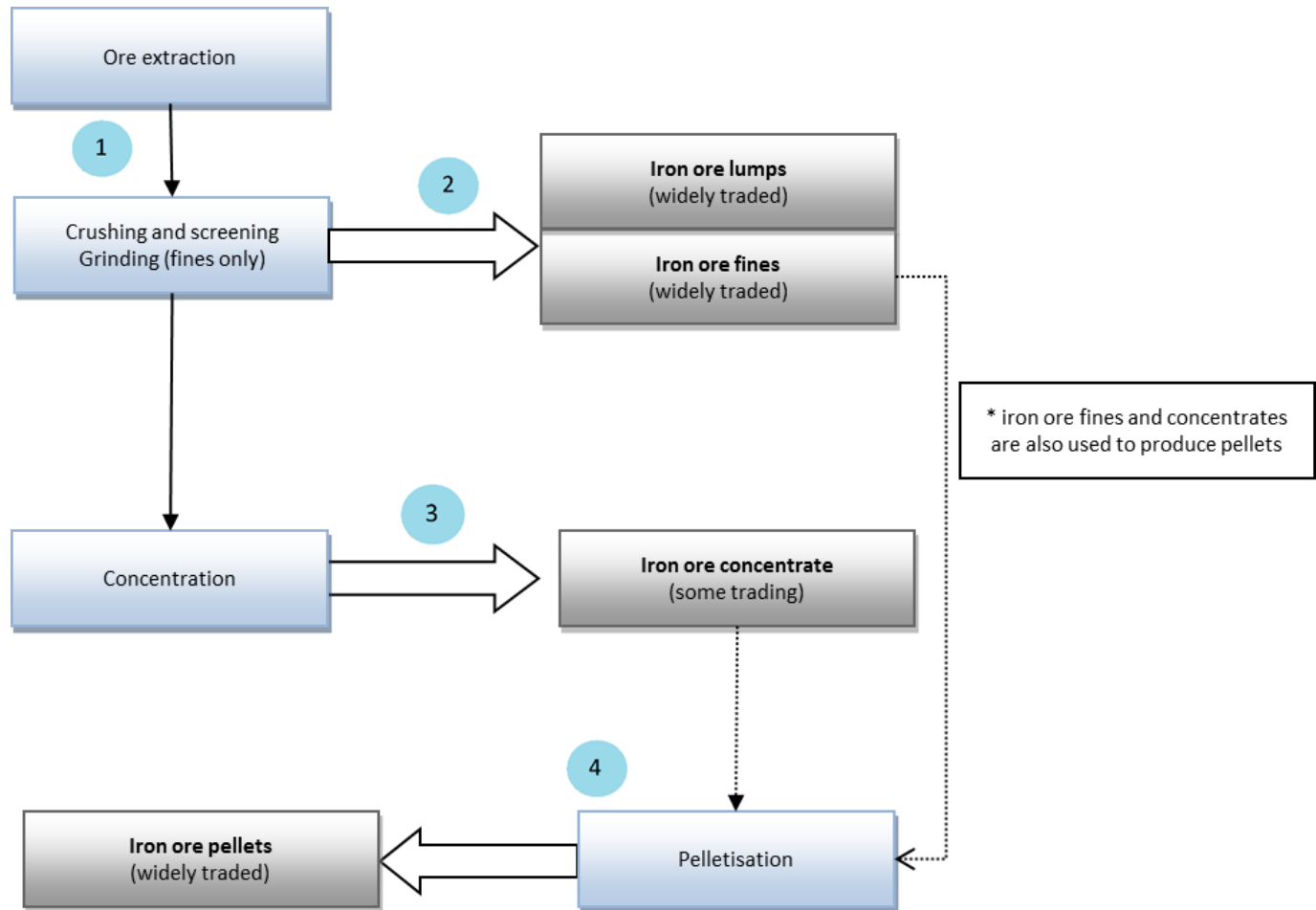
Source: C Fountain, *The Whys And Wherefores Of Penalty Elements In Copper Concentrates*. n.a. – not available. Note: Uranium is also a problem element at high concentrations, making the concentrate harder to sell.

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Case Study: Iron Ore

October 2016

MINING PRODUCTION AND KEY PRODUCTS



Note: Iron ore fines and concentrates are also used to produce sinter products, which are similar to iron ore pellets. However, sinter products are difficult to transport and consequently not frequently traded

Iron Ore Mining

With the exception of hematite (discussed below), most initial beneficiation operations will result in the production of three materials: a concentrate; a middling or very low-grade concentrate, which is either reprocessed or stockpiled; and a tailing which is discarded. Ores of different grades may be separated for different processing paths, and it is common for different parts of the ore to be used in different ways.

Iron Ore Production

- 1 Iron ores are extracted using drilling and blasting processes. Iron ore mines are predominantly open pit. Once the ore has been loosened by blasting, it is transported by large trucks directly to primary crushing machines which break it into smaller pieces. Screens capture pieces that are still too large, which are sent back to be broken down further. Crushed ore is then either taken by conveyor belts to holding piles, or moved directly to further crushing, screening and grinding.
- 2 **Direct Shipping Ores (Hematite and a small amount of magnetite):** Hematite may need only minimal beneficiation before it is able to be sold, particularly where its physical properties make it suitable as an input into iron and steel production (for example, the ore may be able to be fed directly into furnaces). For this reason, high-grade ores such as hematite are often called 'direct shipping ores' (DSO) or 'natural ores'. Hematite ore is generally taken to a mill for crushing and screening, which produces products such as "lumps" (pieces greater than 5 millimetres) or "fines" (pieces finer than 5 millimetres). Once the iron ore is at target size, it is often trucked or railed to port in preparation for export. Blending may also occur either near the mine or at the port.
- 3 **Further Processing (Most magnetite, lower-grade hematite, taconite):** Magnetite ores require initial crushing and screening, but must undergo several additional processes to concentrate the ore and separate it from the gangue. These processes are typically magnetic and gravity separation, and flotation.

Magnetic separation utilises the stronger magnetic properties of magnetite relative to the less magnetic (or non-magnetic) gangue materials. Separation may be performed through several stages with each successive stage applied to finer particles. This can be done using either a dry feed or one mixed with water, creating slurry. Following magnetic separation, further separation may be required through the use of flotation.

Froth flotation is performed on intermediate to low-grade ore to remove waste rock and impurities. There are 5 major flotation processes ("routes"), targeted at separating out silica-rich materials such as quartz and to a lesser extent, other impurities including phosphorous and alumina in particular. The process essentially involves mixing the iron ore material with water and coating the iron minerals with chemicals so that they repel water (become "hydrophobic"). In a large tank, air is pumped through the mixture and agitated to form bubbles. Iron minerals in the mixture attach to the surface of the bubbles (adsorb) and float to the surface. This allows the foam to be separated off. Silica remains in the tank and is pumped out as tailings, with some of the iron that cannot be recovered. The foam is dried to form a powder, or may also be shipped "wet".

These concentration processes create iron ore products typically around 57 to 65 percent iron. The concentrate will be sold or used to produce iron ore pellets or sinter feed.

4

Pelletisation: Iron ore pellets are used by steelmakers in blast furnaces, and in direct reduction steel making plants. To produce, finer iron ore grains are bound together and thermally treated. This is done at a pelletising plant. The iron ore concentrate is ground to a fine powder and mixed with binding agents such as bentonite clay, flux materials such as limestone, and other materials as needed - for example, hematite ore might be mixed with coke or anthracite coal as an internal fuel. The mix is then filtered to remove water, and rolled into balls ("greenballs") that are around 9 to 16 millimetres in size. These balls are screened to ensure they meet target size, and sent to be hardened by drying and progressively heating them to 1200-1350 degrees Celsius. Finally, the pellets are cooled and prepared for transportation. At this stage, pellets are typically 65-70 percent iron, with low levels of impurities.

PRICING PRACTICES

Iron ore products are diverse, targeting a range of customer requirements. The most traded products are iron ore fines, followed by pellets and iron ore lumps. Iron ore concentrates are also traded but make up only a small proportion of international trade (CRU, 2014).

The significant size of the steel industry in China means transactions with Chinese firms play an important role in iron ore demand and price setting. For example, China represented 55.8 percent of apparent iron ore consumption in 2012, followed by Japan at 7.1 percent and India at 6.2 percent (World Steel Organisation, 2015). Many pricing publications consequently focus on transactions with delivery to Chinese ports or regions as being indicative of international market directions.¹⁶

Iron ore pricing has undergone considerable structural change over the last decade. Prior to 2010, the majority of iron ore contract prices were set in annual negotiations between large iron ore suppliers and steel makers. Those agreed prices then formed the a basis for other market transactions, between parties not connected to the initial negotiations.

From 2010 however, contracts moved increasingly towards quarterly or monthly terms as they expired and were renegotiated, with an increasingly accepted “iron ore” spot price emerging (RBA, 2012).¹⁷ Iron ore contracts have now evolved further to the widespread use of price indices, discussed further below.

Iron ore trading is increasingly done using electronic trading platforms, which are membership-based and focused on physical trading. For example, the GlobalORE platform and the China Beijing International Mining Exchange (CBMX) platform are increasingly used in transactions¹⁸ by major iron ore suppliers and purchasers for standardised iron ore products involving physical product delivery, although companies advise this is still small relative to the total number of transactions involving physical delivery.

Pricing Elements in Iron Ore Product Transactions

Iron ore prices are determined fundamentally by prevailing market conditions (and expected future conditions) in both iron ore product supply and the current and expected demand from the global steelmaking industry. For particular iron ore products, prices are determined primarily by the amount of iron (“fe”) in the product.

Other characteristics that affect the final agreed price also include:

- the physical form of product being sold (for example, fines, lumps and pellets) and its suitability as a steelmaking input;

¹⁶ Australia and Brazil comprise around 78 percent of China’s iron ore imports.

¹⁷ This change has been concurrent with an increasing use of centralised marketing entities to manage functions such as customer relationships, contract negotiations, shipping and logistics, and also to manage some financial risks.

¹⁸ GlobalORE is also underpinned by a standardised set of contract terms the Standard Iron Ore Trading Agreement (SIOTA)

- the impurities present in the product; and
- delivery and payment terms.

In addition, other factors such as the duration of the agreement and the relative negotiating skills of the parties affect final agreed prices, albeit at the margin.¹⁹ Market conditions can vary across regions and change over time – even seasonally – but the underlying utility of the iron ore products remains connected to their use as a steelmaking input.

Iron Ore Price Benchmarks

As iron ore contracts have evolved towards shorter durations and greater price transparency, price indices have emerged that are increasingly used to set prices for iron ore products. This is an evolution from contracts that agreed fixed prices for the duration of the contract (The Steel Index, 2013).

In particular, iron ore products are often based around the price of iron ore with 62 percent iron per dry metric tonne, although contracts may be specified using different price metrics (see Box). Several pricing indices have been developed to track the price of 62 percent iron products, including:

- IODEX (published by Platts);
- Mysteel (published by Mysteel.com);
- Metal Bulletin (published by Metal Bulletin Ltd);
- TSI (published by The Steel Index);
- Argus Steel Feedstocks (ICM, published by Argus Media Ltd); and
- China Iron Ore Price Index (CIOPI, published by the China Iron and Steel Association).

These benchmark specifications are also used by many market participants to establish the price of other iron ore grades.

Contract terms

Contract terms will usually refer to an index price which most closely resembles the product under negotiation. This index price is then adjusted to account for any physical differences between the benchmark and the actual product.²⁰ For example, for an iron ore product around the 62 percent iron grade, the price of iron ore products with iron content between 60 and 63.5 percent is adjusted proportionately, based on the actual iron content (percentage) – so a shipment of iron ore fines with iron content of 61 percent would be adjusted (discounted)

¹⁹ For example, an iron ore transaction may cover a package of products such as lumps and fines with a volume discount offered.

²⁰ According to Metal Bulletin Research, in 2011-12, TSI was dominant, with around 70 percent of pricing referencing this index, followed by MBIO and IODEX at around 12 percent each. TSI is now owned by Platts (McGraw Hill).

proportionately to the benchmark 62 percent price.²¹ This proportional adjustment however only applies to iron ore products that have iron content within this range.²²

In addition to this 62 percent grade, there are also pricing mechanisms for higher-grade iron ore (iron content of 65 percent) and lower-grade ore (58 percent), reflecting the different sub-markets for iron ore products. For higher-grades, prices are naturally higher, reflecting both the higher iron content as well as reduced levels of moisture and impurities. Correspondingly, lower-grades have lower prices and typically allow for greater impurities and moisture (Platts, 2015).

Each market segment may experience unique price changes - particularly over short time horizons - as each product may not be readily substitutable for others, because of the time required to reconfigure a beneficiation process or construct new equipment. Over longer time horizons however, iron ore product prices generally move in a correlated way. As a consequence, revenue authorities need to be careful to ensure they are examining the specific market when looking for pricing information to verify a particular transaction.

Box: Published Prices and Contract Prices

In the financial press, the iron ore price is frequently quoted as referring to a dry tonne of iron ore fines containing 62 percent iron ("fe") delivered by sea to Qingdao port in northern China.

However contracts are frequently concluded using different price metrics, such as US cents per metric tonne unit (mtu) of ferrous content. Concentrates for example are frequently priced on this basis. This means conversions may be required to compare such contracts with published "iron ore" prices.

Take as an example, a contract for 50,000 tonnes of concentrate with 64 percent iron, priced at 70.31 c/mtu also going to Qingdao on the same delivery terms.

After converting the price to dollars, it is adjusted by the Fe content: $0.7031 \times 64 = \$45/\text{tonne}$ (since in this case there are 64 units of iron in each 100 units of the concentrate). Depending on how it is expressed in the contract, this may be the price per tonne including moisture ("wet" tonne). To compare against the published dry metric tonne price, the price needs to be adjusted to remove the weight of moisture. Continuing with the example, For example, if the shipment had 8 percent moisture, the price is adjusted as: $\$45 \times 0.92 = \41.4 per dry tonne.²³

For the purposes of freight, wet tonnes are the relevant metric since this is the weight that must be physically transported (ArcelorMittal, 2016).

Adjustments Based on Physical Form

Once the level of iron in the transacted product has been established, prices can be adjusted depending on the physical form of product – both positively and negatively – which may fluctuate over time in accordance with market conditions. For example, products in lump or pellet form attract price premiums relative to fines because they are suitable for immediate use in

²¹ That is, the 62 percent price would be discounted by multiplying it by $61/62$, or 0.983.

²² Platts observes that below 60 percent iron and above 63.5 percent, adjustments are not linear and therefore more variable.

²³Source: Adapted from Garbracht (2010).

furnaces, but this premium for shipments to China may increase during the year if cold weather in China restricts alternative local supplies of fines (Rio Tinto, 2015).²⁴

Commonly applied adjustments are:

- For fines: a penalty adjustment may be applied where pieces are very small (sometimes referred to as “superfines”) reflecting additional processing that may be required;²⁵
- for lumps: unusually large lumps may attract a smaller premium if they exceed a fixed percentage of the shipment, reflecting additional processing that may be required; and²⁶
- for pellets: premiums above fines may be paid depending on the quality of the pellets. In particular, pellets made for use in direct reduction steelmaking processes usually attract a greater premium than pellets made for blast furnaces.

Price adjustments based on size are typically negotiated between the parties depending on the transaction, but some pricing data on lump and pellet premiums is published (see Annex on data sources).

Penalties and Deductions - Impurities

The level of impurities in an iron ore product directly affects negotiated prices. Higher levels of certain impurities will commonly incur penalties relative to standardised grades, because of the unwanted effects they have on the properties of iron (and therefore steel - outlined in Additional Information). The most important impurities affecting prices for iron ore products are silica, alumina, phosphorous, sulphur, and “loss on ignition” impurities, which refers predominantly to moisture content.

Contracts would usually specify limits on each of these impurities, with actual adjustments made on the basis of testing (assay) results. In addition, alkalis such as lithium, sodium and potassium may affect prices if they are above trace amounts, but this is less common.

- For alumina and silica, some market data is available on adjustments for each additional percentage point of impurity within a certain range. In addition, low-alumina iron ore products (alumina below 4 percent) can have their own index price with a higher price than standard grades.
- Moisture levels do not have a significant effect on prices since iron ore products such as fines and lumps are priced per dry metric tonne. Pellets would be very unlikely to attract moisture penalties, as the induration process usually means they have no more than 2 percent moisture.

²⁴ That is, there may be two parts to the premium calculation: iron differentials relative to standard grade fines, and then the premium associated with the pellet form.

²⁵ concentrates typically trade at a premium to fines, but this is largely because they have higher iron percentages and lower impurities, not because of physical form.

²⁶ but this should be unusual given the crushing and screening that usually occurs before sale

- For other impurities, pricing adjustment information is difficult to find and terms would be negotiated bilaterally.

Several factors limit the extent of impurities in iron ore products. In particular, mines usually aim to produce products that adhere to commonly traded impurity levels to ensure products are able to be offered into markets with more buyers and sellers.²⁷ In addition, certain impurities will be limited by maritime transportation rules. For example, maritime safety regulations limit moisture content of iron ore products (IMO, 2009). Where products materially exceed impurities commonly seen in markets, companies may accept harsher penalties if they choose to sell, but this provides strong incentives to blend the ore with other grades if the mine is able to, or at least invest in equipment to enable further beneficiation.

Other factors affecting prices

Adjustments based on physical location and delivery date

As noted above, the size of demand for iron ore from Chinese steel mills means a significant amount of pricing information focuses on Chinese ports where products are imported.

Pricing publications commonly publish prices for products located at Chinese ports, on CFR trade terms. As a result, revenue authorities commonly need to adjust prices to account for differences in delivery terms. In particular, this is often required for freight charges, to establish the price that would be paid at a different geographical location. To make this adjustment, 'netbacks' are often used by contracting parties²⁸ and revenue authorities (see related Toolkit on comparability for a discussion of netback pricing).

The prices obtained in iron ore transactions are also affected by the expected duration of shipment and delivery date. In markets where there is an expectation that iron ore prices will fall²⁹, sellers may be able to obtain a premium relative to a pricing index if they are able to deliver more quickly than what other suppliers might commonly provide. Conversely, for product suppliers offering longer delivery times relative to those commonly available, they may be penalised by adding a discount to the index price.

Contract duration (spot and term contracts)

Iron ore product pricing is affected by the nature of the relationship between the parties, particularly whether the transaction will be once-only or negotiated as part of a longer-term arrangement (a 'term contract'/'offtake agreement').

In the latter, the product seller may offer a lower price or make adjustments to other terms as an inducement to either supplying a larger product volume or otherwise creating a stable longer-term supply arrangement (see Annex 1 for discussion of term contracts).

²⁷ This has led to the development of iron ore product "brands" that aim to offer a product with standardised features including iron present, particle size, impurities and moisture.

²⁸ contracts negotiated under the GlobalORE trading platform use this approach, for example.

²⁹ as indicated by the futures curve sloping downwards, loosely defined as a "backwardation".

According to market observers, iron ore fines are more likely to be traded on spot terms, particularly with Chinese purchasers (Platts, 2015), while lumps and pellets are more likely to be sold under contracts of a fixed duration such as monthly, quarterly or yearly (Metal Bulletin Research, 2015). As noted earlier, term contracts usually reference iron ore price indices, rather than at a fixed price.

ADDITIONAL INFORMATION

Iron Ore – Key impurities

Key impurities in iron ore that must be brought within commonly accepted limits are:

- Silica - increases the brittleness of iron. If silica is left in the iron ore, during iron smelting it can be alloyed into the iron. It is usually relatively easy to remove because of the density difference between silica-rich minerals and iron-rich minerals (Reed, 2013).
- Phosphorous - also makes iron more brittle, and only very low tolerances are accepted (Reed, 2013). It also, however, increases the hardness, strength and fluidity of steel.
- Sulphur - also makes iron more brittle, but also prone to cracking and failure (Reed, 2013).
- Alumina - makes blast furnace and sinter plant operations more difficult and expensive because they force those operations to operate at higher temperatures to prevent excessive slag formation (Lu, 2007).

Steelmaking processes

Iron ore products are used first to make iron, with the resulting iron products produced then used in steelmaking. The steelmaking process ("route") used and steel products to be produced affect which iron ore products are needed and their quantities. The two main routes for steelmaking are the basic oxygen furnace route and the electric arc furnace route.

Basic oxygen furnace: a combination of iron ore, coke, coal and scrap are used in a blast furnace and melted to form molten iron. Pellets or iron ore lumps and are generally included in the blast furnace burden with iron ore fines to allow greater circulation of heated gas between them in the furnace and reaction with the ore (compared to a burden with higher proportion of fines). The liquid iron, which is usually around 92 percent iron is then either transferred directly to the basic oxygen furnace of the steel plant as "hot metal", or cooled and transferred for steel making as iron ingots ("pig iron"). These ingots can also be sold as feedstock to other steel producers (Metal Bulletin Research, 2015).

Electric arc furnace: Primary inputs are scrap iron and steel, but these are supplemented by "metallics" products derived from iron ore such as iron nuggets, direct reduced iron, hot briquetted iron and pig iron.

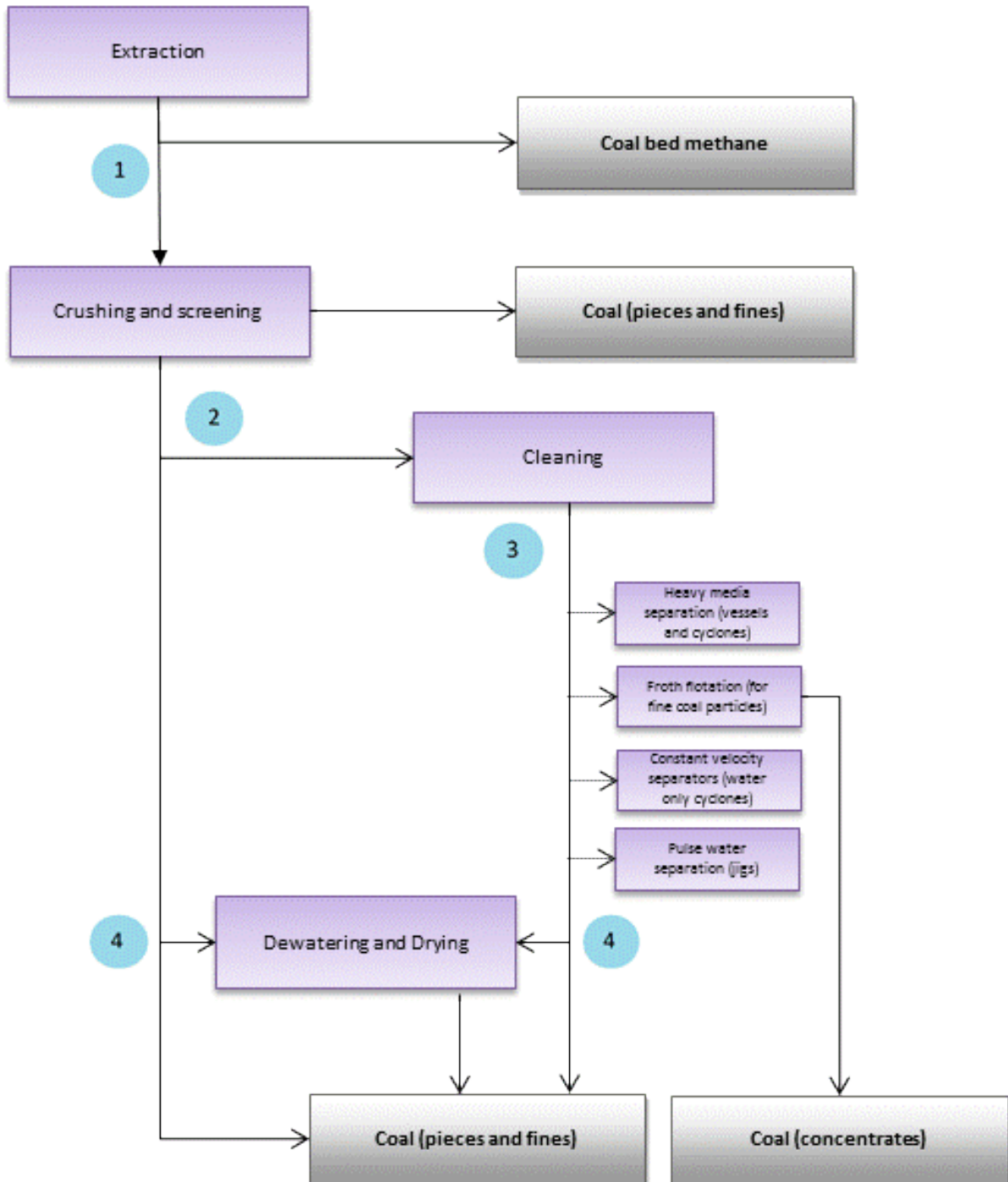
- Iron nuggets are balls typically around 96-98 percent iron, made using iron ore pellets.
- Direct reduced iron (DRI) is a pellet or briquette made from iron ore fines or lumps.
- Hot briquetted iron is a premium form of DRI with greater density (allowing easier transportation) and lower impurities.
- Hot metal/pig iron is also used (Metal Bulletin Research, 2015).

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Case Study: Thermal Coal

COAL MINING AND KEY COAL PRODUCTS

Thermal Coal Transformation Chain and Key Products



Note: Coal bed methane (CBM) may also be the primary focus of resource extraction, rather than coal mining. CBM is naturally produced as organic material becomes coal over time. The gas is stored on the many surfaces of the coal and held in place by water pressure (Lennon, n.d.). The mine may also recover coal bed methane from the seams of the coal bed, bringing it to the surface by pumping water through the coal bed. Pricing of CBM is outside the scope of this study.

Thermal Coal Mining

The coal must first be severed from the surrounding land, using mechanical digging processes. These processes include the use of dragline excavators at open pit mines to dig up the coal, or “bord and pillar” processes at underground mines, which use sections of the coal bed as pillars to hold up the roof of the mine as excavation occurs (Shaw, 2016).

The coal is then moved to an initial stockpile (the “run of mine”) before beneficiation processes begin to transform the coal to a saleable product.

- 1 Crushing and Screening:** The coal is transported to a series of crushers in a circuit, to reduce the pieces to a smaller, more uniform size. Screens are used to remove pieces that remain larger than the target size (e.g. 50 millimetres) and these pieces are sent back for further crushing.
- 2** Once the pieces are at their target size, they may be transported from the mine for delivery to customers (or traders) if impurities and quality are within acceptable limits. Alternatively, further cleaning processes may be required to remove surrounding waste material and to reduce the presence of impurities (particularly ash, sulphur and nitrogen).
- 3 Cleaning:** Coal particles of different sizes may be separated and sent for different washing processes. Numerous processes are used to clean the coal, exploiting differences in the density of the coal relative to surrounding rock (the coal is lighter, IEA, 2014). For example, the coal may be fed into barrels and mixed with fluid causing the coal to float while heavier material sinks and is removed (OTC Journal, 2011).

Very fine particles may be sent through a **flotation process**, in which slurry containing the fine coal particles is mixed with air bubbles, with the coal attaching to the surface of the bubbles and floating to the top of the tank as a froth, where they are removed and dried to form a concentrate (Huynh, n.d.).

Cleaning may also include removing sulphur, especially sulphur dioxide. This may require **chemical processes** where the sulphur is chemically connected to the carbon.

- 4 Drying/Dewatering:** Coal often requires drying to prepare it for sea transportation. Drying reduces transportation costs and improves the efficiency of coal in power generation.

Dewatering processes depend on the type of water being removed (inherent, surface or free water held in the gaps between coal particles) and the type of coal (Speight, 2013). Surface water is often removed using screens which drain the water (particularly higher-rank coals) while finer pieces may require centrifuges or cyclones. Kilns then **dry** the coal.

THERMAL COAL USAGE AND MARKETS

Thermal, or steam coal³⁰ is an energy source consisting primarily of carbon. There is a range of coal with varying energy potential, grouped into four grades or “ranks”, depending on its carbon content and energy available on combustion. Higher rank coals have more energy.³¹ The ranks of coal, from lowest energy potential to highest, are:

- lignite (also known as brown coal);
- sub-bituminous coal;
- bituminous coal (also known as black coal); and
- anthracite coal.

The majority of thermal coal is used by utilities to generate electricity and commercial heat - around two thirds of all thermal coal is used this way.³² Thermal coal is also used in manufacturing where industrial plants have their own power generation facilities or need for steam (such as in paper mills), as well as for concrete and transportation.³³

Coal fired power plants vary in size and design, but put simply, utilities predominantly burn the coal.³⁴ This involves pulverising the coal and blowing it into a boiler where it burns at high temperatures, producing steam.³⁵ This steam then passes through a turbine to generate electricity.

Thermal Coal Markets and Trading

Economic Context

Thermal coal remains a major energy source, second only behind oil in primary energy consumption (coal represented around 30 percent of energy consumption in 2014).

Coal markets are competitive internationally, with arbitrage occurring geographically and also by blending coal grades to meet the particular requirements of the customer. But like other minerals, thermal coal markets have their own unique features and economic context. In particular, coal markets are influenced by external policy factors beyond the international supply and demand of the coal products themselves. For example:

³⁰ This study is on thermal coal. It excludes metallurgical or coking coal, a type of coal used to produce coke (a key input into iron and steelmaking), as well as coal bed methane, peat and oil shale/oil sands.

³¹ More formally, coal is ranked by the amount of alteration it has undergone from its organic material stage. Higher rank coals are those which have undergone the greatest degree of transformation (ABARE, 1997).

³² OECD countries use more than this and non-OECD countries less

³³ There are also smaller coal-to-liquid products in South Africa and China.

³⁴ A small percentage – less than 1 percent of world capacity – uses gasification processes, in which coal is converted to gas to produce a synthesis gas of hydrogen and carbon monoxide for use as fuel.

³⁵ Alternatively the coal can be burnt in a fluidised bed to create steam.

- The energy security policies and environmental policies (particularly policies to limit carbon emissions) of major importers and exporters influence the structure and evolution of coal markets.
- Tighter environmental regulation in China has changed the profile of coal imports to China away from high-impurity coals.
- The Indian Government has recently relinquished its role as the sole trader of coal (via Coal India Ltd) and allowing sub-national governments and private actors to mine and sell directly to end-users (IEA, 2016).

Coal Trade

In 2014, the total trade of thermal coal was 1.05 billion tonnes, of which around 945 million was traded by sea (IEA, 2015). Coal trade is therefore a large international market, but this international trade only represented around 17 percent of total coal production (the remainder was produced and consumed domestically).

The Pacific Basin dominates the international trade of coal, since it is where the largest importers and exporters are located, with the Atlantic Basin being the other main international market.³⁶

On the **export side**, the largest exporters by total tonnage in 2014 were Indonesia (estimated 421 million tonnes, mt), followed by Australia (196 mt), Russian Federation (127 mt), Colombia (85 mt) and South Africa (74 mt). On the **import side**, Asian buyers form the majority of coal importers by weight. China is the largest thermal coal importer, importing an estimated 219 mt in 2014 - representing over 20 percent of coal imports globally. This is followed by India (175 mt), Japan (137 mt), Republic of Korea (96 mt) and Chinese Taipei (58 mt). Countries in Europe and the Mediterranean are also significant purchasers, particularly Germany, United Kingdom, and Turkey.

Price developments in China are highly influential in international price formation, explained by that country's large share of total coal consumption.³⁷ The IEA observes that "... coastal South China is still the clearing market, i.e. the main place where price is formed, in the Pacific Basin, especially for low calorific coal. Imports mainly from Indonesia and Australia compete with domestic seaborne trade, and are sold at the prevailing spot price for the day when the deal was done or even at the prevailing spot price for the day that coal arrives at the port." (IEA, 2015)

Recently, several factors including falls in sea freight rates have worked to increase the integration between the Pacific and Atlantic basins, strengthening the ability of traders to arbitrage between the two markets. This means prices in the two main markets move in line with each other over time, with short-term differentials balanced by changes in trade flows.

³⁶ Russian Federation and South Africa are able to supply both, depending on price conditions.

³⁷ One unique feature of coal trading is that domestic coal sales are usually not linked to international price indices. Further information on domestic coal trading, particularly in China, is available from the IEA.

PRICING AND CONTRACTS

Customer Requirements

Understanding the economic context of the ultimate coal user is essential to understanding which coal they buy and their supply requirements (Shaw, 2016). For example, where there is a continuous need for power such as electricity generators that contribute to generating a region's base load electricity, or in smelting or continuous manufacturing operations, this would typically require a steady supply of coal and put a premium on ensuring consistent supply (some mines are adjacent to the utility, minimising transport costs). Alternatively, the user may have variable energy needs – for example, a power plant may be switched on only at certain times of day, affording the customer greater flexibility in scheduling purchases and using different suppliers.

1. Energy Content and quality

The primary price determinant for coal is its energy content (amount of heat), measured per unit mass of coal on combustion. This is indicated by its calorific value, which is the capacity of the coal to generate heat.³⁸ Energy content is measured in thousands of calories (kilocalories, or kcal) per kilogram of coal or the imperial equivalent, British thermal units per pound. Energy content ranges from approximately 3,400 kcal/kg to 6,700 kcal/kg.

End-users buy coals, first and foremost, based on the quality of the coal. This is to ensure the coal product is compatible with their boiler(s). There are sub-markets for coal products based primarily on the type of coal and its energy content, noting that lower-rank coals are not typically shipped long distances given the higher transport costs per unit of energy.

Parties to a coal transaction will agree either a fixed price, or refer to a coal price index that most closely represents the type of coal being traded and its export location. Fixed price contracts typically have shorter durations, ranging from spot sales to an agreed tonnage to be delivered over the course of one year.

For coal shipments with a calorific value close to the prescribed reference specification (such as small variations in different shipments), an arithmetic adjustment would be made to the price for the proportion of energy in the shipment relative to the price for the agreed reference grade. For example: if a contract refers to a price with energy content of 6,000 kcal/kg, a coal shipment of 5,900 kcal/kg might be discounted by 1.6 percent.³⁹

³⁸ .There are two ways to express calorific value: gross calorific value or net calorific value. The GCV is the amount of heat liberated during a test in a laboratory, where the coal is combusted under standardised conditions at constant volume so that all of the water remains in liquid form. NCV is the maximum achievable heat in a boiler, because some energy is lost converting the water in the coal to vapour. (source: Thomas) NCV is therefore lower than GCV – it is the more “real world” calorific value. See Box for information on converting between GCV and NCV.

³⁹ That is, the price would become $(5900/6000) \times (\text{reference price})$. Standardised coal trading contracts such as the Coal Trading Association 2010 Master Coal Purchase and Sale Agreement also prescribe this approach, specified in BTU per pound (see Exhibit D annex).

Price Indices

Price Indices exist for several coal types originating from major supply ports including coals from South Africa, Australia, Indonesia, Colombia and Russian Federation. These indexes have shorthand names commonly used by traders, referring to the particular publications that monitor and report on prices for those trades.

- “API2” is the most commonly used reference price in the world. It is the benchmark price for imported coal to North West Europe (6000 kcal/kg NAR). The volume of API2-based derivatives is more than 2.5 billion tonnes.
- Other popular indices are API4 and API6. API4 is the benchmark price for coal exported from Richards Bay in South Africa (6000 kcal/g NAR). API6 is the benchmark price for coal exported from Newcastle in New South Wales, Australia (6000 kcal/kg).
- For the Americas, the Central Appalachian Coal Price Benchmark (CAPP) spot prices are the most widely referenced for thermal coal in the eastern USA. CAPP spot coal prices are commonly used to price both physical and financial transactions for short-term and long-term contracts. CAPP spot prices reflect the value of the coal at the CAPP Delivery Zone location. These prices do not reflect delivery costs from the delivery zone to another location, emission abatement costs nor any other handling charges (Tradition, 2013).

Given the range of qualities of coal internationally traded, there are different indices for different qualities. For example, ICI1-ICI5 are five indices published by Argus for coal exported from Indonesia, with calorific values ranging from 3000 to 6200 kcal/kg NAR).

2. Moisture

Moisture content simply refers to the water that is in the coal. As noted above, coal miners will remove as much water as possible, since it adds to transport costs and, if high enough, can pose a risk to the stability of the ship.⁴⁰

Moisture is measured as a percentage of the “air dried” coal (that is, the moisture in the coal after achieving equilibrium with the atmosphere around it).⁴¹ Agreements will typically specify a moisture percentage with a price penalty for small amounts above the agreed level and a maximum above which the shipment can be rejected. For example, total moisture may be specified at 13 percent, with a USD 0.20/tonne for each 0.1 percent above 13 percent up to a rejection level of 14 percent.

⁴⁰ In addition, low grade coals with high humidity content can self-heat, risking carbon emissions, spontaneous combustion or damage to equipment. For this reason they are not stored at power plants for long and need to be delivered efficiently (Osborne, 2013).

⁴¹ Removing “residual” or “inherent” moisture are higher – they can be removed by heating the coal to above 100 degrees Celsius.

3. Impurities

Impurities in coal can damage equipment and/or must be mitigated when the coal is burnt according to environmental regulation, increasing costs. Impurities that routinely result in price penalties (when above commonly observed market levels) are ash and sulphur.

- **Ash Content:** Ash remains after the complete combustion of all organic matter and the oxidation of the mineral matter present in the coal – it is therefore the incombustible material present in the coal. It is measured as a percentage of the air dried coal sample. Since ash does not contribute to the calorific value of the coal, its presence increases costs. In particular, a higher ash content increases transport and handling costs per unit of energy contained in the coal, and also waste management costs because the ash requires disposal after combustion (ABARE, 1997). Coal with ash content exceeding standard contract specifications would therefore face a price penalty.
- **Sulphur Content:** Sulphur, broadly defined,⁴² is a pollutant predominantly emitted as sulphur dioxide gas during combustion (unless utilities install mitigation measures). It can also damage plant equipment by for example, corroding metal surfaces. As a result, power plants usually prefer coals with naturally lower levels of sulphur, or purchase coals within maximum levels, either on their own or after blending.⁴³ Coal with sulphur above standard contract specifications would therefore expect to receive a price penalty.

Outside electricity generation, coal buyers using the coal as energy require coals meeting very precise specifications. In cement production however, tolerance to ash may be higher since it can be incorporated into the clinker, meaning that industry may be able to work with a wider range of qualities (IEA, 2015).

4. Other factors

- **Volatile matter:** This is the proportion of the air-dried coal released as gas or vapour during a standardised heating test (Skompska 1993). This proportion tends to decrease as the rank of a coal increases (ABARE, 1997). Higher volatile matter content indicates coal that is easier to ignite and which will burn with a large, steady flame.⁴⁴ However, if volatile content is too high (exceeding 30 per cent of the air dried coal), it increases the potential risk of spontaneous combustion (ABARE, 1997).
- **Grindability:** Coals with high grindability are relatively soft and easy to prepare for the boiler. Grindability varies with coal rank: it is generally relatively low for anthracite coal (very hard pieces), improving for bituminous coals (most grindable), before falling again for sub-bituminous and lignite coals (Thomas, 2002). The Hardgrove Grindability Index

⁴² Sulphur can occur as elementary sulphur, as sulphates, sulphides or in organic combination in the coal (Speight 2013, in coal handbook).

⁴³ Alternatively, plants may purchase higher-sulphur coals and remove the sulphur either during or after combustion (but at their cost). Utilities in Japan, for example, routinely have sulphur-removing equipment.

⁴⁴ For this reason, volatile matter estimates are often used to calculate combustibility indexes, which indicate the reactivity of the coal.

(HGI) measures grindability. Price adjustments are not usually made for variations in HGI - rather, contracts usually specify a typical HGI value for each shipment, and a (lower) HGI value that would entitle the buyer to reject the shipment.

- **coal piece size distribution:** the size of coal pieces do not usually affect prices, because power plants pulverize the coal down to fine powder immediately before it is used. But contracts will typically specify the particle characteristics of the shipment, with maximum percentages of large pieces (above 50 millimeters) and very small pieces (under 6 millimeters).

Contract Periods

Spot transactions dominate the international trade in thermal coal. But there is a range of customer practices when purchasing thermal coal. The coal contract may specify a fixed price per tonne, or use an agreed reference price. Usually a fixed-price contract will be shorter, and not exceed 12 months. Agreements may be for a specified quantity of coal, delivered as either one shipment, or in multiple shipments within a specified period.

ADDITIONAL INFORMATION

Measuring Calorific Value

There are two ways to express calorific value: gross calorific value or net calorific value. The GCV is the amount of heat liberated during a test in a laboratory, where the coal is combusted under standardised conditions at constant volume so that all of the water remains in liquid form. NCV is the maximum achievable heat in a boiler, because some energy is lost converting the water in the coal to vapour. (source: Thomas) NCV is therefore lower than GCV – it is the more “real world” calorific value. See Box for information on converting between GCV and NCV.

Contract Units of Measurement and Common Terms

Tonnes and Tons: The quantity of coal to be priced will be clearly specified in contracts, either in metric tonnes (1,000 kilograms) or, in transactions involving USA firms, short tons (2000 pounds or equivalent to around 0.907 metric tonnes).

British thermal units (BTUs): approximately 1055 joules of energy (1 BTU/lb = 0.556 Kcal/kg).

Dry Basis: Analytical concept where the coal is calculated to have zero moisture.

Dry Ash-Free Basis: Analytical data calculated to a condition of zero moisture and ash (i.e. first approximation to 'pure coal') to allow comparison of different coals. This is strictly a hypothetical basis because the ash is only generated on the incineration of the coal, but is used frequently because of convenience. Dry mineral matter free basis is more precise, but less easy to obtain.

Gross As Received (GAR) and Net as Received (NAR): contracts may use either gross or net as received as their standard valuation term. As noted above, the difference between GAR and NAR reflects the latent heat⁴⁵ of the oxygen and hydrogen which lowers the effective calorific value in the boiler (Knowledge Infrastructure Systems, n.d.). To make an approximate conversion from GAR to NAR: $NAR = GAR \text{ minus } 260 \text{ kcal/kg}$ (Thomas, 2002).

Fixed carbon content: measured as a percentage of the air dried coal sample, is approximated by taking the difference between 100 per cent and the sum of the estimated inherent moisture content, volatile matter content and ash content, also measured on an air dried sample basis.

“Long Term” Contract: For most countries, this refers to contracts of 1 year duration or less. However in the USA, this refers to contracts of 3 years or less.

45. Latent heat is the amount of energy absorbed or released by a substance during its change in physical state (such as from a solid to a liquid, or liquid to gas), measured in units of energy per “mole or unit of mass undergoing a change of state” (source: <https://global.britannica.com/science/latent-heat>)

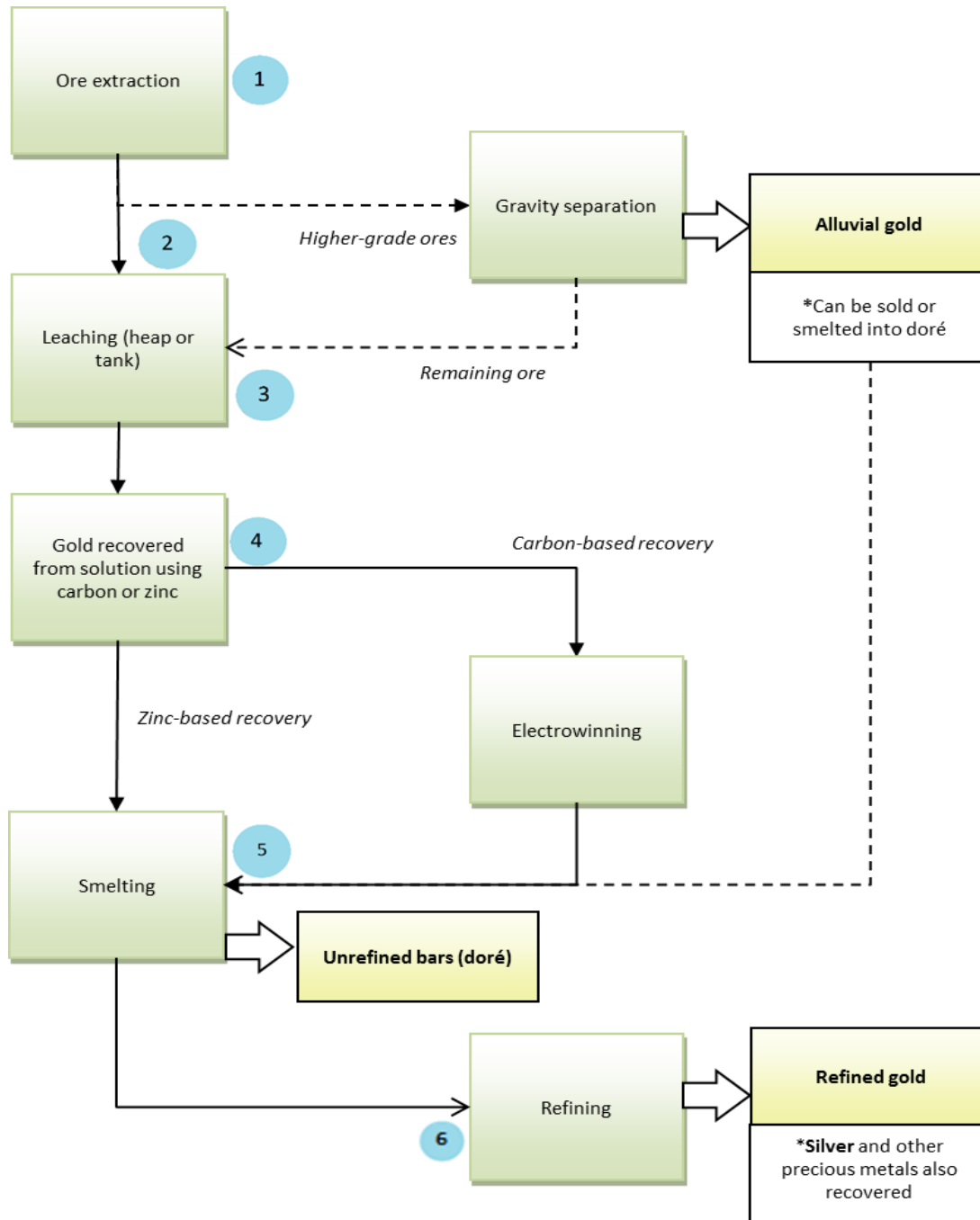
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Case Study: Gold

October 2016

Organisation for Economic Co-operation and Development (OECD)

MINING PRODUCTION AND KEY PRODUCTS



Gold Mining

Gold is usually in microscopic particles in the ore, and only small amounts of gold are typically extracted from each tonne of ore. Large mines may extract ore with an average grade as low as 1 gram per tonne.

Gold Production

- 1 The process of ore extraction depends on the grade and geometry of the ore body, particularly its proximity to the surface. Drilling and blasting are generally used to mine hard rock deposits, but significant amount of gold are also won from easily excavated alluvial deposits.

The ore is initially moved by trucks to a mill to be crushed and ground into increasingly smaller pieces. Primary crushers are used to break down the largest rocks to a size that can be more manageably handled. Conveyor belts move the broken ore to subsequent crushing machines, with screens used to sieve out pieces that are still too large.

- 2 Different “blocks” of the ore may be categorised as either “low grade” (up to 5-6 grams of gold per tonne) or “high grade” (7 grams or more), and may be sent for different recovery processes.

Gravity separation: Where the gold is in larger particles, various processes may be used that exploit the physical differences in the gold relative to the surrounding waste rock to separate them. Once the larger gold pieces have been recovered, the remaining ore is transferred back to recover any gold that is still present.

- 3 **Leaching of the ore:** Cyanide leaching is currently the primary method for gold recovery internationally at medium and large-scale mines. There are several processes used to recover gold dissolved in cyanide that follow a similar path, including the commonly used heap leaching and tank leaching processes.

Low-grade ore is first piled in heaps and cyanide solution is sprayed over the top of the pile. As the liquid passes through the ore, it gradually dissolves the gold into the solution, pooling in ponds over a period of weeks. This approach is relatively low cost and consequently used for lower-grade ores, and the process is repeated over several months to maximise the amount of gold recovered.

For higher-grade ores, leaching is usually done in specialised tanks, which - together with other facilities that must be constructed - makes this process more costly, since these facilities must also provide for carbon-based or zinc-based gold recovery.

- 4 **Recovering the gold: Carbon or Zinc-based approaches**

Carbon-based recovery: Two common carbon-based approaches are the “carbon in pulp” and “carbon in leach” processes which use carbon to bond with the gold, facilitating easier separation. In both processes the ground ore is mixed with water to form a pulp and prepared for an adsorption circuit. This circuit typically involves a series of sequential tanks where the carbon and the pulp mix, passing in opposite directions.

This process gradually transfers the gold onto the surface of the carbon. The main difference between the processes is the carbon can be applied sequentially after the cyanide leaching (this is CIL), or concurrently with the cyanide (CIP). The CIP is used widely, whilst the CIL process is primarily used to treat ores containing organic matter

and other carbon-based components.

Once gold has been adsorbed onto the pores of the carbon, a further cyanide solution is used to strip it back from the carbon and dissolve it again into the solution, with the now-"pregnant" (gold-rich) solution ready for electrolysis. Electrowinning is used to recover the gold from this liquid, "starter sheets" of stainless steel are placed into the solution and an electrical current is passed through the liquid. This causes the precious metals to bond to the starter sheets, gradually forming gold cathodes. The gold cathodes are smelted to separate the gold from the stainless steel.

Zinc-based recovery: An alternative to the carbon-based recovery processes is the "Merrill-Crowe" process. The solution from the leaching tanks is initially clarified using filters and oxygen is removed from the solution in a vacuum tower, so that the zinc will be more effective in attracting the precious metals.

Zinc dust is then mixed with the solution, causing the precious metals to precipitate. These solids are then caught using filters, and excess moisture removed by blowing air over the solids (often referred to as "cementation cake"). It may be necessary at this point to remove any mercury that may be present from the cake. This is done in a retort oven, which heats the solids causing mercury to vaporise and be removed. The solid is then ready for smelting.

5

Smelting: From the Merrill-Crowe process, the dry precipitate is mixed with fluxes and melted in a furnace. The process melts the metals and flux materials, which naturally separate (the gold sinks). The flux draws out the zinc and impurities and the molten (liquefied) material is eventually poured out - because the gold has sunk, the flux pours out first, then the gold is poured into a mould.

From the electrowinning process, the gold is separated from the stainless steel cathodes, either through a rinsing process or by smelting. In the rinsing process, the rinsed-off sludge is pressed and dried, mixed with fluxes and put into the furnace. Impurities are drawn out and the gold eventually poured into moulds to make bars or ingots (as above). In the smelting process, the cathodes are heated to approximately 1,100 degrees Celsius, melting the gold but not the stainless steel and allowing separation.

The smelting process may also incorporate gold obtained from other processes, such as gravity separation.

The bars are cooled. At this stage they are still an amalgam of gold and potentially other metals such as silver. These unrefined bars are known as doré. The bars are typically around 80-85 percent gold, with the balance made up of silver, copper, other base and platinum group metals, and impurities. In some countries the doré may contain more silver than gold.

6

Refining: Mines send their doré bars to a refinery to separate the gold, silver and other metals and remove remaining impurities. There are several different refining processes used depending on the composition of the product to be refined and scale of operations.

Using the “Miller” process, the gold is melted and gaseous chlorine is blown through the molten metal, drawing out impurities, which rise to the surface. This approach will typically produce gold that is 99.5 percent pure. If this purity is sufficient, the molten metal is usually cast into 400 ounce bars, ready for wholesale trade.

For higher purities (99.95 percent), a subsequent electrochemical process is used (the “Wohlwill process” is common), where the 99.5 percent pure gold is cast into anodes and placed into a solution of hydrochloric acid and gold chloride to dissolve it. Cathodes are placed into the liquid and an electrical current passed through the fluid, causing the gold to attach to the cathodes.

Those cathodes are then re-melted and made into small granules by pouring the molten metal through fine screens and then quickly cooled. This allows very precise measurement of gold weight. The (weighed) grains of gold are then poured into moulds and melted, or vice versa. The moulds are standardised sizes ranging from 1 kilogram bars to half-ounce ingots.

PRICING PRACTICES

Intermediate Gold Products⁴⁶

Based on the methods of transformation used by these mines, doré bars and concentrates are the key intermediate gold products that are traded at arm's length.⁴⁷ Substantive international trading in gold ore is rare and where it occurs, is confined regionally since much of the material is waste that makes it uneconomic to transport long distances.

Most gold mines recover, process and smelt gold, silver and other metals into doré, before involving arm's length parties in the final refining stages. Many mines do not have the capacity to refine the doré themselves, and involving external refiners simplifies gold sales.⁴⁸ For developing countries, the gold is usually exported as doré and refined abroad.

At arm's length, the main transaction for miners is to pay for the service of refining the doré to 99.5 percent gold (known as 'toll refining'). The gold to be refined is deposited into the customer's account with the refinery, and following refining, the customer would then choose to sell the gold to the refinery with reference to the prevailing spot price or to transfer the gold to the customer's gold account internationally (see Annex 1 on gold swap arrangements).⁴⁹

The refinery will first analyse (assay) the contents of the bar by melting it to ensure there are no pockets of inconsistent purity. Based on that analysis, the refinery will indicate the quantities of gold and silver present, quote a cost of refining, and indicate the price the refinery would be willing to pay for the metals. This is commonly presented in an "outturn" report (see Additional Information for an example).

Pricing and payments made for doré will depend on the physical properties of the bar and the details of the buyer and seller. The negotiated payment to the mining company are based firstly on the value of the gold and silver ("payable metals") present, reduced by "retention fees", refining charges and in some instances, other fees and taxes such as environmental charges.

Payable Metals and the Reference Price

Doré is priced based on the measured quantities of gold and silver present in each bar. Each troy ounce is priced with reference to prevailing refined gold (and silver) spot prices. Other precious metals such as platinum are usually not paid for (although they may be recovered profitably by refineries).

The reference price is most often based on London Bullion Market Association (LBMA)'s twice-daily electronic auctions. The results of these auctions (AM and PM) are published as an official

⁴⁶ There are several gold mining processes used across a range of small-scale to large mines. The focus of this paper is medium to large-scale mines.

⁴⁷ The revenue losses from non-reporting or under-reporting of the sale of gold products by artisanal miners or intermediaries is outside the scope of this study.

⁴⁸ For example, the mine need not have the exact quantity of gold required for standardised international trades, because their supply can be mixed with that of other mines (Suchecky, 2015).

⁴⁹ This approach is also used for gold from alluvial sources, although with artisanal mining the gold is usually first sold to a trader.

“LBMA Gold Price”, quoted per fine troy ounce in USD, Euro and UK Pound Sterling. Market information services such as Bloomberg and Reuters then republish that information as well as real-time price developments based on information from key refined gold traders.

Refineries may use the LBMA reference price directly for the day the bar was received⁵⁰, or alternatively may slightly adjust this spot price to provide the refinery a commission (that is, the refinery would take a spread on the price they pay for unrefined gold and the price they receive for selling refined gold). This means the mine might receive close to, but not necessarily the full LBMA spot price. Some transactions may use an average of the LBMA price over an agreed time period (quotation period), but this is rare.⁵¹

At the margin, the negotiating skills of the parties may affect the final agreed price, meaning small to medium sized mines with relatively lower bargaining power may achieve prices below those of large miners.⁵²

Pricing Adjustments and Refining Fees

Spot Price - location adjustments

For customers that elect to credit the gold into an “unallocated” gold account in London⁵³, the spot price may be adjusted, to approximate the cost of transporting the gold (see Annex 1 on Loco Swaps).

These adjustments reflect the demand-supply balance in both the buying and selling locations. For example, a refinery located in a market with an excess of gold supply relative to domestic demand would usually sell at a discount to gold physically located in London. For example, the Loco Perth (Australia) discount is approximately US 30-40 cents/ounce to the Loco London spot price. Alternatively, locations with an excess local demand for gold relative to what the refineries in that location supply would sell at price above the London spot price, to attract the delivery of gold.⁵⁴ When physical gold flows are stable, the adjustments are small however.

Metals lost during refining – retention fee

Payments are usually adjusted to account for losses during the refining process, sometimes known as a “retention fee”. These adjustments are not published by refineries. Based on discussions with refineries however, they appear to be small where major refineries are involved – around 0.1 percent for gold and 1 percent for silver.⁵⁵ The adjustment varies across refineries (for

⁵⁰ For example, Rand Refinery in South Africa uses the London PM fix.

⁵¹ For royalty calculations, revenue authorities may prescribe a particular quotation period for valuing the metals, such as the average LBMA gold price for the calendar month in which the doré was sold.

⁵² The refinery may offer a different price, based on their judgement as to the market savvy of the customer and potential for future business.

⁵³ Unallocated accounts are gold accounts that operate much like bank accounts for currency. Gold amounts can be debited and credited to the account, with the balance representing the indebtedness between the two parties. They do not indicate any claim over a specific bar, in contrast to allocated accounts where specific bars are set aside.

⁵⁴ Put another way, where there is excess supply, the supplier will bear the cost of shipping the gold to other locations. Alternatively, in a location with strong demand, the purchaser will pay the shipping cost.

⁵⁵ This small adjustment is in contrast to payable gold in concentrates which are typically larger since concentrates must go through more stages of transformation, each with the potential for metal losses (discussed in the copper case study)

some refineries, it is standardised, for others, it is customer-specific), but it is applied without reference to the actual losses incurred on a particular doré bar.⁵⁶⁵⁷

Refining Charges (RC)

Refining charges are applied for removing impurities and separating the precious metals. Refineries may also include fees for environmental costs and for assay services, but these are small relative to the value of the metal.

Refining charges are set per gross ounce – not troy ounce – of precious metal, but are often negotiated for each individual gold supplier. Negotiated RCs are based on factors such as:

- the amount of gold to be processed and size of the customer (higher quantities attracting a lower charge);
- the expected frequency of refining (i.e. whether a “one off” transaction or part of a longer-term arrangement – the latter usually receiving a lower charge); and
- the purity of the product to be refined (doré with higher percentages of gold will usually have a lower charge per ounce relative to one with more silver, since the separation of the metals may be easier).

The individual refining charges imposed are not however publicly disclosed – they are closely guarded commercial terms. That said, at the time of writing they are estimated to be in the order of USD 1-3 per gross ounce. Given the discussion above, it would also be reasonable to presume larger mining companies, particularly operating on longer-term arrangements with the refinery, would have lower refining charges. Charges that are materially higher than these levels warrant closer review.

⁵⁶ Any difference between the adjustment and actual losses is a revenue stream for the refinery, providing an incentive to ensure the refinery is operating as efficiently as possible.

⁵⁷ One refinery advises the content of each bar will affect the retention fee applied.

ADDITIONAL INFORMATION

Gold - Measurement for trading

The trading unit for gold is fine troy ounces (for silver it is simply troy ounces). A troy ounce is around 31.1 grams, as compared to the standard ounce (around 28.3 grams).

The distinction between gold and silver is that the unit of measurement for gold represents pure gold, irrespective of the purity of a particular bar. In contrast, for silver it represents one ounce of material, of which a minimum of 999 parts in every 1,000 will be silver.

“Fineness” is a measure of the proportion of gold or silver in a bullion bar, expressed in terms of the fine metal content in parts per 1,000 (bullion refers to pure gold that is in bar or ingot form). It is therefore a measure of purity. For gold, retail markets such as the jewellery industry usually express fineness in “carats”, which are parts of fine gold per 24. For example, eighteen carat gold jewellery is 18 parts of pure gold per 24 - in bullion markets it would be referred to as “750 fine” (LBMA, 2015).

Wholesale gold trading

There are two key wholesale markets that determine the spot price of refined gold (and silver). These are the “over the counter” (OTC) market and futures exchanges.

The OTC “market” is an international network of transactions that occur directly between traders that are typically professional or corporate entities trading gold bars on standardised terms such as:

- a specified purity (99.5 percent or “995 fine” – see Annex 1 on measurement);
- gold content (between 350 and 430 ounces, with bars generally close to 200 ounces; and
- contract settlement in London in two business days (LBMA, 2015).

Futures markets are regulated exchanges where the price is quoted for delivery of the metal at specified future dates. The largest market is the US-based COMEX market. The next futures delivery date is sometimes used as a proxy for the spot price, although the LBMA price is the most commonly used reference price.

OTC gold transactions are conducted on bilaterally agreed terms, anchored closely around spot gold prices.

Example of refinery outturn document

MEMORANDUM OF OUTTURN						
Our Ref:						
Date of Lodgement: /11/2011						
Date of Outturn: /11/2011 10:32						
Gold Price: \$ 0.00						
Silver Price: \$ 0.00						
Shipment No.:						
Deposit Number	Receipt Wt(oz)	Official Weight	Assay Report Gold(%)	Assay Report Silver(%)	Fine Gold Allowed(oz)	Fine Silver Allowed(oz)

	Description: SR 4393-					
25790	624.85	620.20	77.150	20.490	478.006	125.808
Description: SR 4395-						
25791	968.77	963.99	87.020	10.870	838.025	103.738
Description: SR 4397-						
25792	906.04	902.94	83.200	14.870	750.495	132.924

Total Fine Allowed					2066.526	362.470

To Metals Account:					2066.526	362.470

Buyer:						
L/No:						

Less Charges: Refining					1,499.79	
Assay					265.50	
Environmental					81.91	
Freight Dep No:25792					2,299.69	
GST					0.00	-4,146.89

					Amount Due To Refinery	
					USD	4,146.89
=====						

Source: Indonesian Stock Exchange

Gold - Location ("Loco") Swaps

Gold markets have developed a system to simplify and manage the transfer of gold internationally, reducing the quantity of gold that needs to be physically transported.

Loco swaps are a linked gold purchase and sale of the same quantity which offset one another, where the two parts of the transaction are for gold in different physical locations. For example, a loco swap might be used to transfer 100 ounces of gold from a refinery in Hong Kong ("loco Hong Kong") to London. In this case, the refinery would:

- buy the gold from the miner in Hong Kong, withdrawing 100 ounces from the miner's account in Hong Kong, and

- sell the gold back to the miner in London, depositing 100 ounces into the miner's London account.

The two transactions are done simultaneously in the same currency, at the prevailing prices for gold in each location - in this hypothetical example, assume the loco London price is \$1002 per ounce, the loco Hong Kong price is \$1000, a discount of \$2 per ounce. The miner would then pay the refiner the location discount, in this case \$200 (100 ounces at the discount of \$2 per ounce).

Source: Perth Mint.

CONCLUSIONS AND POSSIBLE FURTHER WORK

As outlined in this report and the related *Toolkit for Addressing Difficulties in Accessing Comparables Data for Transfer Pricing Analyses*, applying transfer pricing rules to commodity transactions – mineral, hydrocarbons and agriculture - remains a complex task for revenue authorities in both developed and developing countries.

Many elements need to align for developing countries to have confidence that the related party transactions on mineral products reflect common market practices. In particular, transfer pricing rules must be clearly outlined and enforced effectively, drawing on industry understanding and well-developed international information exchange networks. For developing countries, getting all of these elements in alignment remains a massive undertaking.

This work on mineral pricing fills an information gap and should benefit developing countries. But more work is needed. Several developing countries are starting to apply the methodology and draft case studies, forming a foundation for further research and insight. Companies have also reacted positively to the case studies, since they assist in allowing governments and companies to more quickly past discussions as to the structure and operations of domestic mining operations to the products sold and their appropriate treatment under transfer pricing rules.

Continued efforts to assist countries with these challenges are critical. Taking the basic “building blocks” as outlined in the introduction (Box 3), more action could be taken across several fronts.

Practical Industry Knowledge

Additional case studies: Feedback on the initial case studies indicated many countries appreciated the studies chosen, but needed help on other minerals or oil and gas products. Consequently, the initial case studies could be expanded productively according to developing country and DWG priorities, thereby providing countries with additional points to improve their understanding of their commodity sectors. Based on the methodology developed, the work to date could be readily expanded to other mining commodities, and then to hydrocarbon (oil and gas) and potentially even agricultural markets. The OECD intends to continue working on these studies with additional work into rough diamond valuation and bauxite to be delivered in 2017, and a further study, potentially into a rare earth mineral in 2018.

Expanded study areas: Also based on the feedback of developing countries, the work could also be expanded into wider areas including a deeper examination of price setting in freight markets, (both land and seaborne); and onto targeted areas including costs of key mining, smelting or refining inputs, since these determine CIT and royalty deductions. Several organisations have expressed interest in pursuing this work. Further work could also be done comparing cross-country experience in setting prices for tax/royalty purposes through laws or APAs.

Wider issues

Implementing effective transfer pricing rules: The implementation of transfer pricing rules in developing countries and their application remains essential. The toolkit on comparability will address some of these concerns, and other publications appear to be imminent such as a World Bank publication on the transfer pricing issues in the mining sector. Further toolkit work will also continue to include a thematic extractive industry lens wherever possible.

Trading hubs: The remuneration and role of the trading and logistics entities of multinationals is consistently identified as a key area of transfer pricing dispute between taxpayers and tax authorities. Further work to examine the functions, assets and risks of these entities in the mining industry could be worthwhile. However, the forthcoming World Bank publication may address these concerns. If needed, further work may be undertaken by the Platform partners, regional bodies or via partnerships such as between the OECD and the Inter-Governmental Forum on Mining (IGF).

Price risk management (hedging): Understanding the role of price risk hedging in commodity transactions is a particular area of complexity for developing countries. Further work could be undertaken to examine how companies manage their price risks – particularly where hedging is done between related parties in an MNE group - and whether there are base erosion risks from these practices.

Encouraging greater market price transparency for some minerals: For those minerals with opaque markets and no international reference prices, further work could be done to examine how transparent markets have emerged for those that do; what policy settings may be effective in bringing about greater transparency in particular markets where it is needed.

Continued capacity building and training: Country and regional-level assistance remains essential. This assistance continues to be necessary on the design and application of transfer pricing rules, as well as to improve sector knowledge and to access to taxpayer information through information exchange.

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**Annex 1 – Supplementary Mining Industry
Information and Report References**

ADDITIONAL MINING INDUSTRY INFORMATION

Long term supply agreements

Long-term supply agreements establish a relationship between a mining company and a purchaser of mineral products where the purchaser agrees to buy a specified product from the mining company in specified quantities. This may be the mine's entire production, or a proportion. Offtake agreements are often signed before the construction of a mine - the presence of the agreement may assist the mining company to obtain financing for the mine's construction.

Such contracts typically set a pricing mechanism to be used for the duration of the agreement. The pricing formulas often mean shipments of the mine product may occur at prices that do not accord with the spot price. This divergence may be either in the form of a premium or discount to the spot price, which will depend on various factors including the negotiating ability of the parties, market (demand and supply) conditions for the mineral production and the strategic objectives of each side of the agreement. For example, the mining company may offer a discount to the spot price if the offtake agreement allows them to secure a stable buyer of the mine output, thereby minimizing costs associated with searching for new customers and potentially stabilising expected future revenues. This may be particularly important where the mine is uncertain of future demand for its products.

Alternatively - or in addition - a discount may be afforded through an offtake agreement to repay the upfront financing costs of the mine's construction or a production facility. In this case the discount operates in lieu of cash payments. For some other minerals, particularly rare earths, a purchaser may actually offer a premium to assure supply, particularly where a mineral product is critical to its own production process and/or difficult to source.

Blending of mine output

There is considerable diversity in the output of different mines, both within and across countries. Miners may need to blend the output from different mines to create marketable products – that is, mineral products that meet the specifications of an established market with a larger number of buyers and sellers, or of a specific customer, particularly where there is a longer-term supply agreement in place.

In addition, mining companies may blend products to optimize prices for the total mineral assets they control – for example, a mineral concentrate product with a more standardized blend may yield better overall revenues than unblended forms that may only appeal to a smaller number of customers.

Ultimately, the blended products need to be suitable for the requirements of customers. A concentrate with abnormal specifications may not be suitable for a smelter, because it might reduce the efficiency of the smelting process (meaning the process takes more time; requires

additional processes; requires more inputs such as energy or chemicals; or reduces the amount of metals that can be recovered). In addition, the material might have to meet environmental standards (for example, China has prohibited the importation of copper concentrates with arsenic levels above 0.5 percent (Platts, 2014)). The mineral product must also be safe to transport and conform to maritime guidelines (for example, copper concentrate can liquefy during transportation if moisture content is too high).

- For **copper**, blending occurs primarily at the concentrate stage, but may also occur earlier in the value chain. At the ore stage, it involves the use of specialised equipment such as stackers that distribute materials evenly across an existing stockpile until a target set of proportions is achieved (ATO, 1998). For smelters, blending can be done to effectively dilute 'dirty' concentrates (that is, concentrates with higher than accepted levels of deleterious elements) so long as the smelter is usually dealing with relatively 'clean' concentrates (Wellmer et.al, 2008).
- For **iron ore**, blending typically occurs at the mine to ensure iron ore grades conform as closely as possible with widely traded benchmark products.
- For **thermal coal**, blending can occur at the mine. Final users may also blend coal grades to ensure the coal is suitable for their boiler(s).

Shipping - Key Standardised Trade Terms ("Incoterms")

For products transported by sea, another key factor affecting final price will be the costs of transportation. Several incoterms are used depending on market conditions and the bargaining power of the parties. The most common are FOB, CFR and CIF.⁵⁸

- **FOB:** "Free On Board" means that the seller delivers the goods on board the vessel nominated by the buyer at the named port of shipment or procures the goods already so delivered. The risk of loss of or damage to the goods passes when the goods are on board the vessel, and the buyer bears all costs from that moment onwards.
- **CFR:** "Cost and Freight" means that the seller delivers the goods on board the vessel or procures the goods already so delivered. The risk of loss of or damage to the goods passes when the goods are on board the vessel. The seller must contract for and pay the costs and freight necessary to bring the goods to the named port of destination.
- **CIF:** "Cost, Insurance and Freight" means that the seller delivers the goods on board the vessel or procures the goods already so delivered. The risk of loss of or damage to the goods passes when the goods are on board the vessel. The seller must contract for and pay the costs and freight necessary to bring the goods to the named port of destination. The seller also contracts for insurance cover against the buyer's risk of loss of or damage to the goods during the carriage. The buyer should note that under CIF the seller is required to obtain insurance only on minimum cover. Should the buyer

⁵⁸ Source: Incoterms text is quoted directly from International Chamber of Commerce Incoterms 2010 in accordance with ICC expectations. Full terms at ICC bookstore.

wish to have more insurance protection, it will need either to agree as much expressly with the seller or to make its own extra insurance arrangements.

One other term that is used is “ex works”, which means the parties have agreed that the supplier will make the product available at the place it was created, rather than at, for example, the port of export. This means the buyer must pay costs of transporting the product from the factory or place of manufacture, and takes all delivery risks at that point.

Shipping – Key terms

Bulk shipping – methods

- **Bulk Freight** – the ore is free/loose, not in packaging of any sort (and not in a shipping container). The product usually goes straight into storage hold of the ship.
- **Break Bulk** – the commodity is in bags, bales, drums, etc. This can make it more expensive to load/unload.

Payment terms

Several payment terms are referred to in pricing publications, which have different implications for the timing of payments. Selected terms are defined below.

- **At sight:** the purchaser must pay on receipt of an invoice from the seller.
- **Letter of credit:** indication from the purchaser’s bank that it financially supports the transaction (that is, if the buyer refuses to pay, the seller has recourse to the bank for payment).
- **Cash against documents:** seller retains ownership of the product until payment is made. A mutually-agreed intermediary (such as a bank) holds proof of purchase that is provided to the purchaser once payment has been received by that intermediary.
- **Documents against acceptance (D/A):** shipping and title documents are passed to the buyer by an intermediary (such as a bank) only if the buyer accepts the accompanying bill of exchange or draft by signing it.

Documents and communications

- **Bill of Lading (“B/L”)** – A key document used in the transportation of goods, outlining the contents of shipment (type and quantity) and destination of the good being carried. It is a document between the seller and the transporter/carrier.

Source: Investopedia.com

- **Notice of Readiness (NOR)** – A communication from a shipmaster that advises either the sender or receiver of the cargo that the ship has arrived at port and is ready for loading or unloading.

Source: Businessdirectory.com

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Annex 2 – Data Sources on Transactions for Each Case Study

Please note - *The following information has been drawn from the websites of publication service providers and from discussions with company representatives. It is intended as a reference source for revenue authorities, but the OECD does not necessarily endorse the information contained in these publications.*

DATA AND INFORMATION SOURCES

Copper

ITEM	COMPANY & PRODUCT	NOTES	SOURCE
General mine information by country	<p>International Copper Study Group – Directory of Copper Mines and Plants.</p> <p>Contains information on copper product production and key producing countries. It includes information on current, planned and recently closed mines including ownership and key products produced.</p>	<p>From ICSG: "The subscription price for the annual service (2 issues) is €500 for subscriptions originating from institutions based in ICSG member countries* and €750 for subscriptions from non-ICSG member countries. Single copies are available for €400 per year (ICSG member countries*), €600 per year (non-ICSG member countries)."</p> <p>Free sample available at ICSG website (www.icsg.org).</p>	ICSG
Concentrates	<p>CRU: Copper Concentrates Market Outlook.</p> <p>Includes an analysis of concentrate quality, including tables and charts indicating copper grades and specifications for payable and penalty elements.</p>	<p>Biannually (October, April) plus updates.</p> <p>Also access to CRU analysts.</p>	CRU Concentrates
Concentrates - China	<p>Asian Metal.</p> <p>Offer price data on Chinese copper concentrates, including by region.</p>	<p>Concentrate must have minimum 20 percent copper.</p> <p>All prices are "ex works". Prices available for concentrate produced in Jiangxi, Inner Mongolia, Yunnan and Tibet.</p>	Asian Metal
TC/RC - Japan	<p>Platts Metals Daily, Platts Metals Alert and the Platts internal database</p> <p>Publish quarterly information on copper concentrate TC/RC.</p> <ul style="list-style-type: none"> treatment charges (CIF Japan, code: AAFGC00). 	<p>CIF Japan, quarterly.</p>	Platts

	<ul style="list-style-type: none"> Refining charge (CIF Japan, code: MMCCJ00). 		
TC/RC	<p>CRU Copper Report</p> <p>Provides two estimates:</p> <ul style="list-style-type: none"> Mine/trader Chinese smelter 	Calendar monthly. Both are CIF "Asian port".	CRU
TC/RC - China	<p>Shanghai Metals Market (SMM) - China Copper Market report.</p> <p>Includes data on Chinese TC/RCs for imported copper concentrates.</p> <p>SMM publish an annual report, also weekly updates.</p>	Also covers general market conditions.	SMM
TC - China	<p>Asian Metal website</p> <p>Offers data on treatment charges for:</p> <ul style="list-style-type: none"> CIF China (30 percent copper) FOB Chile (30 percent copper) 	Daily information	Asian Metal
Cathode price premiums	<p>CRU Copper Report</p> <p>Provides three estimates:</p> <ul style="list-style-type: none"> Europe – CIF NW European Port - Premium above the official LME cash settlement price for copper at the time of contract confirmation USA – East Coast delivered - Premium above the official first position COMEX price for copper at the time of contract confirmation Far East – CIF Far Eastern Port - Premium above the official LME cash settlement price for copper at the time of contract confirmation 	<p>Monthly, reflecting deals done in the previous week.</p> <p>Europe means: CIF Rotterdam</p> <p>USA means: east coast delivered</p> <p>Far East means: CIF Shanghai</p>	CRU
Cathode price premiums	<p>Asian Metal website</p> <p>Data available on:</p> <ul style="list-style-type: none"> China cathodes Europe grade A cathodes 	<p>Data is all "ex works" (price at the place of refining).</p> <p>Asian Metal has information on regional Chinese prices, for Jiangxi, Shanghai,</p>	Asian Metal

	<ul style="list-style-type: none"> • US cathodes 	Zhejiang, Tianjin and Guangzhou.	
Cathode price premiums	<p>Platts Metals Daily</p> <p>Estimates available for:</p> <ul style="list-style-type: none"> • Europe – Grade A CIF Italy (weekly update) • Europe – Standard CIF Rotterdam: Weekly estimated \$/mt premium for Russian standard grade copper on a CIF Rotterdam basis (weekly update) • Copper C&F China – Daily estimated premium for Grade A cathode, mostly of Chilean origin, over LME cash for C&F China copper business. (daily update) • Copper New York Dealer cathodes premium (US ¢/pound, weekly update) • In-Warehouse Singapore Premium – Daily estimated premium for Grade A material of all origin, in-warehouse Singapore (daily update) 	Premiums estimates usually a range.	Platts Metals Daily
Cathode price premiums	<p>Metal Bulletin Research – Base Metals Weekly Market Tracker</p> <p>Provides information on premiums over spot copper prices for Shanghai, Singapore, Rotterdam and USA.</p>	<p>Publication also contains information on copper demand-supply balance and price forecasts.</p> <p>Free sample available at website.</p>	Metal Bulletin Research
Penalties	<p>CRU: Copper Concentrates Market Outlook.</p> <p>Includes an analysis of concentrate quality, including tables and charts indicating copper grades and specifications for payable and penalty elements.</p>	Biannually (October, April) plus updates. Also access to CRU analysts.	CRU Concentrates

Others checked: Asian Metal has no information on penalties. CRU Copper Raw Materials publication also contains information on sulphuric acid prices obtained by smelters (available at [CRU Concentrates](#))

Gold

ITEM	COMPANY & PRODUCT	NOTES	SOURCE
Gold price per ounce – daily price	LBMA Publishes the daily AM and PM London fix spot prices in USD. Data on website only for 2015.	No data export facility. Indicative (unofficial) prices in EUR and GBP also provided. Free publication.	LBMA
Gold price per ounce – daily price	Wall Street Journal Publishes daily spot price based on PM London fix. Price in USD. Refers to Handy and Harman base price for gold bar.	Data can be exported to MS Excel (XLS), CSV, XML, JSON. Free publication.	WSJ
Gold price per ounce – monthly average	Western Australian Department of Mines and Petroleum Provides schedule of average monthly spot prices (for use in royalty assessment forms).	Monthly average spot price, quoted in USD and AUD. Based on London fix. No daily data. As at April 2015, data ranged from 1996 to end-2014. Free publication.	WA Department of Mining and Petroleum
Gold price per ounce	World Bank “Pink Sheets” Publishes monthly average gold spot price, based on London PM fix.	Quoted in USD. Updated monthly. Data available from 1960 onwards. Free publication.	World Bank
Platts	Platts Metals Daily Third party information on precious metals (eg LBMA AM and PM gold price fix, COMEX spot prices).	Subscription publication. No unique data. Market commentary on price movements.	Platts

Others checked: Asian Metal – no gold information on website. Perth Mint – no pricing data on website. CRU – no precious metals data, but do have information on mines in operation and associated production cost data from 2010. Bloomberg and Thompson Reuters also offer commodity data terminals with real time spot market prices.

Iron Ore

PRODUCT	COMPANY & PRODUCT	NOTES	SOURCE
Iron ore – pricing database	<p>Minerals Valuation Service</p> <p>Provides an analytical tool to compare price information for transactions of common iron ore products, drawing on Platts databases of transactions and research into related price components such as local transport costs.</p>	MVS is owned by Platts.	Platts.com
Iron ore – market data and outlook	<p>UNCTAD Iron Ore Market Report</p> <p>The 2015 issue of the Report covers developments in the iron ore and steel markets in 2014, an overview for 2015-2016, and as well as country, company and project information.</p>	The market report is produced in conjunction with market data firm SNL.	UNCTAD
Iron ore – market data and outlook	<p>UNCTAD Iron Ore Statistics Database</p> <p>Statistics available with a subscription. The data covers key importer and exporter countries, and dates back as far as 1970. The latest data is for October 2015, covering 119 countries and more than 150 ready-to-use analytical country groupings</p>	The statistics are produced in conjunction with market data firm SNL.	UNCTAD
Iron Ore fines	<p>Argus Media – Steel Feedstocks Publication</p> <p>Publication contains:</p> <ul style="list-style-type: none"> • 58% Fe iron ore fines cfr Qingdao • 62% Fe iron ore fines cfr Qingdao (ICX) • 65% Fe iron ore fines cfr Qingdao 	Delivery period is 2-6 weeks.	Argusmedia.com
Iron ore - fines	The Steel Index	TSI is owned by Platts.	TSI

	<p>Offers reference prices for iron ore fines imported into China.</p> <p>Iron Ore Fines, Chinese Imports (CFR Tianjin Port):</p> <ul style="list-style-type: none"> • 62% Fe (US\$/dry tonne) • 58% Fe (US\$/dry tonne) • 62% Fe, 2% Al (US\$/dry tonne) • 63.5/63% Fe (US\$/dry tonne) • 65% Fe (US\$/dry tonne) 	<p>Also offer a monthly Iron Ore Review publication, summarising price movements and market conditions. Sample available at TSI.</p>	
Iron Ore lumps	<p>Argus Media – Steel Feedstocks</p> <p>Publication contains:</p> <ul style="list-style-type: none"> • 63% Fe lump, cfr Qingdao • 63% Fe lump premium, cfr Qingdao 	<p>Delivery period is 2-6 weeks.</p>	<p>Argusmedia.com</p>
Iron ore – key products	<p>Metal Bulletin Research - Steel Raw Materials Weekly Market Tracker</p> <p>Contains information on several iron ore products:</p> <ul style="list-style-type: none"> • Qingdao, China 62% Fines CFR \$/tonne • Qingdao, China 65% Pellet CFR \$/tonne • India 63.5% Fines FOB \$/tonne • China Import Fines CFR \$/tonne • China Import Pellet 65-66% CFR \$/tonne • Domestic Average, China Concentrate Delivered \$/tonne • Domestic Average, China Pellet Delivered 	<p>Updated weekly.</p> <p>Free sample available at website.</p>	<p>Metal Bulletin Research</p>
Iron Ore lump and pellet premiums	<p>Platts – Metals market data package</p> <p>Contains:</p> <ul style="list-style-type: none"> • Estimate of Australian-origin lump price premium (\$USD/dmt) for lumps sold to Chinese steel mills, published quarterly. 	<p>Lump premium is in a dollar range, rather than a point estimate.</p> <p>Pellet premium estimates based on term contracts in sales to European steel mills. Based on 65 percent iron</p>	<p>Platts</p>

	<ul style="list-style-type: none"> Estimate of Atlantic Basin (Brazil-origin) pellet price premium above iron ore fines (\$USD/dmt) 	pellets. Premium is calculated over Brazil FOB fines product which has been adjusted up to 65 percent iron.	
Iron Ore – adjustments for iron content and impurities	<p>The Steel Index</p> <p>Offers price differentials for iron and impurities (average spot market values for Chinese imports). Available for both high-grade reference iron ore (in the range 60-66% Fe) and low-grade iron ore (in the range 55-60% Fe).</p> <ul style="list-style-type: none"> Iron (Per 1% Fe 60-64% Fe) alumina (Per 1% Al up to 4% Al) silica (Per 1% Si 4-9% Si) 	Updated weekly.	TSI
Iron ore - miscellaneous	<p>Tex Report – daily report</p> <p>Daily reports contain news on recent pricing and trade activities, including trade statistics for key iron ore markets.</p> <p>Contains price developments for the Chinese Iron Ore Price Index (CIOPI).</p>	<p>Yearly subscription cost up to \$USD 1850.</p> <p>Access to reports back to 2004.</p> <p>Free trial available at website (www.texreport.co.jp)</p>	Tex Report - Daily
Iron ore - miscellaneous	<p>Tex Report – Iron Ore Manual</p> <p>Contains detailed discussion of iron ore markets, economic developments affecting those markets.</p>	Publication cost is \$US 210-220 depending on region.	Tex Report
Iron ore – geographical adjustments	<p>Platts – metals market data package</p> <p>Contains 'netbacks' which adjust the IODEX index price to remove the cost of shipping from several origins. Denoted in \$USD/DMT. Netbacks available for:</p> <ul style="list-style-type: none"> Australia (FOB port Hedland, Capesize vessel) Brazil (FOB Tubarao, capesize vessel) 	<p>More detail of the specifications available at Platts Methodology and Specifications Guide.</p> <p>Deducts dry bulk freight assessments from IODEX 62 percent Qingdao. Based on common ore moisture levels seen at the origin.</p>	Platts

	<ul style="list-style-type: none"> • East India (FOB Haldia/Paradip, handymax vessel) • West India (FOB Mormugao, handymax, panamax vessels available) • South Africa (FOB Saldahna Bay, capesize vessel) 		
Iron ore – geographical adjustments	<p>The Steel Index – Daily Edition (email)</p> <p>Contains estimates of freight cost, to allow CFR indexes to be adjusted back to FOB terms. Also provide an estimate of CFR Europe price for 62% Fe index. All estimates in US\$/dry tonne. Provided for Brazil, Western Australia and India.</p>	<p>TSI is owned by Platts.</p> <p>Likely the same data as in Platts metals market data package (see shipping data sources).</p>	TSI
Iron ore - concentrates	<p>The Steel Index – Daily Edition (email)</p> <p>Provides price for 65% Fe concentrate, ex-works, Shandong mine (RMB/dmt including VAT). Payment by D/A. Prices updated weekly.</p>	<p>TSI is owned by Platts.</p> <p>Sample available at TSI website.</p>	TSI

Others checked: The Steel Index – no information on moisture price adjustments. Platts – no moisture price adjustments.

Thermal Coal

PRODUCT	COMPANY & PRODUCT	NOTES	SOURCE
Coal price information, market developments	<p>Argus Coal Daily International</p> <p>Publication providing information on recent coal market developments, news and data.</p> <ul style="list-style-type: none"> • API 2 and API 4 swap prices • Argus cif ARA (Amsterdam Rotterdam Antwerp) spot coal assessments • Richards Bay prices (South Africa) • Newcastle prices (Australia) • Asia assessments - cfr south China, cfr east India • Turkish assessments - cif Marmara, cif İskenderun • Russian assessments - fob Baltic ports, fob Vostochny 	<p>Americas covered in separate publication.</p> <p>Includes forward price estimates and derivatives.</p>	Argus Media
Coal price information, market developments	<p>Argus Coal Daily Market Service</p> <p>Provides coal market intelligence, pricing and analysis for the US coal markets. Argus assesses prices in the traditional spot markets for physical and over-the-counter (OTC) coal.</p>	Includes 'deals done', freight rates, and price analysis	Argus Media
Coal price information, market developments	<p>Platts Coal Trader International</p> <p>Includes Platts price assessments for coal trading in the Atlantic and Pacific markets, including independent and editorially assessed thermal coal prices for the Chinese market.</p>	<p>Able to customise data provided</p> <p>Also have a database of information on power plants worldwide.</p> <p>Includes forward price estimates.</p>	Platts
Standardised Coal Trading	<p>GlobalCOAL Standard Coal Trading Agreement (SCoTA)</p>	Viewing the standardised contract is free, but using requires signing up to a	GlobalCOAL

Agreement	Provides standardised set of terms and conditions for international coal sales and purchases.	product licencing agreement.	
Economic developments and analysis of coal markets	<p>IEA Medium Term Coal Market Report 2016</p> <p>Major publication covering coal market developments in wider energy market context. Includes:</p> <ul style="list-style-type: none"> • Trends in coal demand and supply • Developments in trading of coal products globally • Forecasts of demand and supply conditions • Analysis of investment in coal supply • Information on country trade in coal products 	Authoritative source on coal market developments, trading and outlook (economic context to the trade in coal).	International Energy Agency